Human Capital, Female Employment, and Electricity: Evidence from the Early 20th-Century United States∗

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Abstract

This paper revisits the link between electrification and the rise in female labor force participation (LFP), and presents theoretical and empirical evidence showing that electrification triggered a rise in female LFP by increasing market opportunities for skilled women. I formalize my theory in an overlapping generations model and find that my mechanism explains one quarter of the rise in female LFP during the rollout of electricity in the United States (1880–1940), and matches the slow decline in female home-production hours during this period. I then present micro-evidence supporting my theory using newly digitized data on the early electrification of the United States.

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Improving access to electricity has received considerable attention in academic and policy circles recently, and has long been a primary goal of international development programs. This avid interest stems from the belief, widely held by economists and policy makers, that electrification is a precondition for development. According to this view, having access to electricity is not only necessary for modern production, but can also alleviate poverty by fundamentally changing the time-use patterns and organization of households. The increase in opportunities for women following electrification is frequently singled out as one of the main drivers of such changes and thus of the aggregate prosperity that results from expanded access to the grid. Gordon (2016) argues, for instance, that the economic revolution fueled by electricity is unrepeatable, because new technologies are unlikely to have such profound effects on so many people. The main mechanism fueling the effects of electricity on women explored in the literature to date is the reduction in the time burden of housework and consequent rise in female labor force participation (LFP). In a notable paper, Greenwood et al. (2005) formalize this intuition by arguing that the adoption of time-saving appliances following electrification enabled women to be liberated from housework and was one of the main factors leading to the steady increase in female labor supply in the United States during the 20th century. Other work argues, however, that trends in female time spent in home production do not match this intuition. For instance, after closely examining several time-use studies, Ramey (2009) finds that the time spent on housework by women fell only minimally between 1900 and 1965, even though the prevalence of electricity and the use of time-saving appliances increased significantly during the same period.

In this paper, I revisit the link between electricity and female LFP, and present theoretical and empirical evidence supporting a new channel that focuses on the increase in market production opportunities for women and the role of complementary human capital accumulation. I build an overlapping generations (OLG) model where electricity is skill biased and human capital investments are made early in life. The novel insight of my model is showing that electricity complements work tasks that favor women and that these productive benefits require complementary human capital investments. In particular, electricity raises the relative productivity of skilled labor, which is less brawn intensive than unskilled labor and thus more favorable toward women’s employment. These gains can only be capitalized on by women with a high level of schooling, however, since they involve work in skilled tasks. Given that schooling investments are put forward early in life, young women experience a unique advantage relative to older women as they can coordinate human capital decisions to maximize the benefits from electrification. This generational divide, in turn, causes the effects of electrification on female LFP to accrue through generational change, as new generations replace old ones and human capital accumulates. The skill and youth bias of electrification also creates
a direct link between the effects of electrification on the LFP of young skilled women and the aggregate changes in female LFP in the model. This motivates the use of the estimates on the effects of electrification on the employment decisions of young women derived in the empirical section of the paper to discipline the model and quantify the aggregate effects of electrification.

In order to quantify the importance of my channel in explaining female LFP trends, I calibrate a quantitative version of the model to the 1880–1940 United States and simulate the effects of the rollout of electricity. I use my empirical analysis, and in particular the estimate on the effect of electrification on the LFP of highly educated young women, to discipline the model parameters. I find that my mechanism explains approximately one quarter of the rise in female LFP during this period. Moreover, my channel decouples the rise in female labor supply from a decrease in home production hours and helps explain the slow decline in female home production hours that occurred in the first half of the 20th century. In addition, I find that my channel is complementary to the home production channel of electrification suggested by Greenwood et al. (2005). This stems from the fact that, as suggested by Lewis (2014), home electrification allows mothers to take over some of the domestic duties of teenage daughters, in turn enabling the latter to focus more on their studies and take advantage of the productive returns of electrification highlighted in my channel.

I then present empirical evidence supporting the main predictions of my theory and underlying the estimates on the effects of electrification used to calibrate the model. I use microdata from the early 20th-century United States, and focus in particular on the effects of electrification investments made during the 1910s, an interesting and seldom-examined period in the history of electrification. During this era, the proportion of households with electricity rose from 15% to 35% and electrification efforts concentrated in “Middle America,” midsize urban areas that were electrified after large cities, but still early in the expansion of the electric grid across the United States (Rieder (1989), Nye (1992)). I build a new dataset with the universe of utilities and central generating stations in 1911 and 1919 by digitizing historical documents containing information on 5409 and 5631 generators, respectively.1 Using this information, I construct measures of the electric capacity generated within each county in the United States. I then combine this data with an individual-level panel dataset built from the full-count 1910–1940 decennial census waves, using the record-linking algorithm proposed by Abramitzky et al. (2012, 2014).2

1The specific sources I use are two editions of “Central station directory: a complete list of electric light and power companies with data” (McGraw Publishing Company (1911, 1919)).
2All record-linking algorithms rely heavily on between-wave name comparisons to form matches and thus have difficulties in matching women due to maiden-to-married name changes. As a result, women who
Using these combined data sources, I study the effects of electrification in the 1910s on the lifetime outcomes of women of different cohorts. To identify the effect of electrification, I use a triple difference (DDD) approach, focusing on the heterogeneity of the effects of electrification by educational level and cohort. This follows from my model's predictions that a high level of education was critical for taking advantage of the new market opportunities electrification opened up for women, and that age at the arrival of electricity was key due to the existence of "formative years" when human capital investments are made. Since education decisions are affected by electrification and are thus endogenous in my setting, I use a proxy for years of schooling that follows the data and approach of Clay et al. (2021) and thus exploits changes in required years of schooling arising from geographic and temporal variation in compulsory attendance, continuation school, and child labor laws. I provide empirical and anecdotal evidence in support of my identification strategy, along with pre-treatment trend tests. In particular, I show that electrification investments during the 1910s were driven primarily by static cost considerations and continued well into the 1920s. This provides a control group comprising counties of similar characteristics that gained access to electricity at different times. Moreover, my specification includes a rich set of controls comprising demographic, income, and wealth variables, along with individual, year, state-by-year fixed effects, and county fixed effects.

I find that higher levels of required educational attainment increased the employment response of young women to electrification, particularly for those with 8 or more years of required schooling, for all years considered. Specifically, I find that the increase in employment triggered by electrification for women who were 15–20 years old upon electrification was 8 percentage points larger in 1920 (relative to 1910) for those with a required schooling level of 8 years or more years, compared to those with a required schooling level of less than 8 years. This estimate grounds my calibration and is consistent with the prediction in the model that the effects of electrification on female LFP concentrate among educated women who have the required skills to capitalize on the skill bias of electrification. Moreover, I find that the enhancing effect of education on electricity-driven employment is mostly absent among older women. This matches the generational differences in the effects of electrification predicted by my model, stemming from the ability of young women to coordinate key lifecycle decisions.

In addition, I find that the effects of electrification on female employment vary with women's reported being married in the first census wave (1910) are overrepresented in my data. Another group that is overrepresented in this data are women who never married and prioritized career over family. In Appendix M I study whether the baseline results differ for women who were married in 1910, women who ever married, or women who ever had children.
fertility and marital choices. I find that electrification did not differentially increase the employment of young and skilled women who were married in 1910, but did differentially increase the employment of young and skilled women who married or had children in later years. This suggests that women who had competing responsibilities that limited their ability to coordinate key human capital decisions when young were unable to take advantage of the productive returns brought about by electrification. However, women who later married and had families did see an increase in their LFP due to electrification when young, suggesting that the effects of electrification on female LFP are not limited to women who prioritized career over family.

Relatedly, I also find that the changes in female LFP induced by electrification were accompanied by changes in fertility and marriage rates. I find that electrification decreased the fertility and delayed the timing of childbearing of young women (particularly those born in areas with high levels of required schooling), but increased their lifetime marriage rates. These results match the evidence presented by Goldin (2020), who shows that at the turn of the 20th century, women moved from a regime of having to choose between career or family to a regime where they could pursue a career when young and a family afterwards. Taken jointly, my results suggest that electrification fueled deep changes in female work, fertility, and marriage patterns.

The rest of the paper is organized as follows: Section 1 situates this paper and its contributions in the literature. Section 2 provides a brief history of electrification in the United States from 1880 to 1960 and its link to the rise in female LFP, while providing direct evidence of the paper’s mechanism by exploring the rise in skilled female occupations concomitant with the rise in female LFP and electrification. Section 3 presents the simplified benchmark model, which contains the intuitions driving the main results and the discussion of the link between the effects of electrification on the LFP of young skilled women and the aggregate changes in female LFP in the model. Section 4 embeds the main mechanism in a quantitative framework and presents the calibration and quantitative results. Section 5 delineates the data and methods used for the empirical assessment of the mechanisms predicted by the model in the early 20th-century United States and discusses the results of the effects of electrification used to calibrate the model. Section 6 concludes.

1 Related Literature

My theory combines intuitions from two different literatures. First, through the emphasis on the link between new technologies and female LFP, my model is rooted in the time-
use models originally proposed by Becker (1960, 1965) and related to the home production and durable adoption model of Greenwood et al. (2005), as well as recent papers focusing on technological progress and the movement between home and market production, such as Ngai and Pissarides (2008), Buera and Kaboski (2012), and Moro et al. (2017). Second, through its focus on the complementarities between electricity and skilled labor, my paper relates to the literature that links technological change to the rise in skilled wages (Acemoglu (1998), Acemoglu (2002), Autor et al. (2003), Acemoglu and Autor (2011)), and specifically to the literature that explores the role of specific technologies and mechanisms driving skill-biased technical change and the rise of the skill-wage gap (Krusell et al. (2000), Atkeson and Kehoe (2007), Acemoglu and Restrepo (2020), Adão et al. (2019)). Moreover, the advantage faced by young households in coordinating their human capital decisions highlighted in my paper relates to Goldin and Katz (2008), who suggest that technological change in the 20th century has increasingly required the employment of higher-skilled workers and thus the catching up by workers and educational institutions to fully exploit the productive possibilities of the economy.

My paper also relates to the literature studying female LFP and time-use trends in the United States. In particular, my channel helps reconcile the increase in female labor supply documented during the first half of the 20th century with the absence of a decline in the time devoted to housework documented by several studies and labeled by Mokyr (2000) the “Cowan Paradox,” following the work of Cowan (1983). For instance, Ramey (2009) finds that the time spent in housework by prime-age women fell by only 6 hours between 1900 and 1965, and that much of that change could be accounted for by the number and age of children and the increased education levels of housewives. Moreover, my paper relates to studies investigating the sources of the rise in female LFP during the 20th century, particularly those that highlight the contribution of productive opportunities for women (Galor and Weil (1996), Costa (2000)) and the gender wage gap (Goldin (1990), Jones et al. (2015), Gayle and Golan (2012)). Other explanations for this rise include cultural change and learning (Fogli and Veldkamp (2011), Fernández (2013)), the introduction of the contraceptive pill and fertility changes (Goldin and Katz (2002), Bailey (2006), Knowles (2009)), medical advances (Albanesi and Olivetti (2016)), and reductions in the cost of childcare (Attanasio et al. (2008)).

This paper relates to studies that empirically quantify the effects of electrification in two distinct ways. First, by focusing on the US context, this paper is related to the literature examining the effects of electrification in the United States (Lewis (2018), Gray (2013), Kitchens and Fishback (2015), Lewis and Severnini (2017), Kitchens (2014), and Gaggl et al. (2016, 2021)). Most papers in this literature have focused on rural electrification. My paper,
in contrast, focuses on the effects of electrification in “Middle America,” with a particular emphasis on female labor supply and heterogeneity of the effects by cohort and educational level. Within this literature, and by emphasizing the importance of skill bias and human capital, my paper is particularly related to the work of Gray (2013), who shows that electrification changed the demand for skill in manufacturing in the pre-World War II United States, increasing the demand for clerical, numerical, and planning jobs while reducing the demand for manual and dexterity-intensive jobs.

Second, my paper relates to studies in the development literature quantifying the effects of electrification. In particular, the importance of electrifying market production and complementary human capital investments predicted by my theory helps reconcile the large effects found by medium- and long-run studies in the developing world (Lipscomb et al. (2013), Lewis and Severnini (2017), Rud (2012), Kassem (2018), and Dinkelman (2011)) with the sparse effects found in recent short-run studies (Lee et al. (2016), and Burlig and Preonas (2016)). My channel suggests that electrification programs targeting households exclusively or focusing in areas with low human capital will have limited short-run impacts. In this sense, my paper also contributes to the empirical literature exploring the factors mediating the responses to electrification. Some of these factors include the frequent blackouts and general unreliability of grid connections frequently documented in developing settings (Steinbuks and Foster (2010), Lee et al. (2016), Allcott et al. (2016), Lagakos and Fried (2020)), liquidity constraints hindering the purchase of connections or complementary goods (Hanna and Oliva (2015)), and “Keeping up with the Joneses” and information effects to grid connections (Bernard and Torero (2015)).

2 Electrification and Female LFP in the United States

Electrification spread widely in the United States during the first half of the 20th century. This process started in 1882 with the building of the Pearl Street Generating Station in New York City by the Edison Illuminating Company and Thomas A. Edison overseeing its operations. In the next two decades, privately owned utility companies expanded electricity to all large cities. One example is the Commonwealth Edison Company, owned and run by Sam Insull, who played an instrumental role in building electricity infrastructure in Chicago and throughout much of the Midwest (Wasik (2008)). During the 1910s and 1920s, the electrification impetus continued into midsize towns and cities, driven by private-utility interests looking for new opportunities outside large cities. Rural areas, however, lagged behind, with less than 10% of rural homes reporting having access to electricity in 1930 (Lewis (2018)). As a consequence, during the 1930s President Franklin D. Roosevelt issued an executive or-
der establishing the Rural Electrification Administration (REA) as part of the New Deal. The process of electrification of rural America lasted until 1960, by which time virtually all households in the United States reported having access to electricity.

**Figure 2.1: Electrification Rate and Female LFP 1880–1960**

![Graph showing Electrification Rate and Female LFP 1880–1960](image)


During this period, female LFP also increased considerably, as evidenced in Figure 2.1. These two phenomena have traditionally been linked via the home time savings triggered by appliance use and electricity and the possibility of transitioning from home to market. This is motivated by the fact that many appliances were patented and mass produced during this period, like the vacuum cleaner (1908), washing machine (1908), iron (1905), and refrigerator (1915), which increased the productivity of home production. However, this explanation does not fully fit with the timing of the decline in home production hours over the course of the 20th century. Figure 2.2 documents that the adoption of crucial time-saving appliances like the refrigerator, washing machine, and vacuum cleaner increased sharply during the 1900–1960 period, yet female home production hours declined slowly, with the bulk of the decrease occurring after the 1960s.

In this paper, I revisit the relationship between electrification and female LFP, focusing on the effects of electricity on market productivity and the generation of new work opportunities for skilled women rather than home production gains. In particular, I show that my channel better matches the trends in home production hours and explains a sizeable portion of the rise in female LFP from 1880 to 1940. The idea is that electrification creates market opportunities for skilled women, which causes younger generations to accumulate more human capital and further encourages female LFP.

This intuition is backed by the data, and particularly the fact that this large expansion of electricity fueled massive changes in the workplace. Electrification enabled the use of machines
Figure 2.2: Electrical Appliance Adoption and Female Home Production Hours

Source: Lebergott (1976) and Ramey and Francis (2009).

for production and transportation and increased the scale and complexity of production processes (Devine (1983)). These changes created new work opportunities for semi-skilled and skilled labor (see for instance Gray (2013), Goldin and Katz (1998), and Jerome (1934)), and in particular raised the demand for clerical positions where brawn ability was not important and thus female labor was favored (Nye (1992)). In Figure 2.3, I provide some examples of this trend in the forms of photographs depicting telephone switchboard operators in 1915 and female secretaries using early calculating machines in an office during the 1920s.

The positive co-movement of electrification, female LFP, and human capital argued in this paper matches the educational attainment trends of women during this period, as depicted in Figure 2.4, which shows that in addition to the increases in female LFP and electrification discussed before, the proportion of women between 25 and 65 years of age with complete high school education or more rose considerably during the 1880–1960 period. This shift in female career opportunities and women’s educational advancement was accompanied by changes in fertility and marriage patterns during this period (see Figure A.1 for a figure depicting these historical fertility and marriage patterns). From 1900–1940, and prior to the baby boom, the total fertility rate in the United States declined sharply. In 1900, American women had an average of 3.8 children throughout their reproductive years. By 1940, this number had

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3 A specific example is the Ball Brothers Manufacturing Company plant in Muncie, Indiana. The pre-electrification production of Mason jars relied primarily on the heavy physical work of glassblowers who made each jar by hand and cart pushers who moved the glass products around the factory. Electrification and the mechanization of production enabled the production of Mason jars to increase hundredfold (Figure A.2 shows photographs of production prior to and after electrification). This massive increase in scale meant that in turn more bookkeepers, secretaries, and managers were needed.

4 Switchboard operation was one of the most common jobs for young American women in the early 1900s, employing hundreds of thousands of female workers (Feigenbaum and Gross (2020)).
dropped to 2.3 (Haines (2006) and Census). This decline in fertility was accompanied by an increase in the proportion of ever-married women from 45% in 1900 to 56% by 1940.\textsuperscript{5} Taken jointly, these patterns suggest a fundamental shift in the traditional societal role of women occurring during the early 20th century, which empowered women to pursue careers (particularly early in life), in addition to building their families (Goldin (2020)).

\textsuperscript{5}From 1940 to 1960, during the baby boom, the total fertility rate rose again, reaching levels comparable to those of 1900, while the proportion of ever-married women continued to increase.
3 An Analytical Model of Electrification and Human Capital

In this section I present an analytical version of the model. This benchmark framework focuses on the main mechanisms mediating the scope of the productive and skill dimensions of electrification to alter female work patterns. In Section 4, I embed these mechanisms in a quantitative framework and quantify the importance of my channel in explaining empirical trends in female LFP. The results from this section will motivate the empirical exercises in Section 5.

3.1 Households

The model economy is populated by a continuum of size 1 of married couples $i \in [0, 1]$, whose adult life spans two periods: a “young period”, and an “old period”. Men and women are endowed with 1 unit of time each period, which they use to work in one of three sectors: the unskilled market sector, the skilled market sector, or the home sector. During the first period of their lives, men and women must also decide on schooling investments. I assume that the schooling choice is discrete. In particular, men and women can choose to become skilled at a cost of $\rho_{i}^{m}$ and $\rho_{i}^{f}$ units of time, respectively, or remain unskilled. These costs differ across individuals and households and are drawn randomly at the beginning of the household’s life from a given distribution $F$. I allow women and men to differ in the relative productivity with which they perform each task, in order to capture, for instance, the relative importance of brawn across these. For expositional purposes, in what follows I ignore the household index in most expressions.

The lifetime utility of a household is given by the sum of consumption when old and young:

$$U = c_{y} + c_{o}.$$

Households use the income derived from female and male labor to acquire consumption goods in each period:

$$c_{j} = I_{j}^{m} + I_{j}^{f} \quad \text{for } j = \{y, o\}.$$

The incomes of males and females in turn are determined by their choice of work. Women and men can choose to work in the unskilled or skilled market sectors, which pay competitive wages, or engage in home production. I assume all three types of production and wages yield
the same consumption good.\(^6\) To work in the skilled sector, individuals must put forward schooling investments when young. These schooling investments entail a cost of \(\rho^i\) units of time, limiting the time available to work when young.\(^7\)

I also assume that men and women differ in the productivity with which they perform each of these three tasks. In particular, women are more inefficient at unskilled labor relative to men, but relatively less so in skilled production. This stems from the relative importance of brawn in unskilled production, which disfavors women. In addition, men face a sharp disadvantage in home production relative to women. These differences in productivity are presented in Table 3.1:

<table>
<thead>
<tr>
<th></th>
<th>Unskilled Market</th>
<th>Skilled Market</th>
<th>Home</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Women</td>
<td>0</td>
<td>(\mu)</td>
<td>1</td>
</tr>
</tbody>
</table>

with \(0 < \mu < 1\).

These differences in endowed productivity and the schooling time cost required for skilled labor shape the income households derive from engaging in each type of work, as shown in Table 3.2 and Table 3.3:

<table>
<thead>
<tr>
<th></th>
<th>Unskilled Market</th>
<th>Skilled Market</th>
<th>Home</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young ((I_y^m))</td>
<td>(w_u)</td>
<td>(w_s(1 - \rho^m_i))</td>
<td>0</td>
</tr>
<tr>
<td>Old ((I_o^m))</td>
<td>(w_u)</td>
<td>(w_s)</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Unskilled Market</th>
<th>Skilled Market</th>
<th>Home</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young ((I_y^f))</td>
<td>0</td>
<td>(\mu_s w_s(1 - \rho^f_i))</td>
<td>(A_h)</td>
</tr>
<tr>
<td>Old ((I_o^f))</td>
<td>0</td>
<td>(\mu_s w_s)</td>
<td>(A_h)</td>
</tr>
</tbody>
</table>

where \(A_h\) denotes the productivity of home production and \(w_u\) and \(w_s\) denote unskilled and skilled wages, respectively. Because utility follows solely from consumption goods, which can

\(^6\)In the quantitative model, I assume consumption and home goods are distinct and thus not perfectly substitutable.

\(^7\)In the quantitative model, I assume that individuals live with their parents when young and thus schooling decisions are made by their mother and father. With this, I allow for indirect investments in daughters by mothers, which may be an alternative mechanism through which household electrification could encourage female LFP (Lewis (2014)).
be produced using any technology, women’s and men’s choices can be separated and both women and men will aim to maximize their respective lifetime incomes.

### 3.2 Production Functions

Consumption goods can be produced using three production technologies: unskilled market production, skilled market production, and home production.

In the market, the unskilled production technology captures a traditional mode of production that uses unskilled labor only, while the skilled production technology captures a modern mode of production:

$$Y_u = A_u L_u$$
$$Y_s = A_s L_s$$

where $L_u$ and $L_s$ denote effective unskilled and skilled labor inputs, respectively, and $A_u$ and $A_s$ denote Total Factor Productivity (TFP) terms for unskilled and skilled production, respectively. Wages in the skilled and unskilled sectors are thus given by

$$w_u = A_u$$
$$w_s = A_s.$$  

The home production technology, on the other hand, captures the possibility individuals have of producing goods at home, and is given by

$$Y_h = A_h L_h$$

where $L_h$ denotes effective hours of home production and $A_h$ the productivity term.

Each of these production technologies yields the same consumption good, so that the total production of consumption goods is given by

$$Y = Y_u + Y_s + Y_h.$$  

### 3.3 Electricity

Electricity maps directly onto the labor productivity of skilled production.\(^8\) With electrification, machines that enhance the productivity of skilled labor can be used in skilled production. This captures the skill-biased nature of electric technological change:

$$A_s = \begin{cases} 
A_l & \text{prior to electrification} \\
A_h & \text{after electrification}.
\end{cases}$$

\(^8\)In the quantitative version, I assume electrification changes the productivity of electrical power production, and that purchases of electricity are an input of skilled production.
I assume that the decision on electrification and thus the efficiency of electricity technology is exogenous and determined by the government. This matches up with the experience in most settings, where the high fixed costs and natural monopoly features of electrification projects make it unfeasible for firms or individuals to take them on.

3.4 Equilibrium and Results

Since unskilled labor is very unproductive for them, women focus on choosing between skilled and home production, depending on their value of $\rho_i^f$ and wages. Analogously, men focus on choosing between unskilled and skilled market production. These features match the nature of unskilled labor, which is brawn intensive and disfavors women, and the fact that men traditionally focus on market rather than home production. In what follows, I focus on the effects on women, since they and home-to-market movements are the main focus of my theory.

First, since the cost of skill monotonically increases with $\rho_i^f$, while its benefits and the value of home work remain constant, there is a unique cutoff in the cost of skill for women denoted by $\bar{\rho}_i^f$, which determines the proportion of women who decide to get schooling and engage in skilled production rather than home production. This cutoff is given by

$$\bar{\rho}_i^f = 2 \left( 1 - \frac{A_h}{\mu_s w_s} \right).$$

The proportion of women participating in the labor market is fully characterized by this cutoff and the schooling cost distribution: the portion of women whose schooling cost is lower than the schooling cutoff acquire schooling and participate in the labor market. Given this setup, we can characterize female LFP in every period $t$ as the sum of the mass of old and young women participating in the labor market:

$$\text{Female LFP}_t = \frac{1}{2} F(\bar{\rho}_{t-1}^f) + \frac{1}{2} F(\bar{\rho}_t^f),$$

(1)

where $F$ denotes the cdf of the schooling cost distribution, $\bar{\rho}_{t-1}^f$ denotes the schooling cutoff prevalent in period $t-1$ when old women were young and made their schooling decisions, and $\bar{\rho}_t^f$ denotes the schooling cutoff prevalent in period $t$, which guides the schooling decisions of young women.

