The Impact of Home Appliances on Employment Decisions of Married Women: New Evidence from Cross-Sectional Data

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Abstract

One of the leading explanations for the drastic increase in the labor force participation of married women observed in developed countries during the 20th-century, emphasizes the importance of technological progress in the household sector (e.g., Greenwood, Seshadri, and Yorukoglu (2005)). In this paper, we provide an assessment of this theory in two steps. First, we propose a simple choice-theoretic model of employment decisions of married women and home appliances adoption. Second, we use micro-level data from the 1960 and 1970 US censuses to analyze the changes over time in home appliances ownership for households where women work versus households where women do not work. Our model shows that not all women who buy home appliances decide to work. Moreover, the fraction of households that own appliances is slightly higher for women who do not work compared to women who work in both census samples. Finally, the magnitude of the increase in home appliances ownership between 1960 and 1970 is similar for women who work and women who do not work. Based upon these findings, we propose an alternative interpretation of the impact of home appliances on the participation decision of married women, where the demand for home appliances depends on family size and household total income but is unrelated to the work decision. We show that our theory is consistent with all relevant facts, the micro ones and the aggregate ones.

JEL code: O15, J22 - Key Words: Home Appliances, Employment of Married Women, Logit

1 Introduction

One of the leading explanations for the drastic increase in the labor force participation of married women observed in developed countries during the 20th-century, emphasizes the importance of technological progress in the household sector (e.g., Greenwood, Seshadri, and Yorukoglu (2005) (later GSY) or Greenwood, Seshadri, and Vandenbroucke (2005)).[1] In a nutshell, as the price of

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[1]The drastic increase in the labor force participation of married women is perhaps one of the most salient and pervasive change in U.S. labor markets during the 20th-century. In 1900, only five percent of married women were part of the labor force. One hundred years later, the average participation is equal to sixty-five percent, more than a twelve-fold increase (Dora (2000)). Explanations for the rise in employment of married women include the decline in the price of home appliances and the ensuing diffusion of home appliances (Greenwood, Seshadri, and Yorukoglu (2005)), changes in the nature of jobs from "brawn to brain" (Galor and Weil 1996), a narrowing of the gender wage gap (Jones, McGrattan, and Manuelli 2003), the introduction of the pill (Goldin and Katz 2002), changes in social norms (Fernandes, Fogli, and Olivetti 2004), increases in returns to experience favoring women over men (Olivetti 2006), or delay in the timing of births (Buttet and Schonbroodt 2006), to name only a few.

labor-saving home appliances (refrigerator, washer, dryer, dishwasher, and freezer, etc) declines relative to the household median income, the fraction of households that buys these appliances increases. In turn, since productivity at home increases, it takes less time to produce one unit of the home good and women have more time available to allocate to other activities, including work. Several macroeconomic papers find that the decline in the price of home appliances can account for a quantitatively significant fraction of the increase in labor force participation of married women and the diffusion of home appliances. For example, using aggregate data on the price index of home appliances and women's participation rate for a wide sample of OECD countries between 1980 and 1999, Cavalcanti and Tavares (2006) (later CT) show that a ten-percent decrease in the relative price of appliances leads to five-percent increase in female labor force participation (see also GSY or Greenwood and Guner (2004)).

The goal of this paper is to re-evaluate the impact of home appliances on the employment decision of married women by introducing a simple choice-theoretic model and testing the implications of our model using *micro-level* rather than aggregate data. What we seek is a better understanding of the theoretical relationship between home appliances and work, for example what type of women decide to buy home appliances, what type of women choose to work, and whether the purchase of home appliances affects the work decision.

First, our model shows that not all women who buy home appliances decide to work. As the price of home appliances declines, two groups of women decide to buy the home appliances but do not alter their work decision. The first group consists of women who receive high wage offers and always work, even though they initially do not own the home appliances. The second group consists of women who receive low wages and never work. We show that both types of women buy the home appliances as the price of appliances goes down.

