Revisiting the Link between Electrification and Fertility: Evidence from the Early 20th Century United States

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Abstract

The decline in fertility occurring throughout the first half of the 20th century in the United States and preceding the baby boom remains largely unexplored. In this paper, I present empirical and theoretical evidence linking this decline to the spread of electricity during this period. First, I use newly digitized data of early electrification efforts in order to empirically disentangle the two theoretically opposing channels driving the link between electrification and fertility: the rise of time-saving appliances that reduce the time needed for child-rearing and encourage fertility, and the rise of female wages, which increase the opportunity cost of childcare and discourage fertility. I then use these empirical estimates to calibrate a model that features both channels, and quantifies the aggregate effect of electrification on fertility. I find that electrification accounts for 4.6% of the aggregate decline in fertility during 1900–1940 in the United States, and that the opportunity cost channel is preponderant in explaining this response whereas the time-savings channel plays a much smaller role. In addition, I find that this decline in fertility primarily affects young women who were not yet burdened with childcare responsibilities, allowing them to benefit more from the labor market gains of electricity.

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From 1900 to 1940, the total fertility rate in the United States declined sharply. At the beginning of the century, American women had an average of 3.8 children throughout their reproductive years. By 1940, this number had dropped to 2.3 (Haines (2006) and 1900 Census). The magnitude of this decline is comparable to the baby boom, which induced a rise in the total fertility rate of American women of about 1.3 children between 1940 and 1960. However, the drivers behind this large decline in fertility remain largely unexplored. In this paper, I present empirical and theoretical evidence linking this decline to the rollout of electricity in the United States occurring concurrently during this period.

Many papers point to technological change as a key driver of fertility transitions (Galor and Weil (1996), Greenwood et al. (2017) and Bailey and Hershbein (2018)). According to this view, technological change plays an outsize role by altering three key margins mediating the costs and benefits of childbearing: (1) the explicit cost of children (such as the relative cost of food, clothing, and childcare time needs); (2) the opportunity cost of children (such as the time of both parents away from other productive activities); and (3) the utility of children (such as the potential to help with household chores, farm duties or in parental care in old age). Electricity affects several of these margins and as a consequence, the effect of electrification on fertility is theoretically ambiguous. On the one hand, as highlighted by Greenwood et al. (2005), electrification may increase fertility by encouraging the use of time-saving appliances which reduce the time needed for childrearing. On the other hand, electrification may decrease fertility by increasing female wages and thus the opportunity cost of child-rearing as highlighted by Vidart (2023).[1]

In this paper, I first present empirical evidence disentangling these two channels, and documenting the empirical link between electrification and fertility using data from the early electrification of the United States. I focus, in particular, on the effects of electrification investments made during the 1910s, an interesting and seldom-examined period in the history of electrification.[2] I combine 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), with measures of the electric capacity generated within each county in the United States described in Vidart (2023),[3] and measures of prices at the city-level

[1]Like other technological advances, electrification may affect other of these margins, such as income or the relative cost of food and other goods. I focus on the opportunity cost and appliance margins in both the empirics and theory, since they are more unique to electrification as a technology.

[2]During this era, the proportion of households with electricity rose from 15 to 35 percent, 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 America (Rieder (1989), Nye (1992)).

[3]These measures of electric capacity are built from digitized historical documents containing the universe of utilities and central generating stations in 1911 and 1919.

from United States Department of Labor and Statistics. (1992). Using these data sources, I study the effects of electrification in the 1910s on the fertility of women in the 1910-1940 period.

I rely on two empirical estimates in order to disentangle the two channels mediating the relationship between electrification and fertility and pin down the key parameters behind each of these opposing forces in my model. First, I use the differential effect of electrification on the fertility of women who had one or more children in the baseline period of 1910, relative to those who had no children, in order to pin down the effect of electrification working through the opportunity cost channel. Since mothers were much less likely to engage in the labor force due to cultural factors, childrearing responsibilities and other barriers, women who were already mothers upon electrification were less likely to take into consideration changes in female wages or labor opportunities when making their subsequent fertility decisions.[4] Second, I compute the differential effect of electrification on the fertility of women where the residential price of electricity was higher, in order to pin down the effect of electrification on fertility working through the time-savings of home production channel. Since areas with a higher cost of residential electricity face a higher cost of operating time-saving appliances, women living in these areas are less affected by the time-savings dimension of electrification.[5] To identify both of these effects of electrification, I use a triple difference (DDD) approach. 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 made 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, county, year and state-by-year fixed effects.

I find that among women who had one or more children in the baseline period of 1910, the decline in the number of children per woman induced by electrification by 1940 was about

[4]An example of such barriers were marriage bars which were policies adopted by firms and local school boards that restricted the employment of married women. These bars were very common throughout the United States in the first half of the 20th century (Goldin (1991)). In practice, many women kept their marital status secret from employers in order to circumvent these marriage bars (McDonald Way (2018)). Keeping this secret became much harder with pregnancy and childbirth, however.

[5]One potential concern with this strategy is that areas with higher costs of residential electricity also faced higher costs of business electricity, thus also potentially reducing the opportunity cost of labor for women. I show that this does not seem to be the channel operating here since the differential effects of electrification on the fertility of women by residential electricity price are still prevalent, and especially marked among women who were already mothers upon electrification, and thus less prone to be affected by wage or job opportunity changes.

35% smaller relative to those who had no children. This suggests that electrification had a less marked effect in decreasing fertility for women who had a limited attachment to the labor market. Moreover, I find that this differential effect is even more marked among older cohorts, who are even less likely to be attached to the labor market. Further, I find that increasing the price of one mega-watt of residential electricity by $1, increases the decline in the number of children born per woman induced by electrification, although the size of this effect is imprecise. This effect is driven by women who lived in the North. This suggests that the importance of the time-savings channel of electrification was dwarfed in the South, and that other factors, such as the prevalence of Jim Crow laws, were more important drivers of the fertility patterns in this region during the first half of the 20th century. Moreover, I find that the negative effect of electricity prices on fertility is more marked among older women who were less attached to the labor market and thus more affected by the time-saving dimension of electrification than the labor market opportunity cost one.

I then build a model that embeds these time-saving and opportunity cost mechanisms in an overlapping generations structure. In the model, electrification decreases the price of electricity, encouraging appliance use and reducing the time burden of childcare, but also increases female wages, raising the opportunity cost of childcare. I use my empirical estimates to discipline the parameters mediating these two channels. In order to generate the maternal status heterogeneity exploited in the empirical analysis, I introduce household-level heterogeneity in the relative value of female leisure, which in turn changes the relative cost of childcare and motherhood. In addition, in order to generate the regional heterogeneity in electricity prices exploited in the empirical analysis, I assume there are several regions in the model featuring different region-specific technologies for the production of electricity, matching the distribution of prices observed empirically. I further assume that these regions are split into sub-regions, which gain progressive access to electrification.

I calibrate the model to the first half of the 20th century United States, and use my empirical estimates to discipline the parameters mediating these two channels by computing analogous DDD estimates to the ones computed empirically in the context of the model. I simulate the expansion of the electricity grid from 1900–1940 in the United States, and find that my model can explain 4.6% of the decline in fertility in this period. This decline concentrates among young women as these do not have childcare responsibilities that dampen their labor market gains from electricity. This, in turn, changes the incentives for these women to have children after electrification, since the opportunity cost of spending time at home raising children instead of working will be higher. Once women become older and have children, however, fertility trajectories are less affected by electrification, since labor market gains are dampened due to both childcare requirements and the childcare time-savings gains from electrification. This matches the evidence presented in the empirical section suggesting that electrification reduces the fertility of women who were not mothers upon electrification more, and the evidence presented in Goldin (2020), who shows that at the turn of the 20th century, women's female labor force participation concentrated during their youth, and was significantly reduced once they married and became mothers. In addition, I find the opportunity cost channel is preponderant in explaining the response of fertility to electrification, while the time-savings channel plays a smaller role. This matches the empirical evidence, which suggests that the opportunity cost of channel was stronger than the time-savings channel: the decline in fertility induced by electrification by 1940 was considerably stronger for women who had a closer attachment to the labor market, while although electrification had a more marked effect in decreasing fertility for women who faced higher costs for operating appliances in their homes, this result was considerably weaker.[6]

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 fertility and electrification trends in the United States from 1900 to 1940, with a discussion of the importance of different channels in driving the connection between these two phenomena. Section 3 presents data and evidence on the link between electrification and fertility in the early 20th-century United States and, discusses the results of the effects of electrification used to calibrate the model. Section 4 presents the model, calibration and quantitative results. Section 5 concludes.

1 Related Literature

My paper relates to and contributes to multiple strands of literature. My theory features a joint work and fertility framework first formalized by Becker and Lewis (1973), and later explored and extended by several others (Galor and Weil (1996), Greenwood et al. (2005), Becker and Lewis (1973); Becker et al. (1990), De La Croix and Doepke (2003, 2004), Baudin et al. (2015), Doepke et al. (2013)). Within this framework, I embed two mechanisms specifically related to electrification: childcare time savings as first proposed by Greenwood et al. (2005), and relative increase in wages for women (Vidart (2023)). The model developed in Greenwood et al. (2005) features mechanisms similar to the ones presented here in order to explain the baby boom, and the secular decline in fertility that both preceded and succeeded it. In particular, their model and quantitative exercises explain the decline in fertility via the rise in market wages stemming from technological progress in the market sector, and

[6] This result is also consistent with the results found in Appendix C suggesting that overall women's fertility declined in response to electrification.

reconcile the baby boom through the childcare time-savings triggered by electrification and appliance use in the home sector. There are some key differences between this analysis and mine. First, in Greenwood et al. (2005), the direct quantitative role of electrification on the aforementioned mechanisms is not considered. In their model and quantitative assessment, these mechanisms emerge as a consequence of technological progress broadly defined: real wage growth stems from TFP growth in the past 200 years, and household-level productivity is assumed to have a growth burst starting in 1940. In contrast, my paper uses well-identified empirical estimates to discipline the parameters mediating the time-savings and opportunity costs dimensions of electrification, and links these channels to the decline in fertility occurring during the first half of the 20th century.

By exploring the impact of electrification on fertility, this paper also relates to the literature that empirically examines the links between electrification, fertility, (Bailey and Collins (2011), Lewis (2018)), and female outcomes more broadly (Dinkelman (2011), Lewis and Severnini (2017), Cavalcanti and Tavares (2008), Coen-Pirani et al. (2010)). My paper contributes to this literature in three key ways. First, my paper empirically distinguishes and disentangles the two theoretically opposing channels driving the link between electrification and fertility: the rise of time-saving appliances which reduce the time needed for child-rearing and encourage fertility, and the rise of female wages, which increase the opportunity cost of childcare and discourage fertility. This contrasts with most of the papers in this literature, which predominantly focus on the effects of appliance use on fertility or female outcomes. Second, my paper explores the impacts of early electrification efforts, and particularly those occurring in "Middle America," on fertility. Due to data availability, other papers predominantly focus on electrification efforts and consumer durable expansions that occurred many decades later. Finally, my paper approaches this issue from a macro perspective, quantitatively relating the empirical effect of electrification to the aggregate decline in fertility observed during the first half of the 20th century.

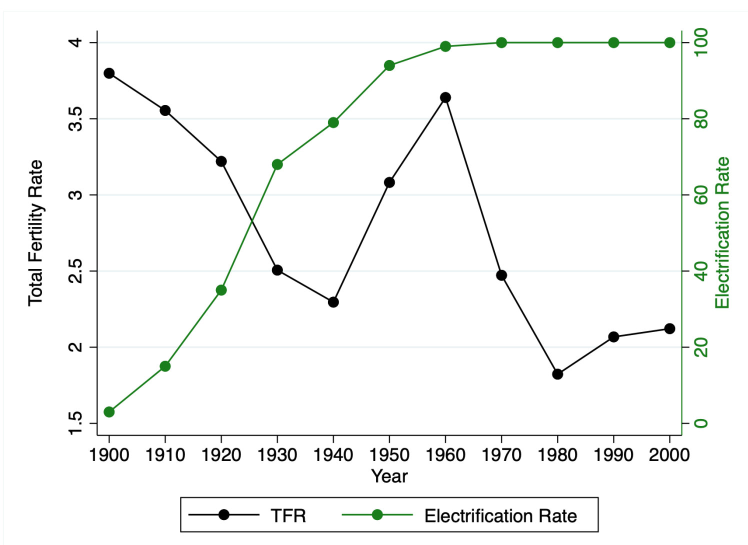
More broadly, my paper relates to the literature exploring the effects of technological change on fertility. This literature includes work examining the relationship between technological progress and changes in fertility and family structure from a macroeconomic perspective (see Greenwood et al. (2017) for a survey of this literature), and work exploring the impact of specific technologies on fertility from an applied perspective (see Lafortune et al. (2020) and Bailey and Hershbein (2018) for surveys). Some of the technologies shown to have an impact on fertility include the contraceptive pill (Goldin and Katz (2002), Bailey (2006), Knowles (2009)), medical advances (Albanesi and Olivetti (2016)), air conditioning (Barreca et al. (2018)), and broadband internet (Guldi and Herbst (2017)).

Finally my paper relates to studies investigating the sources driving the fertility trends observed in the United States during the 20th century (Bailey et al. (2012), Bellou and Cardia (2014), Albanesi and Olivetti (2016), Kitchens and Rodgers (2020), Greenwood et al. (2005), Doepke et al. (2013), Siegel (2017)).[7] By exploring the impact of electrification on the decline of fertility in the first half of the 20th century, my paper particularly relates to Kitchens and Rodgers (2020), who also explore the drivers behind this decline, and focus specifically on the role of increases in crop revenues triggered by World War I.

2 Context and Motivation: The decline of fertility in the first half of the 20th century

From 1900 to 1940, the total fertility rate in the United States declined sharply. At the beginning of the century, American women had an average of 3.8 children throughout their reproductive years. By 1940, this number had dropped to 2.3 (Haines (2006) and Census 1900).[8] From 1940 to 1960, during the baby boom, the total fertility rate rose again, reaching levels comparable to those of 1900. After the baby boom there was a countervailing baby bust that lasted until 1980. Fertility has increased slightly since, with the total fertility rate hovering around 2 children in 1990 and 2000.

Figure 2.1: Total Fertility Rate (TFR) and Electrification Rate in the United States



Source: Lebergott (1976) (Proportion of Electrified Households) and Haines (2006), combined with proportion of women by race from Census.[9]

During the first half of the 20th century, as fertility was declining, electrification spread

[7] See Bailey and Hershbein (2018) for a survey.

[8] This decline was prevalent among both black and white women, see Figure A.1.

widely in the United States, as evidenced in Figure 2.1. 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 mid-size towns and cities, driven by private-utility interests looking for new opportunities outside large cities. Rural America, however, lagged behind, with less than 10 percent of rural homes reporting having access to electricity in 1930 (Lewis (2018)). As a consequence, during the 1930s Franklin D. Roosevelt issued an executive order establishing the Rural Electrification Administration (REA) as part of the New Deal. The process of electrification of rural America lasted until 1960, by which virtually all households in America reported having access to electricity.

Figure 2.2: Electrical Appliance Adoption Rate, Female Labor Force Participation (LFP) and Female High School Completion Rate in 1900–1940

(a) Electrical Appliance Adoption Rate

(b) Female Labor Force Participation (LFP) Rate and Female High School Completion Rate

Sources: Lebergott (1976), Goldin (1977), and own calculations from census data.

Fertility and electrification have been linked via two main explanations. The first explanation highlights the role of childcare time savings triggered by appliance use and electricity. According to this view, electrification led to a rise in fertility by making home production and childcare less time intensive. This explanation is particularly relevant to 1900–1940, since sev-

[9]The fertility rate data provided by Haines (2006) is divided by race. I construct the nation-wide measure of fertility presented here by weighting the race-specific fertility rates with the proportion of 15–49 women of each race at each year.

eral key time-saving appliances were first patented and mass produced during this period,[10] leading to a consistent rise in adoption by American households captured in Figure 2.2a. The second explanation roots the link between electrification and fertility on the fact that the expansion of electricity increased the demand for labor, and fueled the creation of new work opportunities for women. According to this view, electricity increased the demand for skilled and semi-skilled labor (Gray (2013)), and thus led to the creation and expansion of clerical positions where brawn ability was not important and female labor was favored (Nye (1992), Vidart (2023)).[11] This in turn increased the opportunity cost of childrearing and depressed fertility. In Figure 2.2b, I show patterns consistent with this view by depicting the increase in female labor force participation and high school completion rate in 1900–1940. Female labor force participation rose from 20.6% in 1900 to 25.8% in 1940, while high school attainment also rose sharply, from 14.32% in 1900 to 31.1% by 1940. In this paper, I revisit the relationship between electrification and fertility by empirically disentangling these two channels, and then using these empirical estimates in a model of fertility to quantify the aggregate effect of electrification on fertility in 1900–1940 in the United States.

An important issue to note here is the availability of birth control during the period considered, and the agency women had to regulate their fertility. The practice of birth control was common throughout the United States even prior to 1914, when the movement to legalize contraception began. Longstanding techniques include the rhythm method, withdrawal, pessaries, condoms and diaphragms made from linens and animal skin, and prolonged breastfeeding. In the 1840's, condoms and diaphragms made from vulcanized rubber started being mass produced, and became common to regulate fertility. The Comstock laws, however, which were enacted in 1873, deterred the use of these by prohibiting advertisements, information, and distribution of birth control. In response, contraceptive trade was concealed but not eliminated. Advertisements for birth control used euphemisms such as "marital aids" or "hygienic devices", and drug stores continued to sell condoms as "rubber goods" and pessaries as "womb supporters" or "uterine elevators". (Engelman (2011)).

3 Empirical Evidence

I now present empirical evidence on the link between electrification and fertility that focuses on disentangling the opportunity cost and time-savings channels. I use data from the first

[10]Some of these appliances include the vacuum cleaner (patented in 1908), washing machine (patented in 1908), iron (patented in 1905), and refrigerator (patented in 1915). In Figure B.1, I include some examples of ads promoting these appliances at the time.

[11]In Figure B.2, I include two examples of the clerical positions opened and encouraged by electrification favoring women: switchboard operators and secretaries.

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 two triple difference (DDD) approaches, focusing respectively on the heterogeneity of the effects of electrification by maternal status and residential price of electricity, in order to explore the differential impact of electrification on the fertility of women who were more or less likely to be affected by the opportunity cost and time-savings channels of electrification, respectively.

I combine data from three sources. First, I use 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). Second, I use county-level electrification data in the 1910s built from a dataset with the universe of utilities and central generating stations in 1911 and 1919 (Vidart (2023)). Finally, I use data on the prices of residential electricity in the 1910s, using United States Department of Labor and Bureau of Labor Statistics (1992) which contains information from a survey on household-level expenditures and quantities purchased of a variety of goods and services in 100 cities throughout the United States in 1917–1919.

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 percent in 1910 to 35 percent 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)).[12] 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 the creation of new work opportunities for women,

[12] In 1910, roughly 23 percent of the United States 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 United States county-level population).

and increased the demand for labor. The higher demand for labor, and in particular clerical positions where brawn ability was not important, opened up new work opportunities for women (Nye (1992), Vidart (2023)). In addition, this electrification push and the mass commercialization of many domestic appliances fueled a revolution in the home. The proportion of households with each of these appliances increased considerably during the 1910s, rising from 0% in 1910, to 9% in 1920 for vacuum cleaners and from 0% in 1900 to 8% in 1920 for washing machines Lebergott (1976). These changes triggered massive social and economic change that permeated to the way the family was organized.

3.1 Electricity Data

I use county-level measures of electrification in the United States in the 1910s built from a dataset with the universe of central generating stations in 1911 and 1919 (Vidart (2023)). This historical dataset was constructed by digitizing two editions of "Central station directory: a complete list of electric light and power companies with data" (McGraw Publishing Company (1911, 1919)) which contain capacity and location information for 5409 and 5631 generators in 1911 and 1919, respectively. Using this location and generation capacity information, I construct measures of the capacity generated within and around each county in the United States.[13] 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.