The schooling cutoff prevalent in any period and thus the proportion of women who acquire schooling and engage in skilled market work depend positively on the skilled wage $w_s$ of that period. Therefore, by raising the productivity and wage of skilled market tasks, elec-
trification encourages female LFP. In Figure 3.1, I illustrate this process in action. Prior to electrification, the schooling cutoff and proportion of women in the labor force are low, since the returns to skilled labor are smaller than those for home production for the majority of women. In other words, the only women engaging in market production are those with very low schooling cost levels. After electrification, the cutoff and the proportion of women engaging in the labor market rise.

Figure 3.1: Change in Women’s Schooling Cost Cutoff due to Electrification

(a) Pre-electrification

(b) Post-electrification

A key consequence of the importance of skill in my channel is the fact that women who were old upon electrification will have no change in their labor force participation rates. This result follows from two facts: (i) the market returns to electrification can only be capitalized on by skilled women and (ii) the decisions regarding these are concentrated early in life. Since old women are not able to coordinate their human capital decisions to fully maximize the new market opportunities generated by electrification, they exhibit lower levels of schooling and female LFP, relative to young women, upon electrification. Thus, the prevalence of older women dampens the increase in female labor supply in the short run. This generational wedge in turn generates a dynamic effect of electrification on female LFP, which accrues through generational change and human capital accumulation (see Appendix B.1 for a more detailed discussion and description of this result).

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9I assume that when individuals are making their schooling investments, they forecast that their current electricity status will be held constant for the rest of their lives. Thus, unelectrified households cannot forecast when electricity will be available for them. This assumption is important in terms of understanding conceptually why older households face a disadvantage relative to younger households: they cannot coordinate their human capital decisions to take advantage of the new technological regime. In practice, however, imperfect forecasting would still yield an underinvestment in human capital for older households, because for them electrification would arrive later in life and would thus imply fewer periods to enjoy the higher returns from skill stemming from electrification.
Notice also that since new market opportunities concentrate among skilled labor, the productive return from electrification is perceived only by women who invest in acquiring skill. This translates into higher schooling incentives for young generations.\textsuperscript{10}

Using Equation (1), we can write the change in female LFP in period $t$ that follows from a concurrent rise in skilled wages due to electrification as follows:

$$\Delta \text{Female LFP}_t = \frac{1}{2} \left[ F(\bar{\rho}^f_t) - F(\bar{\rho}^f_{t-1}) \right] = \frac{1}{2} \int_{\bar{\rho}^f_{t-1}}^{\rho^f_t} f(\rho_i) d\rho_i, \quad (2)$$

where $\bar{\rho}^f_t$ is the schooling cost cutoff prevalent in period $t$ and $\bar{\rho}^f_{t-1}$ is the schooling cost prevalent in period $t - 1$ (the pre-electrification regime).\textsuperscript{11} This equation highlights two different forces shaping the increase in female labor force participation due to the electrification of production processes.

The first force stems from the increase in the proportion of women becoming skilled, $\bar{\rho}^f_t$. This increase will be given by $\Delta \bar{\rho}^f = \frac{2A_h}{\mu_s} \left( \frac{1}{w_{s,t-1}} - \frac{1}{w_{s,t}} \right)$. The term in parentheses captures the increase in the skilled wage after electrification, which will directly impact the rise in the schooling cost cutoff and thus the response of female LFP. The term $\frac{2A_h}{\mu_s}$ captures the attractiveness of skilled work relative to home production. Note in particular that low levels of endowed productivity in skilled production $\mu_s$ undermine the ability of electrification to stimulate female LFP, because the attractiveness of this sector will be diminished in comparison to home production. This therefore suggests the importance of the relative content of brawn and brain in skilled tasks in determining the aggregate effect of electrification on female LFP. In particular, higher relative female productivity in skilled labor, driven, for instance, by the use of brain rather than brawn capacity in skilled tasks, will enhance the scope of electrification to change the productive opportunities for women and in turn enhance its capacity to drive aggregate growth patterns (see Appendix B.2 for a more detailed discussion and description of this result).

The second force shaping the increase in female labor force participation in my channel follows from the distribution of schooling costs across women. In particular, if there is a

\textsuperscript{10} This positive correlation between electrification and schooling is of empirical interest. In particular, the fact that electrification increases schooling in the model suggests that the early electrification efforts of the 1910–1940 period in the United States might help explain the emergence of the high school movement during this time period and in particular the marked gains for women (Goldin and Katz (1999)). Moreover, my framework ties this increase in schooling to the subsequent gains in female LFP during the middle and latter parts of the 20th century.

\textsuperscript{11} The expression for the change in skilled wages due to electrification in $t + 1$ after the economy reaches the new steady state is symmetric and given by Female LFP$_{t+1} = \frac{1}{2} \left[ F(\bar{\rho}^f_t) - F(\bar{\rho}^f_{t-1}) \right]$.
large density of women with schooling costs between $\bar{\rho}_{t-1}^f$ and $\bar{\rho}_t^f$ per the distribution $F$, the scope of electrification to encourage female LFP will be larger. As a consequence, the response of female LFP to electrification is partially determined by the shape of the schooling distribution.

3.5 Link between Effect of Electrification on Young Skilled Women and Aggregate Effects

There is a direct connection between the effect of electrification on the LFP of young skilled women I estimate in the empirical section and the aggregate rise in female LFP. With some algebraic manipulations, the change in female LFP due to electrification summarized in Equation (2) can be written as

$$\begin{align*}
\Delta \text{Female LFP}_t &= \frac{1}{2} \text{Prop.Skilled}_{Coh_t,el}[DDD] \\
&\quad + \frac{1}{2} \left[ \Delta \text{Prop.Skilled}_{Coh_t} DD_{Coh_t,unel}^{skill} + DD_{Coh_t,unsk} \right],
\end{align*}$$

(3)

where the subscripts $Coh_t$, el/unel, and sk/unsk denote the cohort of women born in period $t$, whether they are electrified or not in period $t$, and whether they are skilled or unskilled, respectively. In addition, $DDD$ denotes the triple difference estimated in the empirical section, capturing the effects of electrification on the LFP of young skilled women: $DDD = DD_{Coh_t,el}^{skill} - DD_{Coh_t,unel}^{skill}$, and

$$
\begin{align*}
DD_{Coh_t,el}^{skill} &= (LFPCoh_t,t,el,sk) - (LFPCoh_t,t-1,el,sk) - (LFPCoh_t,t,el,unsk) + (LFPCoh_t,t-1,el,unsk) \\
DD_{Coh_t,unel}^{skill} &= (LFPCoh_t,t,unel,sk) - (LFPCoh_t,t-1,unel,sk) - (LFPCoh_t,t,unel,unsk) + (LFPCoh_t,t-1,unel,unsk) \\
DD_{Coh_t,unsk} &= (LFPCoh_t,t,unsk,sk) - (LFPCoh_t,t-1,unsk,sk) - (LFPCoh_t,t,unsk,unsk) + (LFPCoh_t,t-1,unsk,unsk)
\end{align*}
$$

(see Appendix B.3 for details on this derivation).

This equation showcases the direct connection between the effects of electrification on the LFP of young skilled women ($DDD$) in the model, which is calibrated to match that of the empirical section, and the aggregate effects in this framework. A larger $DDD$ value will correspond to a larger rise in female LFP due to electrification. This stems from the fact that the $DDD$ captures the change in incentives to engage in market work after electrification for skilled young women, who are precisely the drivers of female LFP in the model.\textsuperscript{12}

\textsuperscript{12}In the empirical section, the specific measure of electrification considered is the county-level change in generating capacity between 1911 and 1919, in 100s of megawatts. As such, the empirical estimate of the $DDD$ corresponds to the increase in the employment of young and skilled women in areas where the
However, the $DDD$ has some limitations for determining the aggregate change in female LFP due to electrification. First, if the proportion of skilled women after electrification $\text{Prop.Skilled}_{\text{coh,el}}$ is small, the scope of the $DDD$ to alter the aggregate change in female LFP due to electrification will be smaller. This is because in this case the $DDD$ effect applies to very few women, so its importance in the aggregate is diminished.

Second, if the second line in this equation is large, it will primarily drive the aggregate effect of female LFP in the model, dwarfing the role of the $DDD$. The first term in the second line corresponds to the product of the change in the proportion of skilled women after electrification and the skill-based difference-in-differences term $DD_{\text{skill}}^{\text{el}}$ within unelectrified areas. If this is large, the rise in female LFP of skilled relative to unskilled women in unelectrified areas is a predominant force, indicating that the process of electrification is not a primary driver of female LFP changes. The second term corresponds to the difference-in-differences coefficient of the effect of electrification within unskilled women. If this is large, the rise in female LFP for unskilled electrified women relative to their non-electrified counterparts is a predominant force, indicating that skill acquisition is not a primary driver of female LFP changes. As a consequence, in both of these cases the role of the $DDD$, which captures the relative impact of electrification on skilled women, is second order.

4 A Model of Electrification and Human Capital: Quantitative Assessment

In order to quantify the importance of my channel, I now embed these mechanisms in a quantitative framework. I calibrate the model to match the United States economy in the 1880–1940 period and simulate the effects stemming from the rollout of the electricity grid. With this, I quantify the importance of my channel in explaining female LFP trends during this period.

4.1 Quantitative Model Setup

As before, the model economy is populated by a continuum of size 1 of men and women. Women and men live for $J$ periods and are endowed with 1 unit of time each period, which

---

Generating capacity increased by 100 megawatts in the 1910s relative to those in areas where the generating capacity did not increase. I choose the generating threshold of 100 megawatts to construct the $DDD$ and calibrate the model based on technological and institutional facts of this era. The 100-megawatts generation threshold is equivalent to 3 to 4 large generating plants. Since my measures of electrification are built 50 miles around each county’s boundaries, and the average county area is 1200 square miles, this capacity threshold guarantees that most households and businesses in the county are located within a 50-mile radius of one of these large plants, and thus have access to electricity.
they use for work, home production, and leisure. During the first period of their lives, men and women live at home with their parents, who in turn must choose their children’s schooling investments. We assume that each couple has a daughter and son of the same age, and that this initial life period for children occurs when parents are of age $K < J$. In particular, parents in family $i$ can choose that each of their children become skilled at a cost of $\rho_i$ units of time or remain unskilled. These costs differ across families and are drawn randomly at the beginning of the daughter and son’s lives life from a beta distribution, $\rho_i \sim \text{Beta}(\alpha_H, \rho_H)$. After this initial period, women and men get married and live as a couple for their remaining lifetimes. Furthermore —and similar to the benchmark model— I allow women and men to differ in the relative productivity with which they perform each task, in order to capture, for instance, the relative importance of brawn across these.

For expositional purposes, in what follows I ignore the household index $i$ in most expressions.

4.1.1 Tastes

We assume that couples only have control over their utility and choices after they leave their childhood home and get married (after the first period of their lives). Couples care about their children’s utility in the periods after making their schooling decisions. Thus, the period utility function of a couple of age $j$ is given by

$$U_j = \begin{cases} 
\log c_j + \sigma_l \left(0.5 \log l_j^m + 0.5 \log l_j^f\right) & \text{if } 1 < j \leq K \\
\log c_j + \sigma_l \left(0.5 \log l_j^m + 0.5 \log l_j^f\right) + U_j^s + U_j^d & \text{if } j > K,
\end{cases}$$

where $c$ denotes consumption and $l^f$ and $l^m$ denote female and male leisure, respectively. $\sigma_l$ denotes the value of leisure relative to consumption and $\sigma_l > 0$. $U_j^s$ and $U_j^d$ denote the utility of the couple formed by the son and daughter, respectively, after leaving the family home during the period when their parents are of age $j$. I assume that at the beginning of period $K$, the daughter and son of each family get betrothed to their respective partners, who in turn are the son and daughter from a different family. The two families then jointly maximize the sum of their utilities.\(^\text{16}\)

---

\(^{13}\)Here I abstract of the fertility decision for households. In Vidart (2021), I explicitly examine the effects of electrification on fertility.

\(^{14}\)This assumption implies that the daughter and son of each family have the same cost of schooling. This is consistent with the similarity between siblings arising from shared nature and nurture.

\(^{15}\)I choose a beta distribution in order to have values bounded by 0 and 1 and thus consistent with a time cost interpretation.

\(^{16}\)I assume that these matches occur across women and men with the same familial background. This implies that parental educational levels, children’s schooling costs, and location (which determines electrification
Consumption is a CES composite of home and market consumption,

\[ c = \left( \nu c_y + (1 - \nu) c_h \right) \theta, \]

where \( c_y \) denotes market consumption and \( c_h \) home production. \( \nu \) denotes the share of market goods in total consumption, while \( \theta \) denotes the elasticity of substitution between market and home goods.

**4.1.2 Time constraints**

The time endowment of women and men is allocated to work, leisure, home production, and schooling. For simplicity, I assume that during the first period of their lives and while living with their parents, women only spend time in schooling or home production, while men only spend time in schooling or work.\(^{17}\) I also assume that men and women only have \( \tau^m \) and \( \tau^f \) units of time during the first period of their lives to allocate to each of their corresponding activities, respectively. With this, and given that I assume that younger individuals spend no time in leisure, I can match the fact that young women and men spend less time in home production and work, respectively, relative to older individuals.

The time constraints of women and men are therefore given by

\[
\begin{align*}
    h_{t,j}^f &= \begin{cases} 
        \tau^f (1 - s^f \rho) & \text{if } j = 1 \\
        1 - n_{t,j}^f - l_{t,j}^f & \text{if } j > 1
    \end{cases} \\
    n_{t,j}^m &= \begin{cases} 
        \tau^m (1 - s^m \rho) & \text{if } j = 1 \\
        1 - h_{t,j}^m - l_{t,j}^m & \text{if } j > 1
    \end{cases}
\end{align*}
\]

respectively, where \( n_{t,j}^f \) and \( n_{t,j}^m \) denote the labor supply of women and men, respectively, at time \( t \), while \( h_{t,j}^f \) and \( h_{t,j}^m \) denote the time dedicated to home production by women and men. The terms \( s^m \) and \( s^f \) denote endogenous indicators that capture the binary schooling decisions for men and women.\(^{18}\)

---

\(^{17}\)This is equivalent to assuming parents only care about schooling and home production for their young daughters and schooling and work for their sons. This matches up with the historical evidence of this period, which suggests that young males spent almost no time in home production (less than 4 hours a week), while young women spent almost no time at work (3–12 hours a week) (Ramey and Francis (2009)).

\(^{18}\)Notice that unlike the benchmark model, in this setup there are no unique cutoffs in the cost of schooling (status) are symmetric across betrothed families and matches the literature showing significant homogamy patterns across parents of husbands and wives, particularly in the late 19th and early 20th centuries (Charles et al. (2013) and Craig et al. (2021)).
\[ s_f^j = \begin{cases} 
1 & \text{if woman becomes skilled when young} \\
0 & \text{otherwise}
\end{cases} \]

\[ s_m^j = \begin{cases} 
1 & \text{if man becomes skilled when young} \\
0 & \text{otherwise}
\end{cases} \]

### 4.1.3 Income and Consumption

Men and women are endowed with differing levels of productivity for each skill level, summarized by

<table>
<thead>
<tr>
<th>Unskilled Market</th>
<th>Skilled Market</th>
<th>Home</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Women</td>
<td>(\mu_u)</td>
<td>(\mu_s)</td>
</tr>
</tbody>
</table>

with \(0 < \mu_u < \mu_s < 1\) reflecting the disadvantage women face in brawn activities and the gender wage gaps in both unskilled and skilled labor.

Note that in what follows, I denote the labor supply and home production of men and women when \(j = 1\) differently, in order to distinguish it from those of their parents. Specifically, superscripts \(f\) and \(d\) denote women at ages \(j > 1\) (main female in household) and \(j = 1\) (daughter), respectively, and the superscripts \(m\) and \(s\) denote men at ages \(j > 1\) (main male in household) and \(j = 1\) (son), respectively.

The household budget constraint is therefore given by

\[
c_y + p_t^E E_j = \begin{cases} 
w_t^m n_{t,j}^m + \mu_s n_{t,j}^f & \text{if } j > 1 \text{ and } j \neq K \\
    w_t^m n_{t,j}^m + \mu_s n_{t,j}^f + w_t^s n_{t,j}^s & \text{if } j = K,
\end{cases}
\]

where \(w_t^m\), \(w_t^f\), and \(w_t^s\) capture the efficiency unit wages faced by men, women, and sons, respectively. For women and men, these wages depend on their schooling choices. Since young men (sons) are still potentially in the process of acquiring skills, we assume they work in the unskilled sector and thus face the unskilled wage. \(n_{t,j}^s\) captures the labor supply of the couple’s son. \(E_{t,j}\) denotes the purchases of electricity of the household at price \(p_t^E\) for men and women determining their choices. This arises from the interaction between siblings in the family. Given that daughter and son from the same family share a common cost of schooling, shifts in the cost of schooling trigger both direct and indirect changes in the education cost of each child, where the latter stem from the change in the sibling’s position. The interaction between these direct and indirect changes may lead to multiple cutoffs in the cost of schooling for both sons and daughters.
The production of home goods $c_h$, on the other hand, is limited by the total home production men, women, and daughters can accomplish when they dedicate $h^m$, $h^f$, and $h^d$ units of time to home production, respectively, and purchase electricity level $E$. Thus, the level of home goods is given by

$$c_{ht,j} = \begin{cases} 
[\omega E_{t,j}^{\frac{\phi-1}{\phi}} + (1 - \omega) \left(h_{t,j}^f + h_{t,j}^m\right)^{\frac{\phi-1}{\phi}}]^{\frac{1}{\phi-1}} & \text{if } j > 1 \text{ and } j \neq K \\
[\omega E_{t,j}^{\frac{\phi-1}{\phi}} + (1 - \omega) \left(h_{t,j}^f + h_{t,j}^m + h_{t,j}^d\right)^{\frac{\phi-1}{\phi}}]^{\frac{1}{\phi-1}} & \text{if } j = K.
\end{cases}$$

I choose this specific CES function for home production, which considers a role for electricity in home production, for three main reasons. First, I want to allow for the mechanisms driving the home production savings channel\textsuperscript{19} in order to compare its predictions to my human capital channel. Second, I want to allow for the possibility that my channel, and in particular the higher wages triggered by electrification, enable some households to acquire more electricity even if prices remain constant.

Third, by assuming that daughters’ home production time enters into this function, I allow for an alternative mechanism through which household electrification could encourage female LFP: indirect investments in daughters by mothers. As suggested by (Lewis (2014)), household technological change led mothers to take over some of the domestic duties that had been the responsibility of teenage daughters, in turn enabling the latter to focus more on their studies. Therefore, this mechanism also introduces a complementarity between the home production and human capital channels, where young women are more able to coordinate their human capital decisions and invest in skills that are now more in demand in the labor market, because their mothers are relieving them from household duties they would otherwise have.

4.1.4 Production of Consumption Goods

Consumption goods are produced competitively using two production technologies. The first production technology captures a traditional (unskilled) mode of production that uses unskilled labor only:

$$Y_u = A_u L_u,$$

\textsuperscript{19}This specification resembles that presented by Greenwood et al. (2005), but differs from it by abstracting from the durable appliance adoption decision. This simplification is not important for the main results in my model, since home production time savings will be generated by reductions in the price of electricity analogous to reductions in the price of durables. Moreover, this setup matches the fact that appliance adoption followed closely after electrification in the United States and was in many cases facilitated by utility companies looking to induce households to use more electricity (Nye (1992)).
where $L_u$ denotes effective unskilled labor and $A_u$ the TFP term for unskilled production. The second production technology captures a modern (skilled) mode of production, and follows a CES production technology that combines skilled labor and electricity:

$$Y_s = A_s \left[ \zeta E_s^{\frac{\gamma-1}{\gamma}} + (1 - \zeta) L_s^{\frac{\gamma-1}{\gamma}} \right]^{\frac{\gamma}{\gamma-1}} \text{ with } \gamma < 1,$$

where $L_s$ denotes effective skilled labor and $E_s$ the level of electricity used, while $A_s$ denotes a TFP term. $\gamma$ is the elasticity of substitution between electrical goods and skilled labor. Since electricity complements skilled labor, $\gamma < 1$. The goods produced by traditional and modern (or unskilled and skilled) production technologies are combined in a CES production function, so that the total production of consumption goods is given by

$$Y = \left[ \lambda Y_u^{\frac{\eta-1}{\eta}} + (1 - \lambda) Y_s^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \text{ with } \eta > 1.$$

### 4.1.5 Production of Electricity

Electricity is produced competitively using a technology with a binary and exogenous productivity level. Prior to gaining access to the power grid (electrification), electricity is produced with an old and inefficient technology (small generators). With electrification, electricity production is produced at central generating stations with higher efficiency. I assume that the decision of the type of technology available to produce electricity is determined exogenously. The production of electricity therefore follows:

$$E = \begin{cases} A_{E,L}X & \text{ prior to electrification} \\ A_{E,H}X & \text{ after electrification} \end{cases},$$

where $X$ denotes inputs in terms of the consumption good and $A_{E,L} < A_{E,H}$. In Appendix C, I present the aggregation and equilibrium results of this model.

### 4.1.6 Effects of Electrification: The Human Capital Channel

Electrification increases the productivity of electricity production, reducing the price of electricity. This price reduction affects both households and firms. The reduction in household-level electricity prices corresponds to the channel highlighted by Greenwood et al. (2005) (home production channel), and leads to time savings in home production. The reduction in firm-level electricity prices corresponds to my human capital channel, and leads to increases in skilled wages.
In my channel, by raising the productivity and wage of skilled market tasks, electrification encourages female LFP. This effect is shaped by the endowed productivities of women in skilled and unskilled labor and the shape of the schooling cost distribution. Note that because new market opportunities concentrate among skilled labor, the productive return from electrification is perceived only by women who are skilled. This translates into higher schooling incentives for young generations and muted labor force participation effects for older generations, who were old upon electrification and had already made their schooling decisions.\(^\text{20}\)

Also note that since daughters can contribute to home production when young, the reduction in the burden of domestic tasks triggered by electrification may allow mothers to take over some of the household duties of daughters, allowing the latter to decrease their home production hours and engage in schooling instead. This feature has two effects. First, it opens an additional channel through which the home production channel could encourage female LFP. Second, it creates the potential for a key complementarity between my channel of skill acquisition and the home production channel, because maternal investments and the increase in the return to skills in the labor market jointly encourage female skill acquisition and ultimately female LFP.

### 4.2 Calibration

I calibrate the above framework to the United States in the 1880–1940 period, which comprises the era when the majority of areas in the United States became electrified.\(^\text{21}\) I simulate the effects that stem from the rollout of electricity during this period (as shown in Figure 4.1) and, particularly in my channel, from the progressive electrification of production processes. Calibrated values appear in Table 4.1. There are three sources for parameter values: the literature, closed-form expressions matching data moments, and the method of moments.

I choose some of the parameters of the market, composite consumption, and home production functions from the literature. In particular, I choose the elasticity of substitution between electricity and labor \(\gamma\) following the work of Hassler et al. (2012), who found that the short-

\(^\text{20}\)Similar to the benchmark model, I assume that when parents are making their children’s schooling investments, they forecast that their current electricity status will be held constant for the rest of their and their children’s lives. Note that imperfect forecasting would still yield an underinvestment in human capital and thus similar results.

\(^\text{21}\)Although the process of electrification expanded into rural and isolated areas after 1940 and until 1960 as shown in Section 2, I focus on the period preceding 1940 for two main reasons. First, my empirical analysis, which generates estimates on the effects of electrification used to calibrate the model, focuses on the 1900–1940 period. Second, after 1940 the US economy and particularly female labor faced dramatic changes due to the advent of World War II, the post-war economic boom, and the baby boom.
term elasticity of substitution between energy and a labor-capital composite that matches postwar aggregate United States data was close to zero (around 0.02), but can be approximated by unity in the long term. Since each period in my model is 5 years long, I take an intermediate value of 0.2. Furthermore, I choose both the share and elasticity parameters entering the CES production function that combines skilled and unskilled production from Goldin and Katz (2008). I take the elasticity of substitution between home and market consumption in total consumption, \( \theta \), to match the estimates found for married couples by Rupert et al. (1995) using the Panel Study of Income Dynamics (PSID). Finally, the share of electricity in home production, \( \omega \), is taken from Greenwood et al. (2005).

![Figure 4.1: Rollout of Electricity Grid](image)

Source: Lebergott (1976).