Second, we compare the home appliances ownership for women who work and women who do not work, using individual data from two cross-sections of the US census for the 1960 and 1970 decades. We find that (i) the fraction of households that own appliances is slightly higher for women who do not work compared to women who work in both samples and (ii) the increase in home appliances ownership between 1960 and 1970 is similar for women who work and women who do not work.

Third, we estimate a logistic model of women's employment decisions for both censuses, where the independent variables are dummy variables equal to one if the household owns a washing machine, dryer, freezer, or dishwasher, respectively. We find that (i) the sign of the coefficients in front of the appliances dummy is negative for the 1960 and 1970 decades and (ii) the coefficients in front of all home appliances dummy variables increase between 1960 and 1970.[2]

We believe that, altogether, our results suggest a different interpretation of the impact of home appliances on the participation decision of married women. For argument's sake, consider two extreme and opposite theories of women's employment. On the one hand, if adopting the home appliances is a true necessary condition for women to join the labor force (a strong version of GSY), then all women who work own the home appliances, while some women who do not work do not own home appliances. As a result, the fraction of households that own the home appliances is larger in households where women work compared to households where women do not work. The data clearly shows that this not the case.

On the other hand, consider a theory where (i) the presence of home appliances has no impact on the participation decision of married women, (ii) the quantity demanded of home appliances

[2]The negative sign for the coefficient in front of the appliances dummy can be counterintuitive at first given the positive relationship between home appliances and women's labor supply reported in macroeconomic studies. Our analysis shows that it comes from the fact that there are more women who do not work and own the home appliances than women who work and own the home appliances.

increases when the price of home appliances goes down relative to the household median income, and (iii) the demand for home appliances shifts upward with household income and other variables related to the "family size".

The implications of the latter theory are consistent with the main facts both at the micro- and aggregate level. First, as technological progress in the household sector unfolds, the price of home appliances declines relative to the median household income, which implies that the fraction of households that buy the home appliances goes up. Second, as participation rates of married women increase, perhaps because of a reduction in the gender wage gap or a decrease in fertility, the price of home appliances and participation rates are negatively correlated as in CT, while the fraction of households that own the home appliances and women's participation rates are positively correlated as in GSY. Finally, and most importantly, the fraction of households that own the home appliances is slightly higher in households where women do not work compared to households where women work.

In the last section of the paper, we analyze the home appliances adoption decision at the household level. Our working hypothesis is that the benefits of using home appliances increases with the demand for home production. As a result, we look at three additional variables related to family size: whether a household own the housing unit where it lives and the number of rooms and bedrooms in the housing unit. We find that three main differences exist between households who own home appliances and those who do not. First, the labor force participation rate of women is greater for households that do not own the home appliances. Second, families that own the home appliances are larger in size, as evidenced by a greater number of children (either present in the household or over the course of a life-time) and housing units with more rooms and bedrooms. Third, the mean and median total household income is twenty percent higher for households that own home appliances. Altogether, these facts suggest that the probability of buying home appliances significantly increases with total household income and variables related to family size.

The remainder of the paper is organized as follows. In the next section, we lay out the assumptions of our theoretical model and derive its properties. In the third section, we describe our data set and estimate two logistic models of work and home appliances adoption. Finally, we offer some concluding remarks.

2 A Simple Theoretical Framework

In this section, we propose a simple static model of women's labor supply and home appliances adoption. Households care about market consumption, c, and leisure, l and their preferences are given by:

$$u(c,l) = c + v(l) \tag{1}$$

The function v is strictly increasing and concave, $v' > 0$ and $v'' < 0$.

Women get a random wage, w_f, drawn from a distribution, $F(\mu, \sigma^2)$, with mean μ and standard deviation σ. Given the wage offer and the price of appliances, p, they must decide whether to work, $e \in \{0,1\}$, and whether she should adopt the home appliances, $a \in \{0,1\}$. The budget and time constraints are given by:

$$\begin{aligned} & c + pa = w_m + w_f e \\ & l + t_w e + \frac{t_k}{\eta^a} n = 1 \\ & e \in \{0,1\}, \quad a \in \{0,1\} \end{aligned} \tag{2}$$

where the symbols w_m, t_w, t_k, n denote the husband's wage, the length of the workweek, the time cost of house chores, and the family size, respectively. Finally, the parameter η represents the time saved when households buy home appliances, with $\eta > 1$.

