Women's Labor Force Participation and Household Technology Adoption*

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Abstract

We examine how women's employment leads to household technology adoption in the context of mid-century United States. We posit a non-monotonic relationship between women's education and household technology adoption, with middle education households purchasing appliances and high education households hiring domestic workers. Using WWII factories and draft rates as instruments for female labor demand, we find that a standard deviation increase in female labor force participation increases washing machine ownership by 0.413 standard deviations, with strongest effects in counties with pre-war education levels in the mid-ranges. Substitution of employed domestic labor with appliances is an important channel.

Keywords: Household technology, Women's labor force participation, Domestic labor, Twentieth-century United States

JEL Codes: J22, N32, O33

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1 Introduction

Technology transformed household productivity and leisure in the twentieth century. Spurred by the near universal installation of running water and electricity in the first half of the twentieth century, Americans purchased electrical appliances in large numbers in mid-century. These labor-saving appliances freed up time for leisure and family, especially for women who performed many of the tasks subsequently done by machines. The dominant view in the economics literature is that household technology was also key to greater women's employment (Greenwood et al., 2005). This paper investigates if women's employment led to greater adoption of household technology, arguing instead that as women proceeded to enter the workforce in greater numbers, appliances such as washing machines, refrigerators and dishwashers eased their physical burdens while maintaining living standards and increasing leisure (Schwartz Cowan, 1983; Aguiar and Hurst, 2007).

In our analysis, domestic work by women and machines are substitutes.[1] Simultaneously, a fraction of households employ domestic workers. Compared to the households who employ them, domestic workers have very different outside employment opportunities. More employment opportunities for women can increase purchases of household appliances by increasing women's incomes, or conversely decrease purchases by making domestic workers more affordable. Thus, the impact of women's work on household technology adoption is likely non-monotonic. Further, while income effects offer one possibility why more women's employment translates into more household technology purchases, we consider several other channels, including the role for greater information about new appliances transmitted through television, lower cost of access

[1]Men's domestic work also substitutes for household technology, but we focus on women rather than men because traditional gender norms imply that women do most domestic chores (Starrels, 1994).

through retail stores, and migration of households, all as consequences of women's labor force participation.

Mid-century United States witnessed widespread adoption of refrigerators, washing machines and vacuum cleaners that arguably transformed family life (Schwartz Cowan, 1983). Concurrently, women entered the formal workforce in large numbers driven by the needs of wartime factories, increases in education, and changing fertility and social norms (Bailey, 2006; Goldin, 2006; Bailey et al., 2012). Large scale labor force participation boosted women's incomes (Acemoglu et al., 2004) and reduced domestic work by women in their own homes (Aguiar and Hurst, 2007), both at a time when employment as paid domestic workers was decreasing (Anderson and Bowman, 1953; Parker and Wang, 2013).

In this setting, we use an instrumental variables strategy to examine how changes in women's labor force participation are associated with appliance ownership by exploiting county-level exogenous shocks to female labor demand during World War II through the presence of wartime factories, as well as the military draft of prime-age men (Acemoglu et al., 2004; Fernandez et al., 2004; Goldin and Olivetti, 2013). We posit that the relationship between women's work and household technology adoption is non-monotonic with respect to education. Since paid employment might yield higher incomes for better educated women, we analyze how appliance purchases differ by educational achievement. We also examine the differential effect of women's work on appliance purchases in places employing large fractions of domestic workers, since, theoretically, domestic workers could dampen (by substituting for women's domestic work) or exacerbate (by seeking outside employment themselves) the effects of increased female employment on household technology adoption.

The central finding is that a standard deviation increase in women's labor force participation in 1950 leads to 0.41 standard deviation greater adoption of washing ma-

chines in 1960. These findings are robust to a number of specifications, including an alternate differences-in-differences estimation in which we examine refrigerator ownership as an outcome variable. Comparing the estimated coefficients to other factors that could drive washing machine adoption suggests that women's labor force participation is perhaps the most important factor that determines adoption of household technology in mid-century United States.

To elucidate potential heterogeneity, we explore a non-monotonic relationship between a women's earning capacity and household technology adoption. The findings show an inverse-U relationship between women's education levels and washing machine ownership, suggesting that in counties with pre-war education levels in the mid-ranges (6 to 8 years of completed education, on average), the effect of women's employment on household technology adoption is strongest relative to counties with the highest average education.

We examine several reasons why increased female labor force participation affects household technology adoption. One straightforward explanation is an income effect. Women's employment increased household income, so appliances became affordable for more households. A related hypothesis is that earning independent incomes increased women's bargaining power compared to men. Insofar that household technology eased their burdens more than men's, women were more likely to advocate buying appliances compared to other goods. Consistent with these hypotheses, we find that women's employment is associated with higher incomes, with subsequent increases in appliance adoption concentrated in mid-income counties.

It is also possible that more information about appliances could facilitate purchases, especially in an environment where households were not experienced with their use. Simultaneously, easier access when large retail stores open close by also facilitate purchases. Finally, women's labor force participation could influence migration

to places where appliances are cheaper or more useful. We examine these potential reasons and find a role for greater information provision through television advertising, but negligible evidence that retail stores or migration are important factors in appliance purchases.

One important channel affecting household technology adoption is through the availability of paid domestic work. Our findings show that counties with a higher share of the female labor force employed in domestic services have significantly lower ownership of washing machines, suggesting that paid domestic work and appliances are substitutes. When we examine how this relationship varies heterogeneously with respect to women's education, we find that relative to counties with the least educated women, counties where women are the most educated have a higher percentage of women employed in domestic services when women's employment expands. This is consistent with our finding that the effect of women's employment on appliance adoption is strongest in the middle-education ranges and suggests that households where women have a higher earning capacity demand more domestic labor instead of household technology when women go to work.

This paper contributes directly to the literature on women's labor force participation and household technology adoption. The dominant view in this literature is that affordable, household labor-saving technologies are productive assets that facilitated women's entry into the workforce (Greenwood et al., 2005; de V. Cavalcanti and Tavares, 2008; Coen-Pirani et al., 2010; Dinkelman, 2011). Qualitatively, it is a well-known that American women began entering the labor force at a time that coincided with widespread appliance adoption. Empirically, however, the direction of this relationship is difficult to distinguish. In the existing literature, this relationship has been established by observing a negative correlation between the relative price of home appliances and female labor force participation. One issue with this approach is that

household technology adoption is endogenous to relative prices; as more households purchase appliances, prices decline. In mid-century United States, appliance purchases occurred unevenly across households, even as real prices declined uniformly to affordable levels (Schwartz Cowan, 1983). In addition, time use data analyzed by Aguiar and Hurst (2007) document that total market and non-market work for women actually declined by 7.8 hours per week between 1965 and 2003, even as several barriers to women's employment fell away. These stylized facts suggest that adoption itself did not directly lead to more paid employment for women, and instead leaves open the possibility that the relationship could proceed the other way. In this vein, we posit that appliance purchases are acquired as a consequence of women's employment and earnings, leading to fewer hours spent on domestic chores and therefore greater welfare.

Our findings add to the considerable literature examining the consequences of women's labor force participation. Women's paid work has had significant impacts on social and political outcomes (Costa, 2000), culture (Fernandez et al., 2004; Fogli and Veldkamp, 2011; Fernandez, 2013), wages (Acemoglu et al., 2004), fertility decisions and demographic changes (Jensen, 2012; Doepke et al., 2015), and intra-household bargaining (Goldin, 1990; Anderson, 2003). Our study contributes to the discussion by examining the effects of women's entry into the formal workforce in mid-century US, highlighting the effects on household technology adoption.

This paper also contributes to the literature on domestic work, both paid and unpaid, which is arguably important for household welfare but rarely recognized in the formal economy. Our framework is perhaps the first to introduce a role for both paid domestic workers as well as household technology, and thus elucidates how these might substitute as more women enter the labor force.[2] This framework has implica-

[2]Most research papers examine the role of migration in analyzing outcomes for domestic workers (Parreñas, 2000; Bakan and Stasiulis, 1997). Sen and Sen (1985) and Noonan (2001) analyze the relationship between supply of domestic workers and women's labor supply, but do not introduce

tions for understanding future household technology adoption, and the role of women's employment in driving these changes.

2 Conceptual framework

The framework in this section illustrates how women's decisions to work, to use appliances and to employ domestic labor vary non-monotonically with changes in parameters. We do not attempt to generate a calibrated model that will fit the data. We use a simple Cobb-Douglas utility function and arbitrary sets of parameter values to construct examples that highlight the main decision functions that underlie the empirical analysis.

Our economy consists of households with a woman and other members. We represent the household's utility as a function of the household's consumption and the woman's leisure. Household income contributed by men is exogenous in our model. The woman may engage in market work as well as domestic work, both of which take away from her leisure. Market work adds to income and subtracts from leisure, while hiring domestic help or purchasing machines subtracts from income and adds to leisure. We assume that domestic help (for instance, a maid) and technological aids (such as washing machines) substitute for each other.

The household therefore has to make three decisions; whether the woman will perform market work (*"work"*) or stay at home (*"no work"*), whether she will do the domestic work herself *("no help")* or use help *("help")*, and whether any help takes the form of hiring a maid or purchasing appropriate machines. Since domestic help and machines are perfect substitutes, the last decision is made based on price. Let the wage of domestic help be w_d and the comparably annualized price of technology be q. Technology is used if $q < w_d$, and the money cost of getting domestic work done is

household technology.

$p = \min\{w_d, q\}$.[3]

The woman has a unit of potential leisure, from which we deduct the time taken by market work, λ if she works outside the home, and time taken by domestic work, θ if she does the housework. The household has an exogenous income y, to which we add the woman's market income (if any) w, and deduct the cost of household help or domestic technology, if employed. We represent w and p as fractions of y, so that $\omega = \frac{w}{y}$ and $\rho = \frac{p}{y}$. Thus, the household's consumption, leisure and utility are contingent on whether the woman does market work and whether she uses help to do domestic work. There are four possible values of utility:

$$\begin{aligned} U_{\text{no work, help}} &= [y(1-\rho)]^{\alpha} 1^{1-\alpha} \\ U_{\text{no work, no help}} &= y^{\alpha}[1-\theta]^{1-\alpha} \\ U_{\text{work, help}} &= [y(1+\omega-\rho)]^{\alpha}[1-\lambda]^{1-\alpha} \\ U_{\text{work, no help}} &= [y(1+\omega)]^{\alpha}[1-\lambda-\theta]^{1-\alpha} \end{aligned}$$

Pairwise comparisons yield the following, where $\gamma = \frac{(1-\alpha)}{\alpha}$ and $\succcurlyeq$ represents weak

[3]Our toy model involves several simplifications insofar as a household that delegated housework could potentially use some combination of domestic workers and machinery, with the balance between the two determined by relative prices. Similarly, the woman would do some amount of housework regardless of whether she employed a maid or had a washing machine. Similarly, we limit the work-choices to "work" and "no work", instead of allowing a range of work-intensity choices.

preference:

$$
\begin{aligned}
\text{(work, help)} \succcurlyeq \text{(work, no help)} &\Leftrightarrow \rho \leq (1+\omega)\{1-\frac{1-\lambda-\theta}{1-\lambda}\}^{\gamma} \\
\text{(work, help)} \succcurlyeq \text{(no work, help)} &\Leftrightarrow \omega \geq (1-\rho)[\{\frac{1}{1-\lambda}\}^{\gamma}-1] \\
\text{(work, help)} \succcurlyeq \text{(no work, no help)} &\Leftrightarrow \omega \geq \rho+\{\frac{1-\theta}{1-\lambda}\}^{\gamma}-1 \\
\text{(work, no help)} \succcurlyeq \text{(no work, no help)} &\Leftrightarrow \omega \geq \{1+\frac{\lambda}{(1-\lambda-\theta}\}^{\gamma}-1 \\
\text{(no work, help)} \succcurlyeq \text{(no work, no help)} &\Leftrightarrow \rho \leq 1-(1-\theta)^{\gamma} \\
\text{(work, no help)} \succcurlyeq \text{(no work, help)} &\Leftrightarrow \omega \geq (1-\rho)\{\frac{1}{1-\lambda-\theta}\}^{\gamma}-1
\end{aligned}
$$

We plot these inequalities on a diagram with ρ and ω on the horizontal and vertical axes respectively, and identify the regions in which each decision pair (work/no work, help/no help) is dominant. In the top left panel of Figure 1, we use a value of 0.25 for λ, which roughly correspond to a 40-hour workweek. We set θ at 0.15, corresponding to between three to four hours of housework a day in a 168 hour week. This agrees with time use data for 1965-75 (see, e.g., Aguiar and Hurst, 2007, Table II). Following Domeij and Floden (2006), we use $\gamma = 1.5$.

The remaining panels show how preferences over different combinations of work and domestic help change with changes in the parameters. An increase in γ from 1.5 to 3 yields the top right panel, an increase in θ from 0.15 to 0.3 gives the bottom left panel, and an increase of λ from 0.25 to 0.4 gives the bottom right.

