Women's Labor Force Participation and Household Technology Adoption*

Gautam Bose Tarun Jain Sarah Walker

UNSW IIM Ahmedabad UNSW

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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 that this relationship is strongest for households with low earning capacity whose consumption-leisure tradeoff crosses a threshold as women go to work. Using WWII factories to instrument for female labor demand, we find that a standard deviation increase in female labor force participation increases washing machine ownership by 0.44 standard deviations, which is driven primarily by counties in the lowest pre-war education quintile. Changes to household income, as well as the substitution of employed domestic labor with appliances, are important channels.

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. In the economics literature, the dominant view is that these household technologies were also key to expanding women's employment (Greenwood et al., 2005). This paper investigates whether women's employment led to greater adoption of household technology, arguing 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. 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 to vary by earnings capacity. 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 through retail stores, and migration of households, all as consequences of women's labor force participation.

[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).

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).

The nominal price of a washing machine was USD 110 in 1911, more than two month's wages for the median household (Cox and Alm, 1997). Not accounting for technological improvements, prices declined to USD 270 in 1956, or less than a fourth of the price in terms of time wages.[2] Early adopters therefore required significant means to purchase such appliances. By the mid-1950s, retailers such as Sears allowed customers to purchase white goods on payment plans that would have been especially attractive to lower-income households, suggesting that by the time we observe major increases in female labor force participation in mid century, it is lower-income households who are likely adopting these appliances.[3]

In this setting, we use an instrumental variables strategy to examine how changes in women's labor force participation lead to appliance ownership by exploiting county-level exogenous shocks to female labor demand during World War II through the presence of wartime factories. We posit that the relationship between women's work and household technology adoption is heterogeneous with respect to education. Since paid

[2]Cox and Alm (1997) document an even more dramatic drop in the cost of refrigerators, for which work-time costs declined by a factor of 10 between 1918 and 1958.

[3]The 1952 Sears Christmas catalog advertises a USD 220 electric washing machine that could be purchased for $10 down and $10 monthly. Relative to average income in 1950 (USD 2250 annual), this represents approximately 8 percent of monthly income.

employment might yield higher incomes for better educated women, we analyze how appliance purchases differ by educational achievement, predicting that households of lower earning capacity will be more likely to adopt household technology when women go to work. 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 for a standard deviation increase in women's labor force participation in 1950, washing machine ownership in 1960 is 0.44 standard deviations higher. These findings are robust to a number of specifications, including an alternate panel IV estimation in which we examine changes in refrigerator ownership. Comparing the estimated coefficients to other factors that could drive washing machine adoption, such as living in a rural area, ownership of other appliances, and the presence of young children, suggests that women's labor force participation is perhaps the most important factor that determines adoption of household technology in mid-century United States.

Examining the relationship between a women's earning capacity and household technology adoption shows that adoption is almost entirely driven by low-education households. For counties in the lowest quintile of women's pre-war education levels (3.5 to 6.9 years of completed education, on average), a standard deviation increase in women's employment in 1950 leads to a 0.438 increase in washing machine ownership in 1960. The magnitude of this relationship is economically almost identical to our main effect.

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 household incomes. Moreover, in line with our framework, we find that the effect of women's employment on washing machine adoption are strongest in counties with household income below the national median in 1950. That is, low earnings capacity households are most likely to purchase appliances when women go to work.

Another 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. As employment opportunities for domestic workers expand over this time period, households begin to substitute paid domestic labor with machines.

More information about appliances could also facilitate purchases, especially in an environment where households were not experienced with their use. Simultaneously, easier access with the opening of large retail stores could also facilitate adoption. Finally, women's labor force participation could influence migration to places where appliances are cheaper or more useful. We examine these potential mechanisms and find that none of these channels are important factors in household appliance adoption when women's employment expands.

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 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 literature, direction 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). Moreover, recent work suggests that at least for cohorts born between 1935 and 1975, household technology cannot explain the rise in employment of married women (Eckstein et al., 2019). Further, 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 lead directly to more paid employment for women, and instead leaves open the possibility that the relationship could proceed the other way. As the canonical model by Greenwood et al. (2005) establishes, it is indeed likely that the introduction of these technologies shifted the labor supply elasticities of women. In our analysis, however, we posit that appliances 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 rich literature examining the consequences of women's labor force participation in 20th century US. Women's paid work 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.

Finally, this paper contributes to the scant 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.[4] This framework has implications for understanding future household technology adoption, and the role of women's employment in driving these changes.

2 Conceptual framework

In this section we provide a simple indicative framework to illustrate how we expect the use of household appliances and domestic help to vary between households in response to the labor force participation status of women. Our economy consists of households. Each household comprises a woman and other members. The woman may do some or all of the domestic work necessary for the household, and she may also perform market work. The household has some income that is exogenous to our model (the "man's income"). The household may hire domestic help and/or purchase labor-saving appliances, specifically a washing machine.

We represent the household's utility as a function of the household's consumption and the woman's leisure. The household's consumption consists of its total income minus the cost of domestic help and labor-saving technology. The woman's leisure

[4]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 household technology.

consists of her total available time minus the time she devotes to perform domestic work and market work. Household help and machines subtract from household income and adds to the woman's leisure. Woman's market work augments household income and reduces the woman's leisure.

Household chores may be performed by the woman herself, by domestic help, or by machines. At any given state of technology, machines are only capable of performing some of the tasks that humans can perform. Within these tasks, some are more expensive per unit of time saved than others. For example, a dollar spent on a refrigerator may save more hours of work than a dollar spent on a washing machine, in which case a household would buy a refrigerator before a washing machine.[5] The price of technology relative to household help, in turn, would determine the point at which the household stops using further machines and turns to hired help. Finally, the marginal utilities of consumption and leisure will determine how much of the chores the woman herself will perform.

In figure 1, let the horizontal axis measure hours devoted to household chores, h, arranged in order of increasing cost per unit of time saved if machines are used to perform the chores. For example, suppose a refrigerator saves 10 hours of work per week, and has an annualized cost of \$30 per year, and a vacuum cleaner saves four hours per week and costs \$16 per year. Then the more costly hours saved by a vacuum cleaner are placed to the right of the less costly hours saved by a refrigerator. The vertical axis measures the cost per hour in appropriate units. Of course there are chores that machines cannot perform, and these are placed furthest to the right. The function $P(h)$ represents the marginal cost of using machines to do different tasks.[6]

We assume that domestic help is capable of performing all chores. The cost per

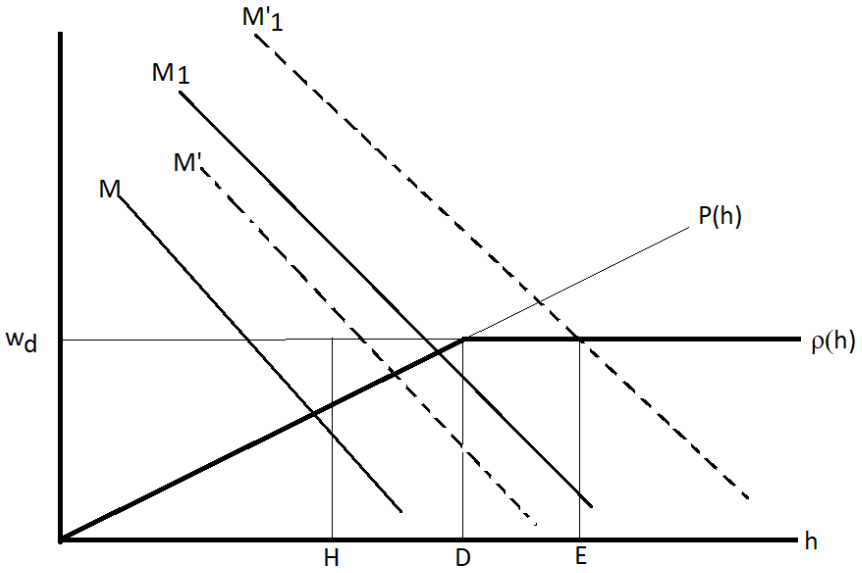
[5]The exact order of purchases does not matter to us, only the fact that there is a natural order.