I choose the values of the share of electricity in skilled production, endowed efficiency, unskilled and skilled productivity, and post-electrification electricity productivity to match select data moments, given closed-form share, wage, and price expressions. I choose the share of electricity in skilled production, \( \zeta \), to match the share of energy expenditures in manufacturing in 1900 documented by Haines and ICPSR (2010).\(^{22}\) I calibrate women’s endowed efficiency in skilled and unskilled labor to match the ratio of average unskilled and skilled male and female occupational scores in 1900.\(^{23}\) To compute these ratios, I use the occupation information available in the 1900 census, in conjunction with the Lasso-adjusted industry,\(^{22}\)

\(^{22}\)Although the skilled sector does not map directly onto manufacturing, I use information from this sector to calibrate the share of electricity in skilled production, \( \zeta \), because manufacturing is one of the most energy-intensive sectors in the economy and there is little information about the share of energy in skilled labor or GDP historically.

\(^{23}\)Since educational attainment variables are not available in the 1900 census, I consider unskilled labor to correspond to the following occupations: farmers, operatives, service workers (in and outside private households), farm laborers, and laborers. Skilled labor, on the other hand, corresponds to the following occupations: professional and technical, managers, officials and proprietors, clerical and kindred, sales workers, and craftsmen.
Table 4.1: Model Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substit. in skilled prod. $\gamma$</td>
<td>0.2</td>
<td>Hassler et al. (2012)</td>
</tr>
<tr>
<td>Share of $Y_u$ in total prod. $\lambda$</td>
<td>0.5</td>
<td>Goldin and Katz (2008)</td>
</tr>
<tr>
<td>Substit. in total prod. $\eta$</td>
<td>1.64</td>
<td>Goldin and Katz (2008)</td>
</tr>
<tr>
<td>Substit. in cons. composite $\theta$</td>
<td>1.57</td>
<td>Rupert et al. (1995)</td>
</tr>
<tr>
<td>Share of $E$ in home prod. $\omega$</td>
<td>0.3</td>
<td>Greenwood et al. (2005)</td>
</tr>
<tr>
<td>Discount factor $\beta$</td>
<td>0.82</td>
<td>4% annualized return</td>
</tr>
</tbody>
</table>

Pinned Down from Model Expressions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Share of $E$ in skilled prod. $\zeta$</td>
<td>0.017</td>
<td>Share of energy in manufacturing in 1900</td>
</tr>
<tr>
<td>Female productivity in unskilled labor $\mu_u$</td>
<td>0.46</td>
<td>Ratio of unskilled female and male LIDO occ. scores in 1900</td>
</tr>
<tr>
<td>Female productivity in skilled labor $\mu_s$</td>
<td>0.57</td>
<td>Ratio of skilled female and male LIDO occ. scores in 1900</td>
</tr>
<tr>
<td>Skilled TFP $A_s$</td>
<td>1.17</td>
<td>Ratio of skilled and unskilled male LIDO occ. scores in 1900</td>
</tr>
<tr>
<td>Electricity prod. after electrification $A_{E,H}$</td>
<td>1.85</td>
<td>Price from small generators vs. grid</td>
</tr>
<tr>
<td>Time availability of young women $\tau^f$</td>
<td>0.4</td>
<td>Ratio of home prod. hrs. for 14–17 to 55–64 unsk women in 1900</td>
</tr>
<tr>
<td>Time availability of young men $\tau^m$</td>
<td>0.8</td>
<td>Ratio of work hrs. for 14–17 to 55–64 unsk men in 1900</td>
</tr>
</tbody>
</table>

Method of Moments

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substit. in home prod. $\phi$</td>
<td>1.74</td>
<td>Female work hours in 1900</td>
</tr>
<tr>
<td>Electricity prod. before electrification $A_{E,L}$</td>
<td>0.37</td>
<td>Female LFP in 1900</td>
</tr>
<tr>
<td>Relative value of leisure $\sigma_l$</td>
<td>0.43</td>
<td>Female home prod. hours in 1900</td>
</tr>
<tr>
<td>Share of market cons. in cons. composite $\nu$</td>
<td>0.75</td>
<td>Prop. of skilled women in 1900</td>
</tr>
<tr>
<td>2nd shape parameter of sch. cost distribution $\rho_H$</td>
<td>0.98</td>
<td>$DDD$ coefficient</td>
</tr>
</tbody>
</table>

Normalized

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>First shape parameter of sch. cost distribution $\alpha_H$</td>
<td>1</td>
<td>Normalized</td>
</tr>
<tr>
<td>Unskilled TFP $A_u$</td>
<td>1</td>
<td>Normalized</td>
</tr>
<tr>
<td>Length of life $J$</td>
<td>10</td>
<td>Each period 5 years; 50 years total life (15–65)</td>
</tr>
<tr>
<td>Age of parents when children are age 1 $K$</td>
<td>7</td>
<td>Age when children are 15–20 = 45–50</td>
</tr>
</tbody>
</table>

demographic, and occupation (LIDO) occupational score approach proposed by Saavedra and Twinam (2020), which adjusts occupation scores by race, sex, age, industry, and geography, and reduces the attenuation bias in gender earnings gaps. I calibrate the TFP of skilled labor $A_s$ to match the ratio of skilled and unskilled male LIDO occupational scores in 1900 from the census.\textsuperscript{24} Finally, I choose the efficiency of electricity production after electrification, $A_{E,H}$, to match the relative price charged for electricity produced by a small generator rather than a large-scale plant, as documented by Institute for Energy Research (2019).\textsuperscript{25} In addition, I choose the time availability of young women and men to match the ratio of home production between young and old unskilled women, and the ratio of work hours between young and old unskilled men, respectively.\textsuperscript{26}

\textsuperscript{24}I thank an anonymous referee for the suggestion of using the data in Haines and ICPSR (2010) to calibrate the share of energy in skilled production and the LIDO occupational scores to calibrate wage-related parameters.

\textsuperscript{25}This calibration follows from comparing the average price of electricity in 1902, when privately run small generators were the primary source of energy, to that in 1930, when central stations provided most of the power (Casazza (2004), Hunter and Lynwood (1991)).

\textsuperscript{26}See Appendix D for details on the calibration of these parameters.
I choose the rest of parameters using the method of moments in order to minimize the distance between model and data moments.\textsuperscript{27} In particular, I choose the elasticity of substitution in home production, $\phi$, the efficiency of electricity production prior to electrification, $A_{E,L}$, the relative weight of leisure in utility, $\sigma_l$, the share of market consumption in the consumption composite, $\nu$, and the second shape parameter of the schooling distribution\textsuperscript{28}, $\rho_H$, to minimize the distance between the moments generated by the model and the following moments in the data: female LFP in 1890, work hours and home hours in 1900, the proportion of women with completed high school in 1900, and the $DDD$ coefficient capturing the rise in female LFP due to electrification for highly educated young women in 1920 (with post-secondary education) estimated in my data.\textsuperscript{29} Details on these moments can be found in Appendix D.6.

4.3 Effects of the Rollout of Electricity: The Human Capital Channel

I now present the effects of the rollout of electricity from 1880 to 1940 on female LFP and other variables predicted by my channel and stemming from the increase in market opportunities for women. This follows from assuming a rollout of electrification in the market production sector, through which a progressively larger portion of households has access to higher electrification-driven wages.\textsuperscript{30} I then present evidence comparing the effects of electrification across cohorts, in order to capture differences that arise from young women’s ability to coordinate their human capital decisions to take advantage of the returns brought about by electrification. In Section 4.4, I examine the role of different parameters in shaping the aggregate rise in female LFP stemming from my channel. In Section 4.5, I allow for home production savings and examine how the effects of my channel change.

In Figure 4.2 I contrast the effects of electrification on female LFP predicted by my mechanism in the model and the data. The results for men are summarized in Figure E.3.\textsuperscript{31} I find that my channel explains 25.31\% of the rise in female LFP in the 1900–1940 period. This

\textsuperscript{27}See Table D.1 for a comparison of the data and model moments targeted in the method of moments.

\textsuperscript{28}In order to solve the model, I discretize the schooling time cost distribution into 10 bins, each containing 10\% of families according to the schooling cost distribution.

\textsuperscript{29}In the empirical section, the specific measure of electrification considered is the county-level change in generating capacity between 1911 and 1919, in 100s of megawatts. As such, the empirical estimate of the $DDD$ corresponds to the increase in the employment of young and skilled women in areas where the generating capacity increased by 100 megawatts in the 1910s relative to the employment of those in areas where the generating capacity did not increase. See Section 5 for further details on my empirical analysis.

\textsuperscript{30}Specifically, in the context of my model, I assume home and market production are served by two distinct sets of electricity technologies, each of which can use either the efficient or inefficient technology.

\textsuperscript{31}The model predicts a slight increase in men’s work hours during the period considered, while male labor force participation remains universal. The increase in men’s work hours is driven by the increase in skilled wages, and the proportion of skilled men.
increase is generated by the relative enhancement of market opportunities stemming from electrification, and particularly the fact that electricity complements skilled tasks that favor female labor. Complementary human capital investments are needed to take full advantage of these returns. This importance of human capital causes the effects of electrification to be more marked among new generations, who make their human capital decisions based on the new technological regime. This causes the effects of electrification to accrue through generational change and thus slows down the rise in female LFP predicted by my channel.\footnote{32}

In what follows, I further explore the importance of human capital acquisition by examining the effects of electrification across women of different cohorts.

**Figure 4.2: Female LFP: Model and Data**

![Graph showing female labor force participation](image)


In Figure 4.3, I plot the paths of schooling and female LFP across different cohorts through time. Panel (a) suggests that cohorts accumulate progressively more schooling as the electricity grid is rolled out, and furthermore, that within each period there is a wedge between the skill of young and old women. Panel (b), on the other hand, shows that the labor force participation of each cohort increases over time. This is driven by both the buildup in electrification that occurred during this era and by the process of human capital accumulation depicted in Panel (a).\footnote{33} In particular, women born after gaining access to electricity can coordinate their schooling decisions to maximize the productive returns of electrification and thus exhibit higher level of participation in the labor market. This is particularly evidenced in the fact that within each period, when all cohorts exhibit the same electrification rates, younger cohorts exhibit higher levels of LFP, driven by the fact that new cohorts have acquired schooling that complements the new work environment. In addition, this plot indicates that the LFP of each cohort of women declines at age $K$ when daughters and sons are engaging in

\footnote{32}{For the effects on all female variables, see Figure E.1.}

\footnote{33}{For the effects on all female variables by cohort, please see Figure E.2.}
school. This decline follows from the increased financial support provided by sons, but also from the fact that mothers relieve daughters from their domestic duties in order to enable the latter to attend school.\(^{34}\)

![Figure 4.3: Proportion of Skilled Women and Female LFP by Cohort](image)

(a) Proportion of Skilled Women
(b) Female LFP

Notes: Ages 2 to \(J\) plotted for every cohort.

### 4.4 Discussion of Key Parameters and Sensitivity Results

I now examine the role of different parameters in shaping the aggregate rise in female LFP stemming from my channel. Motivated by the discussion of Section 3.4, and specifically the forces shaping the aggregate rise in female LFP due to the progressive electrification of production processes highlighted in the benchmark model, I focus on the following parameters: (1) the productivity of electricity production after electrification \(A_{E,H}\), (2) the elasticity of substitution between electricity and labor in skilled production \(\gamma\), (3) female productivity in skilled labor \(\mu_s\), and (4) the second shape parameter of the schooling cost distribution \(\rho_H\). The results from this exercise are discussed in detail in Appendix F and summarized below.

I find that larger values of the productivity of electricity production after electrification \(A_{E,H}\), higher complementarity between electricity and labor in skilled production captured by lower values of \(\gamma\), and larger values of female productivity in skilled labor \(\mu_s\) increase both the rise of female LFP and the decline in female home production hours in my channel. This stems from the fact that these parameters jointly determine the increase in skilled wages perceived by

\(^{34}\)In particular, Figure E.2 indicates that the time spent in home production declines at age \(K\) due to the home production help women receive from daughters in this period. However, the time spent in home production at age \(K\) does not decline among newer cohorts unlike at all other ages, indicating mothers refrain from further reducing their time spent in home production at age \(K\) in order to help daughters with their domestic duties as electrification occurs and the returns to education increase.
women after electrification. $A_{E,H}$ determines the size of the decline in the price of electricity that occurs after electrification and thus the increase in the demand for electricity in skilled firms. $\gamma$, in turn, dictates by how much the demand for skilled labor, and consequently skilled wages, increase after this rise in the demand for electricity. Finally, $\mu_s$ shapes how much of this increase in skilled wages is reflected in women’s compensation.

In addition, I find that larger values of the second shape parameter of the schooling cost distribution $\rho_H$ generally also increase both the rise of female LFP and the decline in female home production hours in my channel. $\rho_H$ dictates the density of the schooling cost distribution and thus governs the response of female employment to the rise in the skilled wage by determining the number of women whose schooling cost is low enough that they will be encouraged to gain skills and join the workforce in response to electrification. Larger values of $\rho_H$ imply a larger mass accumulates at lower values of the schooling distribution, which in turn raises the response of female labor to electrification. In particular, the fraction of this rise my channel can explain increases to about 32% when $\rho_H$ is 150% of its baseline value. This suggests that my quantitative results are quite sensitive to the value of $\rho_H$ and motivates the use of the well-identified empirical estimates of Section 5 to calibrate this parameter and quantify the importance of electrification in the model.\textsuperscript{35}

### 4.5 The Joint Effect of the Human Capital and Home Production Channels

I now examine how the effects of my channel change when I allow for home production savings. To do this, I consider the case when both market and home production are electrified. The calibration for this exercise targets the same moments as before and follows the same structure.\textsuperscript{36} In Appendix H, I examine the case when electrification occurs only within the household (home production channel only).\textsuperscript{37}

\textsuperscript{35}In Section 3.5, I provided a discussion of how the DDD shapes the aggregate response of female LFP to electrification, which motivates its use as the calibration target. Note that although the same intuition linking the DDD to the rise in female LFP due to electrification is present in the quantitative model, other forces such as familial background, and the economic prospects of husbands, sons and daughters also play a role here.

\textsuperscript{36}Since all the moments targeted are set in 1900 or 1890, when only 3% of households were electrified, the parameter values used for this exercise are the same as the ones used before. The only parameter not set in 1900 is the DDD coefficient, which nevertheless is well approximated in the joint model (see Table G.1 for details on the fit of this channel to the data.).

\textsuperscript{37}Note that the exercise of Appendix H is not directly comparable to that of Greenwood et al. (2005), due to the introduction of human capital accumulation and investments in daughters by mothers in my model, which change the incomes and intra-household allocation of men and women. These two mechanisms imply that women’s decisions of home production do not follow from household technology alone, but also change in response to daughters’ current and future prospects.
I present the effects of electrification on female LFP that follow from my channel and the joint model featuring both channels in Panel (a) of Figure 4.4 and contrast them to the data. I find that the joint model explains 29.22% of the rise in female LFP in 1900–1940, which is 3.9 percentage points higher than the human capital channel alone and thus implies that the human capital and home production channels are complementary. This complementarity stems partly from an increase in the indirect investments in daughters by mothers due to the availability of electricity in the household. As a consequence of home electrification, young women are more able to invest in skills that are now more in demand in the labor market due to the electrification of production processes, because their mothers relieved them from household duties they would otherwise have. This matches the intuition in Lewis (2014), who shows that household electrification in 1930–1960 was associated with increased school attendance, particularly among teenage daughters.

I also find that my channel and the joint model predict declines in home production hours that are very close to the data, as evidenced in Panel (b) of Figure 4.4. The decline in the joint model is slightly faster, however, due to the introduction of the home production channel, which triggers a further decline in home production hours after electrification due to the substitutability between hours and electric goods in home production. My human capital channel can match the slow decline in home production hours evidenced in the data while explaining a large fraction of the rise in female LFP for two main reasons. First, my

Appendix H shows that although the overall decline in home production hours in the home production channel is small due to the introduction of human capital accumulation and investments in daughters by mothers in my model, this decline is actually quite large relative to the size of the increase in female LFP predicted in that case.
channel does not trigger gains in home productivity and thus decouples the rise in female labor supply from a decline in home production hours. Second, because complementary human capital investments are needed to take full advantage of the productive returns from electrification, the effect generated by my channel and the transition from home to market become more marked as new generations who make their human capital decisions under the new technological regime replace the old ones.

5 Evidence from the Early Electrification of the US

I now present evidence supporting the theoretical predictions of my model and underlying the estimates on the effects of electrification used to calibrate the model. I use data from the first half of the 20th century in the United States and focus, in particular, on the effects of electrification efforts put forward during the 1910s on the outcomes of individuals in the period from 1920 to 1940. I employ a triple difference (DDD) approach, focusing on the heterogeneity of the effects of electrification by educational level and cohort, given my model’s predictions that (1) a high level of education was critical to taking advantage of the new market opportunities electrification opened for women and (2) the age at the arrival of electricity was key, due to the existence of “formative years” when human capital investments are made. Since readily available electrification data does not exist for this period, I build a dataset with the universe of utilities and central generating stations in 1911 and 1919 by digitizing historical sources to construct county-level measures of electrification. I then combine this electrification data with an individual-level panel dataset built from the full-count 1910–1940 decennial census waves, using the record-linking algorithm proposed by Abramitzky et al. (2012, 2014). In addition, since education decisions are affected by electrification and are thus endogenous in my setting, I use a proxy for years of schooling that follows the data and approach of Clay et al. (2021) and thus exploits changes in required years of schooling arising from geographic and temporal variation in compulsory attendance, continuation school, and child labor laws.40

By focusing on the 1910s, I am able to study the effects of electrification in “Middle America,” smaller urban areas that were electrified after the large cities, but still early in the expansion of the electric grid (Rieder (1989), Nye (1992)). This contrasts with previous studies, which primarily focus on rural electrification and thus rely on much later data sources to study the effects of electrification (Kitchens and Fishback (2015), Kitchens (2014), Gaggl et al. (2016) and Lewis and Severini (2017)).

40I thank an anonymous referee for this suggestion.
The 1910s was a decade of rapid expansion of electricity generation and the electricity grid in the United States. During this period, the proportion of American homes with access to electricity increased by 20 percentage points, rising from 15% in 1910 to 35% in 1920 (Lebergott (1976)). Electrification efforts during this era were primarily focused in “Middle America,” medium-sized counties comprising an urban area with a defined city center, a few streets, and small factories and productive operations (Rieder (1989)). The process of electrification in these areas was marked by two distinct eras. The first, which lasted roughly from 1890 to 1900, was driven by municipal interests, which built small generating plants to power street arc lighting. In the second era, which lasted from 1910 to 1930, new generating plants were built (and older ones expanded) by privately owned electricity utilities looking for new business opportunities and consolidation outside the already-electrified large cities (Nye (1992)). This process was mostly cost driven, with geographical considerations like slope and the length of lines that needed to be built being chief drivers of plant location. The electrification of “Middle America” continued into the 1920s, after which time only rural areas remained to be electrified.

This large expansion of electricity fueled massive changes in the workplace. Electrification enabled the use of machines for production and transportation and increased the scale and complexity of the production process (Devine (1983)). These changes created new work opportunities for semi-skilled and skilled labor (see, for instance, Gray (2013), Goldin and Katz (1998), and Jerome (1934)), which often favored women (Nye (1992)). The rapid changes experienced in the workplace during this time period were coupled with substantial increases in female LFP. The higher demand for labor, in particular clerical positions where brawn ability was not important, opened up new work opportunities for women (Nye (1992)). Moreover, the use of appliances reduced the time needed for chores, while the use of electric lighting enabled the doing of chores at any time of day or night. These two phenomena enabled women to join the labor force. The first made market work more appealing to women, while the latter facilitated it by freeing up women’s time, allowing them to work while still tending to home responsibilities. In this section, I show that the effects of electrification on female LFP interact with education choices, consistent with the human capital channel of electricity highlighted in my model. Moreover, I show that age at the arrival of electricity was key, due to the existence of “formative years” when human capital choices are still being molded.

\[\text{In 1910, roughly 23\% of the US 15+ population lived in “Middle America,” defined as counties with a 15+ population between 15,000 and 30,000 (approx. 70th to 90th percentiles of US county-level population).}\]

\[\text{In Figure 2.3, I provided evidence of this trend in the forms of photographs depicting telephone switchboard operators in 1915 and female secretaries using early calculating machines in an office during the 1920s.}\]

\[\text{In addition, the use of appliances reduced the need for domestic workers, which may have furthered the importance of female human capital in the work environment by displacing a notable source of employment for less-educated women.}\]

33
5.1 Electricity Data

I build an electrification dataset from power plant generation and location data found in the 1911 and 1919 editions of “Central station directory: a complete list of electric light and power companies with data” published by McGraw. Each edition contains a list of all the electric power plants owned by electric and power companies in the United States and is organized as a list of all the cities where power utilities operate. Each city entry contains information on all the utilities operating in the city area and includes their generation capacity and other information. Using the location and generation-capacity information, I am able to construct measures of the electrical capacity within and around each county in the United States. My preferred treatment definition follows from this, and is given by the change in the total electrical capacity within and 50 miles around each county’s boundaries between 1911 and 1919, in 100s of megawatts. Historical constraints in transmission technology made it unfeasible to consume power far from the generation site prior to the expansion of high-voltage AC transmission lines beginning in the late 1920s (Casazza (2004)). This implied that transmission systems (or grids) were highly local during this period and operated separately from one another. Thus, my treatment definition of the change in the total electrical capacity within and 50 miles around each county’s boundaries between 1911 and 1919 approximates the change in the extent of electrification in each county during the 1910s. Moreover, my measure captures the generation of smaller plants, which are important in this period and frequently overlooked in other studies that only consider the output and location of large plants. My measure strongly correlates with measures of farm electrification available from the agricultural censuses in 1930 and 1940, which represent direct measures of area-level electrification. In particular, my measure strongly predicts the proportion of farm dwellings within a quarter mile of an electrical power line in 1940 and the proportion of farm dwellings with electricity from a power line in both 1930 and 1940 at the county level (see Table I.1). I build my preferred measure of electrification and thus the scale of my empirical estimates in 100s of megawatts, based on technological and institutional facts of this era.

44County boundaries have changed throughout time in the United States. In order to maintain consistent county-boundary definitions, I use the county definitions from 1910 and link these back to other years using the crosswalk built by Eckert et al. (2020).
45Starting in the late 1920s, rapid improvements in transmission technology enabled the distance of electricity transmission to be increased. Long-distance transmission ultimately followed from the invention of high-voltage DC transmission in the mid-1950s.
46This is captured in Figure I.2, which depicts four distinct eras of electricity transmission, driven by constraints in the voltage employed by transmission technology.
47My measure has limitations, however, since it does not capture the exact location of lines within each county. To the best of my knowledge, there is no data on electric transmission lines prior to 1919.
48My results are similar when I use an alternate treatment definition based on proximity to large electricity-generating plants. For this, I use a dummy indicating whether the county is 100 miles or less from a large-capacity generating plant (20 megawatts or more). See Appendix L.8 for details.
megawatts generating threshold is equivalent to 3 to 4 large generating plants. Since my measures of electrification are built within and 50 miles around each county’s boundaries and the average county area is 1200 square miles, this capacity threshold guarantees that most households and businesses in the county are located within a 50-mile radius of one of these large plants and thus have access to electricity.

Figure 5.1: Examples of Data from “Central Station Directory: A Complete List of Electric Light and Power Companies with Data”

(a) Data from towns in Colorado

(b) Data from Southern California Edison

In Figure 5.1, I present an example of how the data is organized in the McGraw publications. Panel (a) shows how the data is organized by state and city, with each entry containing information on the utilities operating in each city, along with their generation capacity and other details on the lighting system of the city. The entries for certain cities, typically large ones, also contain information on power plants not located within city boundaries but that are owned by a utility headquartered within the city. This is noted in the books by the separate listing of the name of the plant. Panel (b) in Figure 5.1 lists, for example, Southern California Edison as being headquartered in Los Angeles, but owning hydroelectric generating stations operating in different locations (Big Creek No. 1, Big Creek No. 2, etc). In these cases, the precise locations of the generating stations are not provided, so I complemented
this analysis by performing searches on the names of the plants. Given that most of these plants used hydroelectric power, information on the plants is widely available, as many are still in operation or well documented.

Figure 5.2: Map of County-Level Intensity of Electrification Treatment in the United States

Notes: Electricity-generation capacity within and 50 miles around each county.

In Figure 5.2, I present county-level maps of the change in the total capacity within and 50 miles around county boundaries between 1911 and 1919 that follow from the electrification data digitized from the McGraw books. In this treatment definition, I exclude counties that were already widely electrified before 1911 (above the 90th percentile of generation capacity), in order to focus on areas that gained access to electricity during the 1910s. The excluded areas correspond to large cities such as New York, Washington, DC, Los Angeles, Chicago, Seattle, and Detroit, and areas with substantial generating resources, such as some areas in Montana (hydroelectric resources) and West Virginia (coal resources). My treatment, nevertheless, encompasses most of the United States (in terms of both population and land mass) and has substantial regional variation. A visualization of this measure for Alaska and Hawaii is available in Figure I.1.