Our model is built around three important assumptions. First, the employment and adoption decisions are made at the extensive margin rather than the intensive margin. That is, women choose whether to work and/or adopt home appliances rather than how many hours to work and how many home appliances to buy. This is without loss of generality, however, as shown by GSY. Second, home good consumption is not an input in households' utility function, which implies that the sole benefits derived from buying home appliances are a reduction in the time needed to do the house chores. This assumption allows us to isolate the impact of home appliances on women's participation decisions and to ignore the home appliances effect on home good production. Note that the time cost of house chores increases with the family size. Finally, market consumption is a perfect public good and is the same across all family members (see Jones, Manuelli, and McGrattan (2003) for a model where market consumption of the husband and wife depends on their bargaining power within the couple).

Women compare the gains in marginal utility of leisure to the price of appliances and the market wage in order to make their work and adoption decision. There is no income effect from husband's wage because of the linear utility in consumption. In the Appendix, we show that there exists a reservation wage, $w^*(a)$, such that conditional on the adoption decision a, women are indifferent between working or not working. As a result, they decide to work whenever they get a wage offer greater than the reservation wage, which is equal to:

$$w^*(a) = v(1 - \frac{t_k n}{\eta^a}) - v(1 - t_w - \frac{t_k n}{\eta^a}) \tag{3}$$

Note that $w^*(1) < w^*(0)$ since we assume that the function v is increasing and concave. Intuitively, women who have adopted the labor-saving technology have a lower marginal utility of leisure and accept to work at lower wages.

Similarly, there exists a reservation price, $p^*(e)$, such that conditional on the employment decision e, women are indifferent between adopting or not adopting the home appliances. As a result, they decide to adopt whenever the market price of home appliances is lower than the reservation price, which is equal to:

$$p^*(e) = v(1 - t_w e - \frac{t_k n}{\eta}) - v(1 - t_w e - t_k n) \tag{4}$$

Note that $p^*(0) < p^*(1)$ since we assume that the function v is concave and $\eta > 1$. Intuitively, total household income is larger when women work and households can afford to buy the home appliances at a higher price.

Finally, when $p^*(0) \leq p \leq p^*(1)$ and $w^*(1) \leq w_f \leq w^*(0)$, we define the threshold wage function, $\tilde{w}(p)$, such that, given the price of home appliances, women are indifferent between working and buying home appliances and not working and not buying home appliances. The wage threshold is given by:

$$\tilde{w}(p) = p + v(1 - t_k n) - v(1 - t_w - \frac{t_k n}{\eta}) \tag{5}$$

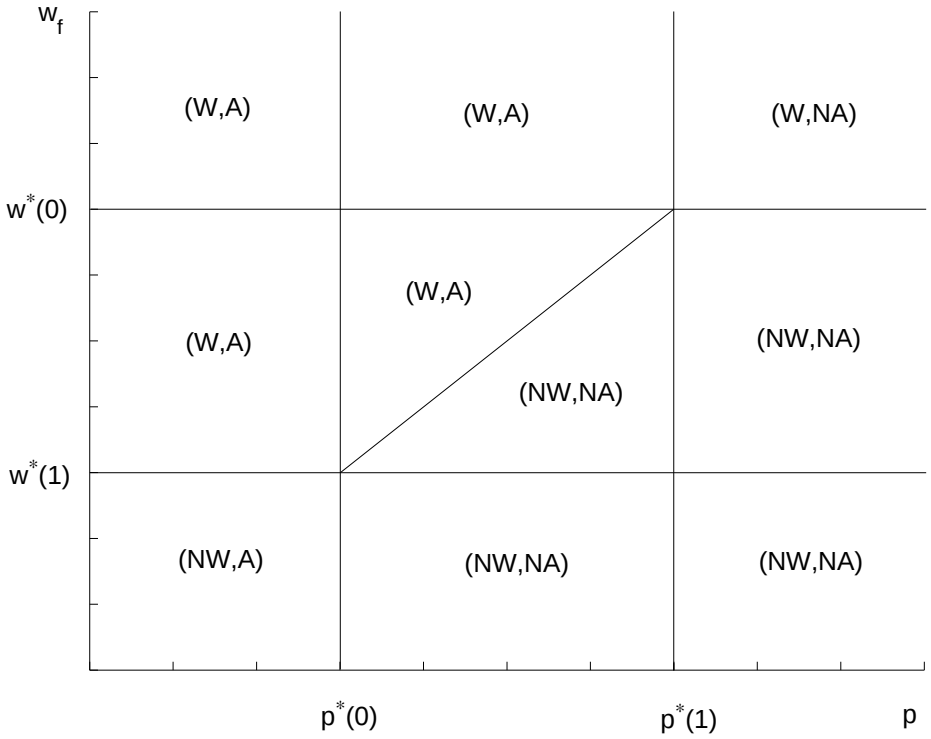
The optimal decisions of households are summarized in the next proposition and Figure 1.