[6]For convenience we represent this as a continuous function. More accurately this would be a step-function, with each step corresponding to a specific task.

hour of domestic help is constant at w_d. It then follows that, in the hierarchy of tasks, there is a point at which the household would prefer to use domestic help rather than machines to perform the next tasks. In the diagram, this is at the point D. If the household uses machines and/or help to perform tasks beyond D, then all tasks to the left of D are completed using machines, and the remaining tasks are done by domestic help. The price of having an additional hour of chores performed using machines or help is then given by:

$$\rho(h) = \begin{cases} P(h) & \text{if} \quad h \leq D \\ w_d & \text{if} \quad h > D \end{cases}$$

Figure 1: Women for whom use of help varies non-trivially with labor market participation status



Any tasks not done using machines and domestic help are performed by the woman herself. As the household moves to the right in the diagram, using machines and domestic help to perform more and more chores, it uses up income and frees up more leisure for the woman. Thus the ratio of the marginal utility of leisure to the marginal utility of consumption (the consumption-leisure tradeoff) must fall as we move to the

right. Let the line M represent this ratio at each level h for a given household, where h is the extent to which machines and/or help is employed. Then this household will use machines to a point just left of H, where M intersects $\rho(h)$. It uses no domestic help and all the remaining chores are done by the woman. A household where the tradeoff is represented by M_1', on the other hand, uses machines up to D, and domestic help up to the point E.

For the purposes of our study, the crucial question is whether the household's decision to purchase a washing machine changes with the labor-market participation status of the woman. Let H represent the position of a washing machine in the hierarchy of tasks. Most households in 1960 owned a washing machine (see Table 1), so it is safe to assume that by this time it was generally cheaper to use a machine than to hire help to do the washing. Hence H is to the left of D. A household would purchase a washing machine if its ratio of marginal utilities curve intersects the cost function $\rho(h)$ to the right of H.

Let the line M represent the tradeoff for a household where only the man performs market work. Compare this with a hypothetical identical household where the woman also performs market work. This latter household would have less total leisure at each h, but more income and therefore higher consumption. Thus, at each h, the household would have a higher marginal consumption-leisure tradeoff, represented by an upward shift from M to (say) M'. The latter household would use more help in carrying out its domestic chores. In our diagram, the household represented by M does not buy a washing machine, while that represented by M' does buy one.

If the man has a sufficiently high earning capability, a household may also use a washing machine whether or not the woman works. In such a household, the consumption-leisure tradeoff is given by the line M_1. This line cuts $\rho(h)$ to the right of H, so the household uses a washing machine. Another identical household where the

woman does perform market work would have a higher tradeoff such as M_1', and would also use a washing machine.

Thus high income households are likely to own washing machines even when the woman does not work outside the home, and this status does not change if the woman enters the workforce. However, households with sufficiently low incomes are likely to not own a machine if the woman does not work, and acquire one if she does. Considering that four out of five households already owned machines at the time of our study, it is likely that this latter group would comprise households at the very low end of the income distribution.[7]

In the empirical investigation that follows, we do not have information on household income prior to the women's labor market shock, but we do know the average education status of women for our observational units. To situate our findings within the above framework we assume that the marriage market matched men and women assortatively according to their education, which we know was true around mid-century and continues to be true to the present (Eika et al., 2019). We also assume that educational attainment, in turn, is positively and significantly correlated with earning potential, which is a well-established result in human capital theory. Together, these two assumptions suggest that the woman's education should be a good predictor of the couple's earning potential, and hence of the incomes of two identical households differentiated only by the labor-market participation status of the woman.[8]

[7]A third category of households, with extremely low incomes, would not use washing machines regardless of the woman's labor-market participation status. Ownership data suggests that this would be a very small segment. Recall that the purchase price of a washing machine was as low as $10 monthly even as early as 1952.

[8]To make this precise, suppose men and women are perfectly assortative matched according to educational attainment, and market wage is also perfectly predicted by educational attainment. Let $\hat{y}(e)$ be the full-time wage of a woman with given education e. Then her partner's wage would be given by $\hat{y}(e)/s$, where s represents the wage-discount that women face on the labor market. We can therefore exactly locate her household income conditional on when the woman does not participate in the labor force, and when she does.The specific value of s is not important for the argument, but for reference we note that in 1960 this was probably about 0.6 (see, for example, O'Neill (1985)).

In Figure 1, these two households are represented by a pair of tradeoff curves corresponding to the woman's education level. There are some households, such as those represented by the pair (M_1, M_1'), for whom washing machine ownership status will be unaffected by the labor-market participation decision of the woman. These correspond to women with high education, who are with high probability matched with men of high education, which makes them in turn likely to earn high incomes. At a high enough income the household buys a washing machine even if the woman does not work. In an otherwise identical household where the woman works, the tradeoff curve is further to the right and this household also buys a washing machine. However, for lower education levels the tradeoff curve intersects $\rho(h)$ to the left of H when the woman does not work, but to the right of H when she does, so there is a change in washing-machine ownership. The pair $M,\ M'$ represent such a household. This is the range where we expect to see our hypothesized variation.

Recall that, by 1960, nearly 80% of households had washing machines. Thus it is likely that the upper education cutoff, above which women are likely to have a washing machine independent of their work status, is not very high. Hence the range where we expect washing machine ownership to vary with labor-market participation should lie somewhere towards the lower end of the education distribution.[9]

In the following sections, we apply this simple framework to our data to elucidate whether changes in women's employment leads to increased adoption of household technologies. We expect that with exogenous increases in women's labor force participation, appliance ownership increases, especially for households with lower earnings capacity.

[9]This prediction is also consistent with Greenwood et al. (2005), who show that wealthier households adopt household technologies earlier and poorer households adopt later.

3 Data

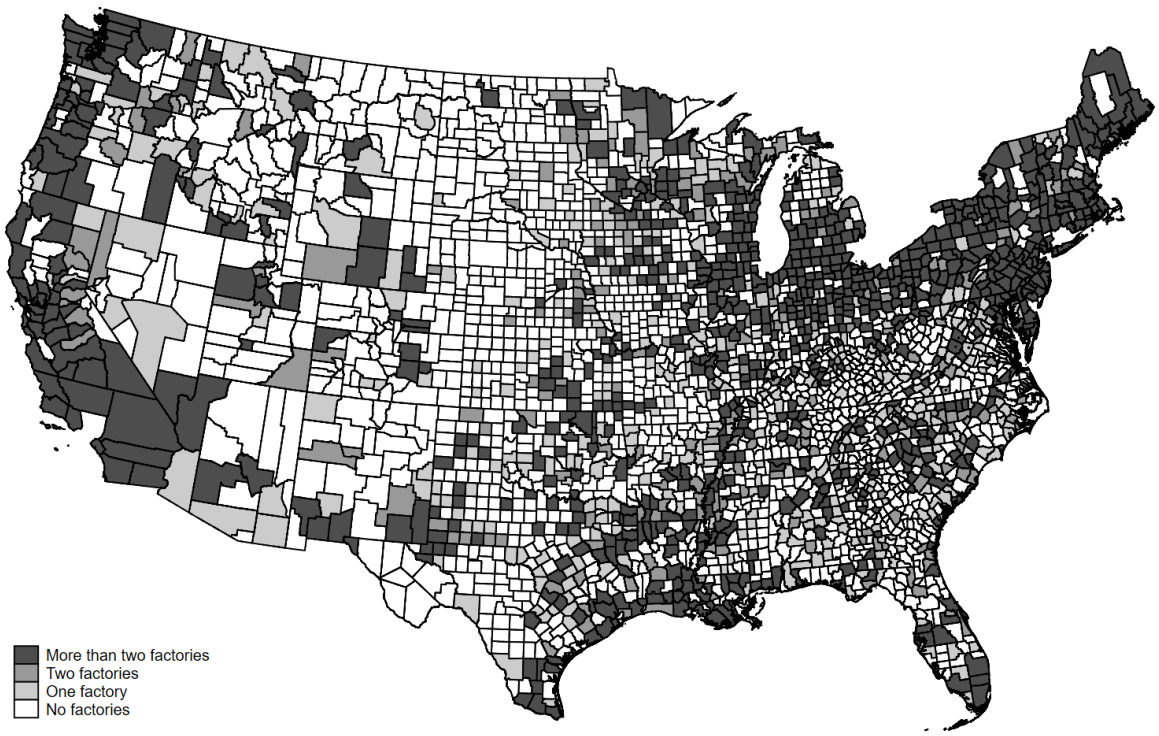
Our primary data for both women's labor force participation and the adoption of washing machines comes from the "Historical, Demographic, Economic, and Social Data: The United States, 1790-2002", produced by the Inter-University Consortium for Political and Social Research (Haines and Inter-university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