Figure 1: **Work and help choices**

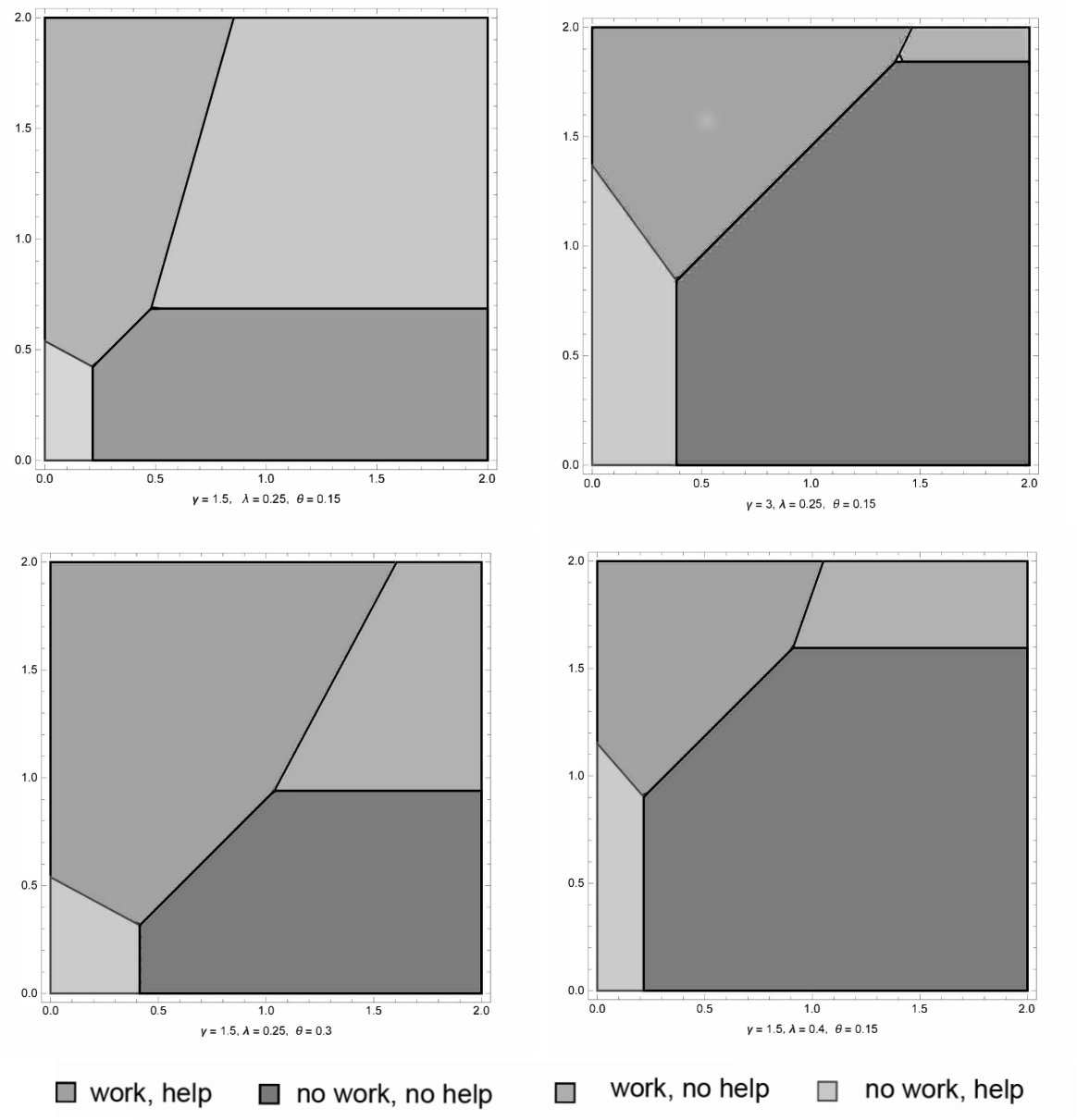
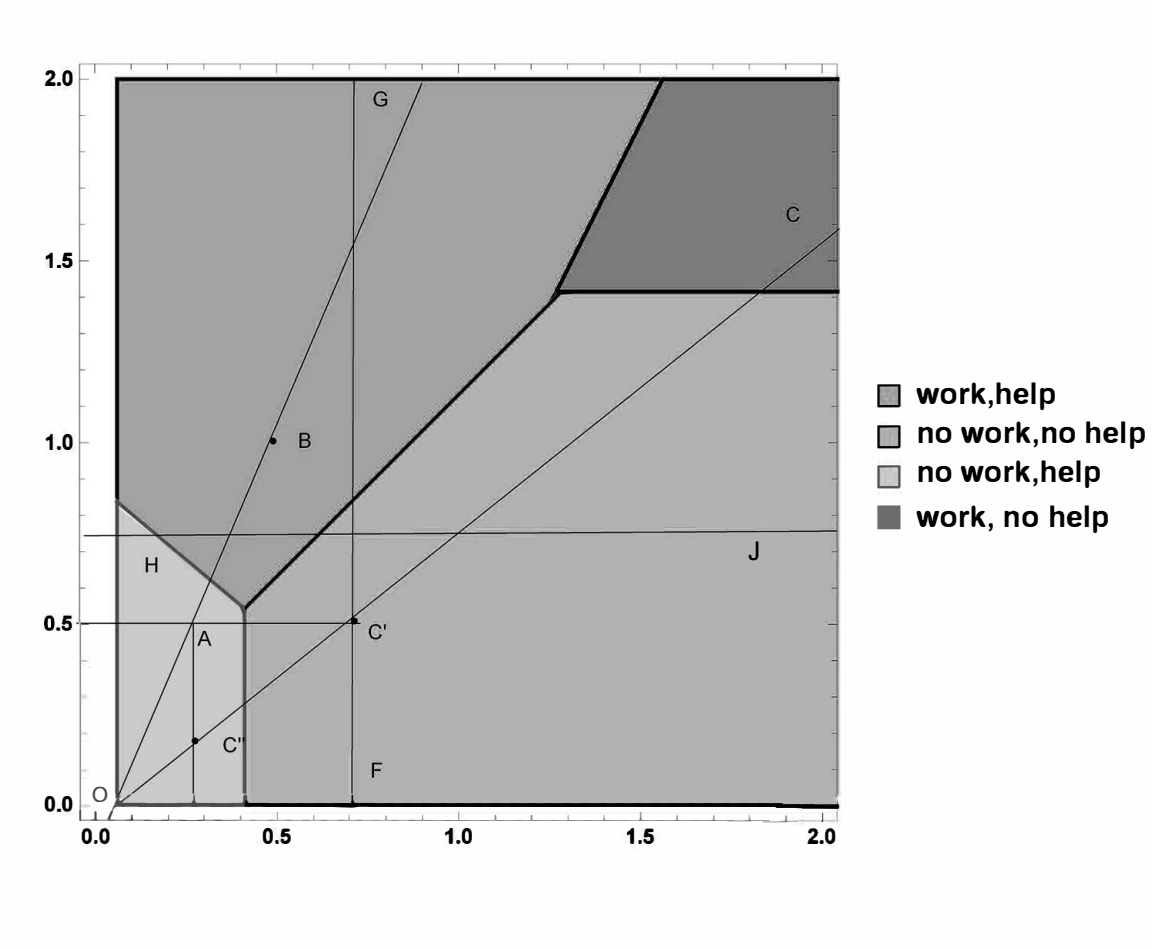


Figure 2: **Optimal choices for different circumstances**



To see how decisions differ between different households, consider first a household where the other income (i.e., the man's income) is equal to the median personal income of \$4,000 in 1960. Suppose the woman's earning capacity if she works is half of this, i.e., \$2000, and the cost of help is a quarter of the median income or \$1000. This yields $\omega = 0.5$ and $\rho = 0.25$, which is represented by the point A on Figure 2. This woman's optimal decision is to hire help (or buy machines) and not engage in market work. But the same woman in a household where the man earns \$2000 would be represented by point B, and she would choose to engage in market work and still hire domestic help. In other words, points along a ray from the origin represent the same ratio of woman's earning to cost of domestic help, but points further away from the origin on this ray correspond to households with lower other income.

A flatter ray such as OC represents a woman who has lower earning capacity relative to the cost of domestic help. As other income in the household ranges from low to high, the woman on ray OC transitions from market work with no domestic help (point C) to no market work and no domestic help (point C') to no market work and domestic help (point C'').[4]

Points on vertical lines such as FG represent women with different earning capacities holding other income and price of help constant. Movement up this line represents increasing earning capacity (for instance, as the woman's education increases). In this case, women with higher earning potential would work and hire help, while women with lower earning potential would not perform market work and do their own domestic work. A vertical line further to the left (through A, for example) represents the same variation in earning potential, but scaled for a higher other income relative to the price of domestic help.

[4]The coordinates of C'' are approximately (0.65,0.5). Holding the price of domestic help at \$1000, we deduce that the woman on OC has an earning capacity of (5/6.5) times \$1000. At point C'', her household has other income of 2 times (5/6.5) times \$1000.

Finally, a horizontal line such as HJ represents variations in the cost of domestic help. Here, the woman's earning capacity is held constant at 0.75 of other income, but as we move to the right along the line the cost of help increases relative to both the woman's income and other income. At high prices, this particular woman will choose "no work, no help", transitioning to "work, help" as prices fall, and then to "no work, help" when prices fall even further. This last choice also illustrates that rising price of help may represent increasing outside income opportunities of domestic workers, while the price of domestic workers is still below the price of technology, while a falling price of help is more likely the result of a fall in the price of household technology.

Thus, our model illustrates how variation in women's employment non-monotonically influences household appliance purchases and domestic help hiring decisions. The next section examines these dynamics in the data.

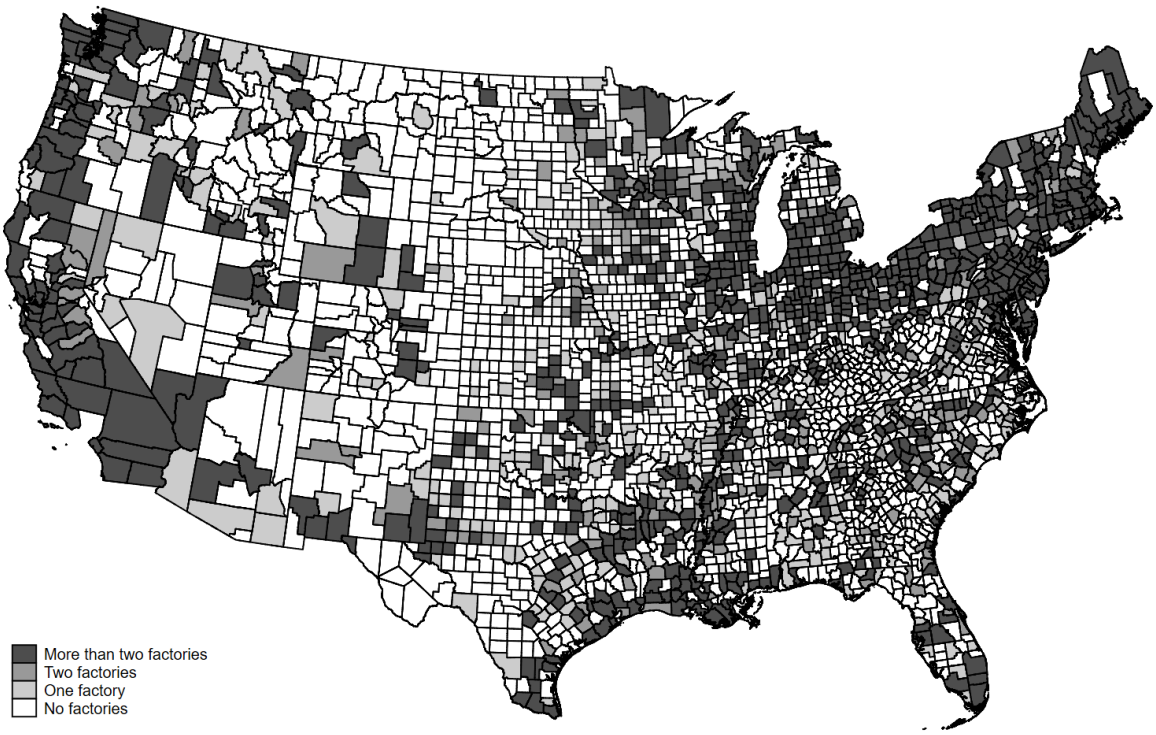
3 Data

Our main data source on both women's labor force participation and the adoption of washing machines is the "Historical, Demographic, Economic, and Social Data: The United States, 1790-2002", produced by the Inter-University Consortium for Political and Social Research (Haines and Inter-university Consortium for Poitical and Social Research, 2010). Our analysis excludes Alaska and Hawaii which were not yet states during World War II. Consistent with the literature, we also exclude Nevada and Washington DC from all estimations since Nevada underwent large population changes between 1940 and 1950, and Washington DC is missing state-level data on draft rates (Acemoglu et al., 2004; Fernandez et al., 2004; Goldin and Olivetti, 2013).