5.2 Construction of Panel Data

I combine the electrification data with an individual-level panel dataset built from the full-count 1910–1940 decennial census waves using the record-linking algorithm proposed by Abramitzky et al. (2012, 2014). I rely on name, birth year, and state or country of birth matches to link records across waves. To allow for the possibility of nicknames or different name spellings, I first transform names into a phonetic code using the NYSIIS algorithm. Moreover, to allow for mismatches in the birth year reported, I allow matches to potentially
differ in the year of birth reported by two years. All record-linking algorithms rely heavily on between-wave name comparisons to form matches and thus have difficulties in matching women, due to maiden-to-married name changes. For this reason women who were married in the first census wave (1910) are overrepresented in my data. Given these name changes, another group that is overrepresented in this data are women who never married and prioritized career over family. Since there exists great and consistent heterogeneity between women with regards to their employment choices, using panel data is ideal, because it enables controlling for individual heterogeneity and focusing on changes within individuals instead.

Table 5.1: Summary Statistics in Panel and Full Repeated Cross-Section Data in 1910

<table>
<thead>
<tr>
<th></th>
<th>Panel</th>
<th>Repeated Cross-Section</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men</td>
<td>Women</td>
</tr>
<tr>
<td>Prop. employed</td>
<td>0.87</td>
<td>0.15</td>
</tr>
<tr>
<td>Prop. attending school</td>
<td>0.18</td>
<td>0.09</td>
</tr>
<tr>
<td>Avg. Years of Required Schooling</td>
<td>3.97</td>
<td>3.42</td>
</tr>
<tr>
<td>Prop. with 8+ Years of Req. Sch.</td>
<td>0.12</td>
<td>0.08</td>
</tr>
<tr>
<td>Avg. children born per woman</td>
<td>2.01</td>
<td></td>
</tr>
<tr>
<td>Prop. married</td>
<td>0.37</td>
<td>0.74</td>
</tr>
<tr>
<td>Prop. urban</td>
<td>0.30</td>
<td>0.33</td>
</tr>
<tr>
<td>Avg. socioeconomic index</td>
<td>19.24</td>
<td>4.68</td>
</tr>
<tr>
<td>Prop. white</td>
<td>0.94</td>
<td>0.94</td>
</tr>
<tr>
<td>Total obs.</td>
<td>670,352</td>
<td>507,292</td>
</tr>
</tbody>
</table>

Notes: The sample for this table consists of individuals who were 15–35 years of age in 1910, were born in the contiguous US, and who lived in areas that gained access to electrification in the 1910s in 1910.

Using this matching algorithm, I am able to follow a total of 723,434 women and 966,998 men born between 1875 and 1895 in the contiguous United States from 1910 to 1940, which roughly correspond to 5.20% and 6.68% of these populations, respectively. The number of men is in line with the results reported in the matching literature, which follow roughly 16% of native-born men from 1900 to both 1910 and 1920 (Abramitzky et al. (2014)). The number of women matched with this algorithm is significantly lower, due to the maiden-to-married name changes that complicate the following of women who were single in 1910. In my analysis, I focus on individuals who during 1910 lived in areas that gained access to electricity during the 1910s, as defined by my treatment variable above. The total number

49In Appendix M I study whether the baseline results differ for women who were married in 1910, women who ever married, or women who ever had children.

50In addition, because educational attainment was only first surveyed in the 1940 census, using panel data is necessary to observe realized schooling. This is particularly important for the analysis performed in Appendix L.1, where I use individual-level educational choices to examine the heterogeneity in the effects of electrification on employment by schooling.
of individuals in the matched panel sample in this category equal 670,352 men and 507,292 women.

In Table 5.1, I report average values for select variables of interest in the panel sample, along with the full repeated cross-section data (encompassing all individuals in each census wave), for individuals born in the contiguous United States in my cohorts and treatment areas of interest. I find that both specifications are fairly similar along all dimensions considered, except for the proportion of married women, and related female outcomes like fertility and school attendance. Appendix J.1 presents summary tables for 1920–1940, characterized by broadly the same patterns.

5.3 Strategy and Identification

My main analysis follows a triple difference (or DDD) strategy with continuous treatment intensity and examines the heterogeneity in the effects of electrification on employment across educational levels and cohorts. With this analysis, I study whether living in counties with a large extent of electrification in the 1910s differentially changes the employment rates\(^51\) of women and men of different cohorts and education levels in 1920, 1930, and 1940 relative to those in 1910 and to their counterparts living in areas with a small extent of electrification.\(^52\) By focusing on the heterogeneity in the effect of treatment by educational attainment levels, I attempt to test the model prediction regarding the role of skill in mediating the effects of electrification for different cohorts.

Since education decisions are affected by electrification and are thus endogenous in my setting, I proxy for educational attainment using the data and methodology proposed by Clay et al. (2021), who construct a measure of required years of schooling using geographic and temporal variation in state compulsory attendance, continuation school, and child labor laws. Clay et al. (2021) construct this measure for each state-year birth cohort through an iterative process that calculates whether attendance was required at each year of life for each cohort in each state, based on the state-specific age limits and exemptions in place in that year. Given that in my model the skill decision is binary (skilled or unskilled), I focus on a binary level of required school attendance, capturing 8 years or more of required schooling.\(^53\) The oldest cohorts with information on required schooling in the Clay et al. (2021) data were

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\(^51\) The US Census considered individuals to be in the labor force if they reported steady, gainful employment for the 1850–1930 censuses. From 1940 onwards the census used a different concept of LFP. For consistency across censuses, I focus on the gainful occupation definition.

\(^52\) It has been documented that the 1910 census overcounted unpaid female farm laborers (Goldin (1986)). I correct for this by excluding all women reported as unpaid female farm laborers in 1910 from the analysis.

\(^53\) In Appendix L.2, I follow the approach of Clay et al. (2021) more closely, and use several binary variables denoting different levels of years of required attendance, namely 1 to 5, 6, 7, and 8 or more.
born in 1875 and were thus 35 years of age in my baseline period of 1910. As such, I focus on four cohorts: individuals who were 15–20 years old in 1910, individuals who were 21–25 years old in 1910, individuals who were 26–30 years old in 1910, and individuals who were 31–35 years old in 1910. Note also that because the required years of schooling data is built at the state of birth by cohort-level, this analysis is limited to individuals born in the contiguous United States.54

I estimate the following regression for each cohort:

$$Employed_{i,h,c,t} = \alpha + \beta_t \Delta Cap_c \times Post_t + \beta_{t \text{Skill}} \Delta Cap_c \times ReqSch_{i,h,c} + \beta_t \text{Post} \times ReqSch_{i,h,c} + \beta_t \text{Post} \times ReqSch_{i,h,c} \times \text{Post} \times ReqSch_{i,h,c} + \alpha_i + \alpha_t + \alpha_{s,t} + \alpha_c + \beta_{X_{i,h,c,1910}} \times Post_t + \beta_{Z_{h,c,1910}} \times Post_t + \epsilon_{i,h,c,t},$$ (4)

where Employed refers to the gainful employment definition, that is, employment in a job with steady work and payment. $i$, $h$, $c$, and $t$ denote the individual, cohort, county of residence, and year, respectively. $\Delta Cap_c$ corresponds to my preferred measure of electrification: change in generating capacity between 1911 and 1919 (in 100s of megawatts), excluding counties that were already widely electrified before 1911 (above the 90th percentile of generation capacity). $\text{Post}_t$ denotes a set of three binary variables indicating post-treatment periods after 1910: 1920, 1930, and 1940. $\text{ReqSch}_{i,h,c}$ denotes a binary variable capturing whether the years of required school attendance were equal to or larger than 8 for individual $i$. My coefficients of interest are thus $\beta_t \text{Cap} \times \text{Skill}$, which capture the heterogeneity in the effect of treatment by required educational attainment. $\alpha_i$, $\alpha_t$, $\alpha_{s,t}$, and $\alpha_c$ denote individual, year, state-by-year, and county fixed effects, respectively. $X_{i,h,c,1910}$ denotes individual-level controls in 1910 (urban status, marital status, and school attendance), while $Z_{h,c,1910}$ denotes cohort by county-level controls in 1910 (total population and socioeconomic index).55 I cluster these results at the 100-mile radius-by-year level following the method proposed by Colella et al. (2019) in order to account for serial correlation stemming from the location of electricity plants. I choose the distance threshold of 100 miles based on the technological constraints associated to the transmission of electricity prevalent during 1910–1935, which prevented the

54In Appendix L.1, I show the results when I do not proxy for educational level. This allows for the inclusion of older cohorts, several educational attainment levels, and individuals born abroad and in excluded territories. These results are not as clean as the baseline ones, however, since education is an endogenous variable to electrification.

55I include the baseline (1910) level of these controls interacted with post-treatment indicators rather than contemporaneous levels to avoid post-treatment bias, since some of the controls might be affected by treatment. Given that I consider a long period of 30 years and that the existence of concurrent shocks or omitted variables biasing the results might be relevant, in Appendix L.4 I repeat this exercise, considering contemporaneous controls and find very similar results.
consumption of electricity far from the generation site (Casazza (2004)).

Identification relies on the assumption that absent change in electrical capacity, individuals with the same required education level and from the same cohort living in counties experiencing a large change in generation capacity would have trended similarly to their counterparts in counties with a small change. Two main concerns threaten this assumption. First, areas with higher electrification investments may also exhibit other related characteristics exerting a time-varying effect on employment rates or education during my period of study. Second, the early 20th century was a period of rapid change driven by key transformative events like World War I, the Great Depression, and the development and expansion of technologies like railroads and telephones, raising the concern that unobservable characteristics or concurrent shocks occurring in areas with high levels of electrification are driving the effects. In what follows, I put forth three pieces of evidence supporting the identification assumption and addressing these concerns.

The first concern is addressed through my data and historical accounts of the process of electrification, which indicate that in “Middle America” the process was primarily driven by static cost considerations and extended beyond my period of interest (1910s) into the 1920s, providing a natural control group of counties with similar characteristics that were electrified a few years later. This is evidenced in Figure K.1, which shows that although most of the electrification during the 1910s focused on medium-sized counties, many of these also experienced small to no change in generation capacity during this period, indicating the staggered nature of this process. This figure also shows that most of the counties that were electrified prior to the period under study had large populations. In Table J.4, I present the averages for individuals aged 15–35 in 1910 for counties above and below the 50th percentile of treatment, respectively, along with counties that had a large generating capacity prior to 1911 and are thus excluded from my analysis. Counties electrified to a significant extent

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56 I thank an anonymous referee for the suggestion of using the method developed by Colella et al. (2019) to cluster standard errors at different radii. In Appendix L.5 I consider the robustness of these results to other clustering levels.

57 This analysis proxies for educational attainment using required years of schooling. Therefore, this framework is equivalent to estimating the reduced-form differential effect of electrification by required years of schooling. I employ this reduced-form approach rather than an instrumental strategy where required schooling is used to predict educational level, like Clay et al. (2021), for two main reasons. First, my setting features far fewer cohorts than those studied by Clay et al. (2021), which greatly reduces the variation in required years of schooling and thus thwarts the predictive strength (or relevance) of the first-stage. This difficulty is compounded in my setting, because my DDD requires first stages for each of the variables that include an interaction with educational attainment (Wooldridge (2010), Chapter 8). Second, and most importantly, the required-years-of-schooling binary variable I employ at baseline, which denotes individuals who were required to attend school for a minimum of 8 years, captures individuals with a guaranteed educational level of completed middle school, and who thus were considered skilled during this time period.

58 For summary statistics for individuals aged 15–35 in the rest of the years, see Appendix J.2.
prior to 1911 are substantially different from those in my analysis. However, the differences between counties above and below the median treatment included in my analysis are much less marked. Moreover, any remaining differences in levels are controlled with the difference-in-differences framework; and the inclusion of a rich set of controls, including individual, county, and state-by-year fixed effects, along with county- and person-level controls, further assures that the results are not driven by omitted characteristics.

To address the second concern, I perform pre-treatment trend tests by examining the effects of an expansion in generation capacity in the 1910s on female and male employment in 1900, the pre-treatment period. The results are performed at the aggregated county-level rather than using the matched sample, because I limited my record linking to the 1910–1940 period in order to maximize the number of matches, and especially because much of the younger cohorts would be missed in this period. In addition, because the youngest cohort would be aged 5–10 in 1900 and thus have no occupational or labor force information, I limit this analysis to the three older cohorts. Also, I do not use data from 1890, because census records from this wave were largely lost to fire. The equation I estimate follows:

\[ \text{Employed}_{h,c,t} = \alpha + \beta_t \Delta \text{Cap}_c \times \text{Pre}_t + \alpha_s + \alpha_{c,t} + \alpha_c + \beta_{X_t,1910} \times \text{Pre}_t + \beta_{Z_t,1910} \times \text{Pre}_t + \epsilon_{h,c,t}, \]  

where \( h, c, \) and \( t \) denote cohort, county, and year, respectively, and \( \text{Pre}_t \) denotes a binary variable indicating the pre-treatment period of 1900. \( X_{h,c,1910} \) denotes cohort by county-level controls in 1910 (proportion urban, proportion married, racial composition, total population, and socioeconomic index). The rest of the notation follows Equation (4).

Finally, given that the bulk of my analysis relies on the heterogeneity in the effects of treatment across cohorts and predicted education levels, some of the concerns regarding identification are alleviated, because for bias to arise, young women who were born in states and eras with a large number of years of required school attendance need to be differentially different from young women who were born in states and eras with a low number of years of required school attendance in treatment relative to control counties. This approach follows from my model, where the complementary influence of skill and the possibility of coordinating schooling decisions enables young cohorts to maximize the returns of electrification on female employment.

In Figure K.3, I present evidence of this in action by plotting the rates of female employment by birth-year cohort in 1940 in more-treated (above-median) and less-treated (below-median) counties to explore heterogeneity in employment across cohorts in 1940, the final period I consider. The graph shows that the differences in employment rates across more- and less-
treated counties are muted for cohorts who were past the age at which key schooling and family decisions are set when electricity arrived. This pattern is substantially different for men, who display consistently lower employment rates for all cohorts in more-treated relative to less-treated counties, except for the youngest cohorts. Taken jointly, these data follow the main insight of my model regarding the importance of timing in the effects of new technologies (which I further explore in my results section) and reassure that potential confounding shocks or omitted characteristics are not driving the results, since the effects of these would likely affect all cohorts.

5.4 Effects of Electrification

In this section, I first study whether the response to electrification of male and female employment varies with required years of educational attainment across different cohorts. At the end of this section, I (1) discuss the robustness of these main results to different specifications, (2) discuss how these effects vary with women’s fertility and marital choices, and (3) show evidence suggesting that these changes in female LFP due to electrification were accompanied by changes in fertility, timing of childbearing, and marriage rates. I present the results on the heterogeneous effects of electrification on the employment status of women and men of different cohorts by required educational attainment. In order to show support for the theoretical prediction that younger and older individuals respond differently to electrification, I focus on the four cohorts mentioned above: individuals who were 15–20 years old in 1910, individuals who were 21–25 years old in 1910, individuals who were 26–30 years old in 1910, and individuals who were 31–35 years old in 1910. Doing this allows me to test the prediction in my model that the new work opportunities triggered by electrification require complementary schooling investments and thus favor young and skilled women.

I find that young women born in areas with a required level of schooling of 8 years or above experienced a significantly higher increase in employment after electrification, relative to their counterparts with lower required levels of schooling, for all years considered (see Figure 5.3). In particular, the increase in employment among young women with a required schooling level of 8 years or more was approximately 8 percentage points higher on average in 1920 (relative to 1910) than that of young women with a required level of schooling level

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60 In Appendix O, I also explore the effects of electrification on male and female employment per se without the heterogeneity/triple difference component. In addition, in Appendix P, I employ a difference-in-differences strategy and study the effects of electrification on schooling by comparing the county-level changes in school attendance for individuals ages 6 to 24 between 1910 and 1940. This analysis relies on aggregated county-level data (not panel) and is thus more suggestive.

61 The last column of Table Q.1 contains tabulates of these results for the young cohort. Tabulates of these results for older cohorts are available upon request.
Figure 5.3: Heterogeneity in the Effects of Electrification on Women’s Employment by Required Educational Attainment of 8 or More Years, For Different Cohorts

Notes: The coefficients plotted correspond to $\beta_t^{CapSkill}$ in Equation (4), estimated for each cohort separately. These coefficients capture the heterogeneity in difference-in-differences effects by required educational attainment of 8 or more years for each of the post-treatment periods (1920, 1930, and 1940, with baseline 1910). The analyses encompass women in the panel sample who were 15–20, 21–25, 26–30, and 31–35 years of age in 1910, respectively, and were born in the contiguous US. 95% confidence intervals built from standard errors clustered at the 100-mile Radius x Year level are plotted.

of less than 8 years in areas with an increase in generating capacity of 100 megawatts in the 1910s. This magnitude of this effect decreases to about 4.5% in 1930 and 3% in 1940, but remains significant at the 5% and 10% levels, respectively. This positive interaction between required education and electrification is consistent with the idea that electricity complements skilled tasks and occupations, and these, in turn, favor women, particularly those who have the necessary education to carry out these jobs. More generally, this effect is suggestive of production-side considerations entailing a role for skill in the response of women’s employment to electrification, which would be absent if the returns from electrification were driven purely by home production savings and skill neutral. This effect is absent for older women. This suggests that young women were more able to coordinate key decisions, such as the length and type of education they pursued or their marital status and fertility, enabling them to capitalize on the market opportunities favoring women generated by electrification to a greater extent than older cohorts.

These intuitions are further hinted at by the results for men presented in Figure 5.4. In particular, a higher level of required educational attainment raised the effect of electrification on male employment only in 1940, particularly for older cohorts. This contrasts with the results for women and indicates that for these it is more critical to be young and thus able to coordinate key decisions to take advantage of the market returns of electrification. Moreover,

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62 The last column of Table Q.2 contains tabulates of these results for the young cohort. Tabulates of these results for older cohorts are available upon request.
when we decompose these results along several levels of required schooling in Appendix L.2, we find that the positive effects of required schooling are more heavily concentrated within the highest required schooling category (8 or more years of required schooling) for women compared to men. This suggests that the shift in the female work environment triggered by electricity focused on more highly skilled jobs, where women face a particular advantage.

Figure 5.4: Heterogeneity in the Effects of Electrification on Men’s Employment by Required Educational Attainment of 8 or More Years, For Different Cohorts

Notes: The coefficients plotted correspond to $\beta_{t}^{Capx\cdot Skill}$ in Equation (4), estimated for each cohort separately. The coefficients capture the heterogeneity in difference-in-differences coefficients by required educational attainment of 8 or more years for each of the post-treatment periods (1920, 1930, and 1940, with baseline 1910). The analyses encompass men in the panel sample who were 15–20, 21–25, 26–30, and 31–35 years of age in 1910, respectively, and were born in the contiguous US. 95% confidence intervals built from standard errors clustered at the 100-mile Radius x Year level are plotted.

Jointly, the results for men and women are also consistent with the argument outlined in Goldin and Katz (2008), who contend that over the last century, technological change has increasingly required the employment of high-skilled workers, and the evidence presented in Gray (2013), who shows that electrification changed the demand for skill in manufacturing by raising the demand for clerical, numerical, and planning jobs and reducing the demand for manual and dexterity-intensive jobs.

In Appendix L I consider the robustness of my results to different specifications, and find broadly the same results. In particular, I consider robustness to (1) not proxying for educational level, (2) following the approach of Clay et al. (2021) more closely and using several binary variables denoting different levels of years of required attendance, (3) including different fixed effects and controls, (4) using contemporaneous controls instead of baseline-level controls, (5) clustering at the 100-mile radius and county-by-year levels, (6) excluding counties in the South, (7) excluding counties in the West, and (8) considering an alternate treatment definition based on the proximity to large electricity-generating plants. I also provide
a discussion of the relationship between World War I and my results.

In addition, and given that women who never married and thus prioritized career over family are overrepresented in my panel sample together with women who were already married in 1910, in Appendix M I study whether the baseline results differ for women who were married in 1910, women who ever married, or women who ever had children. I find that electrification did not differentially increase the employment of young and skilled women who were married in 1910, but did differentially increase the employment of young and skilled women who married or had children in later years (particularly in 1920). This suggests that women who had competing responsibilities that limited their ability to coordinate key human capital decisions when young were unable to take advantage of the productive returns brought about by electrification. However, women who later married and had families did see an increase in their LFP due to electrification when young, suggesting that the effects of electrification on female LFP were not limited to women who prioritized career over family.

Given this intimate link between female LFP, educational choices, and fertility, in Appendix N I explore the impacts of electrification on fertility. With this, I shed light on the role of electrification in driving the significant changes in both women’s careers and family lives in the first half of the 20th century documented in Section 2. I first explore the effects of electrification on the fertility of women of different cohorts. I find that electrification reduced the fertility of women of all cohorts considered and that this effect is especially marked among younger women. In addition, I find that electrification altered the timing of fertility, with women in electrified areas waiting longer to have children. These results are consistent with the findings showing electrification encouraged the female LFP of young and skilled women and suggest that electrification increased the opportunity cost of childcare by creating work opportunities for women. This link between human capital, work, and fertility is further supported when I explore the differential impacts of electrification on fertility by required schooling. I find that young women born in areas with a required level of schooling of 8 years or above experienced a significantly lower increase in fertility after electrification, relative to their counterparts with lower required levels of schooling, for all years considered. Similar to the baseline results on female LFP, these effects are muted for older women.

I then explore the impacts of electrification on women’s ever-married status. Because there is no change in this variable within individuals, I conduct this analysis at the age-group level, and thus compare the county-level trends in the proportion of ever-married individuals of ages 36–55 from 1910 to 1940 in counties that were electrified versus those that were not.63

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63I choose the age group of 36–55 because (1) by this age most marriages have happened and (2) these individuals correspond to those who were 15–35 in 1910 (my cohorts of interest in the main analysis) in
I find that the proportion of ever-married women in the 36–55 years of age range rises from 1910 to 1940 as a consequence of electrification. Although this may seem at odds with the decline in fertility mentioned above, this pattern matches the evidence presented in Goldin (2020), and suggests that electrification fueled deep changes in the societal role of women during the early 20th century. In particular, the advent of electricity changed the productive landscape for women, encouraging them to further their educations and pursue careers during their youth, and pursue marriage and a family in later years.

6 Conclusions

In this paper, I proposed a new channel linking electrification and female LFP that focuses on market production opportunities and the role of human capital accumulation. I formalized my intuitions in an overlapping generations (OLG) model where electricity is skill biased and households make decisions about human capital early in life. Using this framework, I showed that electricity raises the productivity of skilled labor, which is less brawn intensive than unskilled labor and thus more favorable toward women’s employment, encouraging female LFP. However, complementary human capital investments are required to take advantage of these returns, because they involve work in skilled tasks. Since human capital choices are made early in life, young households experience a unique advantage relative to older households, because they can coordinate these decisions to maximize the benefits from electrification. This generational divide causes the effects of electrification on female LFP to accrue through generational change, as old generations who made their decisions prior to electrification are replaced.

I calibrated my model to the 1880–1940 United States and used my empirical analysis, in particular the estimate on the effect of electrification on the LFP of highly educated young women, to quantify the aggregate effects of electrification. My channel explains approximately one quarter of the rise in female LFP in the 1890–1940 period and matches the slow decline in home production hours in the first half of the 20th century by decoupling the rise in female labor supply from a decline in home production hours.

I then presented empirical evidence supporting the main predictions of my theory and underlying the estimates on the effects of electrification used to calibrate the model. I linked individual-level panel data from the full-count 1910–1940 censuses to a new dataset of the universe of central generating stations in 1911 and 1919 in the United States, built by digitizing historical sources. I found that high levels of required educational attainment enhanced the

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the mid-post-treatment period in 1930.
increase in female employment of young cohorts after electrification. This matches the pre-
diction of my model regarding the importance of being young and able to make complementary
human capital investments to reap the market gains generated by electrification. I then
showed evidence that these changes in female LFP due to electrification were accompanied
by changes in fertility and marriage. Taken jointly, these results suggest that electrification
fueled deep changes in female work, education, marriage, and fertility patterns.

The above theoretical and empirical results have policy implications for current electrification
interventions targeted to the developing world. In particular, this paper suggests that the
effectiveness of electrification interventions relies partly on electrifying production processes
and can be boosted through schooling programs, particularly if targeted to women and girls.
Moreover, since sparse firm-level electrification and low levels of human capital dampen the
effects of electrification in the short run, my paper also helps reconcile the large effects found
by medium- and long- run studies in the developing world (Lipscomb et al. (2013), Lewis and
Severini (2017), Rud (2012), Kassem (2018), and Dinkelman (2011)), with the modest effects
found in recent short-run studies (Lee et al. (2016) and Burlig and Preonas (2016)).