Given historical constraints in transmission technology, this treatment definition approximates the change in the extent of electrification in each county during the 1910s.[14] Moreover, this measure captures the generation of smaller plants, which are important in this period and tend to be overlooked in other studies that only consider the output and location of large plants.[15] For details on these books, the digitization process, the construction of the electrification variables, the historical context of transmission and suitability of the county-level electrification measures, please see Vidart (2023).

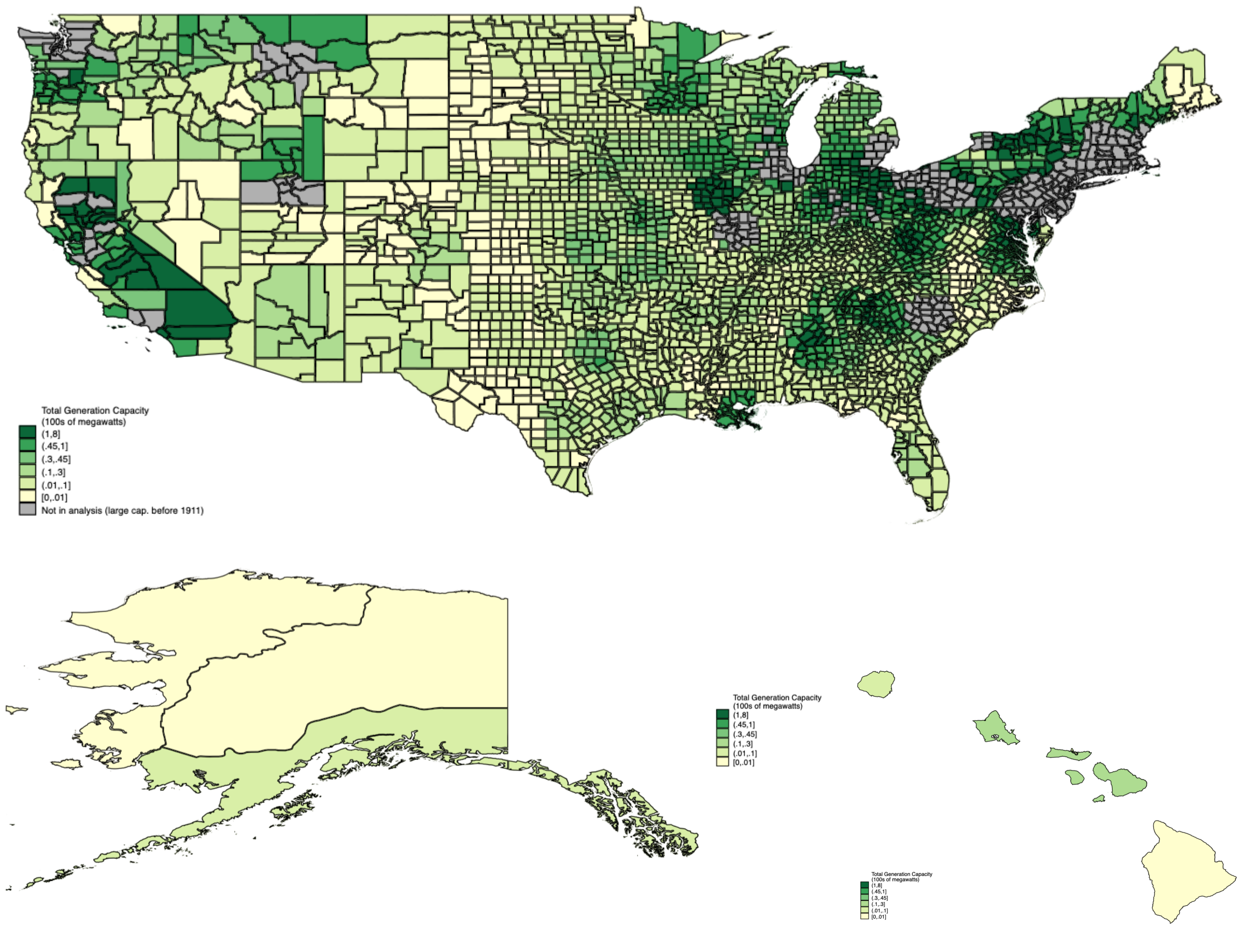
In Figure 3.1, I present county-level maps of the change in the total capacity within and 50 miles around county boundaries between 1911 and 1919 that follow from this electrification

[13] County 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).

[14] My 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.

[15] This measure also strongly correlates with measures of farm electrification available from the agricultural censuses in 1930 and 1940, which represent direct measures of area-level electrification. See Vidart (2023) for details.

Figure 3.1: Map of County-Level Intensity of Electrification Treatment in the United States



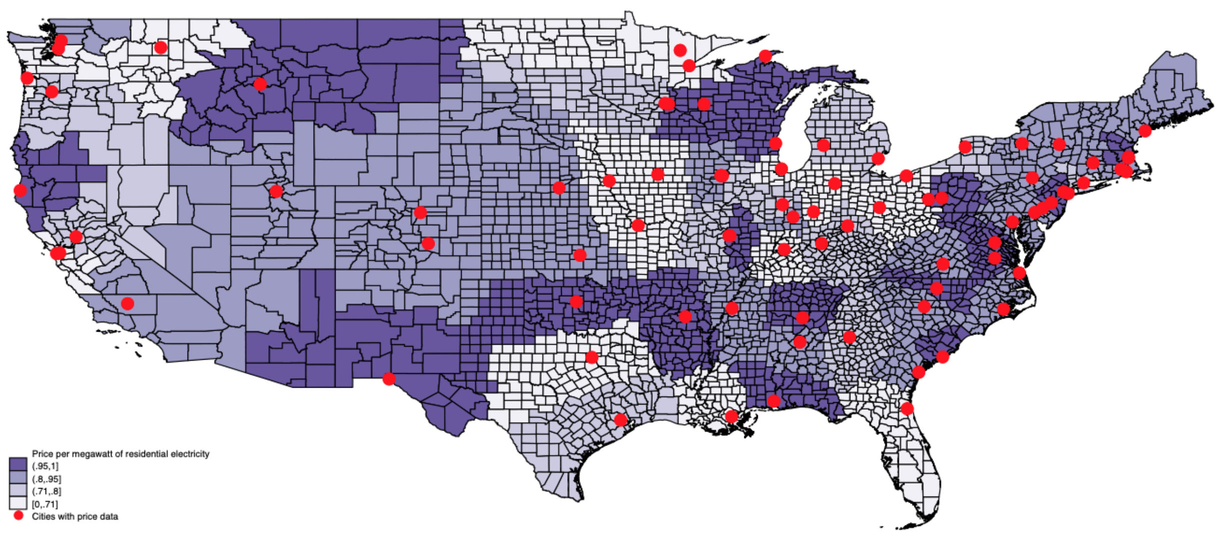
Notes: Electrical generation capacity within and 50 miles around each county.

data. In this treatment definition, I exclude counties that were already widely electrified before 1911 (above 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, however, encompasses most of the United States (in terms of both population and land mass), and has substantial regional variation.

3.2 Residential Electricity Price Data

I use data on the prices of residential electricity in 1917–1919 taken from a household expenditure survey put forward by United States Department of Labor and Bureau of Labor Statistics (1992). This survey aimed to estimate the cost of living of a "typical" American family in 1917–1919, and therefore collected information from families of wage earners or salaried workers in 100 cities across the United States. Specifically, the survey asked about family expenditures and quantities purchased of food, housing, clothing, fuel, furniture, and miscellaneous household items. I use information on the quantity and expenditure of electricity used for heating, cooking or lighting in the household, in order to construct an average measure of the price per kilowatt/hour of residential electricity in each city, and then attach to each county the price in the closest city in the survey, where distance is measured using the county-centroid as the point of reference. In Figure 3.2 I present county-level maps of the prices of residential electricity which denote the cities surveyed. In Table 3.1 I present some summary statistics on the residential electricity price data. For details on this survey and the construction of the residential price of electricity measures please see Appendix B.4.

Figure 3.2: Map of County-Level Residential Electricity Prices in the United States



Notes: Price per megawatt of residential electricity corresponding to that of the closest city in the price survey to the county centroid.

Table 3.1: Summary Statistics on the County-level Residential Electricity Price Data

	(1) Mean	(2) Std. Dev.	(3) Min.	(4) Max.
Price of mw/hour of residential electricity (dollars)	0.82	0.12	0.6	1
Share of total expenditure spent in electricity (for connected HHs)	0.01	0.002	0.006	0.015
Distance to closest city with price data (miles)	103.14	127.92	0.12	2433.72

3.3 Panel Data

I combine the electrification and residential electricity price 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. For details on the construction of this panel data, please see Appendix B.5.

Table 3.2: Summary Statistics in Panel and Repeated Cross-Section Data in 1910 (women of ages 15–44 living in areas that were not electrified in 1910)

	Panel Women	Repeated XSec Women
Avg. children born per woman	2.54	2.79
Avg. number of own children in HH per woman	1.71	1.40
Avg. number of own children $<$18 in HH per woman	1.65	1.32
Labor force participation	0.14	0.2
Prop. attending school	0.07	0.12
Prop. married	0.77	0.60
Prop. urban	0.34	0.37
Avg. socioeconomic index	4.35	5.46
Prop. white	0.94	0.86
Total obs.	551,431	13,064,666

In my analysis, I focus on individuals who were between 15 and 44 years old in 1910, and lived in areas that gained access to electricity during the 1910s using the data and treatment described above and depicted through non-grey areas in Figure 3.1. There are total of 551,431 women in the matched panel sample in this category. In Table 3.2 I report average values for select variables of interest in this panel sample, along with the full repeated cross-section data (encompassing all individuals in each census wave), for individuals in my cohorts and treatment areas of interest. I find that both groups are fairly similar along all dimensions considered, except for the proportion of married women and related female outcomes like fertility and school attendance. This follows from the fact that due to maiden-to-married name changes, women who were married in the the first census wave (1910) are overrepresented in my data. Since my main goal is to study fertility, this is not a significant drawback since most of fertility concentrates among married women. In Appendix B.2 I present this table for 1920–1940, characterized by broadly the same patterns.

3.4 Strategy and Identification

I focus on three fertility variables when studying the effects of electrification on fertility. The first variable corresponds to number of children ever born available in 1910 and 1940.[16] The

[16]This variable encompassed all ever-married age 12+ females in 1910, while only sample-line females in 1940, which reduced the number of observations with this data in 1940.

second and third variables, on the other hand, correspond to the number own children of all ages and under the age of 18, respectively, 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 lives women were most likely to have children living with them. By considering own children residing in the same household of both all ages and under the age of 18 I parse out the possibility of children living in the household longer due to electrification.

I perform two main analyses with my data. The first analysis estimates the effect of electrification working through the opportunity cost channel by following a triple difference strategy that computes the differential effect of electrification on the fertility of women who had one or more children in the baseline period of 1910, relative to those who had no children. Since mothers were much less likely to engage in the labor force due to cultural factors, childrearing responsibilities and other barriers, women who were already mothers upon electrification were less likely to take into consideration changes in female wages or labor opportunities when making their subsequent fertility decisions. This analysis is captured by the following specification

$$\begin{aligned} Fertility_{i,h,c,t} = \alpha + \beta_t \Delta Cap_c \times Post_t + \beta^{mom} \Delta Cap_c \times Mom1910_{i,h,c} \\ + \beta_t^{mom} Post_t \times Mom1910_{i,h,c} + \beta_t^{cap.mom} \Delta Cap_c \times Post_t \times Mom1910_{i,h,c} \\ + \alpha_i + \alpha_t + \alpha_c + \alpha_{s,t} + \beta_{X,t} X_{i,h,c,1910} \times Year_t + \beta_{Z,t} Z_{h,c,1910} \times Year_t + \epsilon_{i,h,c,t}, \end{aligned} \tag{1}$$

where $Fertility$ refers to each of the three fertility variables described above. i, h, c, and t denote the individual, cohort, county of residence, and year, respectively. ΔCap_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). $Post_t$ denotes a set of three binary variables indicating post-treatment periods after 1910: 1920, 1930, and 1940. $Mom1910$ corresponds to an indicator variable taking a value of one if the woman was a mother by 1910, and a value of zero if she was not. α_i, α_t, α_c, and $\alpha_{s,t}$ denote individual, year, county and state-by-year fixed effects, respectively. $X_{i,h,c,1910}$ denotes individual-level controls in 1910 (urban status, marital status, and school attendance), while $Z_{h,c,t}$ denotes cohort by county-level controls in 1910 (total population and socioeconomic index)[17]. Standard errors

[17] I 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

are clustered at the county-by-year level, since the coefficients of interest are derived from county (or treatment) and year interactions. My coefficients of interest in this case are $\beta_t^{cap.mom}$, which capture the heterogeneity in the effect of treatment by maternal status in 1910.

The second analysis also follows a triple difference strategy, which is used to estimate the effect of electrification working through the time-savings channel by computing the differential effect of electrification on the fertility of women who faced higher prices of residential electricity, relative to those who had lower prices. Since areas with a higher cost of residential electricity face a higher cost of operating time-saving appliances, women living in these areas are less affected by the time-savings dimension of electrification. This analysis is captured by the following specification

$$\begin{aligned} Fertility_{i,h,c,t} &= \alpha + \beta_t \Delta Cap_c \times Post_t + \beta^{price} \Delta Cap_c \times PriceResElect1919_c \\ +\beta_t^{price} Post_t &\times PriceResElect1919_c + \beta_t^{cap.price} \Delta Cap_c \times Post_t \times PriceResElect1919_c \\ &+\alpha_i + \alpha_t + \alpha_c + \alpha_{s,t} + \beta_{X,t} X_{i,h,c,1910} \times Year_t + \beta_{Z,t} Z_{h,c,1910} \times Year_t + \epsilon_{i,h,c,t}, \end{aligned} \quad (2)$$

where the notation follows Equation (1), and $PriceResElect1919$ corresponds to a continuous variable capturing the residential price of electricity in each county in 1917–1919, measured as dollars per megawatt/hour of electricity. My coefficients of interest in this case are $\beta_t^{cap.price}$, which capture the heterogeneity in the effect of treatment by the residential price of electricity in 1917–1919.

Identification relies on the assumption that absent changes in electrical generation capacity, individuals with the same maternal status in 1910 or residential price of electricity in 1917–1919 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 fertility 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 evidence supporting the identification assumptions and addressing these concerns.

omitted variables biasing the results might be relevant, in Appendix D.1 I repeat the analysis considering contemporaneous controls and find very similar results.

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 can be evidenced in Figure B.4, which shows that although most of the electrification during the 1910s focused on medium-sizes 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 B.4, I present the averages for individuals aged 15–44 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 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-difference 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 results are not driven by omitted characteristics.

To address the second concern, I examine the differential effects of the expansion in generation capacity in the 1910s by maternal status in 1910 and residential price of electricity in 1917-1919 in 1900 (pre-treatment period). In order to do this, I rely on a sub-sample of my panel sample composed of individuals I can also observe in 1900.[18] I focus on the three fertility outcomes described above for the results concerning the residential price of electricity, but since by construction, women who were not mothers in 1910 will have fertility outcomes of zero in both 1900 and 1910, focus instead on labor force participation for the results concerning maternal status in 1910 as this correlates with fertility decisions. I plot the results of these exercises in Figure B.5, documenting no significant labor force participation and fertility differences by maternal status in 1910 and residential price of electricity, respectively, among women living in areas that were electrified in the 1910s. These results suggest an absence of time-varying confounders in the pre-period driving the results presented below.

In addition, I show that the trends in fertility are parallel and more similar for cohorts who finished their fertility decisions prior to electrification in the 1910s among treated and control

[18]Since women who were between 15 and 24 are too young in 1900, I limit this analysis to women who were 25 and above in 1910. Due to differential death and marriage patterns, this subsample may suffer from selection issues. For summary statistics of this subsample in 1900 and 1910 see Table B.8. In addition, I do not use data from 1890 since census records from this wave were largely lost to fire.

areas, and began diverging afterwards for cohorts who still had scope in their fertility decisions. In Figure B.6, I plot the average number of children per woman reported in 1940 (the final period I consider) across different birth-year cohorts by intensity (quartile) of treatment. The graph shows that the differences in fertility rates across more- and less- treated counties are parallel for cohorts who were born prior to 1870, and thus past childbearing age in 1910 when electricity arrived. In addition, these differences appear to be more muted among these cohorts, indicated particularly by the similarity in the fertility rates reported by women in these older cohorts in the first and second quartiles of treatment. For cohorts born after 1870, the differences in fertility between the different quartiles of treatment, and particularly the first and second quartiles become much more marked, indicating an effect of electrification on fertility. These results further suggest that potential omitted characteristics are not driving the results.[19]

3.5 Results: Disentangling the Two Channels

In this section, I present the results from my two triple difference exercises, which aim to disentangle the two theoretically opposing channels driving the link between electrification and fertility: the rise of time-saving appliances which reduce the time needed for child-rearing and encourage fertility, and the rise of female labor opportunities and wages, which increase the opportunity cost of childcare and discourage fertility. To do this, I study the heterogeneity of the effects of electrification by maternal status and residential price of electricity, in order to explore the differential impact of electrification on the fertility of women who were more or less likely to be affected by the opportunity cost and time-savings channels of electrification, respectively.[20]

[19]Moreover, given that the bulk of my analysis relies on the heterogeneity in the effects of treatment across maternal status and residential electricity price groups, some of the concerns regarding identification are alleviated, because for bias to arise, women who were not mothers in 1910 need to be differentially different from women who were moms in 1910 in treatment and control counties, or women living in areas with higher residential price of electricity need to be differentially different from women with lower residential price of electricity in treatment and control counties.

[20]When I explore the effects of electrification on fertility *per se* in Appendix C, I find that electrification decreased overall fertility, consistent with the existence and predominance of the opportunity cost channel of electrification, per which electrification increased the opportunity cost of childcare due to increased female wages and new work opportunities. Nevertheless, when I decompose these effects by cohort, I find that electrification decreased the fertility of younger cohorts, but increased it for older cohorts. This is consistent with the results outlined in this section, where women who are more attached to the labor market, like younger women, the opportunity cost channel of electrification is particularly important, while for older women this mechanism is muted, and the reduced childcare channel may be more important.

3.5.1 The Differential Effect of Electrification by Maternal Status

I compute the differential effect of electrification on the fertility of women who had one or more children in the baseline period of 1910, relative to those who had no children. With this, I estimate the effect of electrification working through the opportunity cost channel since women who were already mothers upon electrification were less likely to take into consideration changes in female wages or labor opportunities when making their subsequent fertility decisions. I present the of this analysis on the number of children ever born, the number of own children in the household, and the number of own children under the age of 18 in the household in Table 3.3.

Table 3.3: Heterogeneity in the Effects of Electrification on Women's Fertility by Maternal Status in 1910

	No. of Children Born	No. of Own Children in HH	No. of Own Children <18 in HH
ΔCap×1920		-0.41***	-0.40***
		(0.038)	(0.038)
ΔCap×1930		-0.56***	-0.53***
		(0.043)	(0.040)
ΔCap×1940	-0.56***	-0.46***	-0.39***
	(0.12)	(0.040)	(0.038)
ΔCap×1920×Mom1910		0.30***	0.28***
		(0.036)	(0.032)
ΔCap×1930×Mom1910		0.57***	0.55***
		(0.042)	(0.036)
ΔCap×1940×Mom1910	0.18	0.59***	0.56***
	(0.13)	(0.040)	(0.035)
R^2	0.81	0.68	0.67
Year Fixed Effects	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes
County Fixed Effects	Yes	Yes	Yes
State x Year Fixed Effects	Yes	Yes	Yes
Demographic and socioecon. controls	Yes	Yes	Yes
Cluster	County x Year	County x Year	County x Year
N	30,364	2,081,809	2,081,809

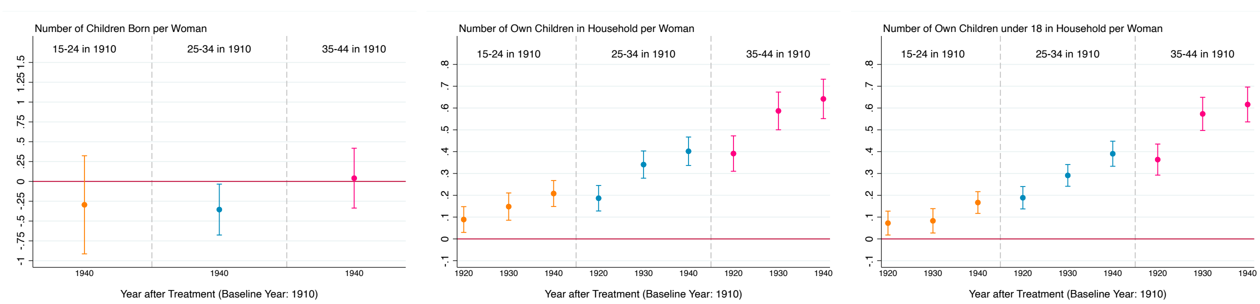
Notes: This specification corresponds to that of Equation (1). Some of the terms omitted due to length. The analyses encompass women in the panel sample who were 15–44 years of age in 1910. Clustered standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

I find that the decrease in fertility triggered by electrification is significantly smaller for women who were already mothers in 1910. In particular, the decrease in the number of children per woman triggered by electrification was 0.18 children lower among women who were already mothers in 1910. This effect is not statistically significant, however, driven partly by the small sample size we get when running this specification, which stems from the fact that the universe of women who were asked about number of children ever born was greatly reduced in 1940.[21] However, the decrease in both the overall and under 18 number of own children living in the household triggered by electrification was significantly lower for women who were mothers in 1910.