Following Fogli and Veldkamp (2011), we use county-level census data on female labor force participation in 1940 and 1950, defined as the total number of females age 14 and older in the civilian labor force divided by the total number of females age

14 and older in the population. From the census data, we also obtain information on household technology adoption. Our primary measure of household technology adoption is the percent of households in each county that own a washing machine.[5] Unlike other appliances with more recent history, the census only includes information on washing machines in 1960. In some robustness checks, we also examine refrigerator ownership, which is available at the county level in 1940 and 1950.

Figure 3: **Map of factory locations**



Data source: Department of Defense.

We augment this data with two measures of World War II mobilization that influenced demand for female workers. The first comes from Department of Defense (DoD) data on factories used for wartime production (Jaworski, 2017), which we use

[5]Specifically, the census question captures whether the household owned any type of washing machine (separate wringer or spinner/automatic or semi-automatic/combined unit) or no washing machine. From responses to this question, the county-level census data reports the "percent occupied housing units with clothes washing machine in 1960."

to construct a binary variable equal to one if county i had a wartime factory. Figure 3 illustrates the spatial distribution of factories across counties in the United States. Instead of creating new facilities, the DoD often converted existing factories for wartime production (Smith, 1991). Factories started large scale production in 1940, initially driven by foreign orders, and by the end of the war, nearly 24 million people (in a total population of 144 million, 96 million of whom were aged 15 to 64) were employed in the industrial war effort. Thus, the establishment of a factory shifted the demand for labor in the county significantly. Consider the following description of Mobile, Alabama (Burns and Novick, 2007):

> World War II utterly transformed Mobile and its economy. The explosion began in the late 1930s, when local companies such as Alcoa began producing war materiel for Japan and European countries. Local shipyards won contracts to build Liberty ships and destroyers in 1940, and by the time America entered the war in late 1941, Mobile was already booming. The Alcoa plant processed millions of pounds of alumina used to build many of the 304,000 airplanes America produced during the war; the Waterman Steamship Company boasted one of the nation's largest merchant fleets, and Mobile became one of the busiest shipping and shipbuilding ports in the nation. In 1940, Gulf Shipbuilding had 240 employees; by 1943, it had 11,600. Alabama Dry Dock went from 1,000 workers to almost 30,000.

The demand for factory labor could not be met by men alone. In early 1943, the War Manpower Commission, at the urging of the Women's Bureau of the Department of Labor and the Industrial Personnel Division of the Army Services Forces, began to actively recruit women for factory work. Special recruitment centers were established in shopping districts and housing developments to specifically appeal to women, while

the War Manpower Commission embarked on a series of high-pressure advertising campaigns (Fairchild and Grossman, 1959). Between 1940 and 1944, the number of women in the labor force increased by more than seven million (Goldin and Olivetti, 2013).

Part of the increased demand for women's labor was due to gaps in the male labor supply as a result of the draft. We therefore augment our data with information on county-level draft rates during World War II. The Selective Training and Service Act (1940) required all men between the ages of 18 and 45 years to register for military service. During the war, 49 million men registered, with 36 million classified as eligible for service. After December 1942, when most mobilization occurred, individuals could not volunteer for service and were instead selected using a lottery system (Presidential EO No. 9279). In this manner, more than 10 million men were inducted into the US military during World War II (Kriedberg and Henry, 1955; Flynn, 1993).

We construct our mobilization rate variable from individual level World War II enlistment records obtained from the US National Archives & Records Administration (National Archives and Records Administration, 2002).[6] The record for each individual in the datafile contains the county and state of residence, along with dates of birth, enlistment and de-enlistment. From this individual file, we compute $DraftRate_i$ for each county i as:

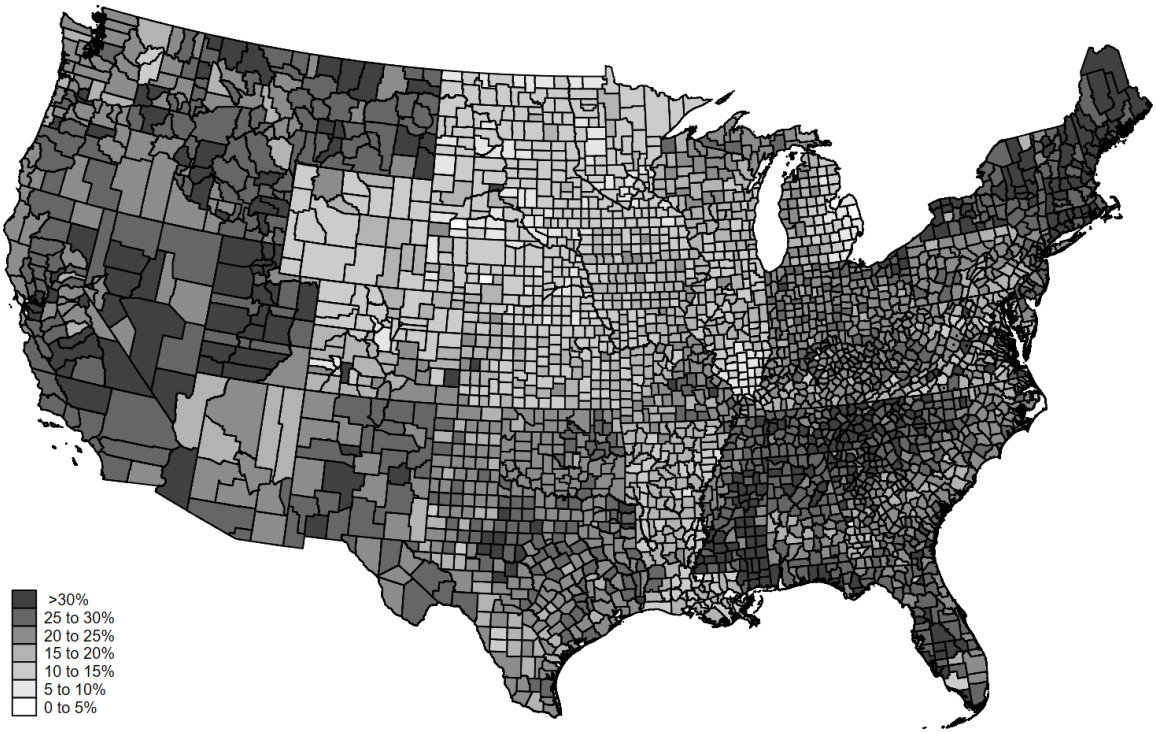
$$DraftRate_i = \frac{\text{Total no. of men drafted in 1940 to 1946}}{\text{No. of men age 15 to 44 in 1940 by county}} \tag{1}$$

Figure 4 shows the variation in draft rates across the country. Table 1 presents the summary statistics for all variables used in the empirical analysis. Factories were located in nearly half of all counties. The table reveals that 78.26% of households had

[6]These records document Army enlistees only, and do not contain information on enlistment in the Navy, Marines, or Coast Guard. However, 8.3 million of the 10 million individuals drafted during WWII were in the Army (Ferrara, 2018).

washing machines in 1960, and 66.85% of households had refrigerators in 1950. Also interesting are increases in women's labor force participation, from 18.49% in 1940 to 30.06% by 1960. This was concurrent with declining employment in domestic work: in 1940, 18.72% of the women's labor force was employed in domestic work, dropping to 9.51% by 1950.

Figure 4: **Draft rate by county**



Data source: National Archives & Records Administration and US Census.

4 Empirical analysis

We are interested in understanding the impact of women's labor force participation on the adoption of household labor-saving technology, which requires exogenous variation in women's employment for causal inference. We draw on a rich literature that establishes the positive impact of World War II mobilization on female labor supply in 1950

(Acemoglu et al., 2004; Fernandez et al., 2004) and its sustained effects in the 1960s (Goldin and Olivetti, 2013).[7] Using cross-sectional, county-level data, we examine how an expansion of employment opportunities for women during WWII corresponds to greater washing machine ownership in 1960.[8] We estimate this relationship in an instrumental variables (IV) framework at the county level, where we instrument women's labor force participation in 1950 with the existence of a wartime factory and, in some specifications, the draft rate.

4.1 Instrumental variables first stage

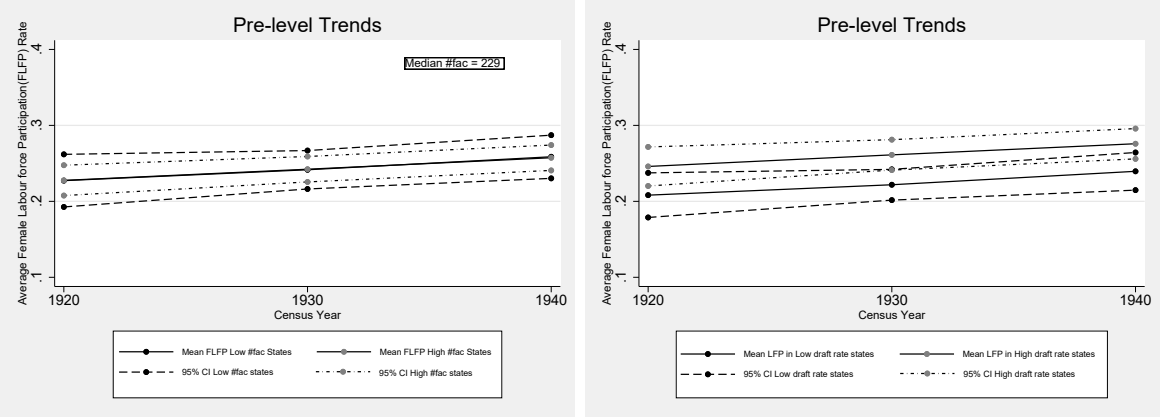
Our empirical identification strategy rests on the assumption that World War II mobilization caused an exogenous increase in women's employment. If female labor force participation in places with high war mobilization differed in a systematic way from places with low mobilization, then any observed relationship between women's employment and war mobilization is possibly due to a difference in trends prior to the War, rather than an exogenous shock. To explore the extent to which places with high and low World War II mobilization follow similar patterns of women's employment prior to the War, we plot their trends over time in Figure 5. Unfortunately, data on female labor force participation prior to 1940 is only available at the state level. Nonetheless, when we examine women's employment at the state level from 1920 to 1940, we find that trends between high and low mobilization states are parallel.

Next, we test the validity of our two instruments, presence of a wartime factory

[7] Goldin and Olivetti (2013) find that in the 1960s, the effect of WWII on labor force participation was strongest for educated women who were married (both with and without children) during the war.

[8] Ideally, we would like to observe washing machine ownership in 1950 - the period that corresponds to the largest effects on women's labor force participation. However, data on washing machines only appears in the 1960 census. In a robustness check, we examine whether women's labor force participation in 1960 corresponds with concurrent washing machine ownership in a way that is consistent with our main analysis (Appendix Table 4).

Figure 5: **Parallel trends in WLFP across war mobilization intensity**



(a) Factories (b) Draft Rates

Data sources: Panel (a) comes from U.S. Department of Defense (Jaworski, 2017). Panel (b) comes from the National Archives & Records Administration and US Census."High" and "low" correspond to counties above and below the median number of factories in panel (a) and draft rates in panel (b).

and the draft rate, by estimating the following first stage regression:

$$WLFP_i^{1950} = \alpha_0 + \alpha_1 Factory_i + \alpha_2 DraftRate_i + \mathbf{X}_i + StateFE_i + \varepsilon_i \qquad (2)$$

where $WLFP_i^{1950}$ is the women's labor force participation rate for each county i in 1950. We regress this on our proposed instruments, $Factory_i$ and $DraftRate_i$, with $\alpha_1 > 0$ and $\alpha_2 > 0$ for instruments to be valid. The vector $\mathbf{X}_i$ consists of county-level geographic characteristics (latitude, longitude, and average ruggedness) and 1940 demographic characteristics (percent farm employment, percent non-white population, average years of education, and women's labor force participation in 1940). We also include state fixed effects in all specifications, which account for unobservable time invariant factors at the state level that influence women's labor force participation at the county level. Standard errors (ε_i) are clustered at the state level.

Table 2 shows that our proposed instruments significantly influence women's labor force participation. In the most restrictive specification in column (4), the presence

of at least one wartime factory increases women's labor force participation by 0.815 percentage points ($p < 0.01$). Relative to a mean of 22.4 percent, this corresponds to a 3.6 percent effect. The coefficient on the draft rate suggests a much smaller relationship: a one percentage point increase in the draft rate raises women's labor force participation by 0.016 percentage points ($p < 0.10$). In terms of standard deviations, this corresponds to a 0.02 standard deviation increase in women's employment for every one standard deviation increase in the draft rate. Nonetheless, to the extent that the demand for women factory workers would be higher in places with a larger absence of men, we include the draft rate as an instrument in several specifications.

4.2 Main specification and results

We identify the relationship between women's labor force participation and household technology adoption by estimating the following equation:

$$y_i^{1960} = \beta_0 + \beta_1 \widehat{WLFP}_i^{1950} + \beta_2 \mathbf{Z}_i + StateFE_i + \epsilon_{is} \tag{3}$$

The dependent variable, y_i^{1960} is the fraction of households in county i owning a washing machine in 1960. Hence, the coefficient β_1 represents the impact of women's employment on appliance purchases. We hypothesize that paid employment positively impacts washing machine ownership in 1960 and therefore expect $\beta_1 > 0$.