More broadly, this paper brings attention to a new feature of electrification that has been
previously overlooked: the rise in female LFP stemming from new market opportunities and
the accumulation of human capital. This paper focuses on documenting theoretically and
empirically the importance of this channel within the context of the United States. How-
ever, the implications of the rise in women’s opportunities may matter for several other key
questions of economic development. For example, the rise in women’s opportunities stem-
ming from electrification may impact gender wage gaps, women’s bargaining power within
the household, children’s outcomes, and declining male work hours.

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A Appendix: Additional Historical Context

Figure A.1: Total Fertility Rate (TFR) and Proportion Ever-Married Women 1900–1960

Source: Census (Proportion Ever-Married) and Haines (2006) combined with proportion of women by race from Census (Total Fertility Rate).64

Figure A.2: The Arrival of Electricity to the Factory: Ball Brothers Manufacturing Company

Prior to Electrification: Glass Blowers and Small Factory

After Electrification: Mechanized Jar Production and Large Factory


64Please note that data from 1890 is not available for fertility because records from the census conducted in this year were largely lost to fire.
B Appendix: Additional Results and Discussion of Benchmark Model

B.1 Generational Differences in the Response to Electrification

In the model, women who were old upon electrification will have no change in their LFP rates, because they are not able to coordinate their human capital decisions to fully maximize the new market opportunities generated by electrification. This dampens the increase in female labor supply in the short run and generates a dynamic effect of electrification on female LFP, which accrues through generational change and human capital accumulation.

Figure B.1: Proportion of Women of Different Ages Engaging in Home and Skilled Production

These phenomena are illustrated in Figure B.1, where I plot the different proportions of young and old women engaging in home and skilled production at the time of electrification and in the new steady state. In particular, upon electrification the fraction of old women with schooling costs between the old and new cutoffs are constrained to remain in home production, although they would prefer to work in the skilled sector. This follows from the fact that these women made their schooling decisions under the previous technological regime and thus do not have the necessary skills to access skilled jobs. This dampens female LFP in the short run, because a large proportion of old women remain in home production. After this cohort of women dies, however, all subsequent will have made their decisions under the new regime and female LFP will rise even more.
B.2 Importance of Women’s Productivity in Skilled Production

The value of women’s endowed productivity in skilled production determines the scope of electrification to generate this positive effect on female LFP. In particular, low levels of endowed productivity in skilled production undermine the ability of electrification to stimulate female LFP, since the attractiveness of this sector will be diminished in comparison to home production. In other words, if women’s productivity in skilled labor is low enough, no women will engage in market production prior to electrification, and electrification will only spur female LFP if the change in skilled wages is large relative to a threshold. This is evidenced in Figure B.2, where even after electrification, the value of skilled labor is not high enough to shift any women from home to market.

Figure B.2: Change in Women’s Value of Skilled Labor due to Electrification (with low $\mu_s$)

For example, if electricity complemented unskilled tasks instead, which are heavily brawn intensive and particularly unfavorable to women, the scope of electricity to shift women from home to market would be diminished, because the change in wages triggered by electrification might not be enough to compensate for the disadvantages faced by women. This therefore suggests the importance of the relative content of brawn and brain in skilled tasks in determining the aggregate effect of electrification on female LFP. In particular, higher relative female productivity in skilled labor, driven, for instance, by the use of brain rather than brawn capacity in skilled tasks, will enhance the scope of electrification to change the productive opportunities for women and in turn its scope in changing aggregate growth patterns.

65 See Section 4.4 for a discussion of the importance of this parameter in the quantitative model.
B.3 Derivation of the Link between DDD Estimates and Aggregate Effects

Consider the two terms in Equation (2), \( F(\tilde{\rho}_t^f) \) and \( F(\tilde{\rho}_{t-1}^f) \), which capture the LFP of young and old women in period \( t \), respectively. Notice that these terms can also be interpreted as the LFP of the cohort of women who were young in period \( t \) and whose location of residence became electrified in that period (and who thus are characterized by \( \tilde{\rho}_t^f \)) and of their counterparts in locations that did not become electrified (and who thus are characterized by \( \tilde{\rho}_{t-1}^f \)). Thus, we can write these two terms as \( \text{LFP}_{\text{Cohort},t,el} \) and \( \text{LFP}_{\text{Cohort},t,unel} \), respectively.

In addition, since in the period prior to electrification both sets of women were unelectrified (and also not born), their pre-electrification/treatment LFP is symmetric and can be simply written as:

\[
\text{LFP}_{\text{Cohort},t-1,el} = \text{LFP}_{\text{Cohort},t-1,unel} = \text{LFP}_{\text{Cohort},t-1}.
\]

Thus we can write the aggregate change in female LFP due to electrification of Equation (2) as

\[
\Delta \text{Female LFP}_t = \frac{1}{2} \left[ (\text{LFP}_{\text{Cohort},t,el} - \text{LFP}_{\text{Cohort},t-1,el}) - (\text{LFP}_{\text{Cohort},t,unel} - \text{LFP}_{\text{Cohort},t-1,unel}) \right].
\]

We can go one step further, however, and note that the LFP for any group of women \( g \) can be written as the weighted sum of the LFP of the unskilled and skilled individuals in the group.\(^{66}\) Given that the proportion skilled is determined when individuals are young, it will remain constant across time periods within each group. We can plug this in the equation above to get

\[
\Delta \text{Female LFP}_t = \frac{1}{2} \left[ \text{Prop.Skilled}_{\text{Cohort},el} \text{DD}_{\text{Cohort},el}^{\text{skill}} - \text{Prop.Skilled}_{\text{Cohort},unel} \text{DD}_{\text{Cohort},unel}^{\text{skill}} \right],
\]

where

\[
\text{DD}_{\text{Cohort},el}^{\text{skill}} = (\text{LFP}_{\text{Cohort},t,el,sk} - \text{LFP}_{\text{Cohort},t-1,el,sk}) - (\text{LFP}_{\text{Cohort},t,el,unsk} - \text{LFP}_{\text{Cohort},t-1,el,unsk})
\]

\[
\text{DD}_{\text{Cohort},unel}^{\text{skill}} = (\text{LFP}_{\text{Cohort},t,unel,sk} - \text{LFP}_{\text{Cohort},t-1,unel,sk}) - (\text{LFP}_{\text{Cohort},t,unel,unsk} - \text{LFP}_{\text{Cohort},t-1,unel,unsk})
\]

\[
\text{DD}_{\text{Cohort},unsk} = (\text{LFP}_{\text{Cohort},t,el,unsk} - \text{LFP}_{\text{Cohort},t-1,el,unsk}) - (\text{LFP}_{\text{Cohort},t,unel,unsk} - \text{LFP}_{\text{Cohort},t-1,unel,unsk}).
\]

Notice that the two \( \text{DD}_{\text{skill}} \) terms are weighted by the proportion of skilled women in each group, since the total aggregate response of female LFP depends on how many women of

\(^{66}\text{Namely, we have } \text{LFP}^g = \text{Prop.Skilled}^g \times \text{LFP}_{\text{skilled},g} + (1 - \text{Prop.Skilled}^g) \times \text{LFP}_{\text{unskilled},g} = \text{Prop.Skilled}^g (\text{LFP}_{\text{skilled},g} - \text{LFP}_{\text{unskilled},g}) + \text{LFP}_{\text{unskilled},g}.\)
each type we have. This relates to the second force driving the change in female LFP from electrification described in the text, which relates to the change in \( \rho^f \) after electrification. As such, we can decompose the proportion of women skilled before electrification as the proportion of women skilled after electrification minus the change in this proportion \( (Prop.Skilled_{Coh_{t,unel}} = Prop.Skilled_{Coh_{t,el}} - \Delta Prop.Skilled_{Coh_{t}}) \) and rearrange to get:

\[
\Delta \text{Female LFP}_t = \frac{1}{2} Prop.Skilled_{Coh_{t,el}} [DD_{Coh_{t,el}} - DD_{Coh_{t,unel}}] \\
+ \frac{1}{2} [\Delta Prop.Skilled_{Coh_{t}} DD_{Coh_{t,unel}} + DD_{Coh_{t,unsk}}].
\]

Notice that the first term in brackets corresponds to the DDD of my empirical section, which estimates the relative rise in female LFP for skilled women living in counties with a larger increase in electrical capacity in the 1910s.

C Appendix: Quantitative Model

C.1 Aggregation and Equilibrium

C.1.1 Human Capital

Unskilled and skilled labor are employed to produce skilled and unskilled goods. The market for labor clears when

\[
L_{u,t}^D = L_{u,t}
\]

\[
L_{s,t}^D = L_{s,t},
\]

where \( L_{u,t}^D \) and \( L_{s,t}^D \) denote the effective unskilled and skilled labor used for the production of consumption goods, respectively, and \( L_{u,t} \) and \( L_{s,t} \) are the total amounts of effective unskilled and skilled labor in the economy, respectively.

\[
L_{u,t} = \sum_{j=1}^J \int_{i:age=j>1} 1_{s_i^m=0} n_{t,j,i}^m + 1_{s_i^f=0} \mu_u n_{t,j,i}^f \, di + \int_{i:age=1} n_{t,j,i}^s \, di
\]

\[
L_{s,t} = \sum_{j=2}^J \int_{i:age=j} 1_{s_i^m=1} n_{t,j,i}^m + 1_{s_i^f=1} \mu_s n_{t,j,i}^f \, di
\]
C.1.2 Output

Output is used for consumption and to produce electricity. The market for output clears when

\[ Y_t = X_t + C_t, \]

where \( X_t \) denotes the inputs in electricity production and \( C_t \) denotes total market consumption in the economy:

\[ C_t = \sum_{j=2}^{J} \int_{\text{age}=j} c_{y,t,j,i} \, di. \]

D Appendix: Calibration

This section includes the values and details for the calibration described in Section 4.2.

D.1 Calibration of \( \zeta \)

\( \zeta \) represents the share of electricity in skilled production. I calibrate this value to match the share of energy expenditures in manufacturing in 1900, taken from Haines and ICPSR (2010). Specifically, I construct the share of energy expenditures in manufacturing by adding the cost of fuel, power, and heat across all counties and dividing this by the total value of manufacturing output. Although the skilled sector does not map directly onto manufacturing, I use information from this sector to calibrate the share of electricity in skilled production, because manufacturing is one of the most energy-intensive sectors in the economy and there is little information about the share of energy in skilled labor or GDP historically. Thus, I set

\[ \zeta = 0.0166. \]

D.2 Calibration of \( \mu_u \) and \( \mu_s \)

I calibrate the efficiency endowments of unskilled and skilled women to match the ratio of LIDO scores of unskilled and skilled men and women, respectively, in 1900. The LIDO occupational score approach, proposed by Saavedra and Twinam (2020), adjusts occupational scores by race, sex, age, industry, and geography and reduces the attenuation bias in gender
earnings gaps. This attenuation bias emerges when constructing gender earnings gaps using the occupational score only, because as highlighted by Saavedra and Twinam (2020), this measure “ignores any variation due to individual characteristics such as race, gender, and age, or individual circumstances, such as industry of employment and geographic location.”

Given that educational attainment variables are not available in the 1900 census, I consider unskilled labor to correspond to the following occupations: farmers, operatives, service workers (in and outside private households), farm laborers, and laborers. Skilled labor, on the other hand, corresponds to the following occupations: professional and technical, managers, officials and proprietors, clerical and kindred, sales workers, and craftsmen.

First, I calibrate the efficiency endowment of unskilled women \( \mu_u \) to match the ratio of LIDO scores of unskilled men and women in 1900. The efficiency wage of unskilled men and women in a given period \( t \) is given, respectively, by

\[
W_u^{m,t} = w_{u,t} \\
W_u^{f,t} = \mu_u w_{u,t}.
\]

Thus, we can rearrange to get

\[
\mu_u = \frac{W_u^{f,t}}{W_u^{m,t}}.
\]

I thus calibrate \( \mu_u \) using

\[
\mu_u = \frac{\text{Avg. LIDO Score of Unskilled Women}^{data}}{\text{Avg. LIDO Score of Unskilled Men}^{data}}.
\]

I calibrate \( \mu_s \) using an analogous procedure to match the ratio of LIDO scores of skilled men and women in 1900:

\[
\mu_s = \frac{\text{Avg. LIDO Score of Skilled Women}^{data}}{\text{Avg. LIDO Score of Skilled Men}^{data}}.
\]

The authors also highlight that because the occupational score is based on 1950 data, “it fails to reflect changes in occupational earnings rankings or changes in how individual characteristics affect within-occupation earnings over time.” Given that there is no earnings data available in the census prior to 1950, it is much more difficult to address this problem.
D.3 Calibration of $A_s$

I calibrate the productivity of skilled production using the ratio between unskilled and skilled men’s LIDO occupational scores in 1900. To do this, I first solve for skilled wages by considering the problem of electric firms along with that of skilled firms. Then, I solve for unskilled wages by considering the problem of unskilled firms along with that of the final goods firm.

**Price of electricity**

First note that from the problem of electric firms, the zero profit condition implies that

$$p^E_t = \frac{1}{A_{E,t}}. \quad (6)$$

**Skilled wages**

Note that since labor is paid its marginal product,

$$w_{s,t} = p_{s,t} A_{s,t} \left[ \zeta E_t^{\gamma-1} + (1 - \zeta) L_{s,t}^{\gamma-1} \right]^{1/(\gamma-1)} (1 - \zeta) L_{s,t}^{-\gamma},$$

where $p_{s,t}$ is the price of skilled goods in period $t$. Further, because skilled firms purchase electricity, the price of this must be equal to its marginal product:

$$p^E_t = p_{s,t} A_{s,t} \left[ \zeta E_t^{\gamma-1} + (1 - \zeta) L_{s,t}^{\gamma-1} \right]^{1/(\gamma-1)} \zeta E_t^{s-1}. \quad (7)$$

Combining these equations and reorganizing,

$$E_t^s = \left( \frac{\zeta w_{s,t}}{(1 - \zeta)p^E_t} \right)^\gamma L_{s,t}. \quad (7)$$

Plugging this in the expression for $w_s$ and reorganizing,

$$w_{s,t} = p_{s,t} A_{s,t} \left[ \zeta \left( \frac{\zeta w_{s,t}}{(1 - \zeta)p^E_t} \right)^{\gamma-1} + (1 - \zeta) \right]^{1/(\gamma-1)} (1 - \zeta). \quad (7)$$

Notice moreover that we can plug the expression we obtained for $E$ into the production function for skilled goods to get
\[ Y_{s,t} = A_{s,t} \left[ \zeta \left( \frac{\zeta w_{s,t}}{p_t^E (1 - \zeta)} \right)^{\gamma - 1} + (1 - \zeta) \right] ^{\frac{\gamma}{\gamma - 1}} L_{s,t}. \]

We can then plug this, in addition to the expression for \( E_t \), into the zero-profit condition \( p_{s,t} Y_{s,t} - p_t^E E_t - w_{s,t} L_{s,t} = 0 \) to get

\[ p_{s,t} A_{s,t} \left[ \zeta \left( \frac{\zeta w_{s,t}}{p_t^E (1 - \zeta)} \right)^{\gamma - 1} + (1 - \zeta) \right] ^{\frac{\gamma}{\gamma - 1}} - p_t^E \left( \frac{\zeta w_{s,t}}{p_t^E (1 - \zeta)} \right)^{\gamma} - w_{s,t} = 0. \quad (8) \]

Equation (7) and Equation (8) jointly characterize \( w_{s,t} \) and \( p_{s,t} \), given that we know the price of electricity via Equation (6).

**Unskilled wages**

Notice that by the zero profit condition, unskilled wages are given by

\[ w_{u,t} = p_{u,t} A_{u,t}. \]

\( A_u \) is normalized to one. Moreover, we can solve for \( p_{u,t} \) using the conditions obtained from the problem of final firms. In particular, notice that because the price of skilled and skilled goods must equal their marginal product, we get:

\[ p_{u,t} = \left[ \lambda Y_{u,t}^{\frac{n-1}{\eta}} + (1 - \lambda) Y_{s,t}^{\frac{n-1}{\eta}} \right] ^{\frac{1}{\eta - 1}} \lambda Y_{u,t}^{\frac{-1}{\eta}} Y_{s,t}^{\frac{-1}{\eta}} \]

\[ p_{s,t} = \left[ \lambda Y_{u,t}^{\frac{n-1}{\eta}} + (1 - \lambda) Y_{s,t}^{\frac{n-1}{\eta}} \right] ^{\frac{1}{\eta - 1}} (1 - \lambda) Y_{s,t}^{\frac{-1}{\eta}} . \]

If we combine these and rearrange, we get:

\[ Y_{u,t} = \left( \frac{\lambda p_{s,t}}{(1 - \lambda)p_{u,t}} \right)^{\eta} Y_{s,t}. \]

We can then plug this back into the FOC for skilled labor and rearrange to get
\[
p_{u,t} = \left( \frac{(p_{s,t}^{\eta-1} - (1 - \lambda))}{\lambda} \right)^{\frac{1}{1-\eta}} \left( \frac{\lambda p_{s,t}}{1 - \lambda} \right).
\]

We can then plug in \( p_{s,t} \) here, found from jointly solving Equation (7) and Equation (8) to find \( p_{u,t} \) and therefore \( w_{u,t} \).

I choose \( A_s \) so that the ratio of unskilled and skilled wages in 1900 predicted by the model matches the ratio of unskilled to skilled men’s LIDO occupational scores from the 1900 census. I assume the old electricity technology was in place during this time period, yielding low electric productivity \( A_{E,L} \) and a high price for electricity. I can then solve for the unskilled and skilled wages in 1900 using the equations above.

Thus, I choose \( A_s \) such that

\[
\frac{w_{s,1900}}{w_{u,1900}} = \frac{\text{Avg. LIDO Score of Skilled Men}^{\text{data}}}{\text{Avg. LIDO Score of Unskilled Men}^{\text{data}}}. 
\]

\section*{D.4 Calibration of \( A_{E,H} \)}

I choose the productivity of electricity production after electrification, \( A_{E,H} \), to match the ratio of prices of electricity produced with private generators relative to central generating stations.

Notice that from the problem of electric firms, the zero profit condition implies that

\[
p^E_t = \frac{1}{A_{E,t}}. 
\]

Thus, I choose \( A_{E,H} \), which depends on \( A_{E,L} \), such that

\[
\frac{A_{E,H}}{A_{E,L}} = \frac{p_{E,L}^{\text{data}}}{p_{E,H}}. 
\]

\( A_{E,L} \), in turn, is chosen using the method of moments.

\section*{D.5 Calibration of \( \tau^f \) and \( \tau^m \)}

I choose the time availability of young women and men, \( \tau^f \) and \( \tau^m \), respectively, to match the ratio of home production between young and old women in 1900, and the ratio of work hours between young and old men in 1900, respectively.
Time availability for women $\tau^f$

First note that the time constraint of young women is given by

$$h^d_i = \tau^f(1 - \rho_i s^d_i).$$

Therefore, $\tau^f$ represents the time young women who are not in school spend in home production: $\tau^f = h^d(\text{unskilled})$.

I choose $\tau^f$ to match the ratio of home production hours between these young unskilled women and unskilled women of age 55–64 in 1900.\(^{68}\) Thus, I choose $\tau^f$ so that

$$\frac{\tau^f}{h^f(J, \text{unskilled})} = \frac{h^d(\text{unskilled})^{data}}{h^f(J, \text{unskilled})^{data}}.$$

Ramey (2009) finds that unskilled older women spent approximately 50 hours a week on home production,\(^{69}\), and that the home production time for women 14–17 is 21 hours per week. The latter, however, encompasses both women who are going to school and those who are not. In particular, we have that

$$21 = h^d(\text{skilled}) \times \text{Prop. of young women who go to school}$$
$$+ h^d(\text{unskilled}) \times (1 - \text{Prop. of young women who go to school}).$$

Ramey (2009), building on several time-use studies, finds that during the school year students spend approximately five hours per week in home production, and that this time has been roughly constant throughout the 20th century. In addition, the census of 1900 suggests that 49.2% of women 14–17 years old were enrolled in school. With these estimates, we can back out $h^d(\text{unskilled})$ from the equation above.

Time availability for men $\tau^m$

First note that the time constraint of young men is given by

$$n^s_i = \tau^m(1 - \rho_i s^s_i).$$

\(^{68}\)I choose these older women because they are well past their childcare years and thus more comparable in terms of home production time to young unmarried women.

\(^{69}\)Specifically, Ramey finds that a woman with no children and at least some high school spent 44 hours per week on home production, and that for a woman who did not attend high school, this time is 6 hours higher.
Therefore, \( \tau^m \) represents the time young men who are not in school spend at work: 

\[
\tau^m = n^m(\text{unskilled}).
\]

I choose \( \tau^m \) to match the ratio of work hours between these young unskilled men and unskilled men of age 55–64 in 1900.\(^7\) Thus, I choose \( \tau^m \) so that

\[
\frac{\tau^m}{n^m(J, \text{unskilled})} = \frac{n^*(\text{unskilled})^{\text{data}}}{n^m(J, \text{unskilled})^{\text{data}}}. 
\]

Ramey and Francis (2009) find that older men spent 46.1 hours a week at work. Estimates by skill level are not provided, but because men overwhelmingly used their time for work regardless of education status, I use this figure as an estimate for older unskilled men. In addition, the work time for men 14–17 estimated by Ramey and Francis (2009) is 29.1 hours per week. This however encompasses both men who are going to school and those who are not. In particular, we have that

\[
29.1 = n^*(\text{skilled}) \times \text{Prop. of young men who go to school} + n^*(\text{unskilled}) \times (1-\text{Prop. of young men who go to school}).
\]

Ramey and Francis (2009) find that in 1900 boys of ages 10–13 spent 7.7 hours per week working. Given that these boys are much more likely to be enrolled in school, this figure provides an estimate for \( n^*(\text{skilled}) \). In addition, the census of 1900 suggests that 45.7% of men 14–17 years old were enrolled in school. With these estimates, we can back out \( n^*(\text{unskilled}) \) from the equation above.

### D.6 Model and Data Moments targeted by the Method of Moments

<table>
<thead>
<tr>
<th>Moment</th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female LFP in 1890 (16+)</td>
<td>0.19</td>
<td>0.18</td>
</tr>
<tr>
<td>Female home production hours in 1900 (25–54)</td>
<td>0.45</td>
<td>0.45</td>
</tr>
<tr>
<td>Female work hours in 1900 (25–54)</td>
<td>0.07</td>
<td>0.04</td>
</tr>
<tr>
<td>Proportion of skilled women in 1900 (20–64, high school or more) †</td>
<td>0.15</td>
<td>0.18</td>
</tr>
<tr>
<td>( DDD ) Coefficient of increase in LFP for women 15–20 due to electrification in 1920</td>
<td>0.08</td>
<td>0.07</td>
</tr>
</tbody>
</table>

Notes: The \( DDD \) of the increase in LFP for young women due to electrification in 1920 follows from results in the empirical analysis. See Section 5 for details. † The first census to include information on educational

---

\(^7\)I choose these older men to match the analysis done for \( \tau^f \). In practice, male work hours changed little from ages 25 to 64 in 1900.
attainment was that of 1940. I compute the educational attainment in 1900 using data from surviving cohorts in 1940 who were between 20 and 64 in 1900.

In my model, young individuals are still at home and thus abstract from many key decisions. As such, I construct my model variables of interest based on information for individuals ages 2 to \( J \), capturing ages 20 to 64. To match this, I use data moments for similar age groups whenever available. The data on female LFP in 1890 comes from Goldin (1977), who constructs these statistics for women ages 16 and above and carefully accounts for methodological and other changes in the labor force participation definition across time. The data on work and home hours in 1900 corresponds to information from individuals ages 25–54, as estimated by Ramey and Francis (2009). I construct the proportion of women with completed high school in 1900 by selecting individuals who were between 25 and 64 years of age at this time from the 1940 census.