I then repeat these analyses splitting the sample across different cohorts. The results of this exercise are summarized in Figure 3.3. Overall, I find that the attenuation in the negative effect of electrification on fertility is especially large among older cohorts of women, who are even less likely to be attached to the labor market. For all women, but for older women in particular, there is a sharp difference in the effect of electrification on the number of children in the household by maternal status in 1910. For women who were mothers in 1910, electrification caused a much smaller decline, or in some cases an increase, in the number of children in the household. As evidenced in panel (c), these differential effects do not stem from a difference in the timing of adult children leaving the household, but rather correspond to differences in the number of own children under 18 living in the household.

Figure 3.3: Differential Effect of Electrification on Women's Fertility for Women who were Mothers in 1910 by Cohort

(a) No. of Children Born (b) No. of Own Children in HH (c) No. of Own Children <18 in HH



Notes: The coefficients plotted correspond to $\beta_t^{cap.mom}$ in Equation (1), estimated for each cohort separately. These coefficients capture the heterogeneity in difference-in-differences effects by maternal status for each of the post-treatment periods (1920, 1930, and 1940, with baseline 1910). The analyses encompass women in the panel sample who were 15–24, 25–34, and 35–44 years of age in 1910, respectively. 95% confidence intervals built from standard errors clustered at the county-by-year level are plotted.

In addition, I also consider these results when comparing mothers of a young child (specifically, women whose eldest child is under 1 year of age) to those who did not have children. With this, I further control for potential differences between mothers and non-mothers by comparing women who just became mothers recently to those who had not yet done so. Since

[21] The variable encompassed all ever-married age 12+ females in 1910, while only sample-line females in 1940, which reduced the number of observations with this data in 1940.

birth of the first child concentrates earlier in life, I focus on the youngest cohort (women between 15 and 24 years of age in 1910) for this analysis. I present the results of this exercise in Table B.9. The effects are similar to those at baseline, with a smaller decrease in fertility triggered by electrification for young women who were mothers of one child in 1910 relative to those who weren't. However, the moderating effects of motherhood effects are attenuated in this case, due to the fact that young mothers with only one child retain more attachment to the labor market relative to those with more children.

3.5.2 The Differential Effect of Electrification by Price of Residential Electricity

I compute the differential effect of electrification on the fertility of women who lived in areas with higher prices of residential electricity, relative to those who lived in areas with lower prices of residential electricity. With this, I estimate the effect of electrification working through the time-savings channel since women living in areas high electricity prices are less affected by the time-savings dimension of electrification. I present the results of this analysis on the number of children ever born, the number of own children in the household, and the number of own children under the age of 18 in the household in Table 3.4.

I find that the decrease in fertility triggered by electrification is consistently larger for women who lived in areas with a higher price of residential electricity. In particular, the number of children born per woman decreases by 0.74 more children in 1940 as a consequence of electrification when the price of one megawatt/hour of electricity is one dollar more expensive. However, and potentially partly due to the coarseness of the price of electricity measure, this effect is quite noisy and not statistically significant.[22,23] Nevertheless, when I restrict this analysis to counties that are not in the South, I find that the negative effect of residential electricity prices on fertility becomes larger and also statistically significant.[24] This suggests that in contrast to the rest of the country, the price of residential electricity and therefore the time-savings channel of electrification was not an important determinant of fertility in the South. This likely stems from the fact that this region followed a significantly different

[22] This matches evidence found by (Bailey and Collins (2011), who cast doubt on the time-savings dimension of electrification on fertility by showing that the Amish, a group that traditionally does not use electrical household appliances, also experienced a baby boom.

[23] One potential concern with these results is that areas with higher costs of residential electricity also faced higher costs of business electricity, thus potentially leading to differential female work effects that contaminate the effect of the time-savings dimension of electrification that we want to recover. In order to address this concern, I repeat specification Equation (2) restricting the sample to women who were already mothers upon electrification, and thus less likely to work or be affected by the business dimension of electrification. I present the results in Table B.10, and find results consistent with the ones above, where the decrease in fertility triggered by electrification is larger for women who lived in areas with a higher price of residential electricity, though not statistically significant.

[24] These results are presented in Table D.6.

path from the rest of the country. For instance, during this time, the South enacted Jim Crow laws disenfranchising African American citizens and thus greatly limited the economic opportunities available to a large swath of people in the region. The results suggest that these disparities and other potential idiosyncrasies of the South were more important than the price of residential electricity for the fertility patterns in this region.

Table 3.4: Heterogeneity in the Effects of Electrification on Women's Fertility by Residential Price of Electricity in 1917–1919

	No. of Children Born	No. of Own Children in HH	No. of Own Children <18 in HH
ΔCap×1920		0.033	0.081
		(0.23)	(0.25)
ΔCap×1930		0.040	0.11
		(0.23)	(0.24)
ΔCap×1940	0.16	0.010	0.16
	(0.60)	(0.23)	(0.24)
ΔCap×1920×PriceResElect1919		-0.31	-0.38
		(0.29)	(0.31)
ΔCap×1930×PriceResElect1919		-0.28	-0.35
		(0.30)	(0.30)
ΔCap×1940×PriceResElect1919	-0.74	-0.096	-0.24
	(0.78)	(0.29)	(0.29)
R^2	0.81	0.65	0.62
Year Fixed Effects	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes
County Fixed Effects	Yes	Yes	Yes
State x Year Fixed Effects	Yes	Yes	Yes
Demographic and socioecon. controls	Yes	Yes	Yes
Cluster	County x Year	County x Year	County x Year
N	30,364	2,081,809	2,081,809

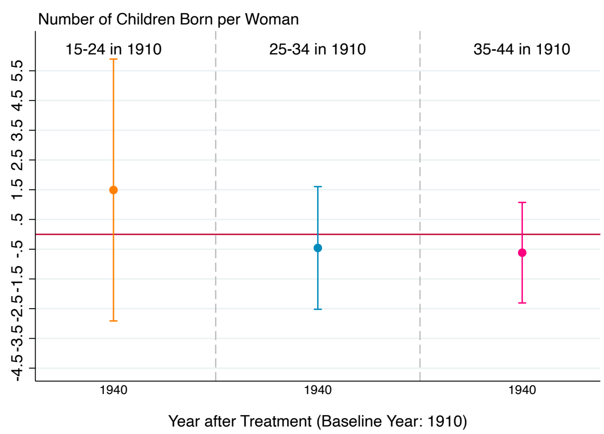
Notes: This specification corresponds to that of Equation (2). Some of the terms omitted due to length. The analyses encompass women in the panel sample who were 15–44 years of age in 1910. Clustered standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Moreover, when I decompose the effects on the number of children born per woman by cohort in Figure 3.4, I find that the boost in the negative effect of electrification on fertility driven by high prices of residential electricity is more marked among older cohorts of women.[25] This is related to the effect documented before, which suggested that women from the older cohorts who were mothers in 1910 experienced a larger attenuation of the negative effect of

[25] The effects on the two other fertility variables by cohort and price of residential electricity can be found in Figure B.7.

electrification on fertility. In particular, since older cohorts of women have a lower attachment to the labor market, the effects of electrification operating through the time-savings channel are more important and salient for this group, than the negative effects operating through the opportunity cost of the labor market channel.

Figure 3.4: Differential Effect of Electrification on Women's Fertility by Residential Price of Electricity in 1917–1919 and Cohort



Notes: The coefficients plotted correspond to $\beta_t^{cap.price}$ in Equation (2), estimated for each cohort separately. These coefficients capture the heterogeneity in difference-in-differences effects by price of residential electricity for each of the post-treatment periods (1920, 1930, and 1940, with baseline 1910). The analyses encompass women in the panel sample who were 15–24, 25–34, and 35–44 years of age in 1910, respectively. 95% confidence intervals built from standard errors clustered at the county-by-year level are plotted.

3.6 Discussion of Results

In the previous sections, I showed that electrification efforts put forward in the 1910s (1) decreased the fertility of women who were already mothers by 1910 less than those that were not, and (2) decreased the fertility of women living in areas where the price of residential electricity was higher more than those that lived in areas where this was cheaper, particularly in the North and for older women who had limited attachment to the labor market.

Taken jointly, these results hint at the existence of the two theoretical channels linking electrification and fertility. First, electrification triggers an opportunity cost channel, through which electrification raises female wages and makes childrearing relatively more costly. This channel is particularly important for women who are more likely to react to labor market shocks, such as non-mothers and younger cohorts. Second, electrification triggers a child-rearing time-saving appliance channel through which electrification and appliance use reduce the time cost of child-rearing, which is particularly important for women living in areas where using these appliances is cheaper, and for women for whom the labor market effects are less important. In Section 4, I use these results to discipline a quantitative model of the effects of electrification on fertility that encompasses the time-saving and opportunity cost channels of electrification in order to quantify the aggregate effects of electrification on fertility.

3.7 Robustness

In Appendix D I consider the robustness of my main results to different specifications, and find the same patterns. In particular, I consider robustness to: (1) using contemporaneous controls instead of baseline level controls; (2) clustering at the county level; (3) excluding counties in the South; (4) excluding counties in the West; (5) considering an alternate treatment definition based on the proximity to large electricity generating plants; and (6) limiting only to married women and controlling for spouses' socioeconomic status. The main results are qualitatively and quantitatively consistent across all specifications, though the effects of the price of residential electricity on fertility are slightly moderated when we include contemporaneous controls, and strongly reinforced when we limit the analysis to women who did not live in the South.

4 Model

I build a model that quantifies the effect of electrification on fertility in the first half of the 20th century. This model embeds the time-saving and opportunity cost channels of electrification in an overlapping generations model. In the model, electrification decreases the price of electricity, reducing the time burden of childcare, but also increases female wages, raising the opportunity cost of childcare. I discipline my model and in particular each of the two channels of interest using the results from the empirical analysis above.

The model economy is populated by a continuum of married couples whose adult life spans for $G + J$ periods, indexed from 1 to $G + J$. G denotes child-bearing years, whereas J denotes the remaining lifetime. Men work continuously for the $G + J$ periods, while women can choose in every period whether or not to participate in the labor market. Couples also decide how many children to have, and when to have them. Parents raise their children for I periods.

I assume there are several regions in the model, featuring different region-specific technologies for the production of electricity. In particular, I assume that each "region" has a different level of productivity for the post-electrification production of electricity. This will yield heterogeneity in the prices for electricity, and captures the fact exploited in the empirical analysis indicating that the resources available in the area (such as abundance of coal, or hydroelectric resources) shape the costs of electricity production after electrification. In the model, these regions and corresponding electricity prices will match the regions and prices documented in Section 3.5.2. Since in the empirical analysis these regions are large and encompass both electrified and non-electrified areas, I further assume that these regions are split into equally sized sub-regions, which have differential access to electrification.[26]

Tastes

The period utility function is given by

$$U = \log c + \sigma_l \left(0.5 \log l^f + 0.5 \log l^m\right) + \sigma_m \log(m+1) \quad \text{with} \quad \sigma_l, \sigma_m \; > 0.$$

c denotes consumption, l^f denotes female leisure, l^m denotes male leisure, and m denotes the number of young children.[27] σ_l denotes the value of female leisure relative to consumption, and σ_m denotes the value of children (taste for fertility) for the couple.

I incorporate preference heterogeneity in order to generate heterogeneous behavior in fertility and labor force participation. In particular, I assume the taste for leisure σ_l differs across couples and is drawn randomly at the beginning of the household's life from a Frechet distribution:[28]

$$\sigma_l \sim Frechet(\text{location of min.=0}, \text{scale=}\xi, \text{shape} = 1).$$

Fertility choice and time constraints

Men work continuously every period. The time endowment of women is allocated to work, leisure, and childcare obligations.[29] In particular, as in De La Croix and Doepke (2004) and Moav (2005), childrearing costs time. This time, in turn, depends on both the number of young children the couple has, and electricity purchases. The time constraints of women (f) and men (m) of age j at time t living in sub-region s are:

[26] In particular, I assume that different sub-regions get electrified at different points in time, and as such that the proportion of households within each region with access to lower prices of electricity, and higher electrification driven wages changes according to the nation-wide trends of electrification documented in Figure 2.1.

[27] An alternative here would be to have the total number of children (including adult) as determinants of utility. Ceteris paribus, doing this would only generate a change in the level of total fertility. As such, in order to reduce the dimensionality of the problem, I consider only young children here.

[28] I choose this since it can be specified to be bounded below by 0, by specifying a location parameter of 0.

[29] These childcare obligations reflect direct time dedicated to childrearing, such as feeding and bathing; but also indirect costs related to home production, such as increased time in doing dishes and cooking, among others. In addition, although men could share part of the time burden of childcare, child-rearing responsibilities have disproportionately fallen on women throughout history, and thus for simplicity, are modeled as corresponding solely to women.

$$n^m_{j,t,s} + l^m_{j,t,s} = 1 \quad n^m_{j,t,s} = \eta_m \forall j,t,s$$

and

$$l^f_{j,t,s} = 1 - \eta_f n^f_{j,t,s} - M_{j,t,s} - \kappa b_{j,t,s}.$$

$n^f_{j,t,s}$ and $n^m_{j,t,s}$ denote male and female labor supply respectively. $n^m_{j,t,s}$ is always equal to η_m, which denotes the time spent in work by men since these are continuously employed. $n^f_{j,t,s}$ can be either zero or one, and η_f denotes the time spent in work by women who work. $M_{j,t,s}$ denotes the time cost of caring for young children, while $b_{j,t,s}$ indicates the decision to have a baby at time t, and $\kappa \geq 0$ is the additional time cost of pregnancy and taking care of a baby.

Fecundity varies with age. The parameter f_j denotes the probability that an attempt to have a baby at age j will result in a live birth. Therefore, conditional on trying to conceive, the increase in the number of children for a couple of age j will be $b_{j,t,s}$ with probability f_j, and 0 with probability $1 - f_j$.[30]

I assume the time cost of childcare depends on both the number of young children, $m_{j,t,s}$, and electricity purchases, $E_{j,t,s}$ and can be written as:

$$M_{j,t,s} = \phi \left(m^y_{j,t,s}\right)^{\psi_m} \left(E_{j,t,s}\right)^{-\psi_E}$$

$\phi > 0$ is a parameter governing the level of the time cost of children, while $\psi_m, \psi_E > 0$ capture the curvature of the time cost of children to the number of young children and electricity purchases respectively.

Income and Consumption

Households purchase market goods and electricity using the combined male and female incomes. The household budget constraint, is therefore given by

$$c_{j,t,s} + p^E_{s,t} E_{j,t,s} = w^m_{s,t}\eta_m + w^f_{s,t}\eta_f n^f_{j,t,s}.$$

$w^m_{s,t}$ and $w^f_{s,t}$ capture the male and female wages available at time t in sub-region s, while $E_{j,t,s}$

[30]For simplicity, I assume that independent of whether the attempt to have a baby at age j results in a live birth, the couple must pay the time costs associated with childrearing of a young child: κ and $M_{j,t,s}$.

denotes the purchases of electricity of the household at $p^E_{s,t}$, the price available in sub-region s.

Production of Consumption Goods

Consumption goods are produced competitively in each sub-region using two production technologies, which employ male and female labor respectively. Both of these technologies follow a CES production function that combines electricity with male and female labor, respectively,

$$Y_{i,t,s} = A_i \left[\zeta_i E_{i,t,s}^{\frac{\gamma_i - 1}{\gamma_i}} + (1 - \zeta_i)\, L_{i,t,s}^{\frac{\gamma_i - 1}{\gamma_i}} \right]^{\frac{\gamma_i}{\gamma_i - 1}} \quad \text{for } i \in \{m, f\}.$$

$i \in \{m, f\}$, denotes the technologies using male and female labor respectively. L_f and L_m denote female and male labor, while E_f and E_m denote electricity purchases for both types of labor, and A_f and A_m denote the corresponding TFP terms. I allow for differences in the share of electricity ζ_i, and the elasticity of substitution between labor and electricity γ_i in the male and female production functions in order to capture potential differences in the complementarities between electrification and male and female labor, and thus in the effects of electrification on male and female wages. I assume that the goods produced by the male and female production technologies are perfect substitutes,[31] and thus total production is given by

$$Y_{s,t} = Y_{m,s,t} + Y_{f,s,t}.$$

4.1 Production of Electricity

Within each sub-region 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 conducted 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 in each sub-region s within region r therefore follows

[31] Although this is a simplification, it does not change the conclusions of my model since the female-bias of electricity yields a higher rise in the female wage than the male wage as long as they are not perfect complements. Moreover, with this I can focus on the trade-off between female and male decisions stemming from intra-household allocations and decision making.

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

where X denotes inputs in terms of the consumption good. $A_{E,L}$ denotes the pre-electrification productivity of electricity production, which is symmetric across sub-regions, while $A_{E,H,r}$ denotes the post-electrification productivity of electricity production, which is heterogeneous across regions. In Appendix E I present the aggregation and equilibrium results of the model.

4.2 What drives fertility?

Before turning to quantitative results, it is instructive to consider how fertility decisions are determined in the model. There are three basic driving forces for these decisions in the model. The first force stems from the fact that fecundity declines after women reach age 32.5, driving most women to have their babies before the probability of conceiving drops substantially. The second force implies however that delaying and/or reducing fertility may be optimal, because (1) more earnings can be generated (especially while young and the opportunity cost of time is still low), and (2) more income is available to purchase electricity and reduce the time-burden of existing children. The final force on the other hand, implies that increasing fertility may be optimal, because the time burden of childcare can be alleviated with electricity purchases. These forces interact with the heterogenous taste for leisure, the heterogenous price of electricity, and the time and opportunity costs of childrearing (which depend on electrification), to determine the total fertility and timing of childbearing.

To see these three forces in action, consider for exposition the case of a woman who does not anticipate re-entering the labor force after having children. The first tradeoff she faces concerns the timing of her first child, and follows from the opportunity cost of having to exit the labor force earlier, which depends on foregone wage income in this period. The value of that foregone wage income, depends on the female wage, but also the marginal utility of consumption, which itself depends on total household income, and therefore also male wages. The second tradeoff she faces concerns having more children after her first child, and follows solely from the increased time cost, and the possibility to reduce it via electricity purchases. The value of childcare time reductions depend on the idiosyncratic value of leisure, the scope of electricity to reduce childcare time, the price of electricity in the region, and the marginal utility of consumption, which itself depends on total household income. As such, in this model, the key determinants of fertility are: (1) women's relative wages (and particularly that of young women), (2) the price of electricity relative to wages, and (3) the idiosyncratic taste for leisure.[32]

The fertility implications of electrification in my model are therefore driven primarily by two factors mapping into the the first two key determinants of fertility explained above. The first factor concerns the impact of electrification on female wages relative to males wages. In the calibration, and motivated by previous work, female labor is more complementary to electricity inputs than male labor, leading female wages to increase more as a consequence of electrification. As illustrated above, this leads women to delay and/or reduce their fertility. This is the *opportunity cost* dimension of electrification on fertility. The second factor concerns the impact of electrification on the price of domestic electricity. In the calibration, electrification reduces the price of domestic electricity about five-fold, matching the increase in the productivity of new generation technologies relative to older ones. This leads women to hurry and/or increase their fertility. This is the *time-saving* dimension of electrification on fertility. We now assess the quantitative importance of each of these channels.