In the instrumental variables framework, causal identification requires that: (i) conditional on pre-war county-level controls, allocation of factories and draft rates were random across counties, and (ii) war mobilization only influenced household technology adoption through its effect on women's labor force participation, known as the exclusion restriction. Regarding the first condition, several factors determined the site of a wartime factory, including the physical nature of the site, its proximity to transportation and power facilities, and the availability of raw materials and labor (Fairchild

and Grossman, 1959). Moreover, at the state level, existing literature establishes that draft rates were determined by farm employment, average education, and the size of the nonwhite population in 1940 (Acemoglu et al., 2004). To assess the relevant factors that correspond to our county-level measures of factories and draft rates, we conduct a balance of covariates test in Appendix Table 1. We find that several pre-war characteristics are correlated with the presence of a wartime factory, as well as the draft rate, including farm employment, average education, women's labor force participation, and the size of the nonwhite population in 1940.[9] We therefore control for these factors in our estimating equations, in addition to important geographic controls, such as latitude, longitude, and ruggedness (Nunn and Puga, 2012), with the vector $\mathbf{Z}_i$.

With regard to the exclusion restriction, one possible concern is that as a result of the GI Bill, men who were drafted obtained higher education after the war. This could affect household technology adoption through several channels, including an income effect, the marriage market, or preferences for women's work. While there is no formal test for the exclusion restriction, we control for male education in 1950 in alternate specifications and find that our main results hold (Appendix Table 3). Another potential threat to the exclusion restriction is that the location of wartime factories is correlated with the availability of household appliances in later years. We argue that this is unlikely, since consumers do not purchase appliances directly from factories or distributors, but rather through retail outlets. We explore the availability of retail outlets as a channel in Section 4.5.

Table 3 presents results from estimating equation (3). Columns (1) and (2) report OLS estimates, which show a negative correlation between WLFP and washing machine ownership. One reason for this finding could be that women's labor force participation

[9]This is consistent with Acemoglu et al. (2004); Fernandez et al. (2004) and Goldin and Olivetti (2013), who find a correlation between the draft rate and pre-war controls at the state level.

is greater in poorer counties, and households in such counties are simultaneously less likely to purchase household appliances. Correcting for potential endogeneity in the decision to work with the IV approach, we find in columns (3) to (6) that counties with a larger fraction of women in the labor force in 1950 have greater subsequent washing machine adoption in 1960. The magnitude of the effects varies with the specification. Inclusion of important demographic controls that correlate with our instruments decreases the magnitude of the effects. In the most restrictive specification in column (6), a one standard deviation increase in female labor force participation increases washing machine ownership by 0.413 standard deviations.

With regard to the validity of the IV, the first stage F-statistic is above 10 in all IV specifications. In column (6), where we include draft rates as an instrument, the F-statistic is barely above 10. As we see from Table 2, this is likely because the magnitude of the correlation between county-level draft rates and women's employment in 1950 is quite small. In column (4), when we use only the factory IV and include the full set of demographic and geographic controls, the F-stat is 21.05 and the results are qualitatively similar to column (6): for every one standard deviation increase in women's labor force participation in 1950, household ownership of washing machines in 1960 increases by 0.442 standard deviations.

To grasp the magnitude of these effects, we benchmark the impact of labor force participation on appliance adoption with other factors that could plausibly influence household technology. These factors include residence in urban versus rural areas since distributional costs might be lower in cities, owning other appliances since appliance purchases might respond to experience with other white goods, as well as the number of children in each household since children add to laundry but reduce available time for parents' domestic chores. Table 4 shows that a one standard deviation increase in the 1950 rural population corresponds to a 0.175 standard deviation change in

washing machine adoption. Greater refrigerator ownership in 1950 is associated with 0.168 standard deviation increase in in the fraction of households who subsequently own washing machines. Finally, counties with proportionally more children in 1950 correspond to a 0.124 standard deviation increase in washing machine ownership in 1960. Comparing these coefficients with our main finding suggests that women's labor force participation is perhaps the strongest driver of household technology adoption.

4.3 Robustness

As discussed earlier, to the extent that participation in WWII allowed men access to higher education with the GI Bill, our specifications that include draft rates as an instrument could possibly violate the exclusion restriction. While there is no formal test of the exclusion restriction, we explore whether male education in 1950 is associated with WWII mobilization by correlating the existence of a wartime factory and the draft rate with the percent of men age 25 or older with any college education (1 to 4 years) in 1950. The results in Appendix Table 2 show that after controlling for demographic characteristics in 1940, the draft rate is uncorrelated with male educational attainment in 1950. In both columns (2) and (4), we find that the presence of a wartime factory is significantly correlated with male education, but the effect size is very small: the percent of men with any college in 1950 is half a percent higher in counties with a wartime factory. Nonetheless, as a robustness check, we run an alternate specification in Appendix Table 3 controlling for male education and find that these results are almost identical to our main findings in Table 3. If anything, the magnitude of the effects are slightly larger when controlling for male education, but this is likely due to the collinearity of male education in 1950 with average years of education in 1940. In addition, note that male education is negatively correlated with washing machine ownership, perhaps as a result of assortative matching in marriage markets in which

highly educated men marry highly educated women, who prefer domestic labor to appliances. We explore heterogeneity in washing machine ownership and domestic labor by women's education levels in section 4.4.

To the extent that the largest effects on women's labor force participation occurred by 1950 (Acemoglu et al., 2004), we would ideally observe washing machine ownership in 1950. This simultaneous work and purchase decision is most consistent with our framework outlined in section 2. Unfortunately, data on washing machines only appears in the 1960 census. To elucidate the extent to which current labor force participation correlates with current household technology adoption, we estimate the relationship between women's labor force participation in 1960 and concurrent washing machine ownership using the same IV framework. The results in Appendix Table 4 are consistent with our main specification and suggest that with a one standard deviation increase in women's labor force participation in 1960, washing machine ownership in 1960 is 0.36 to 0.37 standard deviations greater.

To further elucidate the effect of changes in female labor force participation on concurrent changes in household technology ownership, we exploit county-level panel data from 1940 and 1950, which includes information on refrigerator ownership. Using the panel framework, we employ a difference-in-differences IV approach to causally estimate the effect of increases in women's labor force participation on refrigerator adoption. We estimate a difference-in-differences specification with the following equation:[10]

$$y_{it} = \beta_0 + \beta_1 WLFP_{it} + \beta_2 \mathbf{Z}_{1940} \times Y_{1950} + CountyFE_i + Year_i + \epsilon_{it} \tag{4}$$

The coefficient β_1 captures the effect of increases in women's labor force participa-

[10]The IV first stage specification and results are in Appendix A.

tion on refrigerator adoption between 1940 and 1950. We explore the difference-in-differences effect using both uninstrumented and instrumented measures of women's labor force participation ($WLFP_{it}$). The results in Appendix Table 6 are robust to our main findings for washing machines, and show that increases in women's employment correspond to increases in refrigerator adoption. This relationship holds in both the uninstrumented and IV specifications.

4.4 Heterogeneity

The framework in section 2 suggests that the relationship between a woman's employment and technology adoption likely follows a non-monotonic relationship depending on her earning capacity relative to the cost of hiring domestic help. This section explores heterogeneity in the relationship between women's labor force participation and washing machines by women's education levels in 1940, as well as median family income in 1950.

4.4.1 Women's education

To explore the non-monotonic relationship between women's employment and washing machine adoption with respect to education, we first group counties into bins according to the average years of education that adult women (age $\geq$ 25 years) have completed as of 1940. The bins correspond to 3 years or less, 4 years, 5 years, 6 years, 7 years, 8 years, 9 years, and 10 years or more of schooling. Note that across counties in 1940, the mean of average years of completed education for women was 8.11 years, meaning that on average women had completed junior high, but did not have a high school education.[11]

[11]See Appendix Figure 1 for the distribution of average years of completed education for women in 1940. In some counties, the census could not determine the education level for a fraction of women. Therefore, in all regressions, we control for the proportion of women in a given county for whom educational attainment is unknown.

Using a two-step estimation, we first predict women's labor force participation in 1950 by estimating the first stage equation (2). Next, we interact the predicted values with education bins in 1940 to estimate the following equation:

$$y_i^{1960} = \alpha + \sum_e \beta_e \widehat{WLFP}_i^{1950} * \mathbb{1}(Educ_i^{1940} = e) + \gamma \mathbf{Z}_i + StateFE_i + \epsilon_{is} \qquad (5)$$

Our dependent variable, y_i^{1960}, is the percent of households in county i that own a washing machine in 1960. The subscript e corresponds to the education bin into which the county falls. In the estimation, we exclude the education bin that corresponds to 10 years or more of schooling and bootstrap standard errors, clustered at the state level, over 1000 repetitions.

Figure 6 presents the plotted coefficients for the interaction terms, which clearly illustrate a non-monotonic relationship between women's labor force participation and technology adoption with respect to education.[12] Specifically, we observe an inverted-U relationship, suggesting that in counties with pre-war education levels in the mid-ranges (6 to 8 years of completed education, on average), the effect of women's employment on household technology adoption is strongest relative to counties with the highest average education. Both low and high education counties display no relationship between female labor force participation and washing machine ownership.

These findings are consistent with the predictions of our framework, which suggests that at low levels of earning capacity relative to the cost of hiring domestic help, even when women go to work, the cost of hiring help (either domestic work or household technology) is still prohibitive, such that women work, but do not purchase help. At the highest earning levels, women go to work but do not change their demand for domestic help. However, in middle earnings ranges, women who enter the labor force

[12]The full regression output is presented in Appendix Table 8.

are able to substitute their own domestic labor with washing machines.

4.4.2 Household income

Another source of heterogeneity stems from potential increases in bargaining power for women who join the labor force and begin earning their own income. Acemoglu et al. (2004) show that between 1940 and 1950 the increase in female labor supply lowered wages for women (and men). However, for women entering the labor market for the first time, this new income source would contribute to total household income, both increasing household purchasing power and potentially increasing women's bargaining power over domestic labor.

Appendix Table 9 shows that median family incomes in both 1950 and 1960 are higher in places with more women's employment in 1950, suggesting that household income is an important channel through which washing machine adoption occurred. We explore potential non-linearities in this channel by grouping counties into quintiles of median household income in 1950 and estimating the following equation using a two-step estimation:

$$y_i^{1960} = \alpha + \sum_q \beta_q \widehat{WLFP}_i^{1950} * \mathbb{1}(Income_i^{1950} = q) + \gamma \mathbf{Z}_i + StateFE_i + \epsilon_{is} \quad (6)$$

where q represents the quintile of median household income into which county i falls. We exclude the lowest quintile and bootstrap standard errors, clustered at the state level, over 1000 repetitions.

Our framework in section 2 predicts that as women in the mid-ranges of earning capacity go to work, they begin to substitute their own domestic labor with help. However, women with higher household income almost always demand help, whether they work or not. Figure 7 plots the interaction coefficients, which show that, relative to the poorest regions, counties in the second income quintile experience the largest

increase in washing machine ownership when female labor force participation rises. In the wealthiest counties, higher female labor force participation is associated with lower washing machine ownership.[13] These empirical estimates are consistent with predictions from our framework, with lower ownership of washing machines observed as more women work in wealthier counties, suggesting that the form of help women are using in these places is domestic work and not washing machines. We explore the substitutability between washing machines and domestic work in the next section.

4.5 Channels

4.5.1 Employment as domestic labor

The percent of the female labor force employed in domestic services declined rapidly from around 18% in 1930 to 8% by 1960.[14] With reductions in the availability of cheap domestic labor, it is possible that households began to substitute maids with appliances, as some historians have suggested (Schwartz Cowan, 1983), making domestic labor an important channel through which household technology adoption occurs.

We explore the relationship between domestic labor and washing machine adoption by re-estimating equation (3) and replacing women's labor force participation with the percent of the female labor force employed in domestic labor.[15] If domestic labor and household technology are substitutable, we expect that with an abundance of affordable domestic labor, households will demand less household technology. Similarly, with exogenous declines in domestic labor (or an increase in the price), households will demand more household technology.

Column (1) of Table 5 shows the correlation between the percent of the female la-

[13]The full regression output is presented in Appendix Table 10.

[14]Authors' calculations based on data from Ruggles et al. (2018).

[15]County-level measures of domestic labor can only be constructed for 1940 and 1950. Prior to 1940, county-level census data on labor force participation does not exist. After 1950, data on employment in domestic services is missing.

bor force employed in domestic services in 1950 and rates of washing machine ownership in 1960, controlling for employment in domestic services in 1940, as well as county-level geographic and demographic characteristics. The results show a significant negative correlation, implying that a lower availability of domestic labor is associated with higher household ownership of washing machines.

While intuitive, the results in column (1) likely suffer from several identification issues. The most obvious concern is reverse causality. While declines in the availability of domestic labor could encourage households to adopt labor-saving technologies, the rise in the availability and affordability of these technologies possibly reduced the demand for domestic labor. To address this issue, we introduce an instrumental variable to predict the decline in domestic labor. We first consider our original instrument for female labor force participation, WWII mobilization. Column (2) shows the results of the first stage, indicating that neither county enlistment rates nor the presence of a factory predict the decline in domestic labor. This is unsurprising, considering that the composition of domestic laborers was predominantly black or foreign-born women during this time period, and the group for whom war mobilization had lasting effects on labor force participation were educated, married, white women (Goldin and Olivetti, 2013).