In my empirical analysis, the \( DDD \) coefficient for young women stems from comparing outcomes across treatment and skill types in 1910 and 1920 for individuals who were 15–20 in 1910 and who were thus young upon electrification occurring in the 1910s. In order to focus on the effect of electrification efforts occurring during the 1910s on young women in the model, I exploit the fact that the model period is only 5 years (whereas it is 10 years in the data) and use 1915 as my baseline period. In particular, in my model the \( DDD \) coefficient stems from comparing outcomes across treatment and skill types in 1915 and 1920 for individuals who were 15–20 in 1915.
E Appendix: Model Simulations

Figure E.1: Average Time use and Education Outcomes of Women

(a) Time spent working

(b) Female LFP

(c) Time spent in housework

(d) Time spent in leisure

(e) Proportion skilled
Figure E.2: Average Time use and Education Outcomes of Women by Cohort

(a) Time spent working

(b) Female LFP

(c) Time spent in housework

(d) Time spent in leisure

(e) Proportion skilled

Notes: Ages 2 to 6 plotted for every cohort.
Figure E.3: Average Time use and Education Outcomes of Men

(a) Time spent working

(b) Male LFP

(c) Time spent in housework

(d) Time spent in leisure

(e) Proportion skilled
Sensitivity of Model Results to Changes in Key Parameters

In this section, I examine the role of different parameters in shaping the aggregate rise in female LFP stemming from my channel. Motivated by the discussion of Equation (2) in the benchmark model, and specifically the forces shaping the aggregate rise in female LFP due to the progressive electrification of production processes highlighted there, I focus on the following parameters: (1) the productivity of electricity production after electrification $A_{E,H}$, (2) the elasticity of substitution between electricity and labor in skilled production $\gamma$, (3) female productivity in skilled labor $\mu_s$, and (4) the second shape parameter of the schooling cost distribution $\rho_H$.

In order to examine the sensitivity of my results to these parameters, I re-estimate the model after subsequently changing the value of each of these parameters to be 25%, 50%, 150%, and 175% of the baseline value. The exception to this is $\mu_s$, the value for which I change to be 75%, 90%, 110%, and 125% of the baseline value, since $\mu_s$ must be less than one to capture gender wage gaps favoring male labor. I keep the rest of the parameter values fixed at the baseline calibration and examine how the evolution of female LFP and female home production hours predicted by my mechanism changes in each of these cases.

I plot the results for each of the parameters of interest in Figure F.1. I find that larger values of the productivity of electricity production after electrification $A_{E,H}$ increase the rise of female LFP in my channel, and thus raise the fraction of the rise in female LFP in the 1900–1940 period that my channel can explain. This increase stems from the fact that $A_{E,H}$ determines the size of the decline in the price of electricity that occurs after electrification, and thus has a positive relationship with the increase in the demand for electricity in skilled firms. Due to this, and given that the returns to work increase with $A_{E,H}$, the decline in female home production hours also increases with $A_{E,H}$. Interestingly, when $A_{E,H}$ is 25% of its baseline value, female LFP does not increase, though female home production hours do decline slightly, indicating that in this case adjustments to female labor occur solely along the intensive margin. Similarly, I find that lower values of the elasticity of substitution between electricity and labor in skilled production $\gamma$ increase both the rise of female LFP and the decline in female home production hours in my channel. This stems from the fact that lower values of $\gamma$ increase the complementarity between electricity and labor in the skilled sector, and thus boost the increase in the demand for skilled labor and consequently skilled wages that follow from the rise in the demand for electricity due to electrification.

In addition, I find that in general, larger values of female productivity in skilled labor $\mu_s$
increase both the rise of female LFP and the decline in female home production hours in my channel. This follows from the fact that \( \mu_s \) captures the gender wage gap in skilled labor, and thus larger values of \( \mu_s \) translate into a larger fraction of the increase in skilled wages being reflected in women’s compensations. However, two exceptions are noteworthy. First, when \( \mu_s \) is 150% of its baseline value, female LFP increases less than in the other cases, due to the fact that in this case female labor is strongly favored even prior to electrification, and thus female LFP rates are high to begin with. Second, when \( \mu_s \) is 25% of its baseline value, no increase in female LFP appears in the graph, because female LFP remains at zero before and after electrification given that female labor is heavily disfavored. However, in both of these cases female home production hours decline, indicating adjustments along the intensive margin of work in the first case and an increase in the amount of electricity purchased in the household in the second case.

Finally, I find that in general, larger values of the second shape parameter of the schooling cost distribution \( \rho_H \) increase both the rise of female LFP and the decline in female home production hours in my channel. \( \rho_H \) dictates the density of the schooling cost distribution, and thus governs the response of female employment to the rise in the skilled wage by determining the number of women whose schooling cost is low enough that they will be encouraged to gain skills and join the workforce in response to electrification. Larger values of \( \rho_H \) imply a larger mass accumulates at lower values of the schooling distribution and thus raises the response of female labor to electrification. Specifically, the fraction of this rise my channel can explain increases to about 32% when \( \rho_H \) is 150% of its baseline value.
Figure F.1: Female LFP and Home Production Hours, Sensitivity to Parameters

**Sensitivity to \( A_{E,H} \)**

(a) Female LFP  
(b) Female Home Prod. Hours

**Sensitivity to \( \gamma \)**

(c) Female LFP  
(d) Female Home Prod. Hours

**Sensitivity to \( \mu_s \)**

(e) Female LFP  
(f) Female Home Prod. Hours

**Sensitivity to \( \rho_H \)**

(g) Female LFP  
(h) Female Home Prod. Hours

Data Source: Goldin (1977) and Ramey and Francis (2009). Normalized 1890=1, and 1900=1.
### G Appendix: The Joint Effect of the Human Capital and Home Production Channels

Table G.1: Moments in the Joint Model and Data (targeted by the method of moments)

<table>
<thead>
<tr>
<th>Moment</th>
<th>Data</th>
<th>Joint Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female LFP in 1890 (16+)</td>
<td>0.19</td>
<td>0.18</td>
</tr>
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<td>0.45</td>
</tr>
<tr>
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<td>0.18</td>
</tr>
<tr>
<td><em>DDD</em> Coefficient of increase in LFP for women 15–20 due to electrification in 1920</td>
<td>0.08</td>
<td>0.07</td>
</tr>
</tbody>
</table>

Notes: The *DDD* of the increase in LFP for young women due to electrification in 1920 follows from results in the empirical analysis. See Section 5 for details. † The first census to include information on educational attainment was that of 1940. I compute the educational attainment in 1900 using data from surviving cohorts in 1940 who were between 20 and 64 in 1900.
Figure G.1: Average Time use and Education Outcomes of Women in Joint Model

(a) Time spent working

(b) Female LFP

(c) Time spent in housework

(d) Time spent in leisure

(e) Proportion skilled
H Appendix: The Home Production Channel in the Model

I now examine how the effects of electrification change in my model when electrification occurs only within the household (home production channel only).

Figure H.1: Female LFP and Home Production Hours, Channels

(a) Female LFP
(b) Female Home Production Hours

Data Source: Goldin (1977) and Ramey and Francis (2009). Normalized 1890=1, and 1900=1.

I present the effects of electrification on female LFP that follow from the home production channel in Panel (a) of Figure H.1, and contrast them to my channel and the data. I find that the home production channel can explain 2.22% of the rise in female LFP in the 1900–1940 period. This is substantially lower than reported by Greenwood et al. (2005), who find that their mechanism explains about half of the rise in female LFP. This discrepancy stems the introduction of human capital accumulation and investments in daughters by mothers in my model, which change the incomes and intra-household allocation of men and women. These two mechanisms imply that women’s labor decisions not only follow from household technology, but also change in response to women’s and husbands’ skill levels and daughters’ current and future prospects. In my model, women whose homes become electrified face additional competing responsibilities and choices that thwart their incentives to reduce their home production hours and enter the labor market compared to the model in Greenwood et al. (2005). For example, even without the electrification of production processes of my channel, women’s prospects in the labor market will be less promising if they are not skilled. In addition, women may not reduce home production hours even after electrification in order to further relieve daughters from their home duties.

These competing responsibilities and consequent slow increase in female LFP predicted by the home production channel in my model implies that home production hours also decline slowly relative to the data in this channel as evidenced in Panel (b) of Figure H.1. However, the
decline in female home production hours is actually quite large relative to the small increase in female LFP. Home production hours decline by 1.51% in this channel, while female LFP increases only by 2.48%. A back-of-the-envelope calculation implies that a 32% rise in female LFP, which is roughly the predicted rise in my channel, would correspond to a 19.5% decline in home production hours in the home production channel. This is more than 50% larger than the decline in home production hours observed in the data (13%).\footnote{Simulations of all the effects predicted by the model when only the home production channel operates are available upon request.}
I Appendix: Preferred Measure of Electrification

Figure I.1: Map of County-Level Intensity of Electrification Treatment in Alaska and Hawaii

Notes: Electricity-generation capacity within and 50 miles around each county.

Figure I.2: Transmission Technology Voltages and Stages

Source: Casazza (2004).
Table I.1: Correlation of Preferred Electrification Measure with Measures of Access to Electricity

<table>
<thead>
<tr>
<th></th>
<th>Prop. farms with power line within quarter mile</th>
<th>Prop. farm dwellings with electricity from power line</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1940 (1)</td>
<td>1930 (1)</td>
</tr>
<tr>
<td></td>
<td>1940 (2)</td>
<td>1930 (2)</td>
</tr>
<tr>
<td>∆Cap</td>
<td>0.205*** (0.013)</td>
<td>0.182*** (0.011)</td>
</tr>
<tr>
<td>Total 15+ pop.</td>
<td>0.000*** (0.000)</td>
<td>0.000*** (0.000)</td>
</tr>
<tr>
<td>Prop. urban</td>
<td>0.437*** (0.017)</td>
<td>0.252*** (0.009)</td>
</tr>
<tr>
<td>Prop. married</td>
<td>-0.076* (0.030)</td>
<td>-0.038* (0.017)</td>
</tr>
<tr>
<td>Prop. white</td>
<td>0.226 (0.783)</td>
<td>-8.702*** (0.731)</td>
</tr>
<tr>
<td>Avg. socioecon. index</td>
<td>0.002*** (0.001)</td>
<td>0.000 (0.000)</td>
</tr>
<tr>
<td>Prop. attending school</td>
<td>-0.007 (0.049)</td>
<td>-0.050 (0.031)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.371*** (0.006)</td>
<td>0.077 (0.783)</td>
</tr>
<tr>
<td>R²</td>
<td>0.081</td>
<td>0.334</td>
</tr>
<tr>
<td>Obs.</td>
<td>2930</td>
<td>2929</td>
</tr>
</tbody>
</table>

This regression is performed at the county level in 1930 and 1940, respectively, and follows this specification:

\[ Y_c = \alpha + \Delta Cap_c + Z_c + \epsilon_c. \]

\( Y_c \) denotes different measures of access to electricity in county \( c \), namely the proportion of farms with an electrical power line within a quarter mile and the proportion of farm dwellings with electricity coming from a power line. \( \Delta Cap_c \) corresponds to my preferred measured of electrification: Change in Generation Capacity (100s of megawatts) between 1911 and 1919. \( Z_c \) captures county-level controls in each year (proportion urban, proportion married, racial composition, total population, and socioeconomic index). Controls for the proportion of individuals of other races besides white omitted here due to length. Standard errors in parentheses. *\( p < 0.05 \), **\( p < 0.01 \), ***\( p < 0.001 \).
## J Appendix: Summary Statistics

### J.1 Summary Statistics in Panel and Repeated Cross-Section Data

#### Table J.1: Summary Statistics in Panel and Repeated Cross-Section Data in 1920

<table>
<thead>
<tr>
<th></th>
<th>Panel</th>
<th></th>
<th>Repeated XSec</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men</td>
<td>Women</td>
<td>Men</td>
<td>Women</td>
</tr>
<tr>
<td>Labor force participation</td>
<td>0.83</td>
<td>0.12</td>
<td>0.81</td>
<td>0.18</td>
</tr>
<tr>
<td>Prop. attending school</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Avg. years of required schooling</td>
<td>3.97</td>
<td>3.42</td>
<td>2.99</td>
<td>2.97</td>
</tr>
<tr>
<td>Prop. with 8+ years of req. sch.</td>
<td>0.12</td>
<td>0.08</td>
<td>0.06</td>
<td>0.06</td>
</tr>
<tr>
<td>Prop. married</td>
<td>0.77</td>
<td>0.84</td>
<td>0.75</td>
<td>0.79</td>
</tr>
<tr>
<td>Prop. urban</td>
<td>0.35</td>
<td>0.36</td>
<td>0.39</td>
<td>0.41</td>
</tr>
<tr>
<td>Avg. socioeconomic index</td>
<td>20.48</td>
<td>4.18</td>
<td>19.28</td>
<td>5.42</td>
</tr>
<tr>
<td>Prop. white</td>
<td>0.95</td>
<td>0.94</td>
<td>0.86</td>
<td>0.85</td>
</tr>
</tbody>
</table>

#### Table J.2: Summary Statistics in Panel and Repeated Cross-Section Data in 1930

<table>
<thead>
<tr>
<th></th>
<th>Panel</th>
<th></th>
<th>Repeated XSec</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men</td>
<td>Women</td>
<td>Men</td>
<td>Women</td>
</tr>
<tr>
<td>Labor force participation</td>
<td>0.86</td>
<td>0.15</td>
<td>0.84</td>
<td>0.19</td>
</tr>
<tr>
<td>Prop. attending school</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Avg. years of required schooling</td>
<td>3.97</td>
<td>3.42</td>
<td>2.99</td>
<td>3.01</td>
</tr>
<tr>
<td>Prop. with 8+ years of req. sch.</td>
<td>0.12</td>
<td>0.08</td>
<td>0.06</td>
<td>0.07</td>
</tr>
<tr>
<td>Prop. married</td>
<td>0.86</td>
<td>0.81</td>
<td>0.83</td>
<td>0.79</td>
</tr>
<tr>
<td>Prop. urban</td>
<td>0.38</td>
<td>0.41</td>
<td>0.42</td>
<td>0.45</td>
</tr>
<tr>
<td>Avg. socioeconomic index</td>
<td>23.57</td>
<td>5.05</td>
<td>22.04</td>
<td>5.50</td>
</tr>
<tr>
<td>Prop. white</td>
<td>0.95</td>
<td>0.95</td>
<td>0.87</td>
<td>0.86</td>
</tr>
</tbody>
</table>

#### Table J.3: Summary Statistics in Panel and Repeated Cross-Section Data in 1940

<table>
<thead>
<tr>
<th></th>
<th>Panel</th>
<th></th>
<th>Repeated XSec</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men</td>
<td>Women</td>
<td>Men</td>
<td>Women</td>
</tr>
<tr>
<td>Labor force participation</td>
<td>0.91</td>
<td>0.21</td>
<td>0.89</td>
<td>0.24</td>
</tr>
<tr>
<td>Prop. attending school</td>
<td>0.01</td>
<td>0.00</td>
<td>0.01</td>
<td>0.00</td>
</tr>
<tr>
<td>Avg. years of required schooling</td>
<td>3.97</td>
<td>3.42</td>
<td>3.11</td>
<td>3.12</td>
</tr>
<tr>
<td>Prop. with 8+ years of req. sch.</td>
<td>0.12</td>
<td>0.08</td>
<td>0.07</td>
<td>0.07</td>
</tr>
<tr>
<td>Avg. children born per woman</td>
<td>3.78</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prop. with comp. high school or more</td>
<td>0.17</td>
<td>0.20</td>
<td>0.17</td>
<td>0.21</td>
</tr>
<tr>
<td>Prop. married</td>
<td>0.85</td>
<td>0.70</td>
<td>0.82</td>
<td>0.71</td>
</tr>
<tr>
<td>Prop. urban</td>
<td>0.38</td>
<td>0.42</td>
<td>0.42</td>
<td>0.46</td>
</tr>
<tr>
<td>Avg. socioeconomic index</td>
<td>25.87</td>
<td>6.16</td>
<td>24.07</td>
<td>6.72</td>
</tr>
<tr>
<td>Prop. white</td>
<td>0.95</td>
<td>0.95</td>
<td>0.89</td>
<td>0.89</td>
</tr>
</tbody>
</table>

Notes: The sample for these tables consists of individuals who were 15–35 years of age in 1910, were born in the contiguous US, and who lived in areas that gained access to electrification in the 1910s in 1910.
### J.2 Summary Statistics in Treatment and Control Counties

Table J.4: Averages in Above- and Below- Median Treatment Intensity Counties and Previously Electrified Counties in 1910 (individuals 15–35 years of age)

<table>
<thead>
<tr>
<th></th>
<th>Treat. &lt; 50%</th>
<th>Treat. &gt; 50%</th>
<th>Elect. pre-1911</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prop. of employed men</td>
<td>0.80</td>
<td>0.77</td>
<td>0.73</td>
</tr>
<tr>
<td>Prop. of employed women</td>
<td>0.20</td>
<td>0.22</td>
<td>0.31</td>
</tr>
<tr>
<td>Prop. of 15–20 men attending school</td>
<td>0.46</td>
<td>0.42</td>
<td>0.33</td>
</tr>
<tr>
<td>Prop. of 15–20 women attending school</td>
<td>0.47</td>
<td>0.44</td>
<td>0.33</td>
</tr>
<tr>
<td>Avg. Years of Required Schooling</td>
<td>2.30</td>
<td>3.70</td>
<td>4.84</td>
</tr>
<tr>
<td>Prop. with 8+ years of req. sch.</td>
<td>0.08</td>
<td>0.07</td>
<td>0.04</td>
</tr>
<tr>
<td>Children born per woman</td>
<td>1.96</td>
<td>1.68</td>
<td>1.56</td>
</tr>
<tr>
<td>Prop. urban</td>
<td>0.22</td>
<td>0.43</td>
<td>0.77</td>
</tr>
<tr>
<td>Socioeconomic index</td>
<td>10.15</td>
<td>11.61</td>
<td>13.84</td>
</tr>
<tr>
<td>Prop. married</td>
<td>0.47</td>
<td>0.45</td>
<td>0.42</td>
</tr>
<tr>
<td>Prop. white</td>
<td>0.80</td>
<td>0.89</td>
<td>0.96</td>
</tr>
<tr>
<td>Number of counties</td>
<td>1429</td>
<td>1226</td>
<td>287</td>
</tr>
<tr>
<td>Share of population</td>
<td>0.25</td>
<td>0.38</td>
<td>0.37</td>
</tr>
</tbody>
</table>

Table J.5: Averages in Above- and Below- Median Treatment Intensity Counties and Previously Electrified Counties in 1910 (individuals 15–35 years of age)

<table>
<thead>
<tr>
<th></th>
<th>Treat. &lt; 50%</th>
<th>Treat. &gt; 50%</th>
<th>Elect. pre-1911</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prop. of employed men</td>
<td>0.72</td>
<td>0.69</td>
<td>0.68</td>
</tr>
<tr>
<td>Prop. of employed women</td>
<td>0.20</td>
<td>0.22</td>
<td>0.29</td>
</tr>
<tr>
<td>Prop. of 15–20 men attending school</td>
<td>0.37</td>
<td>0.35</td>
<td>0.30</td>
</tr>
<tr>
<td>Prop. of 15–20 women attending school</td>
<td>0.40</td>
<td>0.37</td>
<td>0.29</td>
</tr>
<tr>
<td>Prop. urban</td>
<td>0.25</td>
<td>0.48</td>
<td>0.81</td>
</tr>
<tr>
<td>Socioeconomic index</td>
<td>9.69</td>
<td>11.59</td>
<td>14.74</td>
</tr>
<tr>
<td>Prop. married</td>
<td>0.49</td>
<td>0.48</td>
<td>0.47</td>
</tr>
<tr>
<td>Prop. white</td>
<td>0.80</td>
<td>0.89</td>
<td>0.95</td>
</tr>
<tr>
<td>Number of counties</td>
<td>1429</td>
<td>1226</td>
<td>287</td>
</tr>
<tr>
<td>Share of population</td>
<td>0.25</td>
<td>0.37</td>
<td>0.38</td>
</tr>
</tbody>
</table>

\[^{71}\] I do not include average years of required schooling and proportion with 8 or more years of schooling for other time periods aside from 1910, given that these are built only for cohorts born between 1875 and 1912.
Table J.6: Averages in Above- and Below-Median Treatment Intensity Counties and Previously Electrified Counties in 1910 (individuals 15–35 years of age)

<table>
<thead>
<tr>
<th></th>
<th>Treat. &lt; 50%</th>
<th>Treat. &gt; 50%</th>
<th>Elect. pre-1911</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prop. of employed men</td>
<td>0.72</td>
<td>0.68</td>
<td>0.66</td>
</tr>
<tr>
<td>Prop. of employed women</td>
<td>0.22</td>
<td>0.25</td>
<td>0.32</td>
</tr>
<tr>
<td>Prop. of 15–20 men attending school</td>
<td>0.42</td>
<td>0.45</td>
<td>0.45</td>
</tr>
<tr>
<td>Prop. of 15–20 women attending school</td>
<td>0.44</td>
<td>0.45</td>
<td>0.41</td>
</tr>
<tr>
<td>Prop. urban</td>
<td>0.31</td>
<td>0.52</td>
<td>0.82</td>
</tr>
<tr>
<td>Socioeconomic index</td>
<td>10.54</td>
<td>12.54</td>
<td>15.70</td>
</tr>
<tr>
<td>Prop. married</td>
<td>0.49</td>
<td>0.48</td>
<td>0.46</td>
</tr>
<tr>
<td>Prop. white</td>
<td>0.81</td>
<td>0.89</td>
<td>0.94</td>
</tr>
<tr>
<td>Number of counties</td>
<td>1429</td>
<td>1226</td>
<td>287</td>
</tr>
<tr>
<td>Share of population</td>
<td>0.24</td>
<td>0.35</td>
<td>0.41</td>
</tr>
</tbody>
</table>

Table J.7: Averages in Above- and Below-Median Treatment Intensity Counties and Previously Electrified Counties in 1910 (individuals 15–35 years of age)

<table>
<thead>
<tr>
<th></th>
<th>Treat. &lt; 50%</th>
<th>Treat. &gt; 50%</th>
<th>Elect. pre-1911</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prop. of employed men</td>
<td>0.79</td>
<td>0.78</td>
<td>0.78</td>
</tr>
<tr>
<td>Prop. of employed women</td>
<td>0.31</td>
<td>0.34</td>
<td>0.42</td>
</tr>
<tr>
<td>Prop. of 15–20 men attending school</td>
<td>0.45</td>
<td>0.49</td>
<td>0.54</td>
</tr>
<tr>
<td>Prop. of 15–20 women attending school</td>
<td>0.45</td>
<td>0.48</td>
<td>0.50</td>
</tr>
<tr>
<td>Children born per woman</td>
<td>1.55</td>
<td>1.41</td>
<td>1.20</td>
</tr>
<tr>
<td>Prop. urban</td>
<td>0.34</td>
<td>0.51</td>
<td>0.76</td>
</tr>
<tr>
<td>Socioeconomic index</td>
<td>12.48</td>
<td>14.58</td>
<td>17.85</td>
</tr>
<tr>
<td>Prop. married</td>
<td>0.51</td>
<td>0.49</td>
<td>0.45</td>
</tr>
<tr>
<td>Prop. white</td>
<td>0.82</td>
<td>0.90</td>
<td>0.94</td>
</tr>
<tr>
<td>Prop. men with comp. high school or more</td>
<td>0.23</td>
<td>0.30</td>
<td>0.34</td>
</tr>
<tr>
<td>Prop. women with comp. high school or more</td>
<td>0.29</td>
<td>0.36</td>
<td>0.37</td>
</tr>
<tr>
<td>Number of counties</td>
<td>1429</td>
<td>1224</td>
<td>287</td>
</tr>
<tr>
<td>Share of population</td>
<td>0.24</td>
<td>0.36</td>
<td>0.40</td>
</tr>
</tbody>
</table>
K  Appendix: Strategy and Identification

Figure K.1: Map of County-Level Intensity of Electrification Treatment and County Population in the United States

Notes: Electricity-generation capacity within and 50 miles around each county. Medium counties have a 15+ population in 1910 between 15,000 and 30,000 (approx. 70th percentile to 90th percentile), and large counties have a 15+ population in 1910 above 33,000.
Figure K.2: Pre-treatment Trends Test: Effects of Electrification on Women’s and Men’s Employment in 1900

Notes: The coefficients plotted correspond to $\beta_t$ in Equation (5), estimated for each cohort separately. These coefficients capture the difference-in-differences effects for the pre-treatment period (1900, with baseline 1910). The analyses encompass women who were 21–25, 26–30, and 31–35 years of age in 1910, respectively, and were born in the contiguous US. 95% confidence intervals built from standard errors clustered at the 100-mile Radius x Year level are plotted.

Figure K.3: Women’s and Men’s Employment in 1940 by Cohort
Appendix: Robustness of Main Empirical Exercise

I now repeat the main analysis, considering (1) not proxying for educational level; (2) following the approach of Clay et al. (2021) more closely, and using several binary variables denoting different levels of years of required attendance; (3) inclusion of different fixed effects and controls; (4) contemporaneous controls instead of baseline level controls; (5) clustering at the 100-mile radius and county-by-year levels; (6) excluding counties in the South; (7) excluding counties in the West; and (8) considering an alternate treatment definition based on the proximity to large electricity-generating plants. I also provide a discussion of the relationship between World War I and my results.