Proposition 1. *The solution to the household maximization problem is given by:*

- *when* $p > p^*(1) : a = 0$ *and* $(e = 1$ *if and only if* $w_f \geq w^*(0))$,

- *when* $p^*(0) < p \leq p^*(1)$: ($a = 1$ *and* $e = 1$) *if and only if* $w_f \geq \tilde{w}(p)$,
- *when* $p \leq p^*(0)$: $a = 1$ *and* ($e = 1$ *if and only if* $w_f \geq w^*(1)$).

Fig. 1: Joint Decision: Appliances - Work



Legend: W: work, NW: Do not work, A: Own appliances, NA: Do not own appliances

We can use our model to analyze the impact of a gradual decline in the price of home appliances on the work and adoption decision. Starting with the case where the price of home appliances is very high ($p > p^*(1)$), no household buy home appliances and only women who receive wage offers higher than $w^*(0)$ decide to work.

How are women's decisions affected when the price of home appliances falls into the region where $p^*(0) \leq p \leq p^*(1)$? The presence of home appliances has a direct and positive impact on the work decision of women whose wage offer becomes greater than $\tilde{w}(p)$ but is less than $w^*(0)$, because these women switch their decision from not working and not buying home appliances to work and buy. However, home appliances have no impact on the work decision of women who receive wage offers higher than $w^*(0)$, because these women decide to buy the home appliances but they do not change their work decision.

When the price of home appliances declines further, $p < p^*(0)$, every household adopts the home appliances and women with wage offers greater than $w^*(1)$ work. The presence of home appliances has no impact on the work decision of women who receive wage offers lower than $w^*(1)$, because these women decide to buy the home appliances but they do not change their work decision.

Our results show that not all women who buy home appliances decide to work. As the price of home appliances declines, two groups of women decide to buy the home appliances but do not alter their work decision. The first group consists of women who receive high wage offers and always

work, even though they initially do not own the home appliances. The second group consists of women who receive low wages and never work. Both types of women buy the home appliances as the price of appliances goes down.

3 Empirical Analysis

In this section, we present our data set and analyze the changes over time in home appliances ownership for households where women work versus households where women do not work. We estimate two separate models of work and home appliances decisions.

3.1 Data Description

Our data set consists of individual-level data for married women from two cross-sections of the US census for the decades 1960 and 1970.[3] We use the census data for these two decades because information about home appliances ownership (washing machine, dryer, freezer, and dishwasher) is available above and beyond the usual demographic and economic characteristics. We do not include the refrigerator as part of home appliances because the fraction of households that owns a refrigerator in our data is very close to one in both samples. Moreover, we do not include home appliances such as the vacuum cleaner or the microwave because no information about these variables is provided in either census.