4.3 Calibration

I present the values of the calibrated parameters in Table 4.1. The first set of parameters are calibrated from the literature and historical context. The first calibration choice concerns the length of a model period. The main characteristic that defines a period in the model is that women can have one child per period. Although in theory this could correspond to nine months at a minimum, women at the time and also currently space their births out longer (Whelpton (1964)). The length of the model period should therefore correspond to the average time between births observed in the data. According to Whelpton (1964), and as highlighted by Doepke et al. (2013), the average spacing of births narrowed from over 3 years for the cohort of mothers born 1916–1920 to slightly above 2 years for the cohort 1931–35. I follow Doepke et al. (2013) in setting the model period to an intermediate value of 2.5 years. The duration of child-bearing period G is then set at 15, to capture the period between 15 and 50 years of age, while the duration of the post-childbearing period J is set to 6 to capture the period between 51 and 65 years of age. The duration of childhood I is set to 6, to capture the period between 0 and 15 years of age. Given that each period is 2.5 years long, I set the time discount factor β to 0.91.

[32] For women who would potentially re-enter the labor force after having children, the argument is slightly more complicated but still similar, with the difference that the relative female wage becomes important also at later stages of life, both due to increase earnings and the possibility of purchasing electricity to reduce the time burden of childcare for existing children.

Table 4.1: Model Parameters

Parameter	Value	Source
Literature and Context		
Length of Model Period	2.5 years	Doepke et al. (2013)
Duration of Childhood I	6	0-15 years of age
Duration of Childbearing Period G	15	15-50 years of age
Duration of Post-Childbearing Period J	6	51-65 years of age
Time spent working by men η_m	0.488	Male work hours in 1900[33]
Time spent working by employed women η_f	0.416	Female work hours in 1900[34]
Time cost of pregnancy/young child κ	0.0640	Differential time cost of young child
Fecundity of women < 32.5, f_j $j \leq 8$	1	Menken et al. (1986)
Fecundity of women $32.5 - 35$, f_9	0.99	Menken et al. (1986)
Fecundity of women $35 - 40$, f_{10}, f_{11}	0.9	Menken et al. (1986)
Fecundity of women $40 - 45$, f_{12}, f_{13}	0.62	Menken et al. (1986)
Fecundity of women $45 - 50$, f_{14}, f_{15}	0.14	Menken et al. (1986)
Level of Child Time Cost ϕ	0.1317	Time spent in childcare outside no. of children
Elasticity of Child Time Cost to No. Children ψ_m	0.55	Change in time spent in childcare to no. of children
Time Discount Factor β	0.91	Standard for 2.5 years per period
Share of electricity in male production ζ_m	0.153	Share of energy in male-dominated industries in 1939
Elasticity of subst. between male labor and electricity γ_m	0.15	Hassler et al. (2012)
Female TFP A_f		Gender wage gap in 1900
Regional electricity prod. after electrif. $A_{E,H,r}$	See Table F.4	Price from small generators vs. grid (IER(2019)) + Empirical Distribution of Prices
Method of Moments		
Electricity prod. before electrification $A_{E,L}$	0.9	Time spent in childcare in 1900
Relative value of children σ_m	0.3	Average fertility in 1900
Share of electricity in female production ζ_f	0.09	Female labor force participation in 1900
Scale parameter of relative value of leisure dist. ξ	1.2	Average female leisure in 1900
Elasticity of subst. between female labor and electricity γ_f	0.18	Empirical estimate of effect of electrification on fertility via opp. cost
Share of electricity in childcare time ψ_E	0.06	Empirical estimate of effect of electrification on fertility via time savings
Normalized		
Male TFP A_m	1	

η_m and η_f are calibrated using male and female labor hours among employed individuals in 1900, respectively (see Appendix F.1 for details). I choose the differential time cost of pregnancy and caring for a baby, κ, in order to match the increased time cost of caring for a child 0–5 years of age (see Appendix F.3 for details).[35] The fecundity parameters f_j,

[35] I choose children ages 0–5 as my benchmark, since this is the information available on the 1965 American

representing the probability of a live birth at every age are calibrated using information on female age-related fertility decline. I follow information presented on Menken et al. (1986), and assume fecundity is unimpaired up to age 32.5 ($f_j = 1$ $j \leq 8$), and begins declining afterwards. I set $f_9 = 0.99$ for ages 32.5–35, $f_{10} = f_{11} = 0.9$ for ages 35–40, $f_{12} = f_{13} = 0.62$ for ages 40–45, and $f_{14} = f_{15} = 0.14$ for ages 45–50.

I now turn my attention to the parameters in the child time cost function. I choose the level parameter ϕ, and curvature parameter on the number of children ψ_m, to match the ratio of time spent in childcare for women with different number of children in 1965 from the American Heritage Time Use Survey (see Appendix F.2 for details).[36]

Regarding production parameters, I choose the elasticity of substitution between electricity and male labor γ_m following the work of Hassler et al. (2012), who found that the short-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 considered is 2.5 years in my model, I take an intermediate value of 0.15. I choose the value of the share of electricity in male labor to match the share of energy fuels and electricity expenditures in male-dominated manufacturing industries (see Appendix F.4 for details). I normalize the TFP of male labor, A_m, and calibrate the TFP of female labor A_f to match the ratio of average male and female occupational scores in 1900. To compute these ratios, I use the occupation information available in the 1900 census, in conjunction with the Lasso-adjusted industry, 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 (see Appendix F.5 for details).

I set the number of regions in the model to 5, and choose the efficiency of electricity production after electrification in each region $A_{E,H,r}$, to match (1) 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);[37] and (2) the distribution of prices of electricity observed empirically and documented in Section 3.5.2 (see Appendix F.6 for details).

I choose the rest of parameters to minimize the distance between model and data moments.[38]

Heritage Time Use Survey.

[36]Although 1965 is later than my period of interest, Ramey and Francis (2009) documents that the time spent on childcare after controlling for number of children did not change almost at all throughout the 20th century after controlling for income, location, and the age of the children.

[37]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 power (Casazza (2004), Hunter and Lynwood (1991)).

[38]See Table F.5 for a comparison of the data and model moments targeted in the method of moments, along

In particular, I choose the values of the efficiency of electricity production prior to electrification, $A_{E,L}$, the relative value of children, σ_m, the share of electricity in female production, ζ_f, the scale parameter of the relative value of leisure distribution, ξ, the elasticity of substitution between female labor and electricity, γ_f, and the share of electricity in the time spent in childcare, ψ_E, to minimize the distance between the moments generated by the model and the following moments in the data: average time spent in childcare in 1900, average fertility in 1900, female labor force participation in 1900, average female leisure time in 1900, and the empirical estimates capturing (1) the effect of electrification on fertility via the work opportunity cost channel summarized in Section 3.5.1, and (2) the effect of electrification on fertility via the childcare time-savings channel illustrated summarized Section 3.5.2. The empirical estimate of the opportunity cost channel corresponds to the 1930 coefficient of the heterogenous effect of electrification on the number of own children in the household for women who were mothers in 1910. The empirical estimate of the time-savings channel is harder to pin-down, however, since this estimate is quite noisy in the empirical analysis, and not statistically different from zero at baseline. Given this, and also given other findings in the literature casting doubt on the impacts of time-saving appliances on fertility during my period of interest in the United States (Bailey and Collins (2011)), I choose the estimate of the time-savings channel to match the lower end of the 50% confidence interval of the 1930 coefficient of the heterogenous effect of electrification on the number of own children in the household in areas where residential electricity is one more dollar more expensive. In Section 4.5 I consider robustness to this choice by examining how the results of the model change when I vary the values of key parameters pinned down by these empirical estimates.[39]

4.4 Results

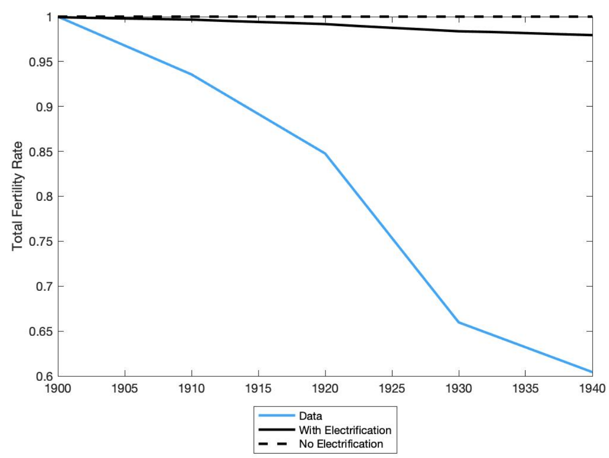
I now present the effects of the rollout of electricity from 1900 to 1940 on fertility and other variables predicted by the model and stemming from the joint impact of the opportunity cost and time-saving dimensions of electricity. I then present evidence comparing the effects of electrification across cohorts, in order to capture differences that arise from young women's enhanced ability to join the labor force to take advantage of the returns brought about by electrification. In Section 4.5, I examine the role of different parameters in shaping the aggregate decline in fertility stemming from my model. Finally, in Section 4.6 I subsequently shut down the opportunity cost and time-savings channels of electricity, and examine the counterfactual evolution of fertility in each case.

with further discussion of the source of the data moments.

[39] In order to solve the model, I discretize the value of leisure distribution into 10 bins, each containing, 10% of individuals according to the parametrized distribution.

In Figure 4.1 I contrast the effects of electrification on fertility predicted by the model and the data. I find that the model explains 4.63% of the aggregate decline in fertility in the 1900–1940 period. This decline is generated by the relative enhancement of market opportunities stemming from electrification, and the consequent rise in the opportunity cost of childcare.[40] However, this decline is moderated by two forces: the time-saving dimension of electrification, which reduces the time needed for childcare and therefore incentivizes women to have more children; and the fact that the opportunity cost effect of electrification is limited to women who are young and still attached to the labor market, and thus has a limited aggregate effect. In what follows, I further explore the importance of these age effects by examining the effects of electrification for women in different age groups through time.

Figure 4.1: Fertility: Model and Data



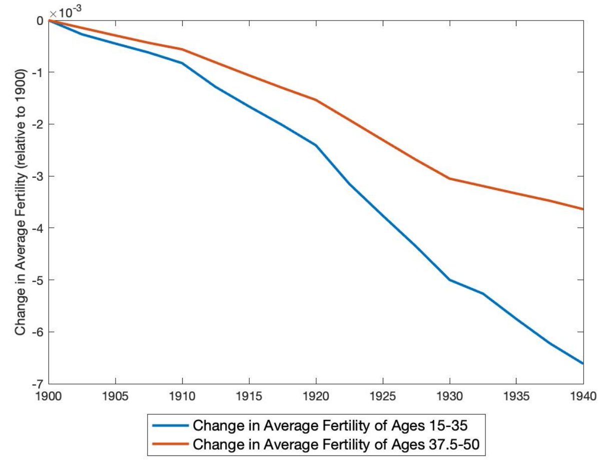
Data Source: Haines (2006), combined with proportion of women by race from Census. Normalized 1900=1.

In Figure 4.2, I plot the change in average fertility for young (15–35 years of age) and old (37.5–50 years of age) age groups in each period in the cases with and without electrification through time. This plot suggests that cross-cohort fertility declines concentrate during the initial periods of each cohort's life. In particular, cross-cohort fertility declines are considerably sharper among younger women relative to their older counterparts. This follows from the fact young childless women have fewer childcare responsibilities to attend to which could dampen their labor market gains from electricity. This, in turn, changes the incentives for these women to have children since due to electrification, the opportunity cost of spending time at home raising children instead of working will be higher. However, once women become older and have children, fertility trajectories vary less across cohorts, since labor market gains are dampened due to childcare requirements, and these requirements themselves are moderated due to the time-saving dimension of electricity.[41]

[40]For the effects on all female variables, see Figure G.1.

[41]Figure G.2 plots the paths of fertility and female LFP across the lifecycle of all cohorts born in 1900–1940.

Figure 4.2: Change in Fertility by Age



4.5 Discussion of Key Parameters and Sensitivity Results

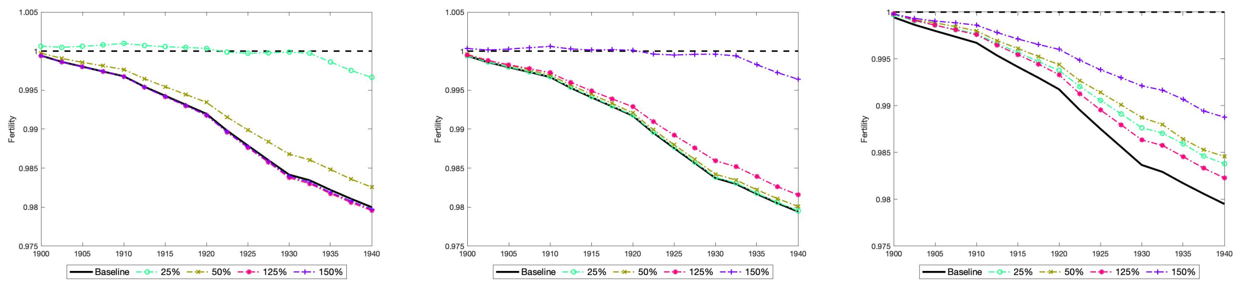
I now examine the role of different parameters in shaping the aggregate decline in fertility stemming from electrification. In order to highlight the importance of the time-savings and opportunity cost channels of electrification, I focus on the following parameters which mediate their strength: (1) the share of electricity in female production ζ_f, (2) the elasticity of substitution between electricity and female labor γ_f, and (3) the share of electricity in childcare time ψ_E. 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%, 75%, 125%, and 175% of the baseline value. I keep the rest of the parameter values fixed at the baseline calibration and examine how the evolution of fertility predicted by the model changes in each of these cases.

I plot the results for each of the parameters of interest in Figure 4.3. First, I find that lower values of the share of electricity in female production ζ_f, and lower complementarity between electricity and female labor captured by larger values of γ_f generally moderate the decline in fertility in my model. This stems from the fact that these parameters jointly determine the increase in female wages and thus the rise in the opportunity cost of children after electrification. In particular, γ_f and ζ_f jointly dictate by how much the demand for female labor increase after the rise in the demand for electricity. The fraction of the decline in fertility the model can explain decreases to about 0.226% when ζ_f is at 25% of its baseline value, and 0.234% when γ_f is at 175% of its baseline value.

In this plot, each line represents the life trajectory of a different cohort.

Figure 4.3: Fertility, Sensitivity to Parameters

(a) Sensitivity to ζ_f (b) Sensitivity to γ_f (c) Sensitivity to ψ_E



Data Source: Haines (2006), combined with proportion of women by race from Census. Normalized 1900=1.

Second, I find that both larger and lower shares of electricity in childcare time ψ_E, can decrease the decline in fertility in my model. This stems from the fact that ψ_E dictates the scope of electricity in reducing childcare time needs. If ψ_E is low, childcare needs are not very sensitive to electricity purchases, while if ψ_E is high, childcare needs will be very sensitive to electricity prices, which reduces the baseline level of fertility even prior to electrification. The fraction of the decline in fertility the model can explain decreases to about 3.65% when ψ_E is at 25% of its baseline value, and to 2.34% when ψ_E is at 175% of its baseline value.

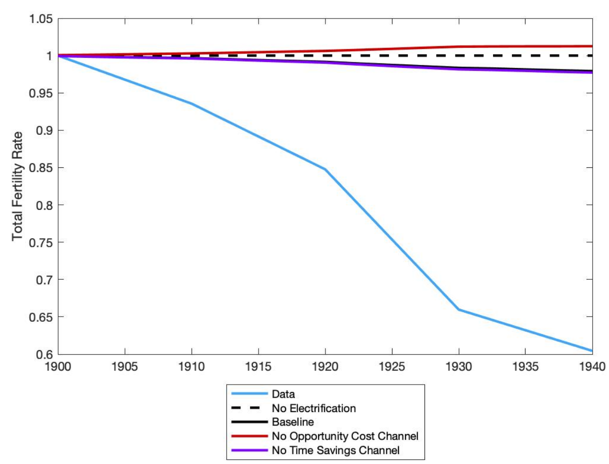
Taken jointly, these results suggest that the quantitative results are quite sensitive to the values of these parameters, and motivates the use of the well-identified empirical estimates of Section 3 to calibrate the model and quantify the importance of electrification on fertility.

4.6 Counterfactual Analysis: Role of Opportunity Cost and Time-Saving Dimensions of Electricity

To better assess the role of the opportunity cost and time-savings channels of electricity in explaining aggregate fertility trends, I now perform counterfactual analyses where I subsequently shut down each of the two channels, and examine how fertility evolves in each case. First, I set female wages to be fixed at the baseline level of 1890 in order to shut down the opportunity cost channel. Then, I set the price of residential electricity to be fixed at the baseline level of 1890 in order to shut down the time-savings channel.

I present the effects of electrification on fertility that follow from shutting down the opportunity cost and time-savings channels of electricity, respectively in Figure 4.4. I find that when the opportunity cost channel is shut off, fertility increases by 1.44% from 1900 to 1940. This is to be expected, since in this case electrification solely operates by reducing the price of using time-saving appliances in the household, thus moderating the time burden of childcare. In addition, I find that when the time-savings channel is shut off, the decline in fertility predicted by the model by 1940 is only 0.56 percentage points larger than in the baseline case. This implies that the opportunity cost channel is preponderant in explaining the response of fertility to electrification, while the time-savings channel plays a smaller role. This matches the empirical evidence, which suggested that the opportunity cost of channel was stronger than the time-savings channel: the decline in fertility induced by electrification by 1940 was considerably stronger for women who had a closer attachment to the labor market, while although electrification had a more marked effect in decreasing fertility for women who faced higher costs for operating appliances in their homes, this result was not very strong. In addition, this result is consistent with the results found in Appendix C suggesting that overall women's fertility declined in response to electrification.

Figure 4.4: Fertility, Counterfactual Analysis



Data Source: Haines (2006), combined with proportion of women by race from Census. Normalized 1900=1.

5 Conclusions

In this paper, I present empirical and theoretical evidence linking the decline in fertility observed during first half of the 20th century in the United States to the rollout of electricity occurring concurrently during this period. First, I empirically disentangled the two theoretically opposing channels driving the link between electrification and fertility: the rise of time-saving appliances which reduce the time needed for child-rearing and encourage fertility, and the rise of female wages, which increase the opportunity cost of childcare and discourage fertility. To do this, I combined an individual-level panel dataset built from the full-count 1910–1940 decennial census waves with measures of the electric capacity generated within each county in the United States during the 1910s and measures of residential electricity prices during this period. Using this data, I computed (1) the differential effect of electrification on the fertility of women who had one or more children in the baseline period of 1910 and thus were less attached to the labor force, relative to those who had no children, in order to pin down the effect of electrification working through the opportunity cost of labor; and (2) the differential effect of electrification on the fertility of women where the residential price of electricity was higher, in order to pin down the effect of electrification on fertility working through the time-savings of home production.

I then built a model that embedded the time-saving and opportunity cost mechanisms in an overlapping generations structure. In the model, electrification decreases the price of electricity, encouraging appliance use and reducing the time burden of childcare, but also increases female wages, raising the opportunity cost of childcare. I calibrate the model to the first half of the 20th century United States, and use my empirical estimates to discipline the parameters mediating these two channels. I simulate the expansion of the electricity grid from 1900–1940 in the United States, and find that my model can explain 4.6% of the decline in fertility in this period. This decline concentrates at the beginning of women's adult lives, matching the evidence presented in the empirical section suggesting that electrification reduces the fertility of women who were not mothers upon electrification, and the evidence presented in Goldin (2020), who shows that at the turn of the 20th century, women's female labor force participation concentrated when they were young, and was significantly reduced once they married and became mothers.