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 years and older in the population. From the census, we also obtain information on household technology adoption. Our primary measure of adoption is the percent of households in each county that own a washing machine.[10] Unlike other appliances with more recent history, the census only includes information on washing machines in 1960. In robustness checks, we therefore explore an alternative proxy for adoption, refrigerator ownership, which is available at the county level in 1940 and 1950.

We augment this data with a measure of World War II mobilization that significantly influenced demand for female workers – the presence of a wartime factory. This information comes from Department of Defense (DoD) data on factories used for

[10]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."

Figure 2: **Map of factory locations**



Data source: Department of Defense.

wartime production (Jaworski, 2017), which we use to construct a binary variable equal to one if a given county had a wartime factory. Figure 2 illustrates the spatial distribution of factories across counties in the United States. There is significant variation in the location of factories, with concentration throughout the industrial Northeast and West Coast, and meaningful variation in other parts of the country, including throughout the Southeast and Midwest.

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 significantly shifted

the demand for labor in the county. 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 material 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), which is roughly 14 percent of all eligible women in 1940.[11]

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

[11] US census records indicate that there were 50,471,900 women aged 14 or older in 1940.

78.26% of households had washing machines in 1960, and 66.85% of households had refrigerators in 1950, which increased from 26.72% in 1940. 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.

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).[12] 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.[13] 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.

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

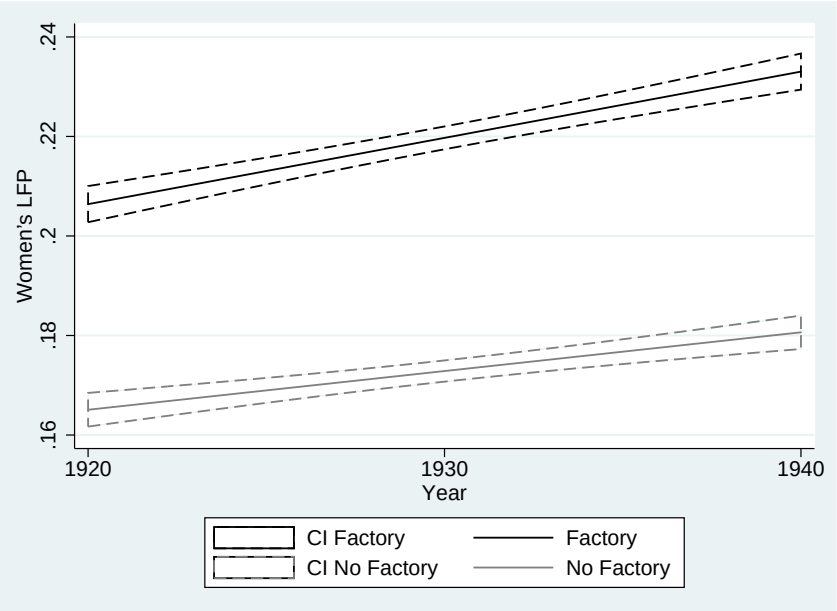
[12]Each of these studies use state-level variation in draft rates to predict increases in female labor force participation immediately after the war. Goldin and Olivetti (2013) also find that the effect is sustained in later decades for educated women who were married (both with and without children) during the war.

[13]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 7).

participation differed systematically between counties with high vs. low mobilization, then any observed relationship between women's employment and war mobilization is possibly driven by differences in trends prior to the war, rather than an exogenous shock. To explore the extent to which places with high and low war mobilization follow similar trends in women's employment prior to the war, we construct county level averages of WLFP using full count census data from 1920 to 1940 (Ruggles et al., 2019) and plot their trends over time in Figure 3. In addition, we formally test the parallel trends assumption by regressing WLFP in 1940 and 1930 on a binary variable equal to 1 if the county had a wartime factory, as well as an indicator variable for the year 1940, controlling for state fixed effects and county level controls. A statistically significant coefficient on the interaction between having a factory and the year 1940 would suggest evidence of parallel trends. We report these results in Appendix Table 2 and find that trends in women's labor force participation prior to the war were not significantly different between counties with and without a factory. Both of these exercises suggest that the parallel trends assumption holds in our setting.

For the existence of a war time factory to be considered a valid instrument it must be true that: (i) conditional on pre-war county-level controls, the allocation of factories was random across counties, and (ii) the existence of a factory only influenced household technology adoption through women's labor force participation (exclusion restriction). Regarding the first condition, we conduct a balance of covariates test to determine the extent to which having a wartime factory correlates with important pre-war characteristics in 1940. We present the results in Appendix Table 1 in which we regress several 1940 outcomes on a binary variable equal to 1 if the county has a wartime factory, controlling for state fixed effects. This exercise suggests that factories are located in counties that are less rugged (i.e., more flat), have a lower percent of the labor force employed in farm work, higher average education, and higher women's

Figure 3: **Parallel trends in WLFP by wartime factory**



Data sources: Information on the existence of a wartime factory comes from U.S. Department of Defense (Jaworski, 2017). County level rates of WLFP were constructed using the full count census for the years 1920, 1930, and 1940 (Ruggles et al., 2019). This figure plots the linear prediction and confidence intervals of trends in women's labor force participation between 1920 and 1940 for counties with and without a wartime factory.

labor force participation in 1940. In our empirical specifications we therefore present estimates both with and without pre-war county level controls.

In regard to the second condition, the exclusion restriction would be violated under several conditions. First, if wartime factories converted to appliance manufacturers after the war, this might have a direct effect on the ability of households to purchase appliances. We believe this is unlikely for several reasons. First, at least in the South, the literature suggests that investment in wartime facilities lead to the expansion of sectors such as lumber, chemicals, rubber, stone, metals, and heavy machinery (Jaworski, 2017), and not appliances per se. Second, we argue that households are unlikely to buy appliances directly from manufacturers and would instead visit retail outlets for such purchases. We explore whether war mobilization is correlated with the existence of a retail appliance store in Appendix Table 3 by regressing the total number of retail

appliance stores in 1954, as measured in the census data, on the existence of a wartime factory, as well as the county-level draft rate. The results indicate that war mobilization is uncorrelated with the presence of retail outlets. As we discuss in section 5, we also control for the total number of retail stores in a county and find that retail outlets are uncorrelated with washing machine ownership. Further, this exercise shows that the inclusion of retail stores does not affect the economic interpretation of our main estimates of the effect of women's employment on appliance adoption.

The exclusion restriction could also be violated if skill complementarities in manufacturing encouraged people, particularly veterans who are eligible for the GI Bill, to obtain more education. In section 5, we examine the impact of war mobilization on male college education in 1950 and find an economically small correlation. We then include male education as a control in our estimates of the effect of women's employment on appliance adoption and find that the main results do not change.