Therefore, we consider the percentage of black women in a given county who participated in the Works Progress Administration (WPA) of the New Deal in 1937 as an alternative instrument. The intuition is as follows. Black women were employed disproportionately in domestic services throughout the mid 20th century. In 1930, 51% of black women in the labor force were employed as domestic servants, compared to 11% of white women. By 1960, these figures declined, but were still heavily skewed toward black women for whom 35% were employed in domestic services (Ruggles et al., 2018). Because of the concentration of black women in domestic services, we argue that

declines in the availability of domestic labor should be disproportionately driven by alternative labor market opportunities for black women.

The WPA was established in 1935, employing millions of – mostly unskilled – people to carry out public works projects. At its peak in 1936, the WPA employed 460,000 women, most of whom were trained to work on sewing projects for hospitals, orphanages, and adoption centers (Howard, 1973). For unskilled women, participation in the WPA afforded them a set of skills that could be used in the labor market after the WPA dissolved in 1943. In this sense, we argue that particularly for black women, participation in the WPA provided an opportunity to move out of domestic services.[16]

We use the proportion of black women employed by the WPA in 1937, relative to the total number of WPA workers in a given county, as an instrument to predict the decline in domestic labor in 1950, controlling for the percent of female labor employed in domestic services in 1940. In addition, we control for the county level percent of the population living in an urban area, the percent of black women in the population, school enrollment rates, and the unemployment rate in 1930, as these are significantly correlated with our instrument (Appendix Table 7). Column (3) of Table 5 shows that the instrument is significantly and negatively correlated with the percent of female labor force participation in domestic services in 1950, suggesting that black female participation in the WPA is associated with reductions in domestic labor.

The second stage results in column (4) provide support for the hypothesis that an important channel of household technology adoption is through a reduction in domestic labor. As the proportion of female labor force participation in domestic services declines, household adoption of washing machines increases. It is worth noting that the magnitude of the coefficient on domestic labor is more than 10 times higher than in the

[16]County-level census data from 1937 reveal that on average, 1.3% of WPA workers were black females, with a standard deviation of 2.6 and maximum of 27%. In the South, the average is slightly higher, at 2.4% with a standard deviation of 3.3.

OLS specification, while the first stage F-statistic is slightly below 10. We therefore interpret the magnitude of this relationship with caution. Nonetheless, both the OLS and IV estimates support the hypothesis that domestic labor and household technology are substitutes in this setting.

While the evidence suggests that washing machines and domestic services are substitutable on average, this likely varies across socio-economic groups. Our heterogeneity results in section 4.4 show that for counties in the mid ranges of education and income, washing machine ownership increases when women's employment rises, suggesting that women in these places substitute their own labor for washing machines. In counties with higher earning capacities, however, this relationship does not exist, and in the case of income is actually negative. This suggests perhaps that in counties with higher earning capacity women, when employment opportunities expand, these women increase demand for domestic help instead of household technology. We directly explore this hypothesis by estimating the following equation in a two-step approach:

$$Domestic_i^{1950} = \alpha + \sum_e \beta_e \widehat{WLFP}_i^{1950} * \mathbb{1}(Educ_i^{1940} = e) + \gamma \mathbf{Z}_i + StateFE_i + \epsilon_i \quad (7)$$

where the dependent variable, $Domestic_i^{1950}$ is the percent of the women's labor force employed in domestic services in county i in 1950. We regress this on the interaction of female labor force participation and women's education categories, excluding the category that corresponds to average education of 4 years or less. We control for county-level geographic and demographic characteristics ($\mathbf{Z}_i$) and state fixed effects, and bootstrap standard errors clustered at the state level over 1000 repetitions.

Table 6 and Figure 8 present the results. Relative to counties with the least educated women, counties where women are highly educated actually observe more women employed in domestic labor when women's employment expands. In counties with av-

erage education of 10 years or more, a one standard deviation increase in women's labor force participation leads to a 0.32 standard deviation increase in the percent of employed women working in domestic services ($p < 0.05$). The coefficients on the other interaction terms are positive, but are either statistically insignificant or weakly significant, suggesting that this effect is strongest for counties with highly educated women.

The coefficient on women's labor force participation corresponding to the excluded category (average education of 4 years or less) is negative and significant. This coefficient suggests that in counties where women are the least educated, increases in women's employment significantly lowers the percent of women employed in domestic services. Since low-skilled women are most likely to work in domestic labor, this result suggests that with new employment opportunities for women during WWII, some low skilled women moved out of domestic work and into other types of employment.

4.5.2 Migration

Migration is an important part of labor market decisions, as some workers choose to migrate to locations where employment opportunities exist. If there is positive selection into migration in terms of skill and income, migration could be an important channel through which women's employment affects household appliance ownership.

Using 1960 census data on migration, we regress total and net migration in a given county on women's labor force participation in 1950 using our IV approach.[17] The results presented in Table 7 show that women's employment in 1950 does not affect migration. In fact, columns (1) and (2) show that counties with higher women's labor force participation in 1950 have lower total migration in 1960. Examining the net change in migrants between 1950 and 1960 in columns (3) and (4) offers no evidence of

[17]Migration data in 1950 are not available in the county-level census data.

a significant correlation between women's employment and migration. Together, these findings suggest that our main result is not driven by changes in migration patterns as a result of increased employment opportunities for women.

4.5.3 Information provision

Televisions (and advertising on television) entered households at a rapid pace throughout the mid 20th century. Information provision through television programming has been shown to affect children's school performance (Gentzkow and Shapiro, 2008), fertility decisions (La Ferrara et al., 2012), and social capital (Olken, 2009), among other outcomes. Here, we explore whether television affected household technology adoption, particularly in places where women's employment expanded.

Using exogenous variation in the roll-out of TV signals from Gentzkow and Shapiro (2008), we re-estimate equation (3) controlling for whether county i had a TV signal by 1952, which we also interact with women's employment.[18] Table 8 displays the results. Columns (1) and (2) show that having a TV signal by 1952 is positively correlated with household technology adoption, but the effect size is small. The coefficient suggests that counties with a TV signal in 1952 have 0.083 percentage point ($p < 0.05$) higher washing machine ownership in 1960. Relative to a mean of 78.27, this corresponds to a 0.1 percent effect.

Note that controlling for TV signals does not change the qualitative interpretation of the estimated relationship between female labor force participation and washing machine ownership. A one standard deviation increase in women's employment in 1950 increases washing machine ownership in 1960 by $\sim$0.4 standard deviations, which is qualitatively similar to our main result in Table 3. Interestingly, when we interact TV signal with women's employment in columns (3) and (4), we find that in places with

[18] We choose the year 1952 because the average year in which counties in our sample first received a TV signal is 1951.88 (median is 1953).

a TV signal, higher women's labor force participation in 1950 is negatively correlated with washing machine ownership. The estimate, however, is sensitive to specification of the IV.

4.5.4 Cost of access

One concern with our IV approach is that the location of wartime factories is correlated with the availability of household appliances, which would violate the exclusion restriction needed for causal interpretation of our main IV specification. To the extent that consumers purchase household appliances from retail outlets, rather than directly from factories, the location of factories should not have a direct effect on washing machine purchases. However, if the location of factories is correlated with placement of retail outlets, then the exclusion restriction is potentially violated. To test this, we correlate our war mobilization measures with the number of retail outlets selling appliances in 1954. Appendix Table 11 shows that neither factories nor draft rates are correlated with the availability of retail appliance stores.

Next, we examine whether the availability of retail stores is an important channel of household technology adoption. To the extent that washing machines (as well as other appliances) are a bulky consumer durable, the cost of access to these technologies could be an important barrier to adoption. Places with more retail outlets selling these appliances would have lower costs of access to this technology. In Table 9, we re-estimate equation (3) controlling for the total number of retail appliance stores in 1954 and also include an interaction with women's employment. The results suggest no significant relationship between the availability of retail appliance outlets and washing machine ownership. The coefficient on the interaction term is positive, suggesting that counties with greater female labor force participation and more retail outlets have higher ownership of washing machines, but this effect is statistically insignificant and

highly dependent on the specification of the IV.

Note that in columns (1) and (2), after controlling for retail stores, the qualitative interpretation of our main effect is consistent with the primary finding in Table 3. A one standard deviation increase in women's labor force participation in 1950 raises washing machine ownership in 1960 by ∼0.4 standard deviations.

5 Discussion

In her book *More Work for Mother*, the historian Ruth Schwartz Cowan questioned whether the introduction of household appliances led to greater labor force participation (Schwartz Cowan, 1983), "Most American housewives did not enter the job market because they had an enormous amount of free time on their hands". Instead, Cowan wrote, "American housewives discovered that, for one reason or another, they needed full-time employment; and subsequently, they discovered that, with the help of a dishwasher, a washing machine, and an occasional frozen dinner, they could undertake that employment without endangering their family's living standards," suggesting a chain of causality from greater labor force participation and earnings leading to appliance ownership.

Our empirical results corroborate Cowan's view by showing how exogenous shocks to women's employment during the second world war were associated with adoption of household technology. These effects apply most strongly to women in the middle of the education distribution, for whom income effects are the most straightforward explanation for more appliance purchases. In contrast, women at the top of the education distribution are more likely to shift to increased employment of domestic labor, not machines. Our findings contrast with the literature on the effects of household technology, which has suggested that the arrival of household technology freed women's time, permitting greater labor force participation.

Our findings from mid-century United States have implications for selection into household technology adoption in contemporary settings in both developing and developed countries. Women's participation in formal labor markets is increasing in developing economies, and our analysis suggests that these households are likely first adopters of labor-saving technologies such as washing machines, dishwashers and microwave ovens. In developed economies, our analysis suggests that households with high labor force participation might be early adopters of new artificial intelligence based technologies.

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Table 1: **Summary statistics**

	N	Mean	SD	Min	Max
Factory	3056	0.49	0.50	0	1
Draft Rate	3056	21.91	9.32	0	100
% Households with washing machine (1960)	3056	78.26	12.65	0	100
% Households with refrigerator (1950)	3056	66.85	17.57	0	97
% Households with refrigerator (1940)	3056	26.72	14.78	1	92
WLFP 1960	3056	30.06	6.34	8	54
WLFP 1950	3056	22.45	6.49	5	47
WLFP 1940	3056	18.49	6.67	5	48
% WLFP Domestic (1950)	3056	9.51	5.78	0	45
% WLFP Domestic (1940)	3056	18.72	7.27	0	69
% Black women employed by WPA (1937)	3048	1.32	2.61	0	27
% Migrant (1960)	3056	17.52	8.52	4	75
Net migration (1950 to 1960)	3056	828.06	33575.61	-372001	1185976
TV signal by 1952	3056	0.39	0.49	0	1
Retail appliance stores (1954)	3056	29.66	110.80	0	3571
% Farm employment (1940)	3056	45.92	21.93	0	94
% Nonwhite (1940)	3056	11.44	17.95	0	86
Average education (1940)	3056	7.99	1.16	2	12
Longitude	3056	-91.57	11.32	-124	-68
Latitude	3056	38.29	4.86	25	49
Ruggedness index	3056	60420.15	76649.00	0	573542

Data source: Department of Defense, National Archives & Records Administration and US Census.

Table 2: **WWII mobilization and women's labor force participation**

Dependent Variable: Women LFP 1950				
	(1)	(2)	(3)	(4)
Factory	1.029***	0.787***	1.071***	0.815***
	(0.174)	(0.171)	(0.164)	(0.178)
Draft Rate			0.042***	0.016**
			(0.010)	(0.008)
Demographic controls:	No	Yes	No	Yes
Observations	3056	3056	3056	3056
Mean of Dep Var	22.451	22.451	22.451	22.451
SD of Dep Var	6.492	6.492	6.492	6.492
R^2	0.735	0.751	0.737	0.751

* p< 0.10, ** p<0.05, *** p < 0.01. Unit of observation is a County. Standard errors clustered at the state level in parentheses. All estimates control for state fixed effects, female labor force participation in 1940 and the following geographic controls county: latitude, longitude, and average ruggedness. Demographic controls include: percent farm employment, percent non-white population, and average education in 1940.

Table 3: **Main results: Women's labor force participation and washing machines**

Dependent Variable: % Households owning washing machine in 1960						
	(1)	(2)	(3)	(4)	(5)	(6)
WLFP 1950	-0.009	-0.073***	0.620**	0.442*	0.931***	0.413*
	(0.059)	(0.046)	(0.526)	(0.465)	(0.603)	(0.446)
Demographic controls:	No	Yes	No	Yes	No	Yes
Specification:	OLS	OLS	IV	IV	IV	IV
Instrument:			Fac	Fac	Fac+Draft	Fac+Draft
Observations	3056	3056	3056	3056	3056	3056
First Stage F-Stat			35.14	21.05	24.27	10.64
Mean of Dep Var	78.26	78.26	78.26	78.26	78.26	78.26
SD of Dep Var	12.65	12.65	12.65	12.65	12.65	12.65
R^2	0.621	0.712	0.514	0.646	0.383	0.653

* p< 0.10, ** p<0.05, *** p < 0.01. Unit of observation is a County. Standardized beta coefficients reported. Standard errors clustered at the state level in parentheses. All estimates control for state fixed effects, female labor force participation in 1940, and the following geographic controls: county latitude, longitude, and average ruggedness. Demographic controls include: percent farm employment, percent non-white population, and average education in 1940.