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 scope for electrification to change fertility patterns depends on the relative importance of the time-savings and opportunity cost channels of electrification, and thus crucially depends on the opportunities available for female labor, and the cost of operating and adopting time-saving appliances. Moreover, this paper suggests that although the time-saving dimension of electricity applies to both young and old women alike, the opportunity cost dimension concentrates among young women who have not yet had children or childcare responsibilities to attend to which could dampen their labor market gains from electricity. This suggests important cohort-level differences in the effects of electrification on fertility, and more broadly, significant cross-cohort differences in the effects of electricity on female empowerment.

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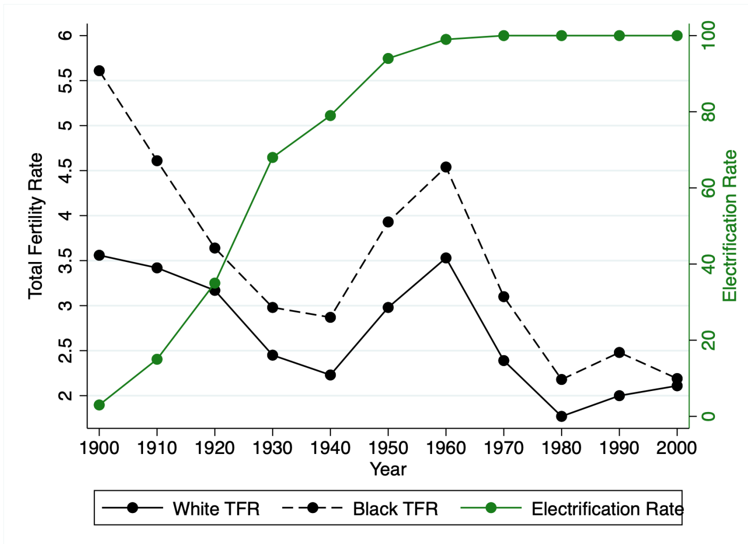
A Appendix: Context and Motivation

Figure A.1: Total Fertility Rate (TFR) and Electrification Rate in the United States



Source: Lebergott (1976) (Proportion of Electrified Households) and Haines (2006)

B Appendix: Data Construction and Empirical Strategy

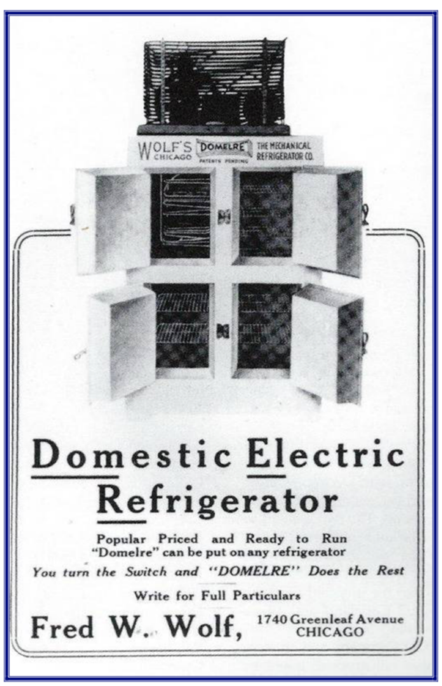
B.1 Context and Background

Figure B.1: Ads for Electric Appliances in the 1910s

(a) Ad for electric washing machine in 1910

(b) Ad for electric vacuum cleaner in 1915

(c) Ad for refrigerator in 1910



(d) Ad for electric iron in 1915

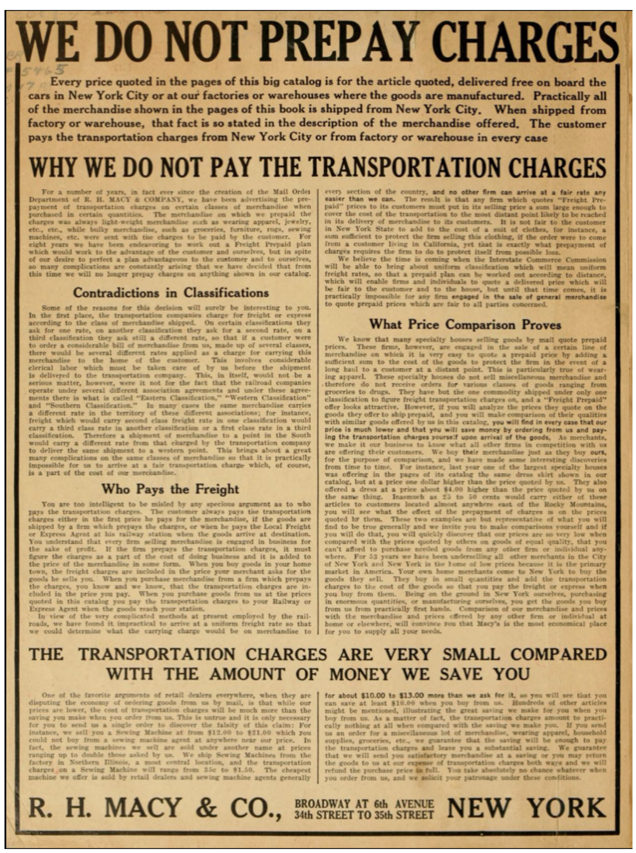
Figure B.2: Market Opportunities for Women in the First Half of the 20th Century

(a) Telephone switchboard operators in 1915

(b) Secretaries in the 1920s

Sources: Harris and Ewing, and Office Museum.

Figure B.3: Information on Shipping Costs from Macy's Catalog from 1911



WE DO NOT PREPAY CHARGES

Every price quoted in the pages of this big catalog is for the article quoted, delivered free on board the cars in New York City or at our factories or warehouses where the goods are manufactured. Practically all of the merchandise shown in the pages of this book is shipped from New York City. When shipped from factory or warehouse, that fact is so stated in the description of the merchandise offered. The customer pays the transportation charges from New York City or from factory or warehouse in every case

WHY WE DO NOT PAY THE TRANSPORTATION CHARGES

For a number of years, in fact ever since the creation of the Mail Order Department of R. H. MACY & COMPANY, we have been advertising the prepayment of transportation charges on certain classes of merchandise when purchased in certain quantities. The merchandise on which we prepaid the charges was always light-weight merchandise such as wearing apparel, jewelry, etc., etc., while bulky merchandise, such as groceries, furniture, rugs, sewing machines, etc. were sent with the charges to be paid by the customer. For eight years we have been endeavoring to work out a Freight Prepaid plan which would work to the advantage of the customer and ourselves, but in spite of our desire to perfect a plan advantageous to the customer and to ourselves, so many complications are constantly arising that we have decided that from this time we will no longer prepay charges on anything shown in our catalog.

Contradictions in Classifications

Some of the reasons for this decision will surely be interesting to you. In the first place, the transportation companies charge for freight or express according to the class of merchandise shipped. On certain classifications they ask for one rate, on another classification they ask for a second rate, on a third classification they ask still a different rate, so that if a customer were to order a considerable bill of merchandise from us, made up of several classes, there would be several different rates applied as a charge for carrying this merchandise to the home of the customer. This involves considerable clerical labor which must be taken care of by us before the shipment is delivered to the transportation company. This, in itself, would not be a serious matter, however, were it not for the fact that the railroad companies operate under several different association agreements and under these agreements there is what is called "Eastern Classification," "Western Classification" and "Southern Classification." In many cases the same merchandise carries a different rate in the territory of these different associations; for instance, freight which would carry second class freight rate in one classification would carry a third class rate in another classification or a first class rate in a third classification. Therefore a shipment of merchandise to a point in the South would carry a different rate from that charged by the transportation company to deliver the same shipment to a western point. This brings about a great many complications on the same classes of merchandise so that it is practically impossible for us to arrive at a fair transportation charge which, of course, is a part of the cost of our merchandise.

Who Pays the Freight

You are too intelligent to be misled by any specious argument as to who pays the transportation charges. The customer always pays the transportation charges either in the first price he pays for the merchandise, if the goods are shipped by a firm which prepays the charges, or when he pays the Local Freight or Express Agent at his railway station when the goods arrive at destination. You understand that every firm selling merchandise is engaged in business for the sake of profit. If the firm prepays the transportation charges, it must figure the charges as a part of the cost of doing business and it is added to the price of the merchandise in some form. When you buy goods in your home town, the freight charges are included in the price your merchant asks for the goods he sells you. When you purchase merchandise from a firm which prepays the charges, you know and we know, that the transportation charges are included in the price you pay. When you purchase goods from us at the prices quoted in this catalog you pay the transportation charges to your Railway or Express Agent when the goods reach your station.

In view of the very complicated methods at present employed by the railroads, we have found it impractical to arrive at a uniform freight rate so that we could determine what the carrying charge would be on merchandise to every section of the country, **and no other firm can arrive at a fair rate any easier than we can.** The result is that any firm which quotes "Freight Prepaid" prices to its customers must put in its selling price a sum large enough to cover the cost of the transportation to the most distant point likely to be reached in its delivery of merchandise to its customers. It is not fair to the customer in New York State to add to the cost of a suit of clothes, for instance, a sum sufficient to protect the firm selling this clothing, if the order were to come from a customer living in California, yet that is exactly what prepayment of charges requires the firm to do to protect itself from possible loss.

We believe the time is coming when the Interstate Commerce Commission will be able to bring about uniform classification which will mean uniform freight rates, so that a prepaid plan can be worked out according to distance, which will enable firms and individuals to quote a delivered price which will be fair to the customer and to the house, but until that time comes, it is practically impossible for any firm **engaged in the sale of general merchandise** to quote prepaid prices which are fair to all parties concerned.

What Price Comparison Proves

We know that many specialty houses selling goods by mail quote prepaid prices. These firms, however, are engaged in the sale of a certain line of merchandise on which it is very easy to quote a prepaid price by adding a sufficient sum to the cost of the goods to protect the firm in the event of a long haul to a customer at a distant point. This is particularly true of wearing apparel. These specialty houses do not sell miscellaneous merchandise and therefore do not receive orders for various classes of goods ranging from groceries to drugs. They have but the one commodity shipped under only one classification to figure freight transportation charges on, and a "Freight Prepaid" offer looks attractive. However, if you will analyze the prices they quote on the goods they offer to ship prepaid, and you will make comparison of their qualities with similar goods offered by us in this catalog, **you will find in every case that our price is much lower and that you will save money by ordering from us and paying the transportation charges yourself upon arrival of the goods.** As merchants, we make it our business to know what all other firms in competition with us are offering their customers. We buy **their** merchandise just as they buy **ours**, for the purpose of comparison, and we have made some interesting discoveries from time to time. For instance, last year one of the largest specialty houses was offering in the pages of its catalog the same dress skirt shown in our catalog, but at a price one dollar higher than the price quoted by us. They also offered a dress at a price about \$4.00 higher than the price quoted by us on the same thing. Inasmuch as 25 to 50 cents would carry either of these articles to customers located almost anywhere east of the Rocky Mountains, you will see what the effect of the prepayment of charges is on the prices quoted by them. These two examples are but representative of what you will find to be true generally and we invite you to make comparisons yourself and if you will do that, you will quickly discover that our prices are so very low when compared with the prices quoted by others on goods of equal quality, that you can't afford to purchase needed goods from any other firm or individual anywhere. For 53 years we have been underselling all other merchants in the City of New York and New York is the home of low prices because it is the primary market in America. Your own home merchants come to New York to buy the goods they sell. They buy in small quantities and add the transportation charges to the cost of the goods so that you pay the freight or express when you buy from them. Being on the ground in New York ourselves, purchasing in enormous quantities, or manufacturing ourselves, you get the goods you buy from us from practically first hands. Comparison of our merchandise and prices with the merchandise and prices offered by any other firm or individual at home or elsewhere, will convince you that Macy's is the most economical place for you to supply all your needs.

THE TRANSPORTATION CHARGES ARE VERY SMALL COMPARED WITH THE AMOUNT OF MONEY WE SAVE YOU

One of the favorite arguments of retail dealers everywhere, when they are disputing the economy of ordering goods from us by mail, is that while our prices are lower, the cost of transportation charges will be much more than the saving you make when you order from us. This is untrue and it is only necessary for you to send us a single order to discover the falsity of this claim: For instance, we sell you a Sewing Machine at from \$12.00 to \$21.00 which you could not buy from a sewing machine agent at anywhere near our price. In fact, the sewing machines we sell are sold under another name at prices ranging up to double those asked by us. We ship Sewing Machines from the factory in Northern Illinois, a most central location, and the transportation charges on a Sewing Machine will range from 35c to \$1.50. The cheapest machine we offer is sold by retail dealers and sewing machine agents generally **for about \$10.00 to \$13.00 more than we ask for it**, so you will see that you can save at least \$10.00 when you buy from us. Hundreds of other articles might be mentioned, illustrating the great saving we make for you when you buy from us. As a matter of fact, the transportation charges amount to practically nothing at all when compared with the saving we make you. If you send us an order for a miscellaneous lot of merchandise, wearing apparel, household supplies, groceries, etc., we guarantee that the saving will be enough to pay the transportation charges and leave you a substantial saving. We guarantee that we will send you satisfactory merchandise at a saving or you may return the goods to us at our expense of transportation charges both ways and we will refund the purchase price in full. You take absolutely no chance whatever when you order from us, and we solicit your patronage under these conditions.

R. H. MACY & CO., BROADWAY AT 6th AVENUE 34th STREET TO 35th STREET **NEW YORK**

Source: R.H. Macy and Co. (1911)

B.2 Summary Statistics in Panel and Repeated Cross-Section Data in 1920, 1930 and 1940

Table B.1: Summary Statistics in Panel and Repeated Cross-Section Data in 1920 (women of ages 15–44 in 1910 living in areas that were not electrified in 1910)

	Panel Women	Repeated XSec Women
Avg. number of own children in HH per woman	2.47	2.09
Avg. number of own children <18 in HH per woman	2.16	1.83
Labor force participation	0.11	0.17
Prop. attending school	0.01	0.01
Prop. married	0.84	0.79
Prop. urban	0.37	0.42
Avg. socioeconomic index	3.82	4.87
Prop. white	0.95	0.87

Table B.2: Summary statistics in Panel and Repeated Cross-Section Data in 1930 (women of ages 15–44 in 1910 living in areas that were not electrified in 1910)

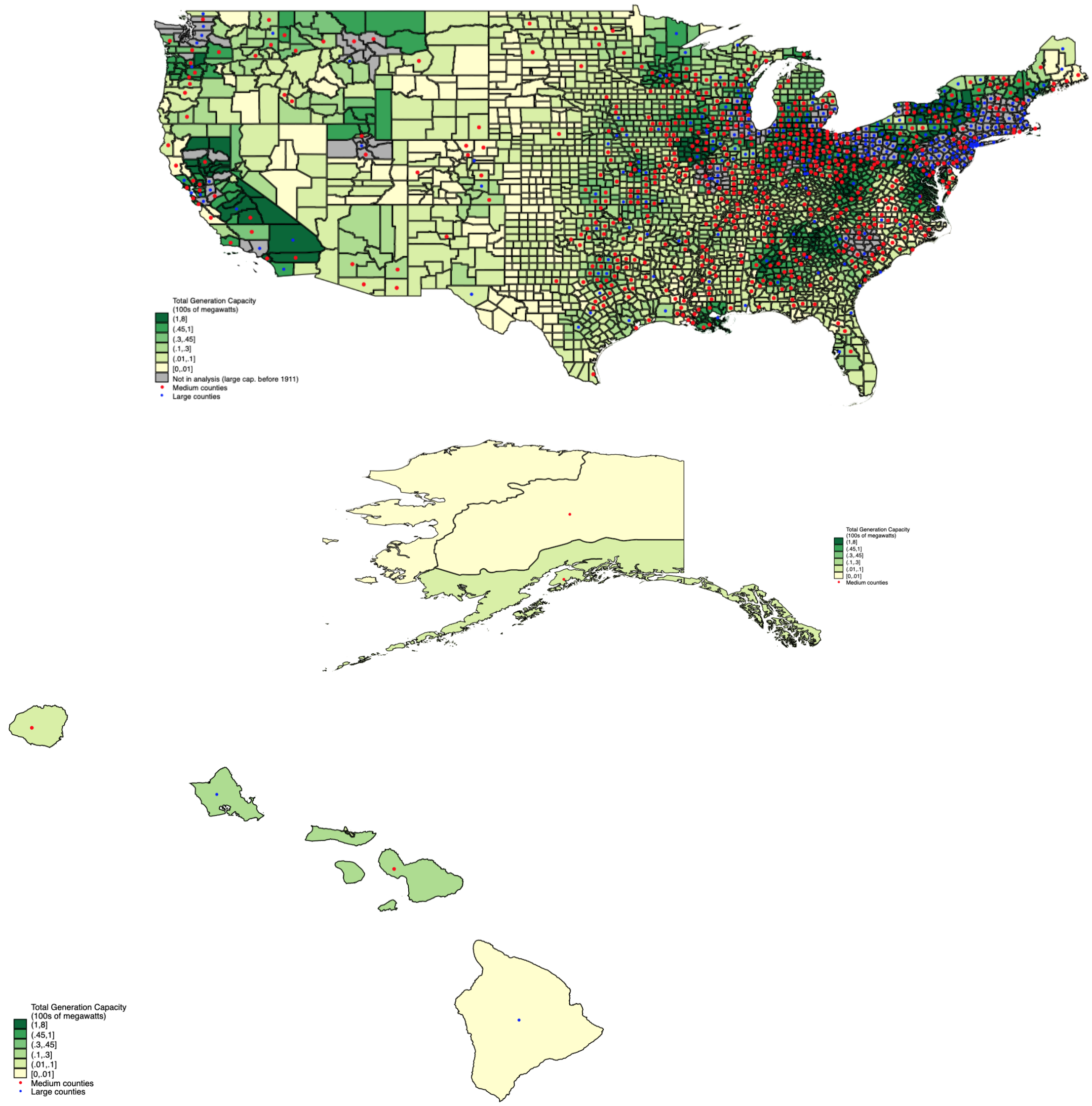
	Panel Women	Repeated XSec Women
Avg. number of own children in HH per woman	1.90	1.88
Avg. number of own children <18 in HH per woman	1.27	1.40
Labor force participation	0.14	0.17
Prop. attending school	0.01	0.01
Prop. married	0.78	0.77
Prop. urban	0.42	0.46
Avg. socioeconomic index	4.57	4.96
Prop. white	0.95	0.88

Table B.3: Summary statistics in Panel and Repeated Cross-Section Data in 1940 (women of ages 15–44 in 1910 living in areas that were not electrified in 1910)

	Panel Women	Repeated XSec Women
Avg. children born per woman	3.85	3.61
Avg. number of own children in HH per woman	1.00	1.14
Avg. number of own children <18 in HH per woman	0.34	0.51
Labor force participation	0.19	0.22
Prop. attending school	0.00	0.01
Prop. with comp. high school	0.18	0.19
Prop. married	0.65	0.66
Prop. urban	0.43	0.47
Avg. socioeconomic index	5.27	5.90
Prop. white	0.96	0.90

B.3 Identification

Figure B.4: Map of County-Level Intensity of Electrification Treatment and County Population in the United States



Notes: Electrical 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.