For both decades, we report the following variables for married women: whether they own at least one washing machine, one dryer, one dishwasher, or one freezer; their age, race, educational attainment, labor force participation, the number of own children in the household, the number of own children under age five in the household, the total number of children ever born, their husband's real wage using 1960 as the base year, the education of the husband, the total household real income using 1960 as the base year; whether the household owns the property where it lives, the number of rooms/bedrooms in the housing unit. The variables washing machine, dryer, dishwasher, freezer are binary dummy variables taking the value of one when households own at least one unit of appliance. Similarly, information about race, labor force participation and ownership of the housing unit is coded using dummy variables which are equal to one when married women are not white, participate in the labor force, and own the housing unit where they live, respectively. Finally, the education attainment is measured by the highest grade of education completed.

We select women who are married, spouse present; who are between age 20 and 60 and who are not in school. We exclude women who live in group quarters or vacant units, whose husbands's real wage is less than \$100, and the households for which information about the ownership of one of the four appliances is missing. These cuts result in sample size of 51,263 observations for the 1960 census and 301,915 observations for the 1970 census. The mean and standard deviation for all variables for both censuses are presented in Table 1.

The sample means for age, number of children present in the household, number of children under age five present in the household, total number of children ever born, and the fraction of whites, are very close across censuses. However, the 1960 and 1970 samples differ in three critical ways. First, the average employment rate increased by eleven percentage points. Second, the fraction of women who own a dryer and a freezer increased by thirty and twelve percentage points, respectively, while the fraction of women who own a washing machine decreased by a modest two percentage points. Finally, the mean husband's wage increases by thirty-three percent from \$5,567

[3]The source for our data is Integrated Public Use Microdata Series (IPUMS USA) at the University of Minnesota.

to $7,365, while total household income by thirty-three percent from $7,219 to $12,439.[4]

Tab. 1: Descriptive Statistics - Mean (std)

Variable	1960	1970
Labor Force Participation (dummy, 1=work)	0.34	0.44
Washing Machine (dummy, 1=own)	0.84	0.82
Dryer (dummy, 1=own)	0.26	0.56
Freezer (dummy, 1=own)	0.21	0.34
Dishwasher (dummy, 1=own)	-	0.26
Age	37.54 (9.95)	37.39 (10.66)
Race (dummy, 0=white)	0.09	0.09
Years of Education	10.47 (2.94)	11.38 (2.73)
Number of children present in HH	1.87 (1.61)	1.85 (1.61)
Number of children under age 5 present in HH	0.56 (0.86)	0.42 (0.71)
Total number of children ever born	2.38 (1.86)	2.46 (1.87)
Education of the husband	10.34 (3.48)	11.49 (3.32)
Husband's Labor Income†	$5,567.19 ($3,247.11)	$7,375.34 ($4,496.63)
Total Household Income††	$7,219.56 ($3,998.69)	$12,439.57 ($7,068.24)
Housing Unit Ownership (dummy, 1=own)	0.65	0.69
Number of Observations	51,263	301,915

For 1960 Census: † Median Labor Income of Husband: $5,050 - †† Median Total Household Income: $6,450.
For 1970 Census: † Median Labor Income of Husband: $6,621 - †† Median Total Household Income: $11,050.

Since our analysis is primarily concerned with assessing the impact of home appliances on the participation decisions of married women, we present the samples means for both censuses by employment status (see Table 2 and 3). Two important facts emerge. First, the fraction of households that own home appliances is slightly higher for women who do not work compared to women who work. For example, for the 1960 census, eighty-seven percent of women who do not work own a washing machine, while only eighty percent of women who work own a washing machine, etc.

Second, the increase in the fraction of households that own home appliances between 1960 and 1970 is similar for women in and out of the labor force. For example, for women out of the labor force, the fraction of households that own a dryer or a freezer has increased by thirty-one and thirteen percentage points, respectively, while for women in the labor force, the fraction of households that own a dryer or a freezer has increased by thirty-two and thirteen percentage points (see Tables 2 and 3).