L.1 Results without Proxying for Educational Attainment

In my baseline analysis, I proxy for educational attainment using required years of schooling. This approach addresses the endogeneity of educational decisions to electrification, but has a few drawbacks. First, the number of cohorts we can consider is limited, since the oldest cohorts with information on required years of schooling in the Clay et al. (2021) data were born in 1875 and were thus 35 years of age in my baseline period of 1910. Second, given that required schooling is constructed at the cohort by state of birth level, using this approach precludes individuals who were born outside the United States, or in Alaska and Hawaii from being considered in the analysis. Finally, this framework does not compare skilled and unskilled individuals directly, but rather compares individuals who were more likely to become skilled (since they had higher levels of required schooling) to those less likely to become skilled.

In this section, I present and discuss the results on the heterogeneous effects of electrification on the employment status of women and men of different cohorts by measured educational attainment levels. This allows for the inclusion of older cohorts, individuals born abroad and in excluded territories, and several educational attainment levels. I focus on the same four cohorts as before (15–20, 21–25, 26–30, and 31–35 in 1910), in addition to five other cohorts comprising older women (36–40, 41–45, 46–50, 51–56, and 56 or older in 1910).

I estimate the following regression for each cohort:

\[
Employed_{i,h,c,t} = \alpha + \beta_t \Delta Cap_c \times Post_t + \beta^\text{Skill}_{t} \Delta Cap_c \times Educ_{t,i,h,c} \\
+ \beta^\text{Skill}_{t} Post_t \times Educ_{t,i,h,c} + \beta^\text{Cap\timesSkill}_{t} \Delta Cap_c \times Post_t \times Educ_{t,i,h,c} \tag{9}
\]

\[
+ \alpha_i + \alpha_t + \alpha_{s,t} + \alpha_c + \beta_{X,t} X_{i,h,c,1910} \times Post_t + \beta_{Z,t} Z_{h,c,1910} \times Post_t + \epsilon_{i,h,c,t}.
\]

This follows the notation of Equation (4), but differs by allowing for the inclusion of different
levels of measured educational attainment, $Educ_{l,h,c}$, directly. $Educ_{l,h,c}$ is a dummy variable capturing whether the individual’s education level is equal to $l$, where $l$ corresponds to middle school, some high school, completed high school, or some or more post-secondary. Educational level is measured using data from 1940 on the highest education level attained (the first census year when educational attainment was collected). Similar to the main results, I cluster these results at the 100-mile radius-by-year level following the method proposed by Colella et al. (2019).

I present the results of this regression for all cohorts of women considered in Figure Q.1. I find that young women with higher levels of schooling experienced a significantly higher increase in employment after electrification, relative to their counterparts with lower levels of schooling, for all years considered. The increase in employment among young women with some high school or more is 4–10 percentage points higher on average between 1920 and 1940 (relative to 1910) than that of uneducated young women, in areas with an increase in generating capacity of 100 megawatts in the 1910s. These estimates are similar in magnitude to that of the baseline results. In addition, I find that the size of this effect increases with educational attainment and is particularly marked among young women with post-secondary education. Consistent with the main results, these effects are largely absent for older women.

I present the results for men in Figure Q.2. These results match the baseline results along two important dimensions. First, the boost fostered by education is considerably smaller for young men compared to young women, particularly within post-secondary education. This suggests that the shift in the female work environment triggered by electricity focused strongly in highly skilled jobs, where women face a particular advantage. Second, for men the heterogeneous effects by schooling are present among cohorts up to 30 years of age in 1910. This contrasts with the results for women, and indicates that for these it is more critical to be young and thus able to coordinate key decisions to take advantage of the market returns of electrification.

L.2 Results with Alternate Measures of Required Schooling

Given that in the model the skill decision is binary, in the baseline empirical analysis I focus on a binary level of required school attendance, capturing 8 years or more of required schooling. In this section I follow the approach of Clay et al. (2021) more closely, and use several different levels of years of required attendance, namely 1 to 5, 6, 7, and 8 or more.

I estimate the following regression for each cohort:
\[
\text{Employed}_{i,h,c,t} = \alpha + \beta_t \Delta Cap_c \times Post_t + \beta_{t}^{\text{Skill}} \Delta Cap_c \times ReqSch_{i,h,c} \\
+ \beta_{t}^{\text{CapxSkill}} Post_t \times ReqSch_{i,h,c} + \beta_{t}^{\text{CapxSkill}} \Delta Cap_c \times Post_t \times ReqSch_{i,h,c} \\
+ \alpha_i + \alpha_t + \alpha_{s,t} + \alpha_c + \beta_{X,t} X_{i,h,c,1910} \times Post_t + \beta_{Z,t} Z_{h,c,1910} \times Post_t + \epsilon_{i,h,c,t}.
\]

This follows the notation of Equation (4), but differs by allowing for the inclusion of different levels, denoted by \( l \), of required years of schooling \( ReqSch_{l,i,h,c} \). I focus on the four cohorts of the baseline analysis: individuals who were 15–20 years old in 1910, individuals who were 21–25 years old in 1910, individuals who were 26–30 years old in 1910, and individuals who were 31–35 years old in 1910. Similar to the main results, I cluster these results at the 100-mile radius-by-year level following the method proposed by Colella et al. (2019).

I present the results of this regression for all cohorts considered in Figure Q.3. Similar to the baseline results, I find that young (15–20) women born in areas with a required level of schooling of 8 years or above experienced a significantly higher increase in employment after electrification, relative to their counterparts with lower required levels of schooling, for all years considered. This positive effect is absent for older women, but also for lower levels of required schooling, suggesting that the shift in the female work environment triggered by electricity focused on more highly skilled jobs. This is further hinted at when we plot the results for men in Figure Q.4, which show that for men the positive influence of required schooling extends to 7 years of required schooling, and also to older cohorts.

### L.3 Inclusion of different Fixed Effects and Controls

My base specification for the heterogeneity in the effects on employment by required educational level comprises a large set of fixed effects and controls. In this section, I consider the robustness of my results to the sequential inclusion of different sets of fixed effects controls.\(^{72}\)

I present these results for the analysis of the heterogeneity in the effects of electrification by required educational level for women who were 15–20 in 1910 in Table Q.1. I find that the increase in employment triggered by electrification is significantly larger for women who were born in areas with a required level of schooling of 8 years or more in all specifications in 1920 and 1930. The magnitude of this effect also remains broadly consistent across specifications, hovering around 8% in 1920 and 4.5% in 1930. In Table Q.2, I present the effects for men who

\(^{72}\)Please note that I include year, individual, and state-by-year fixed effects in all specifications, because the first two are key for the triple difference panel design, while the latter controls for state-level trends that might correlate with the results, given that that required school attendance is constructed at the state by cohort level.
were 15–20 in 1910, and find, as suggested in the baseline analysis, no statistically significant differential effects of electrification by required years of schooling across all specifications in this group.\footnote{Results for older cohorts are available upon request.}

\section*{L.4 Contemporaneous Controls}

Due to the risk of post-treatment bias arising from the effect of treatment on controls, in the baseline specification I included the baseline (1910) level of the controls interacted with post-treatment indicators rather than contemporaneous levels. This, however, leads to concerns about omitted variable bias stemming from the long period considered in the analysis and the possibility of concurrent shocks. In this section, I repeat my analysis considering contemporaneous levels of controls in addition to fixed effects. I estimate the following regression for each cohort:

\begin{equation}
\text{Employed}_{i,h,c,t} = \alpha + \beta_t \Delta \text{Cap}_c \times \text{Post}_t + \beta_{\text{Skill}}^t \Delta \text{Cap}_c \times \text{ReqSch}_{i,h,c}
+ \beta_{\text{Skill}}^t \text{Post}_t \times \text{ReqSch}_{i,h,c} + \beta_{\text{CapxSkill}}^t \Delta \text{Cap}_c \times \text{Post}_t \times \text{ReqSch}_{i,h,c}
+ \alpha_i + \alpha_t + \alpha_{s,t} + \alpha_c + \beta_{X,t} \text{X}_{i,h,c,t} + \beta_{Z,t} \text{Z}_{h,c,t} \times \text{Post}_t + \epsilon_{i,h,c,t},
\end{equation}

where the notation follows from Equation (4) and standard errors are clustered at the 100-mile radius-by-year level following the method proposed by Colella et al. (2019).

The results of this analysis are presented in Figure Q.5. I find that these results are qualitatively and quantitatively similar to the baseline results. Although the differential increase in employment triggered by electrification for young women with 8 or more years of required education is slightly smaller than in the baseline case, these results remain positive and still highly significant in 1920 and 1930. This suggests that the inclusion and type of controls are not fundamental for explaining my results.

\section*{L.5 Alternate Clustering}

In my baseline analysis I cluster the standard errors at the 100-mile radius-by-year level in order to account for potential spatial serial correlation among observations stemming from the location of electricity plants. This level is sensible given my specifications, where the coefficients of interest are derived from treatment and year interactions. However, there might still be a concern of serial correlation among observations at the 100-mile radius level, which persists among different census waves. In order to account for that, in this section I consider the robustness of my results to 100-mile radius level clustering. In addition, I also consider robustness to county-by-year level clustering, given that my treatment is defined at
the county level.

The results when I cluster at the 100-mile radius level are presented in Figure Q.6, whereas the results when I cluster at the county-by-year level are presented in Figure Q.7. In the first case, though the confidence-interval bands are slightly larger as a result of a more conservative level of clustering, I still find that the increase in employment triggered by electrification is significantly larger for young women with 8 or more years of required schooling (while this effect is absent for older women and most men). These same results hold in the second case when I cluster at the county-by-year level.

L.6 Excluding Counties in the South

During the time period under analysis, the South region of the United States followed a significantly different path from the rest of the country. During this time, the South enacted Jim Crow laws disenfranchising African American citizens by limiting the economic and political gains obtained during the Reconstruction Era. In addition, the South was also experiencing the introduction of Rosenwald schools, providing public education for many African-American children for the first time, and the mass migration of African-Americans to cities in the North. Given the stark differences between the South and the rest of the country and the deep changes experienced by the South during this period, there might be some concern that my results are driven by idiosyncrasies of the South rather than the process of electrification. In this section, I account for this by dropping counties in the South. In particular, I drop observations from all counties in the following states: Alabama, Arkansas, Delaware, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia.

The results of this analysis are presented in Figure Q.8. Though the confidence-interval bands are slightly larger as a result of the decreased power induced by having fewer observations, I find that consistent with the baseline results, the increase in employment triggered by electrification is significantly larger for young women with 8 or more years of required education, while this result is absent for older women and most men.

L.7 Excluding Counties in the West

The treatment variable in my main analysis is given by the change in the total electrical capacity within and 50 miles around each county’s boundaries between 1911 and 1919. Due to the technological constraints of transmission in this period that made it unfeasible to consume power far from the generation site, my measure approximates the change in the extent of electrification in each county during the 1910s. However, due to these transmission
constraints, there may be some worry that my measure does not adequately capture the availability of electricity in counties that are larger in area, namely counties in the West region of the United States. In order to account for this, in this section I consider the robustness of my results to excluding counties in the West. In particular, I drop observations from all counties whose centroid lies west of the 100th meridian. The results for the main analysis are presented in Figure Q.9. I find results qualitatively and quantitatively similar to baseline.

L.8 Alternate Treatment Definition: Proximity to Large Plants

The treatment variable in my main analysis is given by the change in the total electrical capacity within and 50 miles around each county’s boundaries between 1911 and 1919. This measure has several advantages, including the fact that it captures the generation of smaller plants, which are important in this period and frequently overlooked in other studies that only consider the output and location of large generating plants.

In this section, I show that my results are robust to using an alternate treatment definition based on location of large plants. In particular, I define treatment through a dummy indicating whether the county-centroid distance to a large-capacity generating plant (20 megawatts or more) is less than 100 miles.\(^{74}\) I estimate the following regression:

\[
Employed_{i,h,c,t} = \alpha + \beta_t DistLargePlant_c \times \text{Post}_t + \beta^{\text{Skill}} DistLargePlant_c \times \text{ReqSch}_{i,h,c} \\
+ \beta^{\text{Skill}}_t \text{Post}_t \times \text{ReqSch}_{i,h,c} + \beta^{\text{CapxSkill}} DistLargePlant_c \times \text{Post}_t \times \text{ReqSch}_{i,h,c} \\
+ \alpha_i + \alpha_t + \alpha_{s,t} + \alpha_c + \beta_{X_t}X_{i,h,c,1910} \times \text{Post}_t + \beta_{Z_t}Z_{h,c,1910} \times \text{Post}_t + \epsilon_{i,h,c,t},
\]  

(12)

where \(DistLargePlant_c\) denotes a dummy variable indicating whether the centroid in county \(c\) is less than 100 miles away from a large-capacity generating plant (20 megawatts or more). The rest of the notation follows Equation (4) and standard errors are clustered at the 100-mile radius-by-year level following the method proposed by Colella et al. (2019). I choose the generating threshold of 20 megawatts and distance threshold of 100 miles based on technological and institutional facts of this era. First, the 20-megawatts generating threshold corresponds to a medium- to large-sized plant in the period considered. As such, this alternate treatment definition captures proximity to a plant with large nameplate capacity.

\(^{74}\)As before, I limit my analysis to counties that were not electrified by 1910 according to this measure. In other words, I exclude counties whose county-centroid distance to a plant with generating capacity of 20 megawatts or more was less than 100 miles by 1910.
producing enough electricity to power all homes and business in its vicinity. This matches similar approaches followed by the literature examining the effects of electrification in the United States. For a later period (1930 to 1940), Lewis and Severini (2017) define treatment as the county-centroid distance to the nearest power plant with at least 30 megawatts of generating capacity. I do not use inverse distance, however, because during my period consuming electricity more than 100 miles away from the generating source was unfeasible. As such, I set the distance threshold of 100 miles based on the technological constraints of the transmission of electricity during this time.

The results for the main analysis are presented in Figure Q.10. I find results consistent with the baseline results. In particular, I find that the increase in employment among young women with a required schooling level of 8 years or more was approximately 3 percentage points higher on average in 1920–1940 (relative to 1910) than that of young women with a required level of schooling level of less than 8 years in counties within a 100-mile radius of a plant with 20 or more megawatts of capacity relative to those outside of this radius. These results are absent for older women and men.

L.9 World War I

Since my period of treatment overlaps with World War I, a major worldwide event that led to significant changes in the US economy, there might be concerns that my results are driven by this, in particular since counties with a greater degree of electrification might be differentially affected by the war. For example, counties with electricity and higher factory production might experience differentially higher credit crunches or female LFP as a result of this war event. However, context regarding this war and my results suggest this is not the case. First, unlike World War II, there was no rationing or constraining of the credit market during World War I. Second, the increase in female employment is markedly higher for more-educated women even in 1920, which is not consistent with female labor supply replacing male labor on factory floors during the war. Moreover, the positive effects on female employment by required education are visible in both 1930 and 1940, many years after World War I ended.

M Appendix: Heterogeneity in Effects of Electrification by Marital and Fertility Choices

In this section I present evidence on the differences in the effects of electrification for women who were married in 1910, women who ever married, or women who ever had children. With
this, I shed light on whether the positive effects of electrification on the employment of young and skilled women are driven by women who prioritized career over family. This is important given that this group of women, together with those who were already married in 1910, are overrepresented in my panel sample due to the difficulties in matching women present in all record-linking algorithms due to maiden-to-married name changes.

Table M.1: Summary Statistics for Marital and Maternal Status in Panel and Repeated Cross-Section Data

<table>
<thead>
<tr>
<th></th>
<th>Panel</th>
<th>Repeated Cross-Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ever married in 1910–1940</td>
<td>0.9103</td>
<td>0.9210</td>
</tr>
<tr>
<td>Ever mother in 1910–1940</td>
<td>0.8569</td>
<td>0.8598</td>
</tr>
</tbody>
</table>

Notes: The sample for this table consists of individuals who were 15–35 years of age in 1910, were born in the contiguous US, and who lived in areas that gained access to electrification in the 1910s in 1910.

In Table M.1, I present some summary statistics that confirm that women who never married or had children are overrepresented in my panel sample. To do this, I first build indicator variables for my panel sample capturing women who (1) ever reported being married in any of the census waves considered (1910–1940) or (2) ever reported having at least one own child living with them in any of the census waves considered (1910–1940). The first row in Table M.1 reports the proportion of women who ever got married in the panel sample, along with the repeated cross-section data, for individuals born in the contiguous United States in my cohorts and treatment areas of interest. I find that the proportion of women who got married during 1910–1940 is slightly smaller in my panel data relative to the repeated cross-section data. The second row reports the proportion of women who had one or more children in the panel sample, along with the repeated cross-section data. I find that the proportion of women who had one or more children during 1910–1940 is also slightly smaller in my panel data relative to the repeated cross-section data. Although these differences may seem small, they are actually quite significant, considering that the panel sample largely overrepresents women who were already married in 1910, as shown in Table 5.1.

I now present results on how the differential effects of electrification by required educational level change with marital and maternal status. To this end, I limit the baseline analysis of...
Equation (4) to young women in each of the following groups: women who were married in 1910, women who ever reported being married in any of the census waves considered (1910–1940), and (3) women who ever reported having at least one own child living with them in any of the census waves considered (1910–1940). With this, I examine whether the effects of electrification on the employment of young and skilled women in these groups are positive and similar in magnitude to those of the baseline analysis considering all women. I plot these effects in Figure M.1 and find two key results.

Figure M.1: Heterogeneity in the Effects of Electrification on Women’s Employment by Required Educational Attainment of 8 or More Years, For Young Women who were Married in 1910, or who Married or had Children in 1910–1940

<table>
<thead>
<tr>
<th>Year after Treatment (Baseline Year: 1910, Required Educ. Attainment of 8+ yrs.)</th>
<th>Women's Employment Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1920</td>
<td>1920</td>
</tr>
<tr>
<td>1930</td>
<td>1930</td>
</tr>
<tr>
<td>1940</td>
<td>1940</td>
</tr>
</tbody>
</table>

Notes: The coefficients plotted correspond to $\beta_t^{CapxSkill}$ in Equation (4), estimated for women who were married in 1910 or who married or had children in 1910–1940 separately. These coefficients capture the heterogeneity in difference-in-differences effects by required educational attainment of 8 or more years for each of the post-treatment periods (1920, 1930, and 1940, with baseline 1910). The analyses encompass women in the panel sample who were 15–20 years of age in 1910 and were born in the contiguous US. 95% confidence intervals built from standard errors clustered at the 100-mile Radius x Year level are plotted.

First, I find that electrification did not affect the employment of young and skilled women who were already married in 1910. This is not surprising, and likely stems from the fact that these women had competing responsibilities that limited their ability to coordinate key human capital decisions to take advantage of the productive returns brought about by electrification. Second, I find that electrification did increase the employment of young and skilled women who were ever married or had children in 1910–1940. This positive effect is especially marked in 1920, when our cohort of interest was still young, though considerably smaller than the effects found in the baseline analysis, which considers all groups of women.\footnote{Formal comparisons of how the differential effects of electrification by required educational level differ between women who were married in 1910 and those who were not, and between women who married or had children in 1910–1940 and those who did not confirm these differences. These results are available upon request.}
This suggests that the effects of electrification on female LFP are not limited to women who prioritized career over family (though they tend to be stronger for these), and thus that skilled women who later married and had families also saw an increase in their LFP due to electrification when young. This matches the evidence presented by Goldin (2020), who shows that at the turn of the 20th century, women moved from a regime of having to choose between career or family to a regime where they could pursue both a career (particularly early in life) and a family.\footnote{Goldin (2020)}

\section{Appendix: Effects of Electrification on Fertility and Marriage}

In this section I present evidence on the effects of electrification on women’s fertility and probability of marriage. With this, I shed light on the role of electrification to drive the significant changes in both women’s careers and family lives that occurred during the first half of the 20th century documented in Section 2.

\subsection{N.1 Effects on Fertility}

First, I present results on the effects of electrification on women’s fertility for each of the four cohorts considered, for individuals born in the contiguous United States. I estimate the following regression for each cohort:

\begin{equation}
FertilityOutcome_{i,h,c,t} = \alpha + \beta_t \Delta Cap_t \times Post_t + \alpha_{i} + \alpha_t + \alpha_{s,t} + \alpha_{c} + \beta_{X_t} X_{i,h,c,1910} \times Post_t \\
+ \beta_{Z_t} Z_{h,c,1910} \times Post_t + \epsilon_{i,h,c,t}.
\end{equation}

(13)

I consider two fertility outcomes. The first outcome corresponds to the number of children ever born to each woman, available in 1910 and 1940. This variable encompasses all ever-married females age 12 and above in 1910, but only sample-line females in 1940, which greatly reduces the number of observations with this data in 1940. The second outcome is the number of own children residing in the same household, available in all waves considered. By comparing the number of children born to women in 1940 relative to 1910, I capture changes in completed fertility patterns across women. On the other hand, by comparing the number of own children living in the household in 1920, 1930, and 1940 relative to 1910, I also capture a dimension of fertility timing, because I can see at which point in their

Tabulates of all the results in this appendix are available upon request.
lives women were most likely to have children living with them. The rest of the notation follows from Equation (4). Similar to the main results, I cluster these results at the 100-mile radius-by-year level following the method proposed by Colella et al. (2019).

Figure N.1: Effects of Electrification on Women’s Fertility Outcomes by Cohort

Notes: The coefficients plotted correspond to $\beta_t$ in Equation (13), estimated for each cohort and fertility outcome variable separately. These coefficients capture the difference-in-differences effects for each of the post-treatment periods (1940, with baseline of 1910 for Panel (a); and 1920, 1930, and 1940, with baseline 1910 for Panel (b)). The analyses encompass women in the panel sample who were 15–20, 21–25, 26–30, and 31–35 years of age in 1910, respectively, and were born in the contiguous US. 95% confidence intervals built from standard errors clustered at the 100-mile Radius x Year level are plotted.

Figure N.1 plots the coefficients capturing the effects of electrification on fertility from estimating Equation (13) for each of the two fertility variables considered for our four cohorts of women. I find that electrification reduced the number of children born for all women in our cohorts of interest, except for the youngest cohort. This likely stems from the fact that the sample size for this cohort is particularly small, with only about 12,000 women in this youngest cohort having information about the number of children born in 1940. For the three older cohorts of women, I find that the fertility of those living in areas with 100 megawatts more of generating capacity in the 1910s increased by 0.24–0.37 fewer children from 1910 to 1940 than that of their counterparts living in areas that did not become electrified during that period. These results are particularly marked among the two middle cohorts.

The results for the number of children in the household paint a similar picture, and show that electrification reduced the number of own children living at home with women in all of our cohorts of interest, particularly for those in the younger cohorts. In addition, these results suggest that the timing of fertility was also altered. The decline in the number of children in the household for the two younger cohorts was particularly marked in 1920 and 1930 (but less so in 1940), suggesting women in electrified areas waited to have children. For
the oldest cohort, there is actually an increase in the number of own children living in the same household in 1940, consistent with a late-life rise in fertility that caused these older cohorts to be caring for young children in the household at a later age.

Then, I explore how the effects of electrification on fertility change with required educational level, as in my main analysis. To do this, I run the following regression:

\[
FertilityOutcome_{i,h,c,t} = \alpha + \beta_t \Delta Cap_c \times Post_t + \beta^{Skill} \Delta Cap_c \times ReqSch_{i,h,c} \\
+ \beta^{Skill} Post_t \times ReqSch_{i,h,c} + \beta^{CapxSkill} \Delta Cap_c \times Post_t \times ReqSch_{i,h,c} \\
+ \alpha_i + \alpha_t + \alpha_{s,t} + \alpha_c + \beta_X X_{i,h,c,1910} \times Post_t + \beta_Z Z_{h,c,1910} \times Post_t + \epsilon_{i,h,c,t},
\]

where again the outcomes considered are the number of children born and number of own children residing in the household. The rest of the notation follows from Equation (4). Similar to the main results, I focus on women born in the contiguous United States who were 15–35 years of age in 1910 and cluster these results at the 100-mile radius-by-year level following the method proposed by Colella et al. (2019).

Figure N.2: Heterogeneity in the Effects of Electrification on Women’s Fertility outcomes by Required Educational Attainment of 8 or More Years, For Different Cohorts

(a) Number of Children Born

(b) Number of Own Children in Household

Notes: The coefficients plotted correspond to \(\beta^{CapxSkill}_t\) in Equation (14), estimated for each cohort and fertility outcome variable separately. These coefficients capture the heterogeneity in difference-in-differences effects by required educational attainment of 8 or more years for each of the post-treatment periods (1920, 1930, and 1940, with baseline 1910). The analyses encompass women in the panel sample who were 15–20, 21–25, 26–30, and 31–35 years of age in 1910, respectively, and were born in the contiguous US. 95% confidence intervals built from standard errors clustered at the 100-mile radius x Year level are plotted.