Table 4: **Benchmarking exercise**

Dependent Variable: % Households owning washing machine in 1960				
	(1)	(2)	(3)	(4)
% Rural population in 1950	0.160***			0.175***
	(0.009)			(0.009)
% Households with own refrigerator in 1950		0.115***		0.168***
		(0.019)		(0.022)
% Population of age 0-17yrs in 1950			0.115***	0.124***
			(0.083)	(0.078)
Demographic controls :	Yes	Yes	Yes	Yes
Specification :	OLS	OLS	OLS	OLS
Observations	3056	3056	3056	3056
R^2	0.709	0.705	0.704	0.721

* p< 0.10, ** p<0.05, *** p < 0.01. Unit of observation is a County in 1960. Standardized beta coefficients reported. Standard errors clustered at the state level in parentheses. All estimates control for state fixed effects, percent farm employment, percent non-white population,and average education in 1940, as well as county latitude, longitude and average ruggedness.

Table 5: **Channel: Domestic work**

	% Own Wash (1960) (1)	% Domestic (1950) (2)	% Domestic (1950) (3)	% Own Wash (1960) (4)
% WLFP Domestic (1950)	-0.114**			-1.756*
	(0.107)			(2.175)
Draft Rate		-0.006		
		(0.011)		
Factory		-0.008		
		(0.154)		
% Black women WPA (1937)			-0.033***	
			(0.023)	
Specification:	OLS	First	First	IV
Observations	3048	3048	3048	3048
R^2	0.700	0.795	0.795	0.146
First Stage F-Stat				9.802
Mean of Dep Var	78.27	9.509	9.509	78.27
SD of Dep Var	12.65	5.786	5.786	12.65

* p< 0.10, ** p<0.05, *** p < 0.01. Unit of observation is a County. Standardized beta coefficients reported. Standard errors clustered at the state level in parentheses. All estimates control for state fixed effects and percent of WLFP employed in domestic work in 1940, as well as county latitude, longitude, average ruggedness, percent urban, percent black female population, school enrollment, and unemployment rate in 1930. In addition, column (2) controls for percent farm employment, percent nonwhite population, and average education in 1940.

Table 6: **WLFP and domestic work by female education**

Dependent Variable: % WLFP employed in domestic work in 1950		
	(1)	(2)
WLFP 1950	-0.408**	-0.429**
	(0.204)	(0.212)
5 years x WLFP 1950	0.188	0.191
	(0.144)	(0.148)
6 years x WLFP 1950	0.251*	0.253*
	(0.139)	(0.145)
7 years x WLFP 1950	0.228*	0.231
	(0.138)	(0.145)
8 years x WLFP 1950	0.237*	0.239
	(0.138)	(0.147)
9 years x WLFP 1950	0.228	0.232
	(0.139)	(0.147)
10 years x WLFP 1950	0.321**	0.326**
	(0.153)	(0.163)
5 years	0.326**	0.328**
	(0.138)	(0.143)
6 years	0.482***	0.484***
	(0.140)	(0.146)
7 years	0.563***	0.566***
	(0.150)	(0.158)
8 years	0.628***	0.631***
	(0.164)	(0.174)
9 years	0.730***	0.732***
	(0.180)	(0.189)
10 years	0.698***	0.696***
	(0.211)	(0.228)
Instrument:	Fac	Fac+Draft
Observations	3056	3056

* p< 0.10, ** p<0.05, *** p < 0.01. Unit of observation is a County. IV estimates. Standardized beta coefficients reported for WLFP and interactions. Bootstrap standard errors clustered at the state level in parentheses (1000 reps). Education categories are equal to 1 if the average years of completed education for females age 25+ in a given county in 1940 falls within the bin and 0 otherwise. The excluded category is 4 years or less. Estimates include the following controls: state fixed effects, county latitude, longitude and average ruggedness, as well as the following 1940 controls: female labor force participation, percent farm employment, percent non-white population, average male education, percent of females age 25+ for whom years of education is unknown, and percent of males age 25+ for whom years of education is unknown.

Table 7: **Channels: Migration (1960)**

	(1) Percent Migrant	(2) Percent Migrant	(3) Net Migration	(4) Net Migration
WLFP 1950	-0.561*	-0.770**	0.124	-0.025
	(0.389)	(0.440)	(1267.364)	(771.527)
Demographic controls :	Yes	Yes	Yes	Yes
Instrument:	Fac	Fac+Draft	Fac	Fac+Draft
Observations	3056	3056	3056	3056
First Stage F-Stat	21.023	10.621	21.023	10.621
Dependent Var mean	17.523	17.523	828.064	828.064
Dependent Var sd	8.520	8.520	33575.610	33575.610
R^2	0.340	0.268	0.129	0.140

* p< 0.10, ** p<0.05, *** p < 0.01. Unit of observation is a County. Standardized beta coefficients reported. Standard errors clustered at the state level in parentheses. Migration measures come directly from the 1960 census data. Percent Migrant is the percent of the population in 1960 that migrated from a different county in the last 5 years. Net Migration is the net change in the population from migration between 1950 and 1960. All estimates control for state fixed effects, total population in 1950, and female labor force participation, percent farm employment, percent non-white population, and average education in 1940, as well as, county latitude longitude and average ruggedness.

Table 8: **Channels: TV**

Dependent Variable: % Households owning washing machine in 1960				
	(1)	(2)	(3)	(4)
(5)	(6)	(7)	(8)	
WLFP 1950				
0.435*	0.377*	0.468*	0.383*	
(0.251)	(0.223)	(0.261)	(0.226)	
TV signal by 1952				
0.083**	0.083**	0.079**	0.081**	
(0.036)	(0.036)	(0.038)	(0.037)	
WLFP 1950 x TV signal by 1952				
		-0.124**	-0.079	
		(0.060)	(0.052)	
Instrument:	Fac	Fac+Draft	Fac	Fact+Draft
Observations	3056	3056	3056	3056
3056	3056	3056	3056	
First Stage F-Stat			27.848	24.401
21.078	10.724	10.423	5.357	
R^2	0.268	0.269	0.217	0.263
0.656	0.670	0.656	0.674	

* p< 0.10, ** p<0.05, *** p < 0.01. Unit of observation is a County. Standardized beta coefficients reported. Standard errors clustered at the state level in parentheses. All estimates control for: state fixed effects, total population in 1950, and female labor force participation, percent farm employment, percent non-white population, and average eduction in 1940, as well as county latitude, longitude and average ruggedness.

Table 9: **Channels: Retail stores**

Dependent Variable: % Households owning washing machine in 1960				
	(1)			
Standardized values of (LFP1950_hat)	0.215			
	(0.157)			
Retail appliance stores (1954)	0.128**			
	(0.065)			
sLFP1950hat_Retail	-0.223***			
	(0.030)			
Instrument:	Fac	Fac+Draft	Fac	Fact+Draft
Observations	3056			
First Stage F-Stat				
R^2	0.723			

* p< 0.10, ** p<0.05, *** p < 0.01. Unit of observation is a County. Standardized beta coefficients reported. Bootstrap standard errors clustered at the state level in parentheses (1000 reps). All estimates control for: state fixed effects, and female labor force participation, percent farm employment, percent non-white population, and average eduction in 1940, as well as county latitude, longitude and average ruggedness.

Figure 6: **Effect of WLFP on washing machine ownership by years of education**

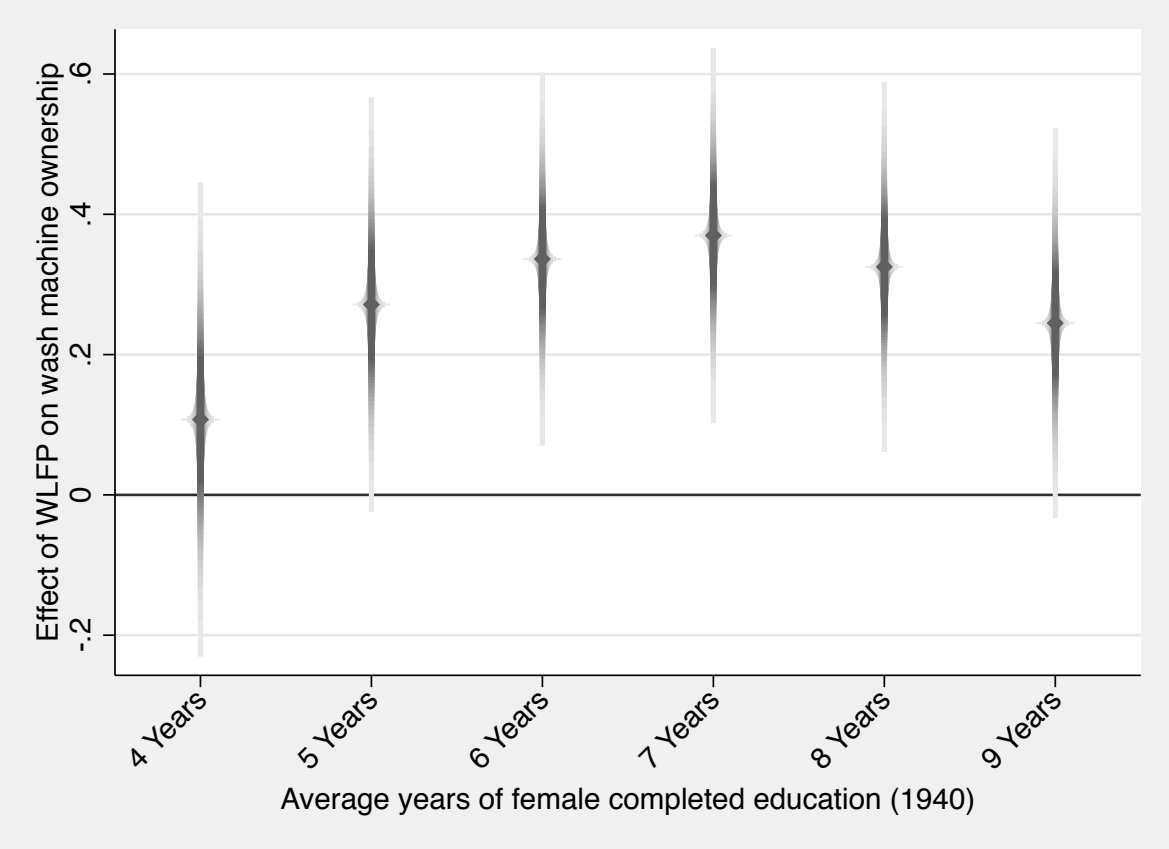


Figure shows coefficients from education interaction effects in Table 8, column (2).

Figure 7: **Effect of WLFP on washing machine ownership by income quintiles**

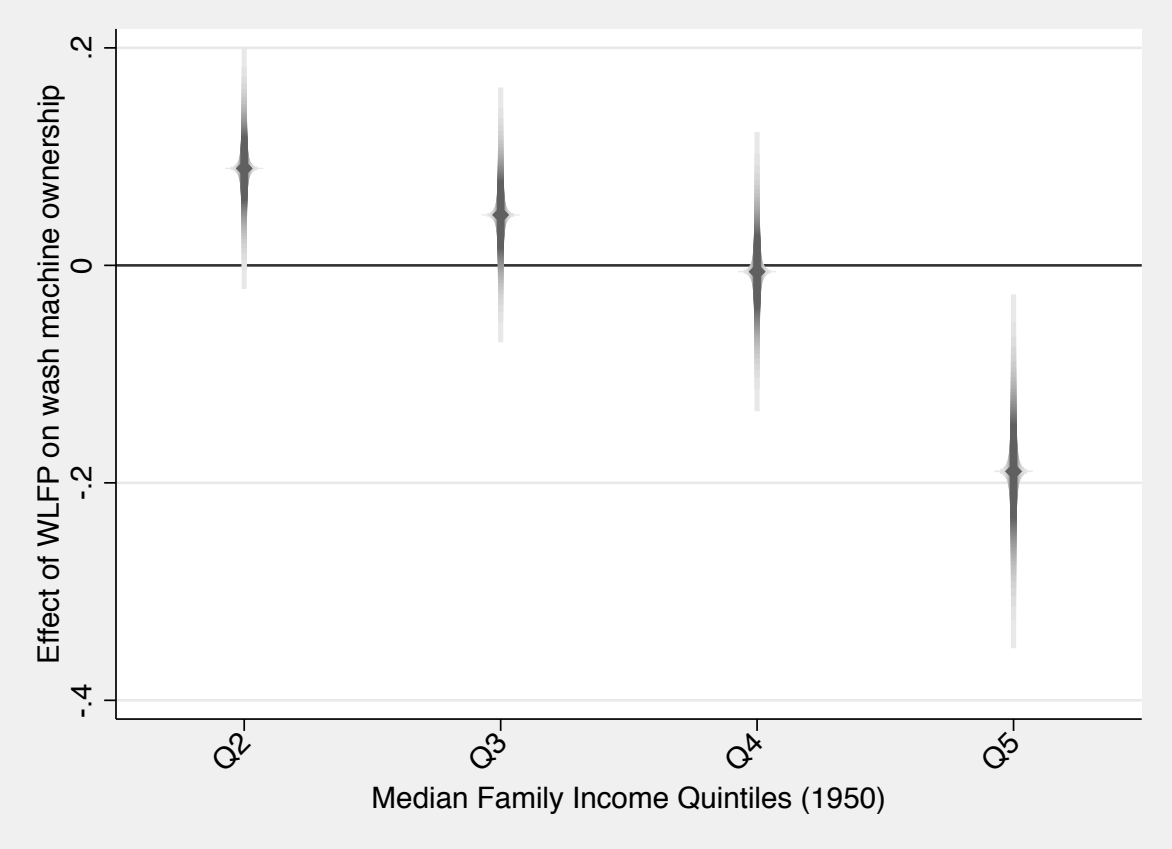


Figure shows coefficients from income quintile interaction effects in Table 10, column (2).