To test the suitability of wartime factories as an instrument, we estimate the following first stage regression:

$$WLFP_i^{1950} = \alpha_0 + \alpha_1 Factory_i + \alpha_{\mathbf{2}} \mathbf{X}_i + StateFE_i + \varepsilon_i \tag{1}$$

where $WLFP_i^{1950}$ is the women's labor force participation rate for each county i in 1950. We regress this on our instrument, $Factory_i$ with $\alpha_1 > 0$ for instrument validity. 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 factors at the state level that influence women's labor force participation at the county level, including macroeconomic factors that could directly

influence washing machine purchases. Standard errors (ε_i) are clustered at the state level.

Table 2 shows that our proposed instrument significantly influences women's labor force participation. In column (1) we present results that do not control for pre-war characteristics and find that the presence of a wartime factory corresponds to a 1 percentage point increase in women's labor force participation. In the most restrictive specification in column (2), the presence of at least one wartime factory increases women's labor force participation by 0.787 percentage points ($p < 0.01$). Relative to a mean of 22.4 percent, this corresponds to a 3.6 percent effect.

4.2 Main specification and results

We estimate the relationship between women's labor force participation and household technology adoption using the following equation:

$$y_i^{1960} = \beta_0 + \beta_1 \widehat{WLFP}_i^{1950} + \beta_2 \mathbf{Z}_i + StateFE_i + \epsilon_{is} \tag{2}$$

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 adoption. We hypothesize that paid employment positively impacts washing machine ownership in 1960 and therefore expect $\beta_1 > 0$.

Table 3 presents results from estimating equation (2). Columns (1) and (2) report standardized coefficients from 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 is greater in poorer counties, and households in such counties are simultaneously less likely to purchase household appliances. This potential omitted variable bias warrants the use of an instrument variable to predict women's labor force participation. We nonetheless explore income as a potential

channel through which women's employment affects household technology adoption in section 5.

In columns (3) and (4) we examine a reduced form specification in which we regress washing machine ownership on the presence of a wartime factory. In the most conservative specification in column (4), which includes pre-war demographic controls, the results suggest that the presence of a wartime factory is associated with 0.05 standard deviation higher washing machine ownership in 1960. This implies that for counties with a wartime factory, washing machine ownership was approximately 0.7 percentage points higher in 1960. Relative to a mean of 78 percent, this is close to a 1 percent effect.

In columns (5) and (6) we employ our IV specification and find 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 instrument 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 0.442 standard deviations. Note that the first stage F-statistic is well above 10, suggesting that our instrument is not weak.

The presence of a wartime factory significantly altered the demand for female labor, which was due in part to gaps in 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 to examine heterogeneity in our main results by high, medium, and low draft rate counties.

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).[14] The record for each individual contains the county and state of residence, along with dates of birth, enlistment and de-enlistment. From these individual records, we compute $DraftRate_i$ for each county i as:

$$DraftRate_i = \frac{\text{Total no. of men drafted in 1940 to 1946}}{\text{No. of men age 15 to 44 in 1940 by county}} \tag{3}$$

We group counties into three bins to identify high, medium, and low draft counties. Low draft rates represent counties in the bottom third of the distribution (<18.09%), medium draft rates represent counties in the middle third (≥18.09% and <24.70%), and high draft rates represent counties in the top third (≥24.70%). We then rerun our main IV specifications separately for low, medium, and high draft rate counties to see how the effects vary across mobilization rates.[15] Table 4 presents the results. We find that the effects are only significant for counties with high draft rates. In these places, a standard deviation increase in women's labor force participation in 1950 increases washing machine ownership in 1960 by 0.93 standard deviations. This exercise suggests that the effect of women's labor market participation on household technology adoption was strongest in places where the labor demand shock was most intense. This finding is

[14]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).

[15]In alternate specifications, we consider using the county level draft rates, as well as casualty rates provided by Ferrara (2018), as instruments to predict the change in female labor force participation. Appendix Table 4 suggests these instruments are not appropriate for our setting.

consistent with our argument that women's employment opportunities drive appliance adoption, and not the other way around.

To grasp the magnitude of our main effects, we benchmark the impact of labor force participation on appliance adoption with other factors that could plausibly influence household technology. These factors include: (i) residence in urban versus rural areas, since distributional costs might be lower in cities, (ii) owning other appliances, since appliance purchases might respond to experience with other white goods, and (iii) the number of children in each household, since children add to laundry but reduce available time for parents' domestic chores. Table 5 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

Here we explore several alternate specifications of the relationship between women's employment and household technology adoption. First, we consider the case in which war mobilization may have encouraged educational attainment, which would violate the exclusion restriction necessary for our IV approach. Without a formal test of the exclusion restriction, we explore whether male education is associated with WWII mobilization by correlating the existence of a wartime factory with the proportion of men age 25 or older who have any college education (1 to 4 years) in 1950. The

results presented in Appendix Table 5 show that after controlling for demographic characteristics in 1940, the presence of a wartime factory is significantly correlated with male education, but the effect size is very small: the proportion of men with any college in 1950 is 0.05 percentage points or half a percent higher in counties with a wartime factory. As a robustness check, we rerun our main specification controlling for male education and find that the results are almost identical to our main findings. Appendix Table 6 shows that the magnitude and statistical significance of the effects are slightly larger when controlling for male education, but this is likely because it is a 'bad control'. In addition, note that male education is negatively correlated with washing machine ownership, perhaps as a result of assortative matching between highly educated men and women who have either already purchased a washing machine by 1960 or prefer domestic labor to appliances, as our framework in section2 illustrates. We explore heterogeneity in washing machine ownership by women's pre-war education quintiles in section 4.4.

Recall that while we observe labor force participation in 1950, our outcome variable is only measured in 1960 due to limitations in the census data. 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. Moreover, this timing is most consistent with our motivating framework in section 2, which describes a simultaneous decision to work and purchase appliances. To elucidate whether labor force participation and household technology adoption correspond contemporaneously, we estimate the relationship between women's labor force participation in 1960 and concurrent washing machine ownership, again using the presence of a wartime factory to predict women's employment. The results in Appendix Table 7 are consistent with our main specification and suggest that for a standard deviation increase in women's labor force participation in 1960, washing machine ownership in 1960 is 0.37 standard

deviations higher. The magnitude of this effect is slightly smaller than our main finding that a standard deviation increase in women's employment in 1950 leads to 0.44 standard deviations greater washing machine ownership in 1960. This result is intuitive, as the labor market shock to women's employment that would lead to appliance adoption was strongest just after the war (Acemoglu et al., 2004).

To further elucidate the effect of changes in female labor force participation on concurrent changes in household technology adoption at a time when the female labor market shock was most intensive, we exploit county-level panel data from 1940 and 1950, which includes information on refrigerator ownership. Refrigerators played an important role in midcentury households by creating a more efficient way to preserve food and reducing the need for regular grocery shopping. Prior to the advent of refrigerators, most households preserved foods through time-consuming techniques such as pickling, drying, salting, and canning, or the use of iceboxes, whose temperatures were unreliable and possibly more expensive to maintain than an electric fridge.[16]

In a panel framework, we employ an IV approach to causally estimate the effect of increases in women's labor force participation on refrigerator adoption by estimating the following equation:[17]

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

The coefficient β_1 captures the effect of increases in women's labor force participation on refrigerator adoption between 1940 and 1950. We estimate the panel specification using both uninstrumented and instrumented measures of women's labor force participation ($WLFP_{it}$). The results in Appendix Table 9 are consistent with our

[16] In the February 1932 issue of *American Magazine*, an advertisement for the Sears Coldspot electric refrigerator claims that their product operates at "about half the cost of ice".

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

main findings for washing machines and show that an increase in women's employment corresponds to an expansion in refrigerator adoption. The IV results suggest that a one standard deviation increase in women's labor force participation leads to a 0.55 standard deviation increase in refrigerator ownership between 1940 and 1950. The magnitude of this effect is slightly larger than what we observe for washing machines, which is intuitive given that the slope of the household technology diffusion curve is likely steeper in 1940 and 1950 relative to 1960.