Table B.4: Averages in Above and Below Median Treatment Intensity Counties, and Previously Electrified Counties in 1910 (individuals of ages 15–44)

	Treat. $<$ 50%	Treat. $>$ 50%	Elect. pre-1911
Avg. children born per woman	3.05	2.64	2.49
Avg. no. of own children in HH per woman	1.56	1.30	1.12
Avg. no. of own children <18 in HH per woman	1.47	1.23	1.06
Male labor force participation	0.81	0.78	0.74
Female labor force participation	0.19	0.21	0.28
Prop. of men attending school	0.13	0.11	0.08
Prop. of women attending school	0.13	0.12	0.08
Prop. married	0.54	0.53	0.51
Prop. urban	0.22	0.43	0.77
Avg. socioeconomic index	10.51	11.87	13.88
Prop. white	0.81	0.89	0.96
Number of counties	1430	1229	287
Share of population	0.24	0.38	0.38

Table B.5: Averages in Above and Below Median Treatment Intensity Counties, and Previously Electrified Counties in 1920 (individuals of ages 15–44)

	Treat. $<$ 50%	Treat. $>$ 50%	Elect. pre-1911
Avg. no. of own children in HH per woman	1.54	1.32	1.19
Avg. no. of own children <18 in HH per woman	1.47	1.26	1.13
Male labor force participation	0.74	0.72	0.70
Female labor force participation	0.19	0.21	0.26
Prop. of men attending school	0.10	0.09	0.07
Prop. of women attending school	0.11	0.10	0.07
Prop. married	0.57	0.56	0.55
Prop. urban	0.26	0.48	0.80
Avg. socioeconomic index	10.10	11.82	14.60
Prop. white	0.81	0.89	0.95
Number of counties	1430	1229	287
Share of population	0.24	0.37	0.39

Table B.6: Averages in Above and Below Median Treatment Intensity Counties, and Previously Electrified Counties in 1930 (individuals of ages 15–44)

	Treat. < 50%	Treat. > 50%	Elect. pre-1911
Avg. no. of own children in HH per woman 1.42	1.27	1.12	
Avg. no. of own children <18 in HH per woman	1.35	1.20	1.05
Male labor force participation	0.76	0.72	0.69
Female labor force participation	0.21	0.23	0.28
Prop. of men attending school	0.13	0.13	0.12
Prop. of women attending school	0.13	0.13	0.11
Prop. married	0.57	0.57	0.56
Prop. urban	0.31	0.52	0.82
Avg. socioeconomic index	11.12	13.08	15.79
Prop. white	0.81	0.89	0.94
Number of counties	1427	1229	287
Share of population	0.23	0.35	0.42

Table B.7: Averages in Above and Below Median Treatment Intensity Counties, and Previously Electrified Counties in 1940 (individuals of ages 15–44)

	Treat. < 50%	Treat. > 50%	Elect. pre-1911
Avg. children born per woman	2.31	2.06	1.79
Avg. no. of own children in HH per woman	1.25	1.11	0.92
Avg. no. of own children <18 in HH per woman	1.18	1.04	0.85
Male labor force participation	0.83	0.82	0.83
Female labor force participation	0.30	0.33	0.39
Prop. of men attending school	0.13	0.14	0.14
Prop. of women attending school	0.12	0.12	0.12
Prop. married	0.59	0.58	0.55
Prop. urban	0.35	0.51	0.77
Avg. ocioeconomic index	13.25	15.50	18.67
Prop. white	0.82	0.90	0.94
Prop. men with comp. high school	0.22	0.28	0.31
Prop. women with comp. high school	0.28	0.34	0.34
Number of counties	1427	1227	287
Share of population	0.24	0.36	0.40

Table B.8: Summary Statistics in Pre-Treatment Sample in 1900 and 1910 (for women 24-44 years of age in 1910 living in areas that were not electrified in 1910)

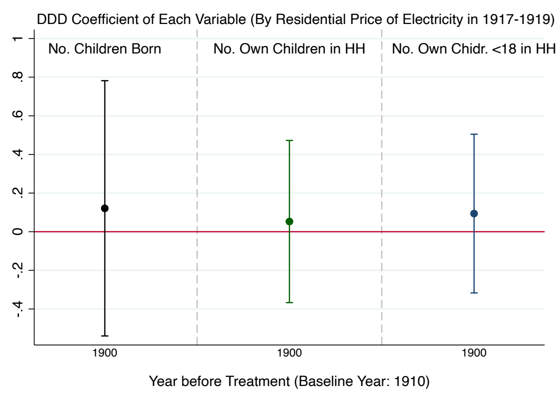
	1900	1910
Avg. children born per woman	2.17	3.44
Avg. number of own children in HH per woman	1.29	2.57
Avg. number of own children <18 in HH per woman	1.28	2.45
Labor force participation	0.11	0.13
Prop. attending school	‡	0.01
Prop. married	0.70	0.86
Prop. urban	0.27	0.33
Avg. socioeconomic index	3.03	4.04
Prop. white	0.94	0.95
Total obs.	185,067	

‡ The universe of people to whom the school attendance question was asked was significantly different in 1900 than other years, and as such not included here.

Figure B.5: Pre-Treatment Trends: Effects of Electrification by Maternal Status in 1910 and Residential Price of Electricity in 1917–1919 on Labor Force and Fertility Variables in 1900

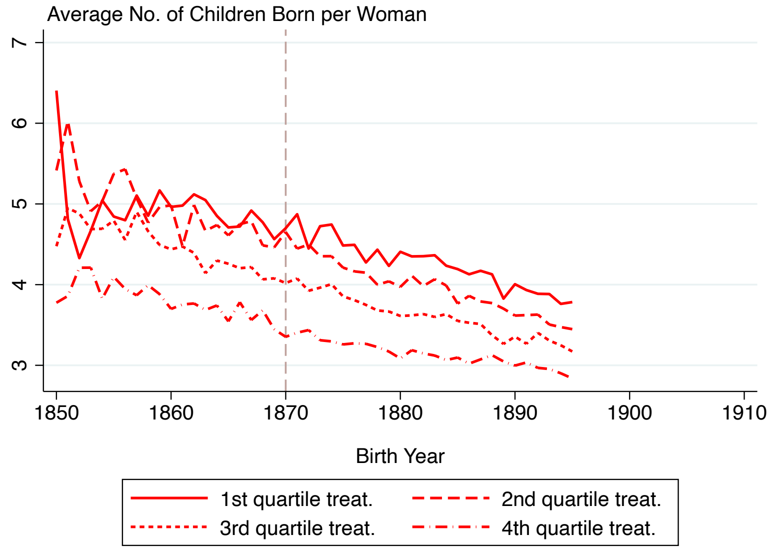
(a) By Maternal Status in 1910

(b) By Residential Price of Electricity in 1917–1919



Notes: The coefficients plotted in panels (a) and (b) correspond to $\beta_t^{cap.mom}$ and $\beta_t^{cap.price}$ in Equation (1) and Equation (2), respectively, but focusing in the 1900 and 1910 periods, and using female labor force participation as the outcome variable for panel (a). Details about the construction of this labor force variable can be found in Vidart (2023). These coefficients capture the heterogeneity in difference-in-differences effects by maternal status and price of residential electricity for each of the post-treatment periods (1920, 1930, and 1940, with baseline 1910). The analyses encompass women in the panel sample who were 25–44 years of age in 1910, and who also have information in 1900. 95% confidence intervals built from standard errors clustered at the county-by-year level are plotted.

Figure B.6: Women's Fertility in 1940 by Cohort and Treatment Intensity



B.4 Residential Electricity Price Data Constriction

In order to construct a county-level measure of the price per kilowatt/hour of residential electricity, I use data from United States Department of Labor and Bureau of Labor Statistics (1992) which contains information on household expenditures in 100 American cities in 1917–1919. I construct the price per kilowatt/hour of residential electricity for each household in the survey by taking the ratio between expenditure and quantity of electricity purchased.[42] I then winsorize these prices both at the state and national level in order to exclude extreme price values (above the 90th and below the 10th percentile). Then, I average the residential electricity prices across all cities surveyed, and exclude cities with information from fewer than 4 households. Finally, I attach to each county the price in the closest city in the survey, where distance is measured using the county-centroid as the point of reference.

An alternate approach here could potentially be to focus on the prices of appliances rather than the prices of electricity, given that the use of the former are the ones leading to time-savings in childcare. In theory this would be possible since the data described above does include expenditures and purchases of certain appliances, namely washing machines, vacuum cleaners and refrigerators. In practice, however this strategy presents a few key challenges. First, the proportion of households in the data who reported purchasing one of these appliances in 1917–1919 is extremely low (2.8% percent for washing machines, 5.1% for vacuum cleaners, and 6.7% for refrigerators). This is because unlike electricity, appliances are durable

[42] About 40% of households in the survey reported access to electricity, and had information on expenditures and quantities purchased.

goods which are purchased only once every several years, whereas electricity is purchased continuously. Second, the price of these appliances varies not only across space and time, but also by brand and model, making it difficult to establish an average or median price. Finally, the price of appliances directly correlates with the distance to the factory or retailer of the appliances. As an example, purchases done via mail order catalogs from large retailers such as Macy's or Sears had a set price for each appliance, but charged additional shipping costs (see Figure B.3 for an example of this in action from a Macy's catalog in 1911). Since the base prices were set and applicable nationwide, differences in prices across the country stem solely from the distance or time from factory to destination, which likely correlate with other factors that could muddle the analysis. Electricity prices, on the other hand, stem from the technology used to generate electricity. For example, areas with abundant hydroelectric resources can produce electricity cheaply after the initial fixed costs of dams are put forward.

B.5 Panel Data Construction

I build an individual-level panel dataset 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.

The total number of women in the matched panel sample in this category equal 796,584 which correspond to 3.77 percent of the population of women who were between 15 and 44 years of age in 1910. This number is in line with the results reported in the matching literature, which follow approximately 16 percent of native-born men from 1900 to both 1910 and 1920 (Abramitzky et al. (2014)). The number of women matched with this algorithm is somewhat lower, however, due to the maiden-to-married name changes that complicate the following of women who were single in 1910.

B.6 Additional Results on the Differential Effect of Electrification by Maternal Status

Table B.9: Heterogeneity in the Effects of Electrification on Women's Fertility by Maternal Status of Young Child in 1910 (for women 15–24 years of age in 1910)

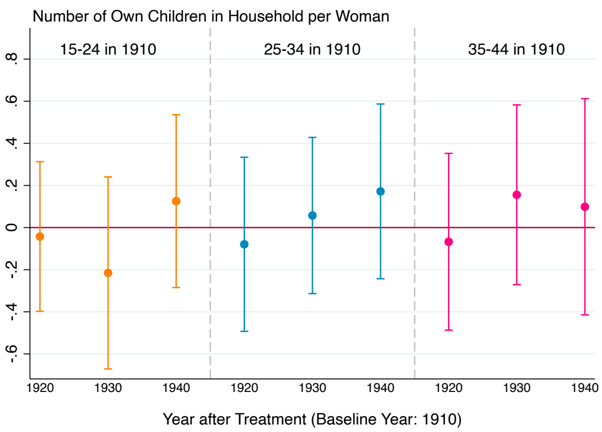
	No. of Children Born	No. of Own Children in HH	No. of Own Children <18 in HH
ΔCap×1920		-0.15***	-0.15***
		(0.024)	(0.023)
ΔCap×1930		-0.24***	-0.22***
		(0.031)	(0.031)
ΔCap×1940	-0.46*	-0.11***	-0.067***
	(0.28)	(0.023)	(0.025)
ΔCap×1920×MomYoungChild1910		0.067*	0.059
		(0.039)	(0.037)
ΔCap×1930×MomYoungChild1910		0.089*	0.001
		(0.047)	(0.046)
ΔCap×1940×MomYoungChild1910	-0.006	0.028	0.016
	(0.48)	(0.044)	(0.039)
R^2	0.79	0.70	0.68
Year Fixed Effects	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes
County Fixed Effects	Yes	Yes	Yes
State x Year Fixed Effects	Yes	Yes	Yes
Demographic and socioecon. controls	Yes	Yes	Yes
Cluster	County x Year	County x Year	County x Year
N	3,014	474,639	474,639

Notes: This specification corresponds to that of Equation (1), but where the variable for maternal status compares young mothers to non-mothers by assigning a one to women whose eldest child was under 1 year of age, and a 0 for women who did not have children. Some of the terms omitted due to length. The analyses encompass women in the panel sample who were 15–44 years of age in 1910. Clustered standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

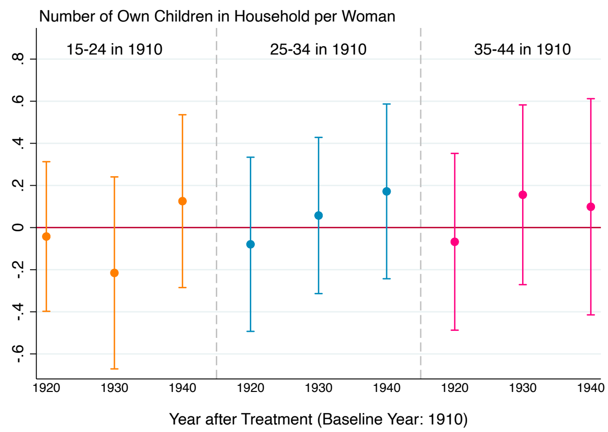
B.7 Additional Results on the Differential Effect of Electrification by Price of Residential Electricity

Figure B.7: Differential Effect of Electrification on Women's Fertility by Residential Price of Electricity in 1917–1919 and Cohort

(a) Number of Own Children in HH



(b) Number of Own Children < 18 in HH



Notes: The coefficients plotted correspond to $\beta_t^{cap.price}$ in Equation (2), estimated for each cohort separately. These coefficients capture the heterogeneity in difference-in-differences effects by price of residential electricity for each of the post-treatment periods (1920, 1930, and 1940, with baseline 1910). The analyses encompass women in the panel sample who were 15–24, 25–34, and 35–44 years of age in 1910, respectively. 95% confidence intervals built from standard errors clustered at the county-by-year level are plotted.

Table B.10: Heterogeneity in the Effects of Electrification on Women's Fertility by Prices of Residential Electricity in 1917–1919, for women who were mothers in 1910

	No. of Children Born	No. of Own Children in HH	No. of Own Children < Children <18 in HH
ΔCap×1920		-0.076	-0.014
		(0.24)	(0.26)
ΔCap×1930		-0.12	-0.024
		(0.24)	(0.24)
ΔCap×1940	0.37	-0.090	0.11
	(0.65)	(0.23)	(0.24)
ΔCap×1920×PriceResElect1919		-0.15	-0.25
		(0.31)	(0.33)
ΔCap×1930×PriceResElect1919		-0.039	-0.14
		(0.30)	(0.30)
ΔCap×1940×PriceResElect1919	-1.02	0.055	-0.14
	(0.84)	(0.29)	(0.30)
R^2	0.81	0.64	0.65
Year Fixed Effects	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes
County Fixed Effects	Yes	Yes	Yes
State x Year Fixed Effects	Yes	Yes	Yes
Demographic and socioecon. controls	Yes	Yes	Yes
Cluster	County x Year	County x Year	County x Year
N	23,922	1,333,151	1,333,151

Notes: This specification corresponds to that of Equation (2). Some of the terms omitted due to length. The analyses encompass women in the panel sample who were 15–44 years of age and mothers in 1910. Clustered standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.[43]

[43]Due to the significant reduction in sample size, I only present results for the number of children in the household, and number of children under 18 in the household.

C Overall Effect of Electrification on Fertility

In this section I present the results on the effect of electrification on number of children ever born and the number of own children in the household. These results are suggestive of the overall effect of electrification on fertility. To this end, I estimate the following regression

$$Fertility_{i,h,c,t} = \alpha + \beta_t \Delta Cap_c \times Post_t + \alpha_i + \alpha_t + \alpha_c + \alpha_{s,t} + \beta_{X,t} X_{i,h,c,1910} \times Year_t + \beta_{Z,t} Z_{h,c,1910} \times Year_t + \epsilon_{i,h,c,t}, \quad \text{(C.1)}$$

which follows the notation from Equation (1).

I present the results from this exercise in Table C.1. I find that an increase in 100mw of generating capacity reduced completed lifetime fertility by 0.43 children for women in 1940 relative to 1910. In addition, I find that an increase in 100mw of generating capacity reduced the number of own children in the household, both overall and for those under the age of 18. These results are consistent with the existence and predominance of the opportunity cost channel of electrification, per which electrification increased the opportunity cost of childcare due to increased female wages and new work opportunities.

Table C.1: Effects of Electrification on Women's Fertility

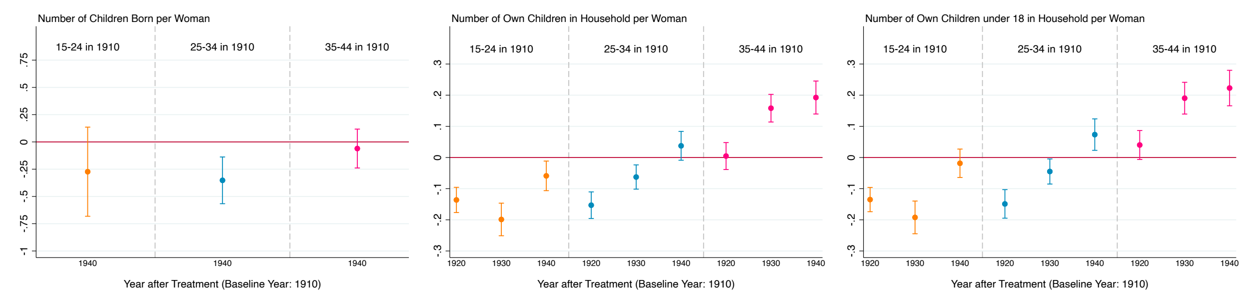
	No. of Children Born	No. of Own Children in HH	No. of Own Children <18 in HH
ΔCap×1920		-0.21***	-0.21***
		(0.029)	(0.032)
ΔCap×1930		-0.18***	-0.16***
		(0.030)	(0.032)
ΔCap×1940	-0.43***	-0.059**	-0.014
	(0.075)	(0.030)	(0.032)
R^2	0.81	0.65	0.62
Year Fixed Effects	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes
County Fixed Effects	Yes	Yes	Yes
State x Year Fixed Effects	Yes	Yes	Yes
Demographic and socioecon. controls	Yes	Yes	Yes
Cluster	County x Year	County x Year	County x Year
N	30,364	2,081,809	2,081,809

This specification corresponds to that of Equation (C.1). Some of the terms omitted due to length. The analyses encompass women in the panel sample who were 15–44 years of age in 1910. Clustered standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

I then repeat these analyses splitting the sample across different cohorts, and find interesting differences. The results for this exercise are summarized in Figure C.1. First, I find that electrification reduced the fertility of women who were younger in 1910. In addition, the results for the number of children in the household suggest the timing of fertility was also altered for these cohorts, since the decline in these variables for the two younger cohorts was particularly marked in 1920 and 1930, and less in 1940, suggesting young women in electrified areas waited to have children.

Figure C.1: Effect of Electrification on Women's Fertility by Cohort

(a) No. of Children Born (b) No. of Children in HH (c) No. of Children <18 in HH



Notes: The coefficients plotted correspond to β_t in Equation (C.1), 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 15–24, 25–34, and 35–44 years of age in 1910, respectively. 95% confidence intervals built from standard errors clustered at the county-by-year level are plotted.

In contrast, for older cohorts, the results suggest an increase in the number of own children living in the same household in latter years. These patterns match those found when we look at the effects on the number of own children under the age of 18 in the household, and suggest that electrification induced these older cohorts to have children. This suggests that for women who are more attached to the labor market, like younger women, the opportunity cost channel of electrification is particularly important, while for older women this mechanism is muted, and the reduced childcare channel may be more important.

D Appendix: Robustness of Main Empirical Results

I now repeat the main results in the empirical section presented in Table 3.3 and Table 3.4 using the following alternate specifications: (1) using contemporaneous controls instead of baseline level controls; (2) clustering at the county level; (3) excluding counties in the South; (4) excluding counties in the West; (5) considering an alternate treatment definition based on the proximity to large electricity-generating plants; and (6) limiting only to married women and controlling for spouses' socioeconomic status.[44]

D.1 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 two main analyses considering contemporaneous levels of controls in addition to fixed effects. I estimate the following regressions:

$$\begin{aligned} Fertility_{i,h,c,t} &= \alpha + \beta_t \Delta Cap_c \times Post_t + \beta^{mom} \Delta Cap_c \times Mom1910_{i,h,c} \\ &+ \beta_t^{mom} Post_t \times Mom1910_{i,h,c} + \beta_t^{cap.mom} \Delta Cap_c \times Post_t \times Mom1910_{i,h,c} \\ &+ \alpha_i + \alpha_t + \alpha_c + \alpha_{s,t} + \beta_{X,t} X_{i,h,c,t} + \beta_{Z,t} Z_{h,c,t} + \epsilon_{i,h,c,t} \end{aligned} \tag{D.1}$$

$$\begin{aligned} Fertility_{i,h,c,t} &= \alpha + \beta_t \Delta Cap_c \times Post_t + \beta^{price} \Delta Cap_c \times PriceResElect1919_c \\ &+ \beta_t^{price} Post_t \times PriceResElect1919_c + \beta_t^{cap.price} \Delta Cap_c \times Post_t \times PriceResElect1919_c \\ &+ \alpha_i + \alpha_t + \alpha_c + \alpha_{s,t} + \beta_{X,t} X_{i,h,c,t} + \beta_{Z,t} Z_{h,c,t} + \epsilon_{i,h,c,t}, \end{aligned} \tag{D.2}$$

where the notation follows from Equation (1) and Equation (2), respectively, and standard errors are clustered at the county-by-year level.