Figure N.1 plots the coefficients capturing the effects of electrification on fertility from estimating Equation (13) for each of the two fertility variables considered for our four cohorts of women. I find that young women born in areas with a required level of schooling of 8 years
or above experienced a significantly lower increase in fertility after electrification, relative to their counterparts with lower required levels of schooling, for all years considered. In particular, the increase in the number of own children in the household among women of the younger two cohorts with a required schooling level of 8 years or more was 0.15–0.25 children lower on average in 1940 (relative to 1910) than that of young women with a required level of schooling level of less than 8 years in areas with an increase in generating capacity of 100 megawatts in the 1910s. These effects are more muted for older women. These results are not significant for the number of children born, however, likely due to the small sample sizes in this case.

N.2 Effects on Marriage Rates

I now explore the effects of electrification on marriage rates, and particularly ever-married status. Since there is no change in this variable within individuals, a panel or a cohort-level analysis following the same individuals over time is not informative. Instead, I conduct this analysis at the age-group level, and thus compare the proportion of ever-married individuals born in the contiguous United States and of ages 36–55 from 1910 to 1940 in counties that were electrified versus those that were not. I choose the age group of 36–55 for several reasons. First, in the mid-post-treatment period of 1930, these individuals would correspond to those who were 15–35 in 1910, corresponding to my cohorts of interest in the main analysis. Second, because this analysis focuses on marriage rates, it is important to choose an age range that is high enough so that most first marriages occur by that age. I estimate the following equation:

$$\text{EverMarried}_{c,t} = \alpha + \beta_t \Delta \text{Cap}_c \times \text{Post}_t + \alpha_t + \alpha_{s,t} + \alpha_c + \beta_{Z,t} Z_{c,1910} \times \text{Post}_t + \epsilon_{c,t}, \quad (15)$$

where EverMarried captures the proportion of women of 36–55 years of age in each county who reported ever being married in year t and county c. $\Delta \text{Cap}_c$ corresponds to my preferred measure of electrification, change in generating capacity between 1911 and 1919 (in 100s of megawatts). $Z_{c,1910}$ denotes county-level controls in 1910 (proportion urban, racial composition, total population, and socioeconomic index). Similar to the baseline results, I cluster these results at the 100-mile radius-by-year level following the method proposed by Colella et al. (2019). Since this analysis is performed at the aggregated county-level, the results should be interpreted as suggestive.

I find that the proportion of ever-married women in the 36–55 years of age range rises from 1910 to 1940 as a consequence of electrification. Although this may seem at odds with the
decline in fertility mentioned above, this pattern matches the evidence presented in Goldin (2020), and suggests that electrification fueled deep changes in the societal role of women during the early 20th century. In particular, the advent of electricity changed the productive landscape for women, encouraging them to further their educations and pursue careers during their youth, and pursue marriage and a family in later years.\textsuperscript{79,80}

Figure N.3: Effects of Electrification on Women’s Ever-Married Status

![Graph showing effects of electrification on women's ever-married status.]

Notes: The coefficients plotted correspond to $\beta_t$ in Equation (15), estimated for each age-group separately. These coefficients capture the difference-in-differences effects for the post-treatment periods (1920, 1930, and 1940 with baseline 1910). The analysis encompasses women 36–55 years of age in each year who were born in the contiguous US. 95\% confidence intervals built from standard errors clustered at the 100-mile Radius x Year level are plotted.

O Effects of Electrification on Employment (Difference-in-Differences)

In this section I present results on the effects of electrification on women’s and men’s employment per se for each of the four cohorts considered and for individuals born in the contiguous United States. I estimate the following regression for each cohort:

\[
\text{Employed}_{i,h,c,t} = \alpha + \beta_t \Delta \text{Cap}_c \times \text{Post}_t + \alpha_i + \alpha_t + \alpha_{s,t} + \alpha_c + \beta_{X,t}X_{i,h,c,1910} \times \text{Post}_t + \beta_{Z,t}Z_{h,c,1910} \times \text{Post}_t + \epsilon_{i,h,c,t}. \tag{16}
\]

This equation follows the notation from Equation (4). Similar to the main results, I cluster these results at the 100-mile radius-by-year level following the method proposed by Colella et al. (2019).

\textsuperscript{79}I do not examine the heterogeneity of these results by schooling, because individuals in my age group of interest have no required schooling information in 1910.

\textsuperscript{80}Tabulates of all the results in this appendix are available upon request.
Figure O.1: Effects of Electrification on Women’s Employment by Cohort

Notes: The coefficients plotted correspond to $\beta_t$ in Equation (16), estimated for each cohort separately. These coefficients capture the difference-in-differences effects for each of the post-treatment periods (1920, 1930, and 1940, with baseline 1910). The analyses encompass women in the panel sample who were 21–25, 26–30, and 31–35 years of age in 1910, respectively, and were born in the contiguous US. 95% confidence intervals built from standard errors clustered at the 100-mile Radius x Year level are plotted.

Figure O.1 plots the coefficients capturing the effects of electrification on employment from estimating Equation (16) for our four cohorts of women. I find that electrification did not change the employment of women in the two younger cohorts (15–20 and 21–25 in 1910), but increased the employment of women in the two older cohorts (26–30 and 31–35 in 1910). These results jointly point to the mechanisms highlighted in the model, per which electricity encourages female LFP, but also human capital acquisition. In particular, the increase in female LFP triggered by electrification among older cohorts is consistent with the intuition highlighted in the model, where electricity encourages female LFP by complementing skilled tasks and occupations where women face a higher productivity than in unskilled jobs that emphasize brawn. However, the increase in women’s labor supply stemming from electrification is moderated for women who are still potentially engaged in school or have younger children, suggesting that competing educational, marital, and childcare responsibilities limit the scope of electrification to increase female labor supply.

The results for men are notably different. In particular, the results suggest that increases in generation capacity in the 1910s lowered the proportion of employed men in 1920, 1930, and 1940, relative to 1910. This result is interesting, because it further hints at the skill bias aspect of electrification, which disproportionately affected women’s work prospects, given their considerable disadvantage in unskilled labor, the predominant work source in the pre-electricity world.\textsuperscript{81}

\textsuperscript{81} Tabulates of all the results in this appendix are available upon request.
Figure O.2: Effects of Electrification on Men’s Employment by Cohort

Notes: The coefficients plotted correspond to $\beta_t$ in Equation (16), estimated for each cohort separately. These coefficients capture the difference-in-differences effects for each of the post-treatment periods (1920, 1930, and 1940, with baseline 1910). The analyses encompass men in the panel sample who were 21–25, 26–30, and 31–35 years of age in 1910, respectively, and were born in the contiguous US. 95% confidence intervals built from standard errors clustered at the 100-mile Radius x Year level are plotted.

P Appendix: Effects of Electrification on Schooling

I now present evidence of how schooling decisions changed in response to electrification. Since my measurements span for 40 years and are 10 years apart, a cohort-level analysis following the same individuals over time is not informative, given that schooling is concentrated in the first 20 years of life. Instead, I conduct this analysis at the age-group level, and thus compare the county-level trends in school attendance of school-age (6–24) individuals in the period from 1910 to 1940 in counties that were electrified versus those that were not. 82 Because this analysis is performed at the aggregated county-level, the results should be interpreted as suggestive. This analysis allows me to test the model’s prediction that electrification raised the returns to education by complementing skilled-work tasks. To do this, I estimate the following equation:

$$PropSchoolAttend_{c,t} = \alpha + \beta_t \Delta Cap_c \times Post_t + \alpha_t + \alpha_{s,t} + \alpha_c + \beta_{Z,t}Z_{c,1910} \times Post_t + \epsilon_{c,t},$$

(17)

where $PropSchoolAttend$ captures the proportion of individuals 6–24 in each county who report they are attending school. Similar to Equation (15), $c$ and $t$ denote county and year, respectively. $\Delta Cap_c$ corresponds to my preferred measure of electrification, change in gen-

82 Given that educational attainment is only first asked about in 1940, I focus on school attendance, which is asked about in all census waves considered, thus allowing me to conduct a difference-in-differences analysis.
erating capacity between 1911 and 1919 (in 100s of megawatts). $Z_{c,1910}$ denotes county-level controls in 1910 (proportion urban, proportion married, racial composition, total population, and socioeconomic index). Similar to the baseline results, I cluster these results at the 100-mile radius-by-year level following the method proposed by Colella et al. (2019).

Figure P.1: Effects of Electrification on Women’s and Men’s School Attendance

![Graph]

Notes: The coefficients plotted correspond to $\beta_t$ in Equation (17). These coefficients capture the difference-in-differences effects for each of the post-treatment periods (1920, 1930, and 1940, with baseline 1910). The analyses encompass women and men 6–24 years of age in each year. 95% confidence intervals built from standard errors clustered at the 100-mile Radius x Year level are plotted.

I plot the results from this exercise in Figure P.1, and find that schooling attendance did not change much for both women and men ages 6 to 24 with electrification. However, when I decompose this effect for different age groups in order to study possible heterogeneities in the effect of electrification across different schooling levels I find interesting patterns. To do this, I estimate Equation (17) for each 3-year age group and plot the results in Figure P.2.

I find that for both men and women, school attendance declined for individuals ages 6–15, while it rose for individuals 19–21. This is consistent with two stories. First, the increase in post-secondary attendance captured by the increase in schooling in the 19–21 group suggests the skill bias of electricity particularly favored highly skilled and specialized education, consistent with the results found in Appendix L.1. Moreover, this pattern is consistent with evidence presented in Goldin and Katz (2008) suggesting technological change has increasingly required higher-skilled labor and thus the catching up of workers and educational institutions to fully exploit new productive possibilities in the economy. Second, the decline among lower schooling levels is consistent with other papers that have found that new productive opportunities reduce schooling, such as Atkin (2016) and Uribe-Castro (2019). Both of these results are also consistent with the work of Gray (2013), who finds that electrification
was unskill biased for blue-collar tasks but skill biased in the aggregate.\footnote{Tabulates of all the results in this appendix are available upon request.} 

Figure P.2: Effects of Electrification on Women’s and Men’s School Attendance by Age Group

Notes: The coefficients plotted correspond to $\beta_t$ in Equation (17), estimated for each age-group separately. These coefficients capture the difference-in-differences effects for each of the post-treatment periods (1920, 1930, and 1940, with baseline 1910). The analyses encompass women and men of 6–8, 9–11, 12–15, 16–18, 19–21, and 22–24 years of age in each year, respectively. 95% confidence intervals built from standard errors clustered at the 100-mile Radius x Year level are plotted.
Appendix: Robustness Results of Main Empirical Exercise

Q.1 Without Proxying for Educational Attainment

Figure Q.1: Heterogeneity in the Effects of Electrification on Women’s Employment by Educational Attainment, For Different Cohorts

(a) 15–20 in 1910
(b) 21–25 in 1910
(c) 26–30 in 1910
(d) 31–35 in 1910
(e) 36–40 in 1910
(f) 41–45 in 1910
(g) 46–50 in 1910
(h) 51–55 in 1910
(i) 56+ in 1910

Notes: The coefficients plotted correspond to $\beta^{CapxSkil}_t$ in Equation (9), estimated for each cohort separately. These coefficients capture the heterogeneity in difference-in-differences effects by educational level (baseline education: No schooling) for each of the post-treatment periods (1920, 1930, and 1940, with baseline 1910). The analyses encompass women in the panel sample who were 15–20, 21–25, 26–30, 31–35, 36–40, 41–45, 46–50, 51–55, and 56 or more years of age in 1910, respectively. 95% confidence intervals built from standard errors clustered at the 100-mile Radius x Year level are plotted.
Figure Q.2: Heterogeneity in the Effects of Electrification on Men’s Employment by Educational Attainment, For Different Cohorts

(a) 15–20 in 1910  
(b) 21–25 in 1910  
(c) 26–30 in 1910  
(d) 31–35 in 1910  
(e) 36–40 in 1910  
(f) 41–45 in 1910  
(g) 46–50 in 1910  
(h) 51–55 in 1910  
(i) 56+ in 1910

Notes: The coefficients plotted correspond to $\beta_{t}^{\text{CapxSkill}}$ in Equation (9), estimated for each cohort separately. These coefficients capture the heterogeneity in difference-in-differences effects by educational level (baseline education: No schooling) for each of the post-treatment periods (1920, 1930, and 1940, with baseline 1910). The analyses encompass men in the panel sample who were 15–20, 21–25, 26–30, 31–35, 36–40, 41–45, 46–50, 51–55, and 56 or more years of age in 1910, respectively. 95% confidence intervals built from standard errors clustered at the 100-mile Radius x Year level are plotted.
Q.2 Alternate Measures of Required Schooling

Figure Q.3: Heterogeneity in the Effects of Electrification on Women’s Employment by Levels of Required Educational Attainment, For Different Cohorts

Notes: The coefficients plotted correspond to $\beta_{Cap_xSkill}$ in Equation (10), estimated for each cohort separately. These coefficients capture the heterogeneity in difference-in-differences effects by different levels of required educational attainment (baseline required educational attainment of 0 years) for each of the post-treatment periods (1920, 1930, and 1940, with baseline 1910). The analyses encompass women in the panel sample who were 15–20, 21–25, 26–30, and 31–35 years of age in 1910, respectively, and were born in the contiguous US. 95% confidence intervals built from standard errors clustered at the 100-mile Radius x Year level are plotted.
Figure Q.4: Heterogeneity in the Effects of Electrification on Men’s Employment by Levels of Required Educational Attainment, For Different Cohorts

(a) 15–20 in 1910

(b) 21–25 in 1910

(c) 26–30 in 1910

(d) 31–35 in 1910

Notes: The coefficients plotted correspond to $\beta_{CapxSkill}^{t}$ in Equation (10), estimated for each cohort separately. These coefficients capture the heterogeneity in difference-in-differences effects by different levels of required educational attainment (baseline required educational attainment of 0 years) for each of the post-treatment periods (1920, 1930, and 1940, with baseline 1910). The analyses encompass men in the panel sample who were 15–20, 21–25, 26–30, and 31–35 years of age in 1910, respectively, and were born in the contiguous US. 95% confidence intervals built from standard errors clustered at the 100-mile Radius x Year level are plotted.
Q.3 Appendix: Inclusion of Different Fixed Effects and Controls

Table Q.1: Heterogeneity in the Effects of Electrification on Women’s Employment by Required Educational Attainment of 8 or More Years, for Women 15–20 in 1910

<table>
<thead>
<tr>
<th></th>
<th>Women’s employment</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>ΔCap×1920</td>
<td>-0.0019</td>
<td>-0.0097</td>
<td>-0.0033</td>
</tr>
<tr>
<td></td>
<td>(0.0085)</td>
<td>(0.0087)</td>
<td>(0.0075)</td>
</tr>
<tr>
<td>ΔCap×1930</td>
<td>-0.0126</td>
<td>-0.0201*</td>
<td>-0.0134*</td>
</tr>
<tr>
<td></td>
<td>(0.0081)</td>
<td>(0.0082)</td>
<td>(0.0067)</td>
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<tr>
<td>ΔCap×1940</td>
<td>-0.0025</td>
<td>-0.0098</td>
<td>-0.0025</td>
</tr>
<tr>
<td></td>
<td>(0.0083)</td>
<td>(0.0082)</td>
<td>(0.0067)</td>
</tr>
<tr>
<td>ΔCap×ReqSch</td>
<td>0.0253</td>
<td>-0.0768***</td>
<td>-0.0593***</td>
</tr>
<tr>
<td></td>
<td>(0.0352)</td>
<td>(0.0222)</td>
<td>(0.0176)</td>
</tr>
<tr>
<td>1920×ReqSch</td>
<td>0.0349*</td>
<td>0.0445**</td>
<td>0.0050</td>
</tr>
<tr>
<td></td>
<td>(0.0147)</td>
<td>(0.0138)</td>
<td>(0.0111)</td>
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<tr>
<td>1930×ReqSch</td>
<td>0.0203</td>
<td>0.0349***</td>
<td>0.0041</td>
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<td>(0.0106)</td>
<td>(0.0078)</td>
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<td>1940×ReqSch</td>
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<td>0.0450***</td>
<td>0.0178*</td>
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<td>(0.0130)</td>
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<td>(0.0089)</td>
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<tr>
<td>ΔCap×1920×ReqSch</td>
<td>0.0829**</td>
<td>0.0792***</td>
<td>0.0788***</td>
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<tr>
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<td>(0.0253)</td>
<td>(0.0228)</td>
<td>(0.0196)</td>
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<tr>
<td>ΔCap×1930×ReqSch</td>
<td>0.0486*</td>
<td>0.0425*</td>
<td>0.0424*</td>
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<td>(0.0214)</td>
<td>(0.0200)</td>
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</tr>
<tr>
<td>ΔCap×1940×ReqSch</td>
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<td>0.0331</td>
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<td>(0.0229)</td>
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<th>0.464</th>
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<tr>
<td>Individual Fixed Effects</td>
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<tr>
<td>State x Year Fixed Effects</td>
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<tr>
<td>County Fixed Effects</td>
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<tr>
<td>Demographic and socioecon. controls</td>
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Cluster 100-mile x Year 100-mile x Year 100-mile x Year

N 371073 371073 371073

Notes: The specification corresponds to that of Equation (4). The analysis encompasses women in the panel sample who were 15–20 years of age in 1910 and were born in the contiguous US. Some of the terms are omitted due to length. Clustered standard errors in parentheses. * p < 0.05, ** p < 0.01, *** p < 0.001.
Table Q.2: Heterogeneity in the Effects of Electrification on Men’s Employment by Required Educational Attainment of 8 or More Years, for Men 15–20 in 1910

<table>
<thead>
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<th>Women’s employment</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
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<tr>
<td>∆Cap × 1920</td>
<td>-0.0138*</td>
<td>-0.0189*</td>
<td>-0.0028</td>
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<tr>
<td></td>
<td>(0.0070)</td>
<td>(0.0077)</td>
<td>(0.0070)</td>
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<td>∆Cap × 1930</td>
<td>-0.0160*</td>
<td>-0.0220*</td>
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<tr>
<td></td>
<td>(0.0075)</td>
<td>(0.0090)</td>
<td>(0.0077)</td>
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<tr>
<td>∆Cap × 1940</td>
<td>0.0076</td>
<td>0.0009</td>
<td>0.0087</td>
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<tr>
<td></td>
<td>(0.0073)</td>
<td>(0.0093)</td>
<td>(0.0083)</td>
</tr>
<tr>
<td>∆Cap × ReqSch</td>
<td>-0.0831**</td>
<td>-0.1111***</td>
<td>-0.0549***</td>
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<tr>
<td></td>
<td>(0.0265)</td>
<td>(0.0262)</td>
<td>(0.0129)</td>
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<tr>
<td>1920 × ReqSch</td>
<td>0.1342***</td>
<td>0.1365***</td>
<td>0.0533***</td>
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<td>(0.0074)</td>
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<td>1930 × ReqSch</td>
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<td>0.1464***</td>
<td>0.0618***</td>
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<td>(0.0075)</td>
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<tr>
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<td>0.1336***</td>
<td>0.0542***</td>
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<td>-0.0088</td>
<td>-0.0051</td>
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<td>(0.0167)</td>
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<td>∆Cap × 1940 × ReqSch</td>
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<tr>
<td>State x Year Fixed Effects</td>
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<tr>
<td>County Fixed Effects</td>
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<tr>
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</tbody>
</table>

Cluster 100-mile x Year 100-mile x Year 100-mile x Year

N 822107 822107 822107

Notes: The specification corresponds to that of Equation (4). The analysis encompasses men in the panel sample who were 15–20 years of age in 1910 and were born in the contiguous US. Some of the terms are omitted due to length. Clustered standard errors in parentheses. * \( p < 0.05 \), ** \( p < 0.01 \), *** \( p < 0.001 \).
Q.4 Contemporaneous Controls

Figure Q.5: Heterogeneity in the Effects of Electrification on Women’s and Men’s Employment by Required Educational Attainment of 8 or More Years (with Contemporaneous Controls), For Different Cohorts

(a) Women

(b) Men

Notes: The coefficients plotted correspond to $\beta_{CapxSkill}$ in Equation (11), estimated for each cohort separately. These coefficients capture the heterogeneity in difference-in-differences effects by required educational attainment of 8 or more years for each of the post-treatment periods (1920, 1930, and 1940, with baseline 1910). The analyses encompass women and men in the panel sample who were 15–20, 21–25, 26–30, and 31–35 years of age in 1910, respectively, and were born in the contiguous US. 95% confidence intervals built from standard errors clustered at the 100-mile Radius x Year level are plotted.

Q.5 Alternate Clustering

Figure Q.6: Heterogeneity in the Effects of Electrification on Women’s and Men’s Employment by Required Educational Attainment of 8 or More Years (with 100-mile Radius Clustering), For Different Cohorts

(a) Women

(b) Men

Notes: The coefficients plotted correspond to $\beta_{CapxSkill}$ in Equation (4), estimated for each cohort separately. These coefficients capture the heterogeneity in difference-in-differences effects by required educational attainment of 8 or more years for each of the post-treatment periods (1920, 1930, and 1940, with baseline 1910). The analyses encompass women and men in the panel sample who were 15–20, 21–25, 26–30, and 31–35 years of age in 1910, respectively, and were born in the contiguous US. 95% confidence intervals built from standard errors clustered at the 100-mile Radius level are plotted.
Figure Q.7: Heterogeneity in the Effects of Electrification on Women’s and Men’s Employment by Required Educational Attainment of 8 or More Years (with County x Year Clustering), For Different Cohorts

(a) Women

(b) Men

Notes: The coefficients plotted correspond to $\beta_{\text{Cap x Skill}}^t$ in Equation (4), estimated for each cohort separately. These coefficients capture the heterogeneity in difference-in-differences effects by required educational attainment of 8 or more years for each of the post-treatment periods (1920, 1930, and 1940, with baseline 1910). The analyses encompass women and men in the panel sample who were 15–20, 21–25, 26–30, and 31–35 years of age in 1910, respectively, and were born in the contiguous US. 95% confidence intervals built from standard errors clustered at the County x Year level are plotted.

Q.6 Appendix: Excluding Counties in the South

Figure Q.8: Heterogeneity in the Effects of Electrification on Women’s and Men’s Employment by Required Educational Attainment of 8 or More Years (excluding Counties in the South), For Different Cohorts

(a) Women

(b) Men

Notes: The coefficients plotted correspond to $\beta_{\text{Cap x Skill}}^t$ in Equation (4), estimated for each cohort separately. These coefficients capture the heterogeneity in difference-in-differences effects by required educational attainment of 8 or more years for each of the post-treatment periods (1920, 1930, and 1940, with baseline 1910). The analyses encompass women and men in the panel sample who were 15–20, 21–25, 26–30, and 31–35 years of age in 1910, respectively, and were born in the contiguous US but did not live in the South. 95% confidence intervals built from standard errors clustered at the 100-mile Radius x Year level are plotted.
Q.7 Appendix: Excluding counties in the West

Figure Q.9: Heterogeneity in the Effects of Electrification on Women’s and Men’s Employment by Required Educational Attainment of 8 or More Years (excluding Counties in the West), For Different Cohorts

(a) Women
(b) Men

Notes: The coefficients plotted correspond to $\beta_{i}^{\text{CapxSkill}}$ in Equation (4), estimated for each cohort separately. These coefficients capture the heterogeneity in difference-in-differences effects by required educational attainment of 8 or more years for each of the post-treatment periods (1920, 1930, and 1940, with baseline 1910). The analyses encompass women and men in the panel sample who were 15–20, 21–25, 26–30, and 31–35 years of age in 1910, respectively, and were born in the contiguous US but did not live in the West. 95% confidence intervals built from standard errors clustered at the 100-mile Radius x Year level are plotted.

Q.8 Appendix: Alternate Treatment Definition

Figure Q.10: Heterogeneity in the Effects of Electrification on Women’s and Men’s Employment by Required Educational Attainment of 8 or More Years (with Alternate Treatment Definition), For Different Cohorts

(a) Women
(b) Men

Notes: The coefficients plotted correspond to $\beta_{i}^{\text{CapxSkill}}$ in Equation (12), estimated for each cohort separately. These coefficients capture the heterogeneity in difference-in-differences effects by required educational attainment of 8 or more years for each of the post-treatment periods (1920, 1930, and 1940, with baseline 1910). The analyses encompass women and men in the panel sample who were 15–20, 21–25, 26–30, and 31–35 years of age in 1910, respectively, and were born in the contiguous US. 95% confidence intervals built from standard errors clustered at the 100-mile Radius x Year level are plotted.