4.4 Heterogeneity by women's education

The framework in section 2 suggests that the relationship between a woman's employment and technology adoption varies depending on her education level. This section explores heterogeneity in the relationship between women's labor force participation and washing machines by women's education levels in 1940.

We first group counties into quintiles according to the average years of education that adult women (age ≥ 25 years) have completed as of 1940. 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.[18]

In a two-stage least squares framework, we interact women's labor force participation with education in 1940 to estimate the following equation:

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

where our dependent variable is the percent of households in county i that own a

[18]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.

washing machine in 1960. The subscript q corresponds to the education quintile into which the county falls. In the estimation, we exclude the highest quintile, which represents counties where on average women have more than 9.25 years of schooling.

Figure 4 presents the plotted coefficients for the interaction terms, which clearly illustrate a heterogeneous relationship between women's labor force participation and technology adoption with respect to education.[19] Specifically, we observe that the effect of women's employment on household technology adoption is strongest in counties where women are the least educated relative to counties with the highest average education. For counties in the lowest quintile of women's average education prior to the war, a standard deviation increase in women's labor force participation in 1950 leads to 0.438 standard deviation increase in washing machine ownership in 1960. The magnitude of this effect is almost identical to our baseline results in Table 3, suggesting that the main effect of women's employment on household technology adoption during this period is primarily driven by low-education households.

These findings are consistent with the predictions of our framework, which posits that when women with lower education go to work, their consumption-leisure tradeoff curve shifts above a certain threshold on the marginal cost function to a point where they now purchase machines that have a higher cost per unit of time saved. We observe no such effect for women in higher education categories because with higher earnings capacities, their consumption-leisure tradeoff curves are already above this threshold regardless of whether they are working or not.

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

5 Channels

5.1 Household income

An important mechanism through which women's employment affects household appliance purchases 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 chores.

Appendix Table 11 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. A standard deviation increase in women's labor force participation in 1950 corresponds to a 1.5 standard deviation increase in median household income in both 1950 and 1960.

In Table 6 we include median household income as a control in our main estimation of the relationship between women's labor force participation and washing machines, recognizing that it is a bad control, since it is determined by women's employment. This exercise, however, further elucidates income as an important mechanism. In column (1), controlling for median income in 1950 completely diminishes the effect of women's employment on washing machine adoption. Further, the interaction between women's employment and household income reveals again that it is lower income households that are most likely to increase purchases of washing machines with rises in women's labor for participation. In column (3) we interact women's labor force participation

with a binary variable equal to 1 if the median household income in a given county is lower than the national median in 1950. The coefficient on the interaction term suggests that for a standard deviation increase in women's labor force participation in 1950, washing machine ownership is 0.27 standard deviations higher in 1960 in lower income counties.

These findings are consistent with our framework in section 2, which shows that when women from households with lower earning capacity go to work, the consumption-leisure tradeoff curve shifts above a certain threshold and they purchase time-saving appliances. No such phenomenon occurs for wealthier households with consumption-leisure tradeoff curves which are already above this threshold. We see this empirically by examining the coefficient on women's labor participation in 1950 in column (3), which represents the effect of a women's employment on washing machine adoption for counties with median household income above the national median. The coefficient is indistinguishable from zero, suggesting that households in wealthier counties do not purchase appliances when women go to work.

5.2 Paid Domestic labor

The percent of the female labor force employed in domestic services declined rapidly from around 18% in 1930 to 8% by 1960.[20] 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 paid 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 (2) and replacing women's labor force participation with the

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

percent of the female labor force employed in domestic labor.[21] If hired domestic help 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 7 shows the correlation between the percent of the female labor 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 paid 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, war mobilization. Column (2) shows the results of the first stage, indicating that the presence of a factory does not 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

[21] 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.

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.[22]

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 12). Column (3) of Table 7 shows that the instrument is significantly and negatively correlated with the percent of female

[22]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.

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 larger than in the 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 is an important channel through which women's employment affects household technology. In this case, it is the changing employment opportunities for domestic workers that leads to a reduction in their availability, and hence a replacement of domestic labor with technology.

5.3 Other channels

5.3.1 Information provision

Televisions, and thus television advertising, 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 variation in the roll-out of TV signals from Gentzkow and Shapiro (2008), we first explore whether women's employment is correlated with the availability of television. The first column in Appendix Table 13 shows that places with higher women's labor force participation are more likely to have a TV signal in 1952, suggesting that

perhaps the placement of TV signals was in some way correlated with labor market outcomes for women.[23]

To explore whether television access is a mechanism of the effect of women's employment on appliance adoption, we re-estimate equation (2) controlling for whether county i had a TV signal by 1952. The first column in Table 8 shows that television access is positively correlated with household technology adoption, but the magnitude 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.

Television access is an unlikely channel through which women's employment leads to appliance adoption, noting that controlling for TV signals does not change the qualitative interpretation of our main finding. A one standard deviation increase in women's employment in 1950 increases washing machine ownership in 1960 by $\sim$0.44 standard deviations, which is almost identical to our main result in Table 3.

5.3.2 Cost of access

Recall from our discussion in section 4.1 that the exclusion restriction necessary for causal interpretation of our IV results would be violated if the location of wartime factories is correlated with the availability of household appliances. 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 may not hold. To examine this, we correlate our war mobilization measures with the number of retail outlets in 1954 that specifically sell appliances. Appendix Table 3 shows that neither factories nor draft rates are

[23]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).

correlated with the availability of retail appliance stores.

Nonetheless, the availability of retail stores could be an important channel of household technology adoption by lowering the cost of access to bulky consumer durables. In Appendix Table 13 we explore whether the expansion of women's employment in 1950 is correlated with the availability of retail appliances stores in 1954 and find no evidence of a relationship. We then re-estimate our main IV specification, controlling for retail outlets, and find in column (2) of Table 8 that the availability of retail appliance stores does not appear to affect washing machine ownership. Moreover, after controlling for retail outlets, the qualitative interpretation of our main effect is consistent with the primary findings in Table 3. A one standard deviation increase in women's labor force participation in 1950 increases washing machine ownership in 1960 by 0.46 standard deviations.

5.3.3 Migration

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

Using 1960 census data on migration, we regress net migration, as well as the percent of population growth due to migration, in a given county on women's labor force participation in 1950 using our IV approach.[24] The results in Appendix Table 13 show that women's employment in 1950 does contribute to population growth from migration between 1950 and 1960. For every standard deviation increase in women's labor force participation in 1950, population growth from migration is 0.92 standard deviations higher. We then re-estimate our main IV specification in columns (3) and (4) of Table

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

8, controlling for migration, and find that while counties with higher net migration do observe more washing machine ownership, migration appears to be uncorrelated with washing machine ownership after accounting for population growth resulting from migration. Also note again that controlling for migration does not change the qualitative interpretation of our main findings. The coefficients on women's labor force participation are consistent with our main findings and suggest that with a standard deviation increase in women's employment in 1950, washing machine ownership in 1960 is 0.46 standard deviations higher.[25]

6 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 lower end of the education distribution, for whom income effects are the most straightforward

[25] An alternative method of ruling out these channels is to examine the correlation between WLFP and TV access, retail stores and migration. Using this method yields qualitatively same outcomes. Results available on request.

explanation for more appliance purchases. At the same time, as domestic laborers expanded employment opportunities, households began substituting paid domestic work with household appliances.

At first glance, our results seem to counter the prevailing view in the economics literature that household technologies liberated women from the household by reducing the time spent on domestic labor and facilitating entry into the labor market. We argue, however, that these two sets of findings actually complement one another. The introduction of household technologies to American consumers mid-century likely shifted the labor supply elasticities of women, as the canonical model by Greenwood et al. (2005) shows, making it easier to consider the notion of going to work and maintaining living standards at the same time. Our evidence further suggests that the decision to adopt these appliances did not occur until women acquired the means to do so through labor market participation, particularly for households with lower earnings capacity.

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
Net migration (1950 to 1960)	3056	828.06	33575.61	-372001	1185976
% Pop growth from migration (1950 to 1960)	3056	-9.45	24.85	-64.90	319.1
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 sources: Department of Defense, National Archives & Records Administration, and US Census.