Figure 8: **Effect of WLFP on domestic labor by years of education**

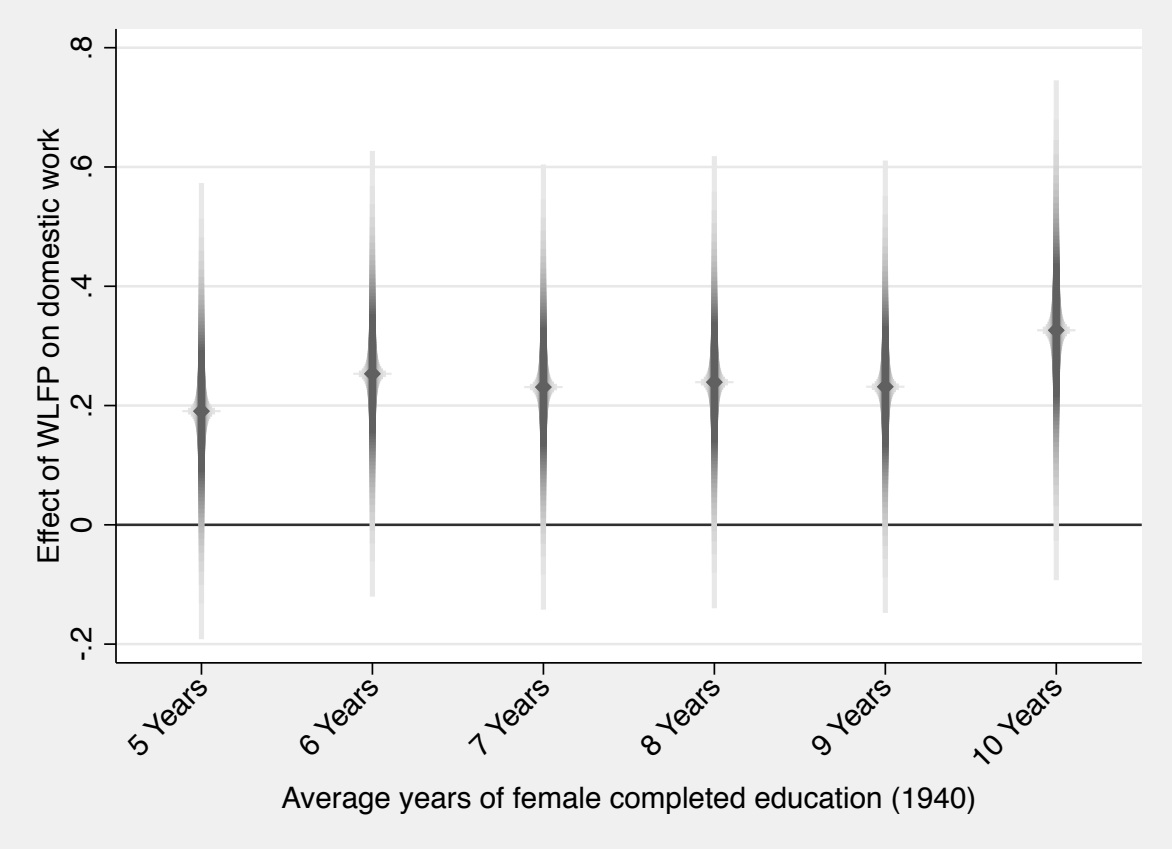


Figure shows coefficients from income quintile interaction effects in Table 6, column (2).

Appendices

A For Online Publication

We predict changes in women's employment by estimating the following first stage regression:

$$\begin{aligned} WLFP_{it} &= \alpha_0 + \alpha_1 Factory_i * Y_{1950} + \alpha_2 Draft_i * Y_{1950} + \alpha_3 \mathbf{Z}_{1940} * Y_{1950} \\ &\quad + CountyFE_i + Year_i + \epsilon_{it} \end{aligned}$$

Our dependent variable is women's labor force participation in 1940 and 1950 ($WLFP_{it}$). We interact the WWII mobilization instruments with a post-war indicator variable equal to one in the year 1950 (Y_{1950}) and control for pre-war characteristics ($\mathbf{Z}_{1940}$) interacted with the post-war time period. We include county fixed effects to control for time-invariant unobservables at the county level that affect women's labor force participation, as well refrigerator adoption. The specification includes year fixed effects and clusters standard errors at the county level.

Appendix Table 5 shows that having a wartime factory leads to a 0.48 to 0.50 percentage point increase in women's labor force participation in 1950. Relative to a mean of 18.5 percent in 1940, these magnitudes correspond to a 2.6 to 2.7 percent effect. Interestingly, in the panel framework, county-level draft rates are negatively correlated with women's entry into the labor force after the war.[19]

[19]Using individual level data on hours and weeks worked, Acemoglu et al. (2004), Fernandez et al. (2004), and Goldin and Olivetti (2013) all find that state-level draft rates increase the hours and weeks worked by women between 1940 and 1950.

Appendix Table 1: **Balance of covariates**

	Longitude	Latitude	Rugged	% Farm 1940	% Nonwhite 1940	Avg. Ed 1940	LFP 1940
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A: Factory (0/1)							
Factory	0.234*	-0.068	-7428.517**	-13.698***	1.070	0.238***	4.165***
	(0.127)	(0.075)	(2898.929)	(1.193)	(0.899)	(0.042)	(0.387)
Panel B: Draft Rates							
Draft Rate	0.000	0.004	-212.418	-0.764***	-0.256*	0.025***	0.184***
	(0.009)	(0.006)	(336.254)	(0.088)	(0.153)	(0.005)	(0.018)
Observations	3056	3056	3056	3056	3056	3056	3056
R^2	0.976	0.939	0.503	0.410	0.603	0.578	0.352

* p< 0.10, ** p<0.05, *** p < 0.01. Unit of observation is a County. Standard errors clustered at the state level in parentheses. All estimates control for state fixed effects.

Appendix Table 2: **WWII mobilization and male education**

Dependent Variable: % Males 25+ with any college (1950)				
	(1)	(2)	(3)	(4)
Factory	0.232***	0.050***	0.228***	0.050***
	(0.217)	(0.177)	(0.214)	(0.185)
Draft Rate			0.199***	0.002
			(0.010)	(0.009)
Demographic controls:	No	Yes	No	Yes
Observations	3056	3056	3056	3056
Mean of Dep Var	9.700	9.700	9.700	9.700
SD of Dep Var	5.013	5.013	5.013	5.013
R^2	0.286	0.567	0.309	0.567

* p< 0.10, ** p<0.05, *** p < 0.01. Unit of observation is a County. Standard errors clustered at the state level in parentheses. All estimates control for state fixed effects, WFLP in 1940, and the following geographic controls: county latitude, longitude, and average ruggedness. Demographic controls include: percent farm employment, percent non-white population, and average education in 1940.

Appendix Table 3: **WLFP and washing machines, controlling for male education**

Dependent Variable: % Households owning washing machine in 1960						
	(1)	(2)	(3)	(4)	(5)	(6)
WLFP 1950	-0.009	-0.068***	0.620**	0.477**	0.931***	0.431*
	(0.059)	(0.047)	(0.526)	(0.473)	(0.603)	(0.444)
% males with college (1950)		-0.033		-0.079**		-0.075**
		(0.078)		(0.090)		(0.088)
Demographic controls:	No	Yes	No	Yes	No	Yes
Specification:	OLS	OLS	IV	IV	IV	IV
Instrument:			Fac	Fac	Fac+Draft	Fac+Draft
Observations	3056	3056	3056	3056	3056	3056
First Stage F-Stat			35.14	20.59	24.27	10.53
Mean of Dep Var	78.26	78.26	78.26	78.26	78.26	78.26
SD of Dep Var	12.65	12.65	12.65	12.65	12.65	12.65
R^2	0.621	0.713	0.514	0.639	0.383	0.651

* p< 0.10, ** p<0.05, *** p < 0.01. Unit of observation is a County. Standardized beta coefficients reported. Standard errors clustered at the state level in parentheses. All estimates control for state fixed effects, WFLP in 1940, and the following geographic controls: county latitude, longitude, and average ruggedness. Demographic controls include: percent farm employment, percent non-white population, and average education in 1940.

Appendix Table 4: **WLFP in 1960 and washing machine ownership in 1960**

Dependent Variable: % Households owning washing machine in 1960						
	(1)	(2)	(3)	(4)	(5)	(6)
WLFP 1960	0.013	-0.052**	0.538**	0.373*	0.779***	0.355*
	(0.073)	(0.040)	(0.461)	(0.403)	(0.546)	(0.380)
Demographic controls:	No	Yes	No	Yes	No	Yes
Specification:	OLS	OLS	IV	IV	IV	IV
Instrument:			Fac	Fac	Fac+Draft	Fac+Draft
Observations	3056	3056	3056	3056	3056	3056
First Stage F-Stat			27.21	21.55	14.54	14.26
Mean of Dep Var	78.26	78.26	78.26	78.26	78.26	78.26
SD of Dep Var	12.65	12.65	12.65	12.65	12.65	12.65
R^2	0.621	0.712	0.499	0.638	0.362	0.644

* p< 0.10, ** p<0.05, *** p < 0.01. Unit of observation is a County. Standardized beta coefficients reported. Standard errors clustered at the state level in parentheses. All estimates control for state fixed effects, female labor force participation in 1940, and the following geographic controls: county latitude, longitude, and average ruggedness. Demographic controls include: percent farm employment, percent non-white population, and average education in 1940.

Appendix Table 5: **WLFP and mobilization: difference in differences**

Dependent Variable: Δ WLFP		
	(1)	(2)
Factory × Year=1950	0.502***	0.481***
	(0.152)	(0.152)
Draft rate × Year=1950		-0.0175*
		(0.009)
Counties:	3057	3057
Mean DV (1940):	18.49	18.49
SD of DV (1940):	6.67	6.67
Observations	6114	6114

* p< 0.10, ** p<0.05, *** p < 0.01. Panel fixed effects estimates. Unit of observation is a US County from 1940 to 1950. Standard errors clustered at the county level in parentheses. All estimates include county and year fixed effectsas well as the following 1940 county level covariates interacted with the year 1950: percent rural farm population, percent black, and average years of education of the adult population.