The results of these analyses are presented in Table D.1 and Table D.2. I find that these results are qualitatively and quantitatively similar to the baseline results, with one difference: in this specification, increasing the price of residential electricity does not accelerate the decline in fertility induced by electrification. This likely stems from the fact that this specification includes concurrent county socioeconomic indices, and thus controls for the fact that electrification also changes incomes. In particular, this suggests that an important part

[44] For these exercises, and in the interest of space, I only show the results of the triple difference coefficients.

of the effect of electricity prices on fertility follows from the fact that in places where the price of electricity is higher, the productive and household income gains are smaller, and therefore these prices are more relevant to household decisions.

Table D.1: Heterogeneity in the Effects of Electrification on Women's Fertility by Maternal Status in 1910 (with contemporaneous controls)

	No. of Children Born	No. of Own Children in HH	No. of Own Children <18 in HH
ΔCap×1920×Mom1910		0.25***	0.23***
		(0.034)	(0.030)
ΔCap×1930×Mom1910		0.54***	0.52***
		(0.040)	(0.034)
ΔCap×1940×Mom1910	0.16	0.55***	0.52***
	(0.13)	(0.037)	(0.034)
R^2	0.81	0.69	0.67
Year Fixed Effects	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes
County Fixed Effects	Yes	Yes	Yes
State x Year Fixed Effects	Yes	Yes	Yes
Demographic and socioecon. controls	Yes	Yes	Yes
Cluster	County x Year	County x Year	County x Year
N	30,364	2,081,809	2,081,809

Notes: This specification corresponds to that of Equation (D.1). Some of the terms omitted due to length. The analyses encompass women in the panel sample who were 15–44 years of age in 1910. Clustered standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table D.2: Heterogeneity in the Effects of Electrification on Women's Fertility by Residential Price of Electricity in 1917–1919 (with contemporaneous controls)

	No. of Children Born	No. of Own Children in HH	No. of Own Children <18 in HH
ΔCap×1920×PriceResElect1919		0.048	0.049
		(0.19)	(0.18)
ΔCap×1930×PriceResElect1919		0.20	0.19
		(0.13)	(0.12)
ΔCap×1940×PriceResElect1919	-0.27	0.38*	0.27
	(0.79)	(0.22)	(0.23)
R^2	0.81	0.62	0.57
Year Fixed Effects	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes
County Fixed Effects	Yes	Yes	Yes
State x Year Fixed Effects	Yes	Yes	Yes
Demographic and socioecon. controls	Yes	Yes	Yes
Cluster	County x Year	County x Year	County x Year
N	30,364	2,081,809	2,081,809

Notes: This specification corresponds to that of Equation (D.2). Some of the terms omitted due to length. The analyses encompass women in the panel sample who were 15–44 years of age in 1910. Clustered standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

D.2 Alternate Clustering

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

The results of these analyses are presented in Table D.3 and Table D.4. Though the standard errors are slightly larger as a result of a more conservative level of clustering, the significance of the results is unaltered relative to the baseline case.

Table D.3: Heterogeneity in the Effects of Electrification on Women's Fertility by Maternal Status in 1910 (with alternate clustering)

	No. of Children Born	No. of Own Children in HH	No. of Own Children <18 in HH
ΔCap×1920×Mom1910		0.30***	0.28***
		(0.034)	(0.031)
ΔCap×1930×Mom1910		0.57***	0.55***
		(0.059)	(0.049)
ΔCap×1940×Mom1910	0.18	0.59***	0.56***
	(0.16)	(0.056)	(0.048)
R^2	0.82	0.68	0.67
Year Fixed Effects	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes
County Fixed Effects	Yes	Yes	Yes
State x Year Fixed Effects	Yes	Yes	Yes
Demographic and socioecon. controls	Yes	Yes	Yes
Cluster	County	County	County
N	30,364	2,081,809	2,081,809

Notes: This specification corresponds to that of Equation (1). Some of the terms omitted due to length. The analyses encompass women in the panel sample who were 15–44 years of age in 1910. Clustered standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table D.4: Heterogeneity in the Effects of Electrification on Women's Fertility by Residential Price of Electricity in 1917–1919 (with alternate clustering)

	No. of Children Born	No. of Own Children in HH	No. of Own Children <18 in HH
ΔCap×1920×PriceResElect1919		-0.31	-0.38
		(0.39)	(0.42)
ΔCap×1930×PriceResElect1919		-0.28	-0.35
		(0.40)	(0.41)
ΔCap×1940×PriceResElect1919	-0.74	-0.096	-0.24
	(1.02)	(0.34)	(0.34)
R^2	0.81	0.65	0.62
Year Fixed Effects	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes
County Fixed Effects	Yes	Yes	Yes
State x Year Fixed Effects	Yes	Yes	Yes
Demographic and socioecon. controls	Yes	Yes	Yes
Cluster	County x Year	County x Year	County x Year
N	30,364	2,081,809	2,081,809

Notes: This specification corresponds to that of Equation (2). Some of the terms omitted due to length. The analyses encompass women in the panel sample who were 15–44 years of age in 1910. Clustered standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

D.3 Excluding Counties in the South

During the time period under analysis, the southern region of the United States followed a significantly different path from the rest of the country. Given this, there might be some concern that my results are driven by idiosyncrasies of the South rather than the opportunity cost and time savings dimensions of electrification on fertility. 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 these analyses are presented in Table D.5 and Table D.6. I find that these results are qualitatively and quantitatively similar to the baseline results, though in this specification the negative effect of residential electricity prices on fertility is much larger. This indicates that the time-savings channel of electrification on fertility was more muted in the South relative to the North.

Table D.5: Heterogeneity in the Effects of Electrification on Women's Fertility by Maternal Status in 1910 (excluding counties in the South)

	No. of Children Born	No. of Own Children in HH	No. of Own Children <18 in HH
ΔCap×1920×Mom1910		0.13***	0.13***
		(0.036)	(0.032)
ΔCap×1930×Mom1910		0.42***	0.43***
		(0.042)	(0.035)
ΔCap×1940×Mom1910	0.006	0.48***	0.44***
	(0.13)	(0.040)	(0.035)
R^2	0.82	0.71	0.69
Year Fixed Effects	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes
County Fixed Effects	Yes	Yes	Yes
State x Year Fixed Effects	Yes	Yes	Yes
Demographic and socioecon. controls	Yes	Yes	Yes
Cluster	County x Year	County x Year	County x Year
N	20,860	1,432,872	1,432,872

Notes: This specification corresponds to that of Equation (1). Some of the terms omitted due to length. The analyses encompass women in the panel sample who were 15–44 years of age in 1910, and who did not live in the South. Clustered standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table D.6: Heterogeneity in the Effects of Electrification on Women's Fertility by Residential Price of Electricity in 1917–1919 (excluding counties in the South)

	No. of Children Born	No. of Own Children in HH	No. of Own Children <18 in HH
ΔCap×1920×PriceResElect1919		-0.93***	-1.06***
		(0.35)	(0.38)
ΔCap×1930×PriceResElect1919		-0.98***	-1.06***
		(0.36)	(0.37)
ΔCap×1940×PriceResElect1919	-0.35	-0.65*	-0.74*
	(0.85)	(0.35)	(0.38)
R^2	0.82	0.68	0.63
Year Fixed Effects	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes
County Fixed Effects	Yes	Yes	Yes
State x Year Fixed Effects	Yes	Yes	Yes
Demographic and socioecon. controls	Yes	Yes	Yes
Cluster	County x Year	County x Year	County x Year
N	20,860	1,432,872	1,432,872

Notes: This specification corresponds to that of Equation (2). Some of the terms omitted due to length. The analyses encompass women in the panel sample who were 15–44 years of age in 1910, and who did not live in the South. Clustered standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

D.4 Excluding Counties in the West

Technological constraints associated to the transmission of electricity during the first half of the 20th century made it unfeasible to consume power far from the generation site. Due to these constraints, there may be some worry that my county-level electrification measure does not adequately capture the availability of electricity in counties that are larger in area, namely counties in the Western 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 hundredth meridian.

The results of these analyses are presented in Table D.7 and Table D.8. I find that these results are qualitatively and quantitatively similar to the baseline results.

Table D.7: Heterogeneity in the Effects of Electrification on Women's Fertility by Maternal Status in 1910 (excluding counties in the West)

	No. of Children Born	No. of Own Children in HH	No. of Own Children <18 in HH
ΔCap×1920×Mom1910		0.34***	0.33***
		(0.038)	(0.033)
ΔCap×1930×Mom1910		0.62***	0.59***
		(0.043)	(0.036)
ΔCap×1940×Mom1910	0.25	0.64***	0.60***
	(0.15)	(0.041)	(0.035)
R^2	0.81	0.69	0.67
Year Fixed Effects	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes
County Fixed Effects	Yes	Yes	Yes
State x Year Fixed Effects	Yes	Yes	Yes
Demographic and socioecon. controls	Yes	Yes	Yes
Cluster	County x Year	County x Year	County x Year
N	27,018	1,959,344	1,959,344

Notes: This specification corresponds to that of Equation (1). Some of the terms omitted due to length. The analyses encompass women in the panel sample who were 15–44 years of age in 1910, and who did not live in the West. Clustered standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table D.8: Heterogeneity in the Effects of Electrification on Women's Fertility by Residential Price of Electricity in 1917–1919 (excluding counties in the West)

	No. of Children Born	No. of Own Children in HH	No. of Own Children <18 in HH
ΔCap×1920×PriceResElect1919		-0.22	-0.27
		(0.30)	(0.32)
ΔCap×1930×PriceResElect1919		-0.081	-0.16
		(0.30)	(0.31)
ΔCap×1940×PriceResElect1919	-0.50	0.093	-0.059
	(0.86)	(0.29)	(0.31)
R^2	0.81	0.65	0.62
Year Fixed Effects	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes
County Fixed Effects	Yes	Yes	Yes
State x Year Fixed Effects	Yes	Yes	Yes
Demographic and socioecon. controls	Yes	Yes	Yes
Cluster	County x Year	County x Year	County x Year
N	27,018	1,959,344	1,959,344

Notes: This specification corresponds to that of Equation (1). Some of the terms omitted due to length. The analyses encompass women in the panel sample who were 15–44 years of age in 1910, and who did not live in the West. Clustered standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

D.5 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 the 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.[45] I estimate the following regressions:

$$
\begin{aligned}
Fertility_{i,h,c,t} = \alpha + \beta_t DistLargePlant_c \times Post_t + \beta^{mom} DistLargePlant_c \times Mom1910_{i,h,c} \\
+\beta_t^{mom} Post_t \times Mom1910_{i,h,c} + \beta_t^{dist.mom} DistLargePlant_c \times Post_t \times Mom1910_{i,h,c} \\
+\alpha_i + \alpha_t + \alpha_c + \alpha_{s,t} + \beta_{X,t} X_{i,h,c,1910} \times Year_t + \beta_{Z,t} Z_{h,c,1910} \times Year_t + \epsilon_{i,h,c,t}
\end{aligned}
\tag{D.3}
$$

$$
\begin{aligned}
Fertility_{i,h,c,t} = \alpha + \beta_t DistLargePlant_c \times Post_t + \beta^{price} DistLargePlant_c \times PriceResElect1919_c \\
+\beta_t^{price} Post_t \times PriceResElect1919_c + \beta_t^{dist.price} DistLargePlant_c \times Post_t \times PriceResElect1919_c \\
+\alpha_i + \alpha_t + \alpha_c + \alpha_{s,t} + \beta_{X,t} X_{i,h,c,1910} \times Year_t + \beta_{Z,t} Z_{h,c,1910} \times Year_t + \epsilon_{i,h,c,t}
\end{aligned}
\tag{D.4}
$$

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).[46] The rest of the notation follows Equation (1) and Equation (2), respectively.

The results of these analyses are presented in Table D.9 and Table D.10. I find results consistent with the baseline results. In particular, I find that the decrease in fertility among women who were mothers in 1910 was 0.15 children smaller in 1940 (relative to 1910) than

[45] As before, and to ensure comparability with the main results, I limit my analysis to counties that were not electrified by 1910 according to my main measure.

[46] 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 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 Severnini (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.

that of women who were not mothers in 1910 in counties within a 100-mile radius of a plant with 20 or more megawatts of capacity relative to those outside of this radius. In addition, I find that increasing the price of one mega-watt of residential electricity by $1, increases the decline in the number of children in the household induced by electrification by roughly 0.1 children in 1940 in counties within a 100-mile radius of a plant with 20 or more megawatts of capacity relative to those outside of this radius.

Table D.9: Heterogeneity in the Effects of Electrification on Women's Fertility by Maternal Status in 1910 (with alternate treatment definition)

	No. of Children Born	No. of Own Children in HH	No. of Own Children <18 in HH
DistLargePlant×1920×Mom1910		0.16***	0.15***
		(0.034)	(0.031)
DistLargePlant×1930×Mom1910		0.41***	0.40***
		(0.040)	(0.035)
DistLargePlant×1940×Mom1910	0.13	0.44***	0.40***
	(0.14)	(0.038)	(0.034)
R^2	0.82	0.68	0.66
Year Fixed Effects	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes
County Fixed Effects	Yes	Yes	Yes
State x Year Fixed Effects	Yes	Yes	Yes
Demographic and socioecon. controls	Yes	Yes	Yes
Cluster	CountyxYear	CountyxYear	CountyxYear
N	30,364	2,081,809	2,081,809

Notes: This specification corresponds to that of Equation (D.3). Some of the terms omitted due to length. The analyses encompass women in the panel sample who were 15–44 years of age in 1910. Clustered standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table D.10: Heterogeneity in the Effects of Electrification on Women's Fertility by Residential Price of Electricity in 1917–1919 (with alternate treatment definition)

	No. of Children Born	No. of Own Children in HH	No. of Own Children <18 in HH
DistLargePlant×1920×PriceResElect1919		-0.11	-0.11
		(0.18)	(0.18)
DistLargePlant×1930×PriceResElect1919		-0.051	-0.058
		(0.18)	(0.18)
DistLargePlant×1940×PriceResElect1919	0.032	-0.070	-0.15
	(0.60)	(0.17)	(0.18)
R^2	0.81	0.65	0.62
Year Fixed Effects	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes
County Fixed Effects	Yes	Yes	Yes
State x Year Fixed Effects	Yes	Yes	Yes
Demographic and socioecon. controls	Yes	Yes	Yes
Cluster	CountyxYear	CountyxYear	CountyxYear
N	30,364	2,081,809	2,081,809

Notes: This specification corresponds to that of Equation (D.4). Some of the terms omitted due to length. The analyses encompass women in the panel sample who were 15–44 years of age in 1910. Clustered standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

D.6 Controlling for Spouses' Socioeconomic Status

In the baseline specification I do not control for husbands' socioeconomic index since this would require limiting only to women who are married, and given the potential risk of post-treatment bias arising from the effect of electrification on men's outcomes and spousal decisions. This, however, leads to concerns about the possibility that the observed changes follow from changes to men's situations rather than women's.

In this section, I repeat my two main analyses after limiting only to married women and controlling spouses' socioeconomic status in each wave. I estimate the following regressions:

$$\begin{aligned} Fertility_{i,h,c,t} &= \alpha + \beta_t \Delta Cap_c \times Post_t + \beta^{mom} \Delta Cap_c \times Mom1910_{i,h,c} \\ &+ \beta_t^{mom} Post_t \times Mom1910_{i,h,c} + \beta_t^{cap.mom} \Delta Cap_c \times Post_t \times Mom1910_{i,h,c} \\ &+ \alpha_i + \alpha_t + \alpha_c + \alpha_{s,t} + \beta_{X,t} X_{i,h,c,1910} \times Year_t + \beta_{Z,t} Z_{h,c,1910} \times Year_t + \beta_{SSI} SSI_{i,h,c,t} + \epsilon_{i,h,c,t} \end{aligned} \tag{D.5}$$

$$\begin{aligned} Fertility_{i,h,c,t} &= \alpha + \beta_t \Delta Cap_c \times Post_t + \beta^{price} \Delta Cap_c \times PriceResElect1919_c \\ &+ \beta_t^{price} Post_t \times PriceResElect1919_c + \beta_t^{cap.price} \Delta Cap_c \times Post_t \times PriceResElect1919_c \\ &+ \alpha_i + \alpha_t + \alpha_c + \alpha_{s,t} + \beta_{X,t} X_{i,h,c,1910} \times Year_t + \beta_{Z,t} Z_{h,c,1910} \times Year_t + \beta_{SSI} SSI_{i,h,c,t} + \epsilon_{i,h,c,t}, \end{aligned} \tag{D.6}$$

where $SSI_{i,h,c,t}$ denote each woman's spouse's socioeconomic index in each year, the rest of the notation follows from Equation (1) and Equation (2), respectively, and standard errors are clustered at the county-by-year level.

The results of these analyses are presented in Table D.11 and Table D.12. I find that these results are qualitatively and quantitatively similar to the baseline results.

Table D.11: Heterogeneity in the Effects of Electrification on Women's Fertility by Maternal Status in 1910 (for married women)

	No. of Children Born	No. of Own Children in HH	No. of Own Children <18 in HH
ΔCap×1920×Mom1910		0.22***	0.21***
		(0.041)	(0.038)
ΔCap×1930×Mom1910		0.52***	0.49***
		(0.047)	(0.040)
ΔCap×1940×Mom1910	-0.062	0.49***	0.48***
	(0.34)	(0.046)	(0.040)
R^2	0.83	0.74	0.72
Year Fixed Effects	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes
County Fixed Effects	Yes	Yes	Yes
State x Year Fixed Effects	Yes	Yes	Yes
Demographic and socioecon. controls	Yes	Yes	Yes
Spouse's socioecon. index control	Yes	Yes	Yes
Cluster	County x Year	County x Year	County x Year
N	2,720	344,639	344,639

Notes: This specification corresponds to that of Equation (1). Some of the terms omitted due to length. The analyses encompass women in the panel sample who were 15–44 years of age in 1910, and who did not live in the West. Clustered standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table D.12: Heterogeneity in the Effects of Electrification on Women's Fertility by Residential Price of Electricity in 1917–1919 (for married women)

	No. of Children Born	No. of Own Children in HH	No. of Own Children <18 in HH
ΔCap×1920×PriceResElect1919		-0.47	-0.54
		(0.36)	(0.37)
ΔCap×1930×PriceResElect1919		-0.56	-0.61*
		(0.37)	(0.36)
ΔCap×1940×PriceResElect1919	-2.29	-0.28	-0.43
	(2.15)	(0.37)	(0.37)
R^2	0.84	0.70	0.67
Year Fixed Effects	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes
County Fixed Effects	Yes	Yes	Yes
State x Year Fixed Effects	Yes	Yes	Yes
Demographic and socioecon. controls	Yes	Yes	Yes
Spouse's socioecon. index control	Yes	Yes	Yes
Cluster	County x Year	County x Year	County x Year
N	2,720	344,639	344,639

Notes: This specification corresponds to that of Equation (1). Some of the terms omitted due to length. The analyses encompass women in the panel sample who were 15–44 years of age in 1910, and who did not live in the West. Clustered standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

E Appendix: Aggregation and Equilibrium

E.1 Male and Female Labor

Female and male labor are employed to produce consumption goods. The market for labor clears within each sub-region s when

$$L^D_{f,t,s} = L_{f,t,s}$$

and

$$L^D_{m,t,s} = L_{m,t,s},$$

where $L^D_{f,t,s}$ and $L^D_{m,t,s}$ denote the effective female and male labor used for the production of consumption goods, and $L_{f,t,s}$, $L_{m,t,s}$ are the total amounts of effective female and male labor supplied by households to the economy:

$$L_{f,t,s} = \sum_{j=1}^{G+J} P_{j,t,s} \int_0^\infty \eta_f n^f_{j,t,s} dF(\sigma_l)$$

and

$$L_{m,t,s} = \sum_{j=1}^{G+J} P_{j,t,s}.$$

$P_{j,t,s}$ denotes the size of the cohort of age j in period t at sub-region s, and is described in detail below.