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

Dependent Variable: Women's LFP 1950		
	(1)	(2)
Factory	1.029***	0.787***
	(0.174)	(0.171)
Demographic controls:	No	Yes
Observations	3056	3056
Mean of Dep Var	22.451	22.451
SD of Dep Var	6.492	6.492
R^2	0.735	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*
	(0.030)	(0.023)			(0.270)	(0.239)
Factory			0.098**	0.054*		
			(0.047)	(0.028)		
Demographic controls:	No	Yes	No	Yes	No	Yes
Specification:	OLS	OLS	Reduced	Reduced	IV	IV
Mean of DV:	78.26	78.26	78.26	78.26	78.26	78.26
SD of DV:	12.65	12.65	12.65	12.65	12.65	12.65
Observations	3056	3056	3056	3056	3056	3056
First Stage F-Stat					35.140	21.047
R^2	0.621	0.712	0.622	0.711	0.514	0.646

* p< 0.10, ** p<0.05, *** p < 0.01. Unit of observation is a County. Standardized coefficients reported. Standard errors clustered at the state level in parentheses. Columns (1)-(2) report the OLS estimates. Columns (3)-(4) report the reduced form estimates. Columns (5)-(6) report the IV estimates. 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: **Heterogeneity: Women's labor force participation and washing machines by draft rates**

Dependent Variable: % HHs own washing machine in 1960			
	(1)	(2)	(3)
WLFP (1950)	-0.193	0.326	0.934**
	(0.416)	(0.298)	(0.419)
Demographic controls:	Yes	Yes	Yes
Specification:	IV	IV	IV
Draft rates:	Low	Medium	High
Mean of DV:	78.26	78.26	78.26
SD of DV:	12.65	12.65	12.65
Observations	1019	1019	1018
First Stage F-Stat	7.208	8.626	12.584
R^2	0.719	0.711	0.434

* p< 0.10, ** p<0.05, *** p < 0.01. Unit of observation is a County. Standardized coefficients reported. Standard errors clustered at the state level in parentheses. Low draft rates represent counties in the bottom third (<18.09%). Medium draft rates represent counties in the middle third (≥18.09% and <24.70%). High draft rates represent counties in the top third (≥24.70%). 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 5: **Benchmarking exercise**

Dependent Variable: % Households owning washing machine in 1960				
	(1)	(2)	(3)	(4)
% Rural population in 1950	0.160***			0.175***
	(0.019)			(0.018)
% Households with own refrigerator in 1950		0.115***		0.168***
		(0.027)		(0.030)
% Population of age 0-17yrs in 1950			0.115***	0.124***
			(0.033)	(0.031)
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 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 6: **Channel: Income**

Dependent Variable: % Households owning washing machine in 1960			
	(1)	(2)	(3)
WLFP (1950)	0.235	0.103	0.110
	(0.264)	(0.227)	(0.264)
Median income (1950)	0.133***	0.128***	
	(0.032)	(0.033)	
Median income x WLFP (1950)		-0.133**	
		(0.060)	
Below median x WLFP (1950)			0.269**
			(0.107)
Below median income (1950)			-0.073
			(0.051)
Specification:	IV	IV	IV
Observations	3056	3056	3056
First Stage F-Stat	17.556	8.518	9.139
R^2	0.693	0.707	0.681

* p< 0.10, ** p<0.05, *** p < 0.01. Unit of observation is a County. IV estimates. Standardized coefficients reported. *Median income (1950)* is the median household income in a given county in 1950. *Below median income (1950)* is a binary variable equal to 1 if the median household income in a given county is below the national median. Standard errors clustered at the state level in parentheses. 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.

Table 7: **Channel: Domestic work**

	% Own Wash (1960) (1)	% Domestic (1950) (2)	% Domestic (1950) (3)	% Own Wash (1960) (4)
% WLFP Domestic (1950)	-0.114**			-1.754*
	(0.049)			(0.994)
Factory		-0.016		
		(0.028)		
% Black women WPA (1937)			-0.033***	
			(0.011)	
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

* p< 0.10, ** p<0.05, *** p < 0.01. Unit of observation is a County. Standardized 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 8: **Other Channels: TV, retail stores, and migration**

Dependent Variable: % Households owning washing machine in 1960				
	(1)	(2)	(3)	(4)
WLFP (1950)	0.435*	0.460*	0.455*	0.460*
	(0.251)	(0.248)	(0.249)	(0.250)
TV signal by 1952	0.083**			
	(0.036)			
Retail appliance stores (1954)		-0.103		
		(0.102)		
Net Migration (1950-60)			0.075***	
			(0.021)	
% Pop growth migration (1950-60)				0.005
				(0.033)
Specification:	IV	IV	IV	IV
Observations	3056	3056	3056	3056
First Stage F-Stat	21.078	20.998	20.967	19.090
R^2	0.656	0.649	0.654	0.648

* p< 0.10, ** p<0.05, *** p < 0.01. Unit of observation is a County. Standardized coefficients reported. Standard errors clustered at the state level in parentheses. Migration measures come directly from the 1960 census data. Net Migration is the net change in the population from migration between 1950 and 1960. Percent population growth from migration is the change in population between 1950 and 1960 resulting from migration. All estimates control for: state fixed effects, 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.

Figure 4: **Effect of WLFP on washing machine ownership by years of education**

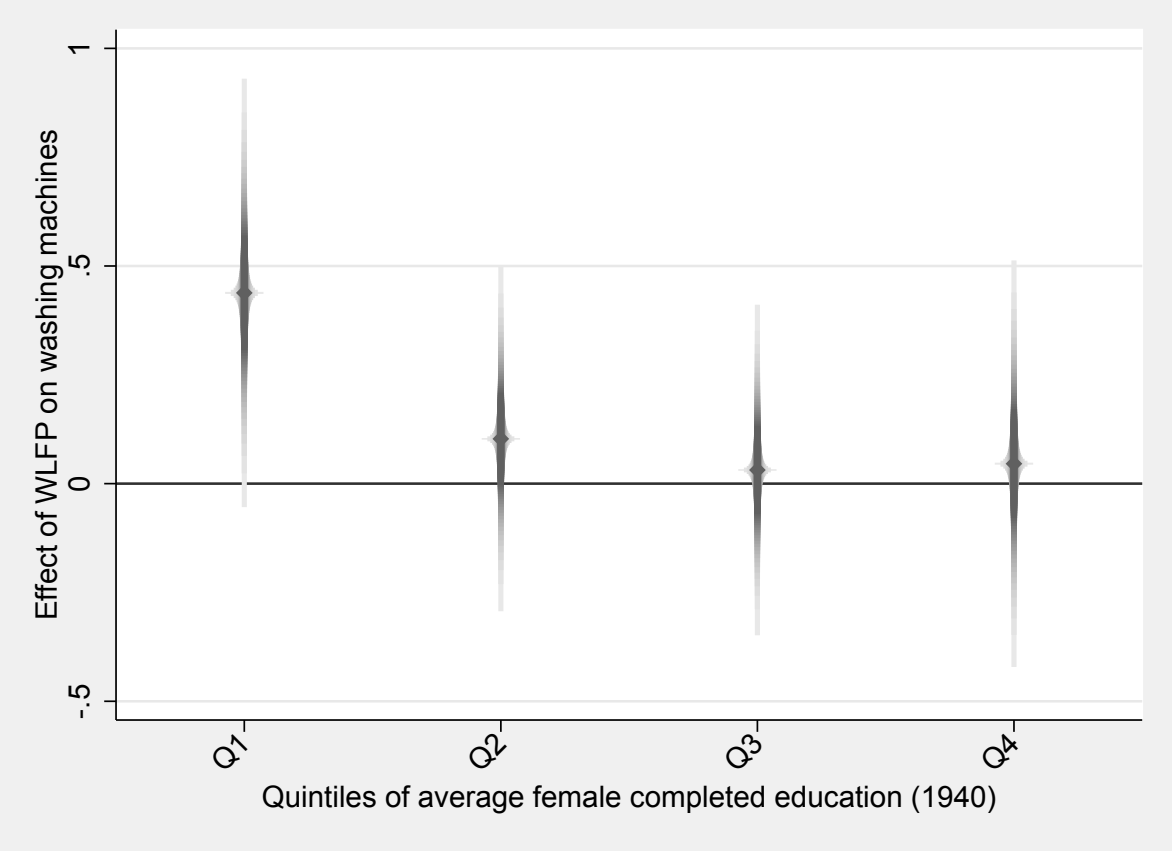

Figure shows coefficients from education interaction effects in Table 10.