Appendix Table 6: **WLFP and refrigerators: difference in differences IV**

Dependent Variable: Δ % HH own refrigerator				
	(1)	(2)	(3)	(4)
WLFP	0.165***	0.035*	0.928***	1.318***
	(0.068)	(0.074)	(1.313)	(1.390)
Specification:	Panel FE	Panel FE	IV	IV
Demographic controls:	No	Yes	Yes	Yes
Instrument:			Fac	Fac+Draft
Counties:	3057	3057	3057	3057
Mean DV (1940):	26.74	26.74	26.74	26.74
SD of DV (1940):	14.84	14.84	14.84	14.84
Observations	6114	6114	6114	6114
First Stage F-Stat			10.91	7.085

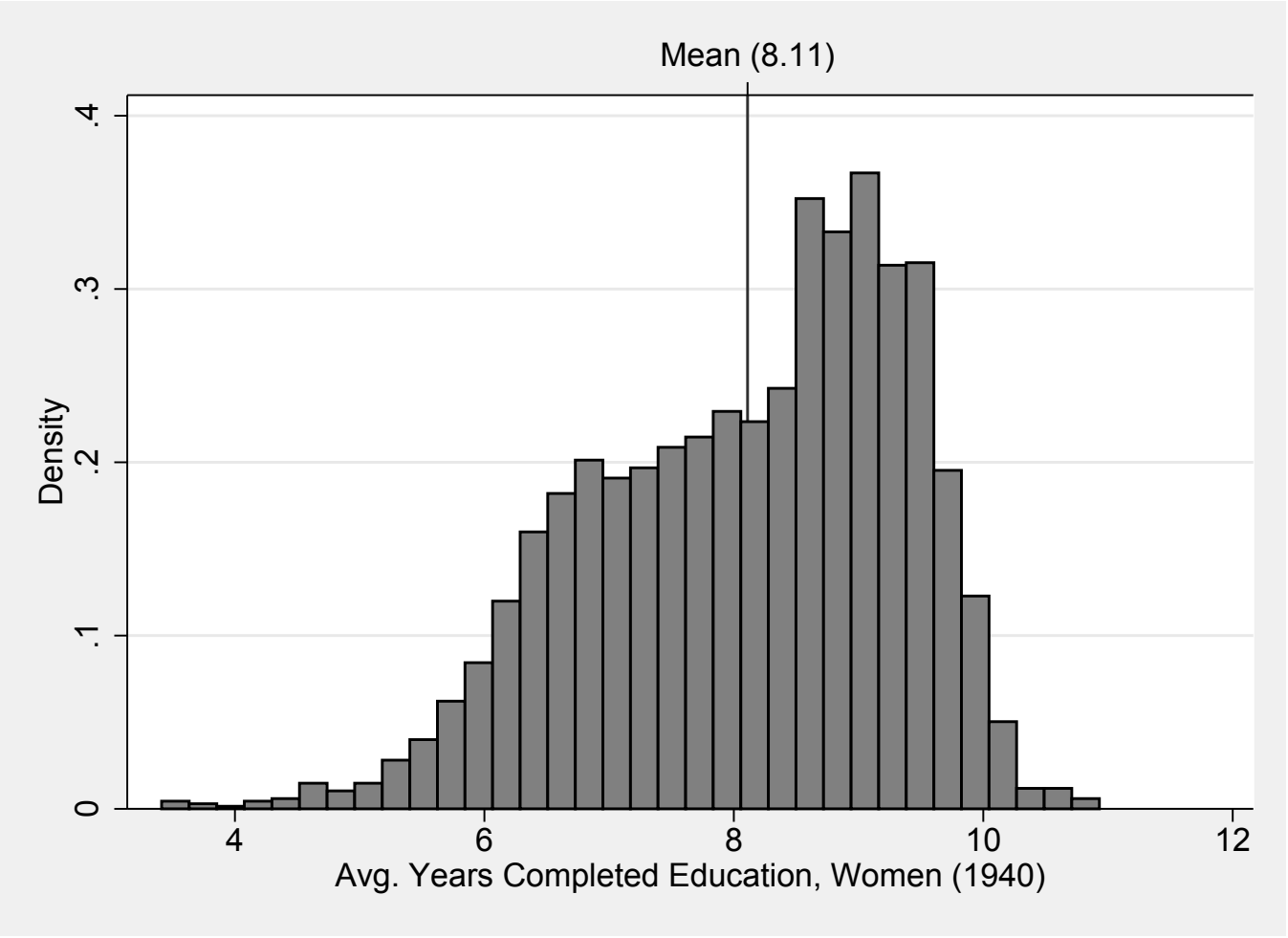
* p< 0.10, ** p<0.05, *** p < 0.01. IV estimates. Standardized beta coefficients reported. Unit of observation is a US County from 1940 to 1950. Standard errors clustered at the county level in parentheses. All estimates include county and year fixed effects and the following 1940 county level covariates interacted with the year 1950: percent rural farm population, percent nonwhite, and mean years of education of the adult population.

Appendix Table 7: **Determinants of black women's participation in the WPA**

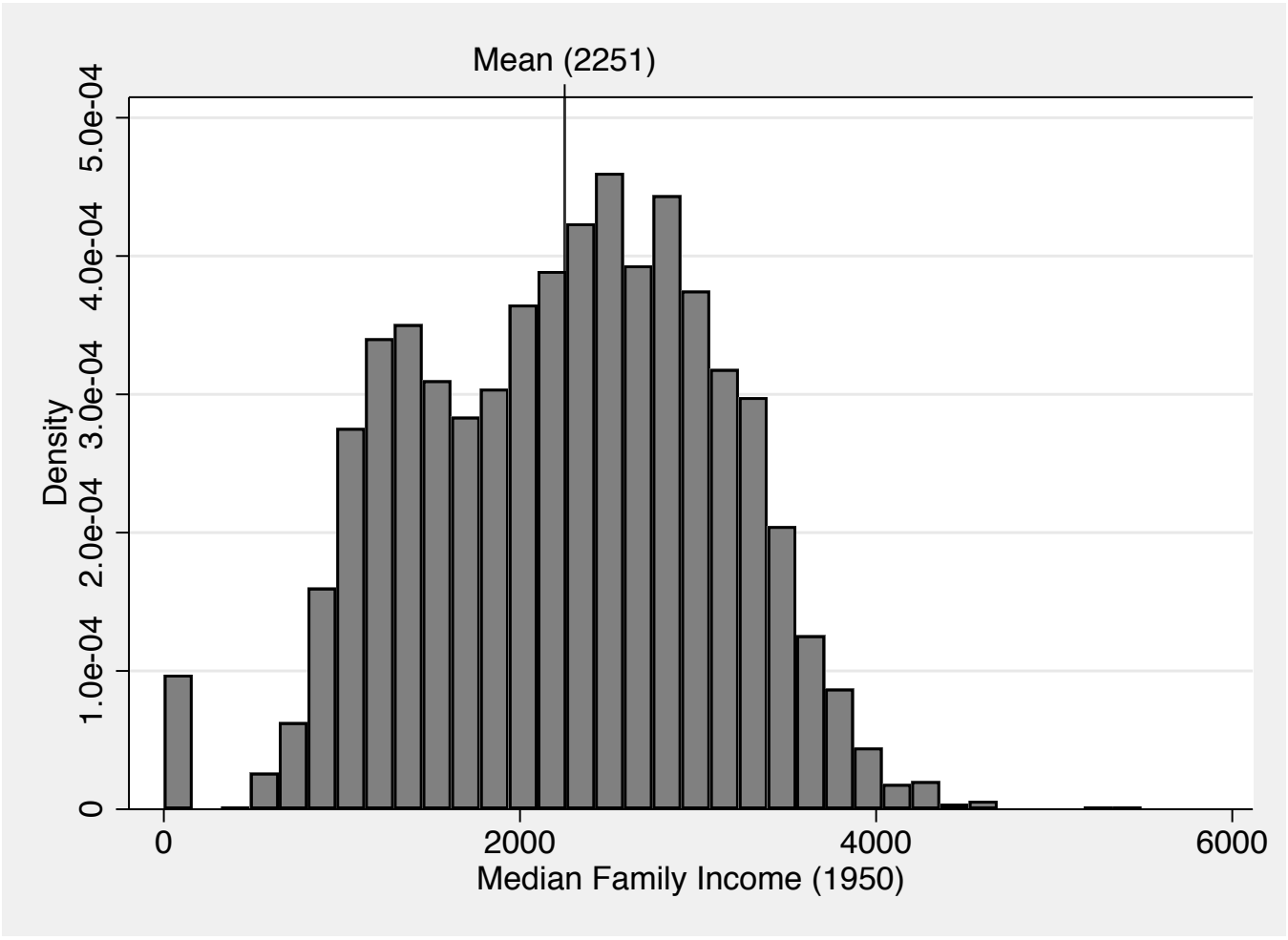
Determinants of Proportion of Black Women in WPA						
	(1)	(2)	(3)	(4)	(5)	(6)
% Black female pop. (1930)	0.177***	0.176***	0.175***	0.180***	0.179***	0.176***
	(0.032)	(0.032)	(0.033)	(0.031)	(0.033)	(0.032)
% Urban (1930)		0.028***				0.025***
		(0.005)				(0.004)
% Area in farmland (1930)			-0.007			-0.004
			(0.004)			(0.003)
School enrollment (1930)				0.031**		0.020**
				(0.014)		(0.010)
Unemployment rate (1930)					0.259***	0.050
					(0.062)	(0.031)
Observations	3048	3048	3046	3048	3048	3046
R^2	0.432	0.491	0.437	0.435	0.459	0.494

* p< 0.10, ** p<0.05, *** p < 0.01. Unit of observation is a County in 1937. Standard errors clustered at the state level in parentheses. All estimates control for state fixed effects, county latitude, longitude, and average ruggedness.

Appendix Figure 1: **Distribution of average years of female education (1940)**



Appendix Figure 2: **Distribution of median family income (1950)**



Appendix Table 8: **WLFP and washing machines by female education**

Dependent Variable: % Households owning washing machine in 1960		
	(1)	(2)
3 years x WLFP 1950	4.029	3.996
	(6.514)	(5.532)
4 years x WLFP 1950	0.105	0.107
	(0.130)	(0.131)
5 years x WLFP 1950	0.267**	0.271**
	(0.113)	(0.115)
6 years x WLFP 1950	0.333***	0.336***
	(0.100)	(0.103)
7 years x WLFP 1950	0.368***	0.370***
	(0.099)	(0.104)
8 years x WLFP 1950	0.325***	0.325***
	(0.102)	(0.102)
9 years x WLFP 1950	0.244**	0.245**
	(0.105)	(0.108)
WLFP 1950	0.060	0.012
	(0.202)	(0.197)
3 years	6.063	5.983
	(11.755)	(10.043)
4 years	0.122	0.122
	(0.231)	(0.236)
5 years	-0.021	-0.021
	(0.190)	(0.195)
6 years	0.136	0.136
	(0.170)	(0.170)
7 years	0.084	0.082
	(0.155)	(0.152)
8 years	-0.075	-0.077
	(0.140)	(0.138)
9 years	-0.078	-0.078
	(0.133)	(0.130)
Instrument:	Fac	Fac+Draft
Observations	3056	3056

* p< 0.10, ** p<0.05, *** p < 0.01. Unit of observation is a County. IV estimates. Standardized beta coefficients reported for WLFP and interactions. Bootstrap standard errors clustered at the state level in parentheses (1000 reps). Education categories are equal to 1 if the average years of completed education for females age 25+ in a given county in 1940 falls within the bin and 0 otherwise. The excluded category is 10 or more years of education. Estimates include the following controls: state fixed effects, county latitude, longitude and average ruggedness, as well as the following 1940 controls: female labor force participation, percent farm employment, percent non-white population, average male education, percent of females age 25+ for whom years of education is unkown, and percent of males age 25+ for whom years of education is unknown.

Appendix Table 9: **WLFP and median family income**

	(1)	(2)	(3)	(4)
	Med inc (1950)	Med inc (1950)	Med inc (1960)	Med inc (1960)
WLFP 1950	1.552***	1.294***	1.546***	1.225***
	(56.172)	(53.882)	(69.740)	(55.660)
Demographic controls :	Yes	Yes	Yes	Yes
Instrument:	Fac	Fac+Draft	Fac	Fac+Draft
Observations	3056	3056	3056	3056
First Stage F-Stat	21.023	10.621	21.023	10.621
Dependent Var mean	2250.909	2250.909	4163.485	4163.485
Dependent Var sd	853.788	853.788	1311.780	1311.780
R^2	0.187	0.360	0.303	0.501

+ p< 0.15, * p< 0.10, ** p<0.05, *** p < 0.01. Unit of observation is a County. Standardized beta coefficients reported. Dependent variable is median family income in 1950 or 1960. Standard errors clustered at the state level in parentheses. All estimates control for state fixed effects, total population in 1950, and female labor force participation, percent farm employment, percent non-white population, and average education in 1940, as well as county latitude, longitude and average ruggedness.

Appendix Table 10: **WLFP and washing machines by income quintiles**

Dependent Variable: % Households owning washing machine in 1960		
	(1)	(2)
WLFP 1950	0.041	0.051
	(0.173)	(0.171)
Q2 x WLFP 1950	0.089*	0.089**
	(0.046)	(0.043)
Q3 x WLFP 1950	0.047	0.046
	(0.047)	(0.045)
Q4 x WLFP 1950	-0.005	-0.006
	(0.053)	(0.050)
Q5 x WLFP 1950	-0.189***	-0.189***
	(0.064)	(0.063)
Median Income Q2	0.304***	0.303***
	(0.049)	(0.050)
Median Income Q3	0.322***	0.322***
	(0.063)	(0.067)
Median Income Q4	0.395***	0.394***
	(0.072)	(0.076)
Median Income Q5	0.531***	0.530***
	(0.077)	(0.082)
Instrument:	Fac	Fac+Draft
Observations	3056	3056

* p< 0.10, ** p<0.05, *** p < 0.01. Unit of observation is a County. IV estimates. Standardized beta coefficients reported for WLFP and interactions. Bootstrap standard errors clustered at the state level in parentheses (1000 reps). Estimates include the following controls: state fixed effects, county latitude, longitude and average ruggedness, as well as the following 1940 controls: female labor force participation, percent farm employment, percent non-white population, and average male education.

Appendix Table 11: **Retail outlets (1954) and war mobilization**

Number of Retail Appliance Stores (1954)		
	(1)	(2)
Factory	-0.0160	0.102
	(1.020)	(0.937)
Draft Rate		0.0821
		(0.084)
Observations	3056	3056
R^2	0.926	0.926
Mean of Dep Var	29.66	29.66
SD of Dep Var	110.8	110.8

* p< 0.10, ** p<0.05, *** p < 0.01. Unit of observation is a County. Standard errors clustered at the state level in parentheses. All estimates control for: state fixed effects, total population in 1950, and percent farm employment, percent non-white population, and average eduction in 1940, as well as county latitude, longitude and average ruggedness.