E.2 Output

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

$$Y_{t,s} = X_{t,s} + C_{t,s}.$$

$X_{t,s}$ denotes the inputs in electricity production, and $C_{t,s}$ denotes total consumption in the economy:

$$C_{t,s} = \sum_{j=1}^{G+J} P_{j,t,s} \int_{0}^{\infty} c_{j,t,s} \; dF(\sigma_l).$$

E.3 Cohort Size

The size of cohorts $P_{j,t,s}$ evolves through time based on the fertility choices of households. Since children spend I periods with their parents before they become adults themselves and join a couple, the evolution of the size of cohorts is given by

$$P_{1,t,s} = \frac{1}{2} \sum_{j=1}^{G} P_{j,t-I,s} \int_{0}^{\infty} f_j b_{j,t-I,s} dF(\sigma_l).$$

The factor $\frac{1}{2}$ enters the law of motion because fertility is measured in terms of individuals while cohort size is measured in terms of couples (or of men or women independently). In this expression, $f_j b_{j,t-I,s}$ is the average number of births of a couple of age j at time $t-I$ in sub-region s. Integrating over all couples of age j and multiplying by cohort size $P_{j,t-I,s}$ gives the total number of children born in period $t-I$ to parents of age j at sub-region s. Adding this over all cohorts who are in childbearing age in period $t-J$ (those aged 1 to G) yields the total number of children born in period $t-I$, and who will turn adult in t. Notice also that since cohort size stays fixed throughout life, we have $P_{j+1,t+1,s} = P_{j,t,s}$ for $j < G+J$.

F Appendix: Calibration

F.1 Time spent working by men η_m and time spent working by employed women η_f

η_m and η_f are calibrated using the average hours worked by employed men and women, respectively, in 1900. I use the work hours of men and women ages 14 and above in this period compiled by Ramey and Francis (2009), and divide by the male and female labor force participation rates respectively.[47] Using this procedure, I get that the hours worked by employed males and females were $\frac{44.8}{0.819} = 54.7$ and $\frac{9.6}{0.206} = 46.6$, respectively. Those values correspond 48.8% and 41.6% of 112, the total waking hours, respectively. As such, I set η_f to 0.416, and η_m to 0.488.

F.2 Children Time Cost Function

I choose the level parameter ϕ, and curvature parameter on the number of children ψ_m, to match the ratio of time spent in childcare for women with different number of children in 1965 from the American Heritage Time Use Survey. First notice that I can take a natural logarithm of the time spent in childcare M for any woman at any given time period to get

$$\log(M) = \log(\phi) + \psi_m \log(m^y) - \psi_E log(E).$$

I use data on the time spent on childcare from the 1965 American Time Use Survey (available at IPUMS) to recover the parameters ϕ and ψ_E by following structure of the equation above. Although I do not observe electricity or appliance purchases, I control for household income, urban status and demographics (age, race, marital status and employment status) of each of the women in the couple, which correlate with factors outside of the number of children influencing the time spent in childcare, including electricity and appliance purchases. In addition, all observations in 1965 correspond to Michigan, offering further control for location-specific factors.

The regression I estimate is:

$$\log(M_i) = \log(\phi) + \psi_m \log(m_i^y) + \beta X_i + \epsilon_i, \tag{F.1}$$

[47] Female labor force participation follows from Goldin (1977), while male labor force participation follows from Bureau of the Census (U.S. Department of Commerce) (1970).

where i denotes each observation, and X_i denotes the income, location and demographic controls of each woman. I limit the estimation of this regression to women with at least one child under the age of 18 in the household, and weight the regression using the sampling weights provided in the data.

The time spent in childcare, M_i, is measured in four different ways: (1) time spent in childcare as a main activity, (2) time spent in childcare as a main and secondary activity (preferred specification), (3) time spent in home production activities including time spent in childcare as a main activity, and (4) time spent in home production activities including time spent in childcare as a main and secondary activity.[48]

The results from these regressions are presented in Table F.1. I find that my estimate of ϕ is 37 and 126 minutes per day respectively for dependent variables that encompass childcare, while it hovers around 250 minutes per day when the dependant variable encompasses all home production. In the context of my model, where the time endowment is normalized to one, the value of 126.47 of my preferred specification would imply a value $\phi = \frac{126.47/60}{16}$.

Table F.1: Estimation of the level and curvature parameters on the number of children

	Log Childcare (Main)	Log Childcare (Main + Sec.)	Log Home Prod. + Childcare (Main)	Log Home Prod. + Childcare (Main+Sec)
Constant ($\log(\phi)$)	3.61***	4.84***	5.37***	5.62***
	(0.28)	(0.30)	(0.27)	(0.28)
$\log(m^y)$	0.52***	0.55***	0.29***	0.30***
	(0.099)	(0.093)	(0.050)	(0.051)
R^2	0.28	0.30	0.44	0.44
Demog. and Socioecon. Controls	Yes	Yes	Yes	Yes
N	497	533	638	638

The specification corresponds to that of Equation (F.1). Controls include age controls, marital status, race (black or other), household income, educational attainment, home ownership status, employment status, urban status. The regression is weighted using the sample weights provided in the data. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

I find that the estimate of ψ_E hovers around 0.52-0.55 when the dependent variable considered is time spent in childcare solely, and 0.29 when the dependent variable considered also encompasses home production. These values are in line with the value of 0.417 found by Doepke et al. (2013), who use a similar methodology and the 1975 American Time Use Survey. For my analysis, I take a value of 0.55 for ψ_E, following from my preferred specification.

[48] I consider the time spent in home production in addition to that spent in childcare solely because the time spent in activities such as washing clothes, washing dishes, cooking, etc increases with children as well, even if it does not correspond to childcare directly.

F.3 Differential time cost of pregnancy and caring for a young child κ

I choose the differential time cost of pregnancy and caring for baby, κ, in order to match the increased time cost of caring for a young child. To do this, I time use data from the American Heritage Time Use Survey in 1965, and estimate a regression similar to the one described in Appendix F.2, but with a few differences. First, the regression includes both the total number of children and the number of children under 5 as explanatory variables, in order to separate the time cost effect of having one child under 5 above and beyond having one extra child. Second, I estimate the regression in levels rather than logarithms. The regression I estimate is thus:

$$M_i = \alpha + \beta_1 m_i^y + \beta_2 m_i^{und.5} + \beta_3 X_i + \epsilon_i, \tag{F.2}$$

where M denotes total time spent in childcare, m^y denotes total number of children under 18 in the household, and $m^{und.5}$ denotes the number of children under 5. As before, i denotes each individual observation, and X_i denotes the income, location and demographic controls of each woman. I limit the estimation of this regression to women with at least one child under the age of 18 in the household, and weight the regression using the sampling weights provided in the data.

Table F.2: Estimation of the additional time cost of young children

	Childcare (Main)	Childcare (Main + Sec.)	Home Prod. + Childcare (Main)	Home Prod. + Childcare (Main+Sec)
m^y	2.81	5.85	20.36***	23.41***
	(2.53)	(3.76)	(6.90)	(7.66)
$m^{und.5}$	44.7***	61.41***	78.97***	95.68***
	(4.91)	(7.28)	(13.34)	(14.82)
R^2	0.40	0.39	0.43	0.44
Demog. and Socioecon. Controls	Yes	Yes	Yes	Yes
N	640	640	640	640

The specification corresponds to that of Equation (F.2). Controls include age controls, marital status, race (black or other), household income, educational attainment, home ownership status, employment status, urban status. The regression is weighted using the sample weights provided in the data. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

As before, the time spent in childcare, M, is measured in four different ways: (1) time spent in childcare as a main activity, (2) time spent in childcare as a main and secondary activity (preferred specification), (3) time spent in home production activities including time spent in childcare as a main activity, and (4) time spent in home production activities including time spent in childcare as a main and secondary activity.

The results from these regressions are presented in Table F.2. I find that the additional time cost of having one more child under the age of 5 in the household corresponds to roughly 45–60 minutes a day for the dependent variables that encompass childcare, while it falls between 80 to 95 minutes a day when the dependant variable encompasses all home production. In the context of my model, where the time endowment is normalized to one, the value of 61.41 of my preferred specification would imply a value $\kappa = \frac{61.41/60}{16}$.

F.4 Share of electricity in male labor

I choose the value of the share of electricity in male labor, ζ_m, to match the share of energy fuels and electricity expenditures in male-dominated manufacturing industries. To this end, I use data from both the 1940 population census, and the 1939 manufacturing census.

First I use industry information from the 1940 population census to find the most male-dominated manufacturing industries. I focus my attention on manufacturing industries where 95% or more of the workforce is male: logging; ship building and repairing; blast furnaces, steel works, and rolling mills; and cement, concrete, gypsum and plaster products.[49]

Table F.3: Estimation of the level and curvature parametesr on the number of children

Male-Dominated Manufacturing Industry	Portion Male Workforce	Expenditure in Fuels & Electricity	Value of Production	Ratio of Fuels & Electr. in Value of Prod.
Logging	98.8%	1,600,833	69,620,906	0.0230
Ship building and repairing	97.5%	4,137,536	327,387,099	0.0126
Cement, concrete, gypsum and plaster products[50]	96.7%	1,916,317	130,393,396	0.0147
Average				0.0168

Then, I compute the share of electricity in each of these industries using the census of manufactures in 1939. In particular, I take the ratio between the expenditure in all fuels and electricity and the production value in each industry. I average these values to get the mean share of electricity in production in male-dominated manufacturing industries. This average pins down the value of ζ_m, and corresponds to 0.0168.

[49]Please note that blast furnaces, steel works, and rolling mills industries are also heavily male-dominated, with 97.4% of the workforce being male, but are excluded here since their expenditure in fuels and electricity is an outlier.

In Table F.3 I summarize the information of these two steps in the first three columns. In particular, I tabulate the male portion of the workforce in each male-dominated manufacturing industry from the population census in 1940, along with the expenditure in all fuels and electricity, and value of production in each industry from the census of manufactures in 1939. In the last column, I include the ratio between the expenditure in all fuels and electricity and the value of production.

F.5 Female and Male TFPs: A_f and A_m

I normalize the TFP of male labor, A_m, to one, and calibrate the TFP of female labor A_f to match the ratio of average male and female occupational scores in 1900. I first solve for male and female wages, by considering the problem of male- and female-focused firms. Since labor is paid its marginal product, wages can be written as

$$w_{i,t,r} = A_i \left[\zeta_i E_{i,t,r}^{\frac{\gamma_i - 1}{\gamma_i}} + (1 - \zeta_i) L_{i,t,r}^{\frac{\gamma_i - 1}{\gamma_i}} \right]^{\frac{1}{\gamma_i - 1}} (1 - \zeta_i) L_{i,t,r}^{\frac{-1}{\gamma_i}} \quad \text{for } i \in \{f, m\}.$$

Further, since both female- and male-focused firms purchase electricity, the price of this must be equal to its marginal product in both firms:

$$p_{t,r}^E = A_i \left[\zeta_i E_{i,t,r}^{\frac{\gamma_i - 1}{\gamma_i}} + (1 - \zeta_i) L_{i,t,r}^{\frac{\gamma_i - 1}{\gamma_i}} \right]^{\frac{1}{\gamma_i - 1}} \zeta_i E_{i,t,r}^{\frac{-1}{\gamma_i}} \quad \text{for } i \in \{f, m\}.$$

Combining each of these equations with the corresponding wage equations above and reorganizing yields

$$E_{i,t,r} = \left(\frac{\zeta_i w_{i,t,r}}{(1 - \zeta_i) p_{t,r}^E} \right)^{\gamma} L_{i,t,r} \quad \text{for } i \in \{f, m\}.$$

Plugging this in the expression for $w_{i,t,r}$ and reorganizing we get

$$w_{i,t,r} = A_i \left[\zeta_i \left(\frac{\zeta_i w_{i,t,r}}{(1 - \zeta_i) p_{t,r}^E} \right)^{\gamma_i - 1} + (1 - \zeta_i) \right]^{\frac{1}{\gamma_i - 1}} (1 - \zeta_i). \tag{F.3}$$

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

$$p^E_{t,r} = \frac{1}{A_{E,t,r}}.$$

Notice thus that once we know $p^E_{,r}$ from the above, Equation (F.3) fully characterizes $w_{i,t,r}$ for $i \in \{f, m\}$ in every period.

I choose A_f to match the ratio of average male and female occupational scores in 1900. To compute these ratios in the data, I use the occupation information available in the 1900 census in conjunction with the Lasso-adjusted industry, 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 assume the old electricity technology was in place during this time period in all regions, yielding low electric productivity $A_{E,L}$ (which is symmetric across regions) and a high price for electricity. I can then solve for the wage in 1900 using the equation before. Thus, I choose A_f so that

$$\frac{w_{f,1900}}{w_{m,1900}}^{model} = \frac{\text{Avg. LIDO Score of Women}^{data}}{\text{Avg. LIDO Score of Men}^{data}}.$$

F.6 Regional productivity of electricity production after electrification: $A_{E,H,r}$

I calibrate the efficiency of electricity production after electrification in each region, $A_{E,H,r}$, to match (1) the fact that the relative price charged for electricity when produced by a small generator is 5 times larger than when produced by a large-scale plant (Institute for Energy Research (2019)); and (2) the distribution of prices of electricity observed empirically in 1917-1919, and documented in Section 3.5.2.

To start, first we notice that in the model there are a certain number of regions R. We have that the median price of electricity in this distribution is 5 times lower than that obtained with the old technology of electricity. Therefore, we have

$$A_{E,H,\frac{R}{2}} = 5 \times A_{E,L}$$

.

We can then recover the efficiency of electricity production after electrification in each region $A_{E,H,r}$ using the R-percentile empirical distribution of the price of electricity from the individual-level data on prices. In particular we will get vector of size R with the average empirical prices per percentile:

$$[p*_1, p*_2, ...p*_R]$$

If we divide each of these by the median price $p*_{\frac{R}{2}}$, we get:

$$\left[\frac{p*_1}{p*_{\frac{R}{2}}}, \frac{p*_2}{p*_{\frac{R}{2}}}, ...\frac{p*_R}{p*_{\frac{R}{2}}}\right]$$

We can then use this to recover the efficiency of electricity production after electrification in each region $A_{E,H,r}$ by noting that

$$\frac{p*_r}{p*_{\frac{R}{2}}} = \frac{A_{E,\frac{R}{2}}}{A_{E,r}} = \frac{5 \times A_{E,L}}{A_{E,r}}.$$

We rearrange to get

$$A_{E,H,r} = 5 \times A_{E,L} \times \frac{p*_{\frac{R}{2}}}{p*_r} \; \forall r.$$

Table F.4 summarizes the values obtained from this procedure.

Table F.4: Regional efficiency of electricity production after electrification

Parameter	Value
$A_{E,H,1}$	$5 \times A_{E,L} \times 0.83$
$A_{E,H,2}$	$5 \times A_{E,L} \times 0.91$
$A_{E,H,3}$	$5 \times A_{E,L}$
$A_{E,H,4}$	$5 \times A_{E,L} \times 1.12$
$A_{E,H,5}$	$5 \times A_{E,L} \times 1.25$

F.7 Model and Data Moments targeted by the Method of Moments

Table F.5: Moments in Model and Data (targeted by the Method of Moments)

Moment	Data	Model
Average fertility in 1900	3.79	3.84
Female LFP in 1900	0.21	0.17
Average time in childcare in 1900	0.11	0.15
Average female leisure time in 1900	0.68	0.77
DDD Coefficient of differential decline in # of own children in HH due to electrification for mothers in 1930	0.57	0.48
50% lower CI of DDD coefficient of differential decline in # of own children in HH due to electrification by price of electricity in 1930	-0.09	-0.10

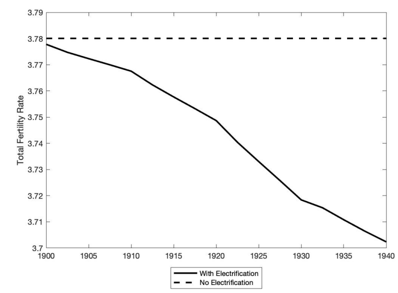
Notes: The DDD coefficients of the differential change in fertility due to electrification follow from results in the empirical analysis. See Section 3 for details.

In my model, variables for women are constructed from ages 15 to 65. To match this, I use data moments for similar age groups whenever available. The data on fertility comes from Haines (2006), who computes the total fertility rate for women of different races, combined with proportion of women by race from the Census. The data on female LFP in 1890 comes from Goldin (1990), who constructs these statistics for women ages 15 and above and carefully accounts for methodological and other changes in the labor force participation definition across time. The data on leisure corresponds to information from individuals ages 25–54, as estimated by Ramey and Francis (2009). The data on childcare time comes from Ramey (2009) (Table 4), who computes the increase in home production hours (which encompasses childcare) stemming from having children of different ages using data from the early 20th century, combined with proportion of women with and without children from the census, along with the average number of children in each age category. In order to match the structure of the model, where women spend time on work, childcare, and leisure, the data on leisure and childcare hours is normalized using the sum of time spent in these three activities, where work hours correspond to those of women ages 14 and above as estimated by Ramey and Francis (2009).

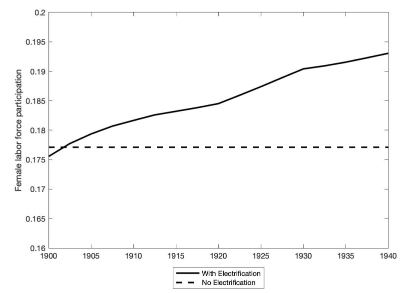
G Appendix: Model Simulations

Figure G.1: Average Outcomes for Women

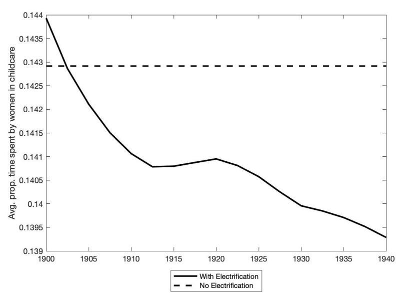
(a) Fertility



(b) Female LFP



(c) Time spent in childcare



(d) Time spent in leisure

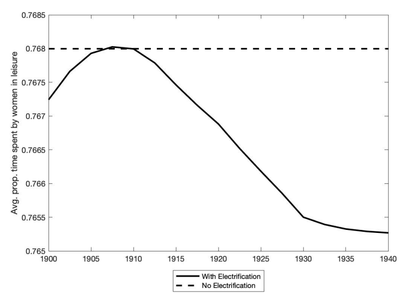
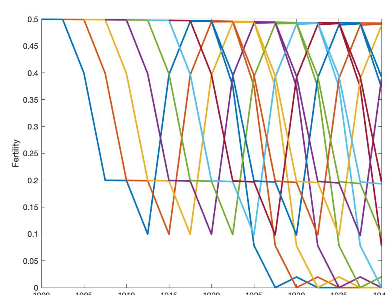
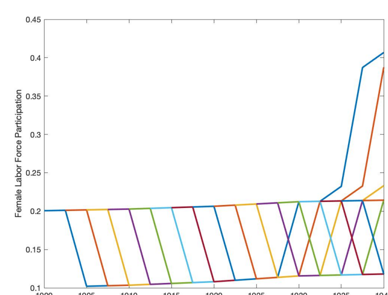


Figure G.2: Average Outcomes for Women by Cohort

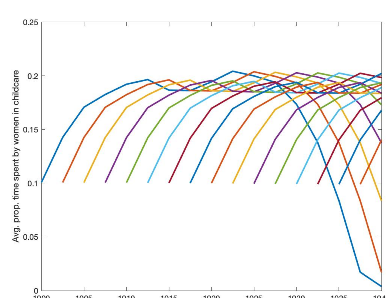
(a) Fertility



(b) Female LFP



(c) Time spent in childcare



(d) Time spent in leisure