Appendices

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In the panel setting, 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 8 shows that having a wartime factory leads to a 0.6 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 3 percent effect.

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)
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)
Observations	3056	3056	3056	3056	3056	3056	3056
Mean of DV	-91.569	38.291	60420.148	45.916	11.445	7.991	18.488
SD of DV	11.322	4.863	76648.997	21.928	17.948	1.160	6.670
R^2	0.977	0.939	0.505	0.429	0.593	0.564	0.395

* 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: **Parallel trends in WLFP**

Dependent Variable: Women's LFP		
	(1)	(2)
Factory x 1940	0.003	0.003
	(0.002)	(0.002)
1940	0.008**	0.008**
	(0.003)	(0.003)
Factory (0/1)	0.042***	0.013***
	(0.004)	(0.004)
State FE:	Yes	Yes
County-level controls:	No	Yes
Mean DV (1930 No Factory):	0.17	0.17
SD of DV (1930 No Factory):	0.70	0.07
Observations	6111	6111

* p< 0.10, ** p<0.05, *** p < 0.01. Unit of observation is a US County in 1930 and 1940. Standard errors clustered at the state level in parentheses. County level controls include: latitude, longitude, ruggedness, and percent farm employment, non-white population, and average education in 1940.

Appendix Table 3: **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 nonwhite population, and average eduction in 1940, as well as county latitude, longitude and average ruggedness.

Appendix Table 4: **Draft rates and casualty rates**

Dependent Variable: Women's Labor Force Participation						
	(1)	(2)	(3)	(4)	(5)	(6)
Draft rate	0.057***		0.056			
	(0.012)		(0.036)			
Casualty rate		-30.181**	-31.803***			
		(11.584)	(10.993)			
Draft rate × Year=1950				-0.010		-0.007
				(0.010)		(0.011)
Casualty rate × Year=1950					-10.239	-9.791
					(9.051)	(9.133)
Fixed Effect:	State	State	State	County	County	County
Sample:	1950	1950	1950	1940-50	1940-50	1940-50
Controls: Yes	Yes	Yes	Yes	Yes	Yes	
Observations	3057	3038	3038	6114	6076	6076
Mean of DV	22.446	22.362	22.362	20.466	20.374	20.374
SD of DV	6.496	6.413	6.413	6.875	6.780	6.780
R^2	0.579	0.570	0.572	0.580	0.583	0.583

* p< 0.10, ** p<0.05, *** p < 0.01. Unit of observation is a US County. Standard errors in parentheses. The sample in columns (1)-(3) is for the year 1950, only. The sample in columns (4)-(6) is for the years 1940 and 1950. All estimates include the following county level geographic and 1940 controls: latitude, longitude, ruggedness, percent rural farm population, percent nonwhite, and average years of education of the adult population. Columns (4)-(6) include a dummy for the year 1950, which is also interacted with the geographic and demographic controls.

Appendix Table 5: **WWII mobilization and male education**

Dependent Variable: % Males 25+ with any college (1950)		
	(1)	(2)
Factory	2.323***	0.502***
	(0.217)	(0.177)
Demographic controls:	No	Yes
Observations	3056	3056
Mean of DV	9.700	9.700
SD of DV	5.013	5.013
R^2	0.286	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 6: **WLFP and washing machines, controlling for male education**

Dependent Variable: % Households owning washing machine in 1960		
	(1)	(2)
WLFP (1950)	0.706**	0.477**
	(0.306)	(0.243)
% males with college (1950)	-0.083*	-0.079**
	(0.048)	(0.036)
Demographic controls:	No	Yes
Specification:	IV	IV
Mean of DV:	78.26	78.26
SD of DV:	12.65	12.65
Observations	3056	3056
First Stage F-Stat	29.859	20.593
R^2	0.487	0.639

* p< 0.10, ** p<0.05, *** p < 0.01. Unit of observation is a County. Standardized 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 7: **WLFP in 1960 and washing machine ownership in 1960**

Dependent Variable: % Households own washing machine in 1960				
	(1)	(2)	(3)	(4)
WLFP (1960)	0.013	-0.052**	0.538**	0.373*
	(0.037)	(0.020)	(0.231)	(0.202)
Demographic controls:	No	Yes	No	Yes
Specification:	OLS	OLS	IV	IV
Instrument:			Fac	Fac
Mean of DV:	78.26	78.26	78.26	78.26
SD of DV:	12.65	12.65	12.65	12.65
Observations	3056	3056	3056	3056
First Stage F-Stat			27.211	21.547
R^2	0.621	0.712	0.499	0.638

* p< 0.10, ** p<0.05, *** p < 0.01. Unit of observation is a County. Standardized 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 8: **WLFP and mobilization: difference in differences**

Dependent Variable: Δ WLFP	
	(1)
Factory × Year=1950	0.559***
	(0.153)
Counties:	3057
Mean DV (1940):	18.49
SD of DV (1940):	6.67
Observations	6114

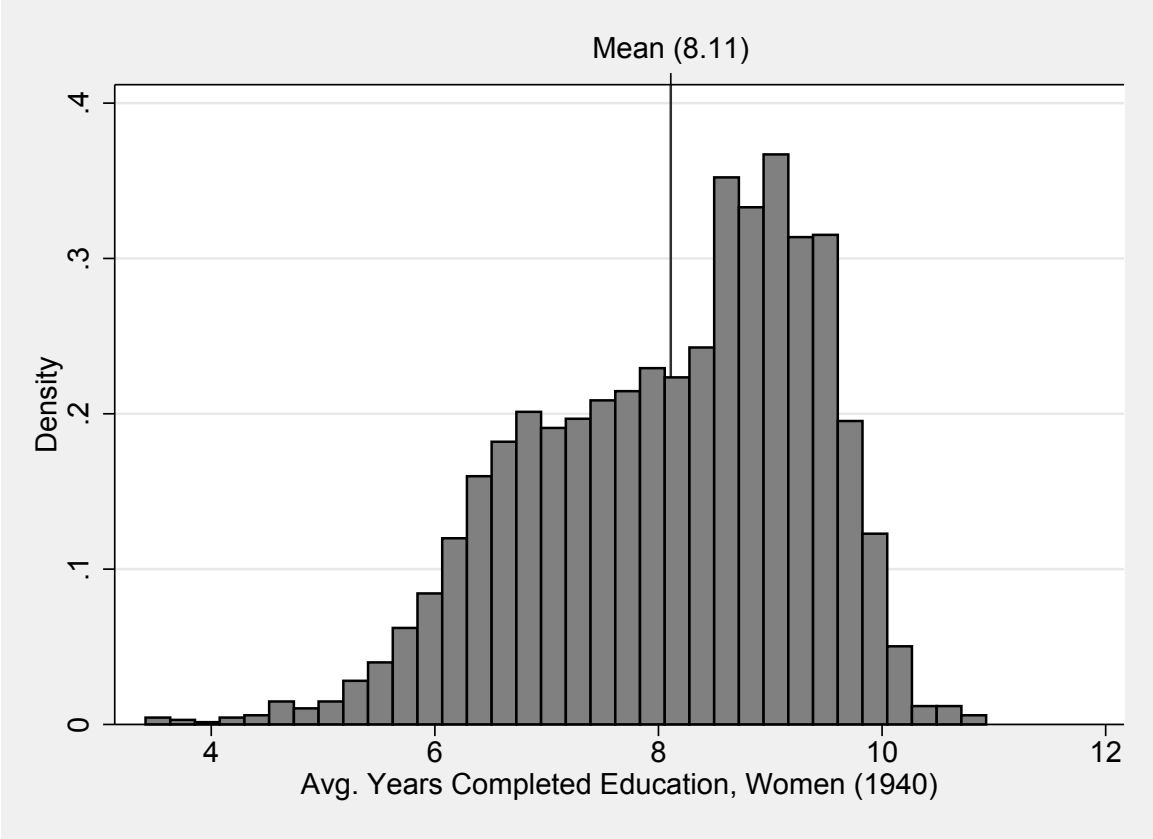
* p< 0.10, ** p<0.05, *** p < 0.01. Panel fixed effects estimates. Unit of observation is a US County from 1940 to 1950. Standard errors clustered at the county level in parentheses. All estimates include county and year fixed effects, as well as the following county level geographic and 1940 covariates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

Appendix Table 9: **WLFP and refrigerators: panel estimates**

Dependent Variable: Δ % HH own refrigerator			
	(1)	(2)	(3)
WLFP	0.165***	0.030	0.545**
	(0.018)	(0.019)	(0.233)
Specification:	Panel FE	Panel FE	IV
Demographic controls:	No	Yes	Yes
Counties:	3057	3057	3057
Mean DV (1940):	26.74	26.74	26.74
SD of DV (1940):	14.84	14.84	14.84
Observations	6114	6114	6114
First Stage F-Stat			13.364

* p< 0.10, ** p<0.05, *** p < 0.01. IV estimates. Standardized 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 geographic and 1940 county level covariates interacted with the year 1950: ruggedness, latitude, longitude, percent rural farm population, percent nonwhite, and mean years of education of the adult population.

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



Appendix Table 10: **WLFP and washing machines by female education**

Dependent Variable: % Households owning washing machine in 1960	
	(1)
WLFP (1950)	0.269
	(0.304)
Q1 female ed (1940) x WLFP (1950)	0.438**
	(0.191)
Q2 female ed (1940) x WLFP (1950)	0.103
	(0.154)
Q3 female ed (1940) x WLFP (1950)	0.031
	(0.147)
Q4 female ed (1940) x WLFP (1950)	0.046
	(0.181)
Q1 female ed	0.413
	(0.320)
Q2 female ed	0.175
	(0.239)
Q3 female ed	0.070
	(0.125)
Q4 female ed	-0.007
	(0.086)
Specification:	IV
Observations	3056

* p< 0.10, ** p<0.05, *** p < 0.01. Unit of observation is a County. IV estimates. Standardized coefficients reported. Standard errors clustered at the state level in parentheses. The excluded category is the 5th quintile 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 unknown, and percent of males age 25+ for whom years of education is unknown.

Appendix Table 11: **WLFP and median family income**

	(1) Med inc (1950)	(2) Med inc (1960)
WLFP (1950)	1.552***	1.546***
	(0.427)	(0.345)
Demographic controls :	Yes	Yes
Mean of DV:	2250.9	4163.5
SD of DV:	853.8	1311.8
Specification:	IV	IV
Observations	3056	3056
First Stage F-Stat	21.023	21.023
R^2	0.187	0.303

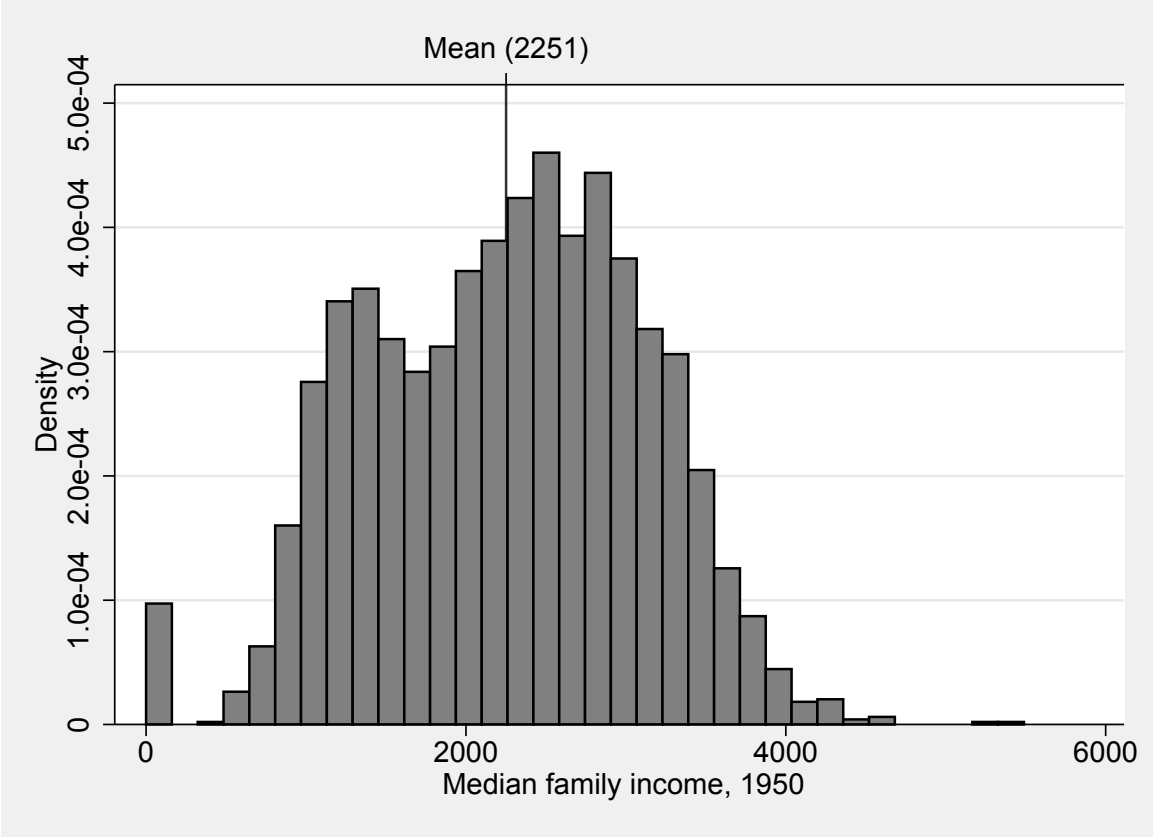
* p< 0.10, ** p<0.05, *** p < 0.01. Unit of observation is a County. Standardized beta coefficients reported. Dependent variable is median family income in 1950 or 1960. Standard errors clustered at the state level in parentheses. All estimates control for state fixed effects, total population in 1950, 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 12: **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)
% Farm area (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 2: **Distribution of median family income (1950)**



Appendix Table 13: **WLFP (1950), TV signal, retail outlets, and migration**

	(1) TV Signal (1952)	(2) Retail Stores (1954)	(3) Net Migration	(4) Pop Δ from Mig
WLFP (1950)	0.352**	-0.001	0.124	0.923**
	(0.168)	(0.036)	(0.245)	(0.452)
Specification:	IV	IV	IV	IV
Observations	3056	3056	3056	3056
First Stage F-Stat	27.848	27.848	21.023	21.023
R^2	0.217	0.926	0.129	0.165

* p< 0.10, ** p<0.05, *** p < 0.01. Unit of observation is a County. Standardized coefficients reported. Standard errors clustered at the state level in parentheses. The dependent variable in columns (1) is a dummy variable equal to 1 if the county had a TV signal by 1952. The dependent variable in columns (2) is the number of retail stores in 1954 that sell appliances. Migration measures come directly from the 1960 census data. Net Migration is the net change in the population from migration between 1950 and 1960. Percent population growth from migration is the change in population between 1950 and 1960 resulting from migration. All estimates control for: state fixed effects, 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.