A possible explanation for the lower ownership rate of home appliances among working women is that these women find optimal to buy market provided services that are close substitutes of goods produced at home. For example, working women can decide to have their clothes washed at a dry-cleaning store rather than doing their laundry at home. Similarly, working women might prefer to eat out rather than cook at home. However, since the market for dry-cleaning is small in

[4]One reason for the increase in the mean (median) income is a rise in the top coding of wages from $25,000 in the 1960 census to $50,000 in the 1970 census. The standard deviation also increased by thirty-eight percent from $3,247 to $4,496 which either reflects an increase in income inequality between 1960 and 1970 or the increase in the top coded wages.

size (more than eighty percent of women own a washing machine) and eating out is probably not very convenient when women have young children, we do not pursue this research avenue in this paper.

Tab. 2: Women Out of the Labor Force: Descriptive Statistics - Mean (std)

Variable	1960	1970
Washing Machine (dummy, 1=own)	0.87	0.85
Dryer (dummy, 1=own)	0.27	0.58
Freezer (dummy, 1=own)	0.21	0.34
Dishwasher (dummy, 1=own)	-	0.26
Age	36.91 (10.01)	37.05 (10.64)
Race (dummy, 0=white)	0.07	0.07
Years of Education	10.37 (2.93)	11.17 (2.71)
Number of children present in HH	2.09 (1.62)	2.07 (1.63)
Number of children under age 5 present in HH	0.71 (0.92)	0.55 (0.79)
Total number of children ever born	2.59 (1.87)	2.66 (1.88)
Education of the husband	10.46 (3.53)	11.54 (3.37)
Wage income of the husband	\$5,873.54 (\$3,502.61)	\$7,907.40 (\$4,997.31)
Total Household Income††	\$6,863.41 (\$4,084.63)	\$11,685.08 (\$7,402.39)
Housing Unit Ownership (dummy, 1=own)	0.66	0.69
Number of Observations	33,923	167,905

For 1960 Census: † Median Labor Income of Husband: \$5,250 - †† Median Total Household Income: \$6,050.
For 1970 Census: † Median Labor Income of Husband: \$7,176 - †† Median Total Household Income: \$10,050.

3.2 Labor Force Participation

We use the logistic model in equation (6) to quantify the impact of home appliances ownership on the labor participation decision of married women.

$$Prob(e_i = 1|\delta_1, \delta_2, \delta_3, \delta_4, X) = \frac{1}{1 + e^{-\alpha_0 - \alpha_1\delta_1 - \alpha_2\delta_2 - \alpha_3\delta_3 - \alpha_4\delta_4 - \alpha_5' X}} \tag{6}$$

where $(\delta_1, \delta_2, \delta_3, \delta_4)$ are binary dummy variables equal to one when households own a dishwasher, a dryer, a freezer, and a dishwasher, respectively, and X is a vector of control variables that includes information about age, age×age, race, years of education, number of own children present in the household, number of children under age five present in the household, total number of children ever born, number of years of education of husband, and the logarithm of the husband's wage. The results of the estimation of model one are presented in Table 4.

First, the model passes a likelihood ratio test and a Wald test so we can reject the hypothesis that all coefficients are equal to zero. Moreover, all individual coefficients but the ones in front of the dryer and freezer variables for the 1960 decade are statistically significant at the one-percent level.

Second, the coefficients in front of the washing machine and freezer are negative for the 1960 decade and equal to -0.26 and -0.0182, respectively. The coefficient in front of the dryer is positive for the 1960 decade and equal to 0.0101, but it is not statistically different from zero.

Tab. 3: Women in the Labor Force: Descriptive Statistics - Mean (std)

Variable	1960	1970
Washing Machine (dummy, 1=own)	0.80	0.79
Dryer (dummy, 1=own)	0.22	0.54
Freezer (dummy, 1=own)	0.20	0.33
Dishwasher (dummy, 1=own)	-	0.25
Age	38.76 (9.70)	37.81 (10.65)
Race (dummy, 0=white)	0.11	0.11
Years of Education	10.67 (2.99)	11.65 (2.74)
Number of children present in HH	1.44 (1.49)	1.56 (1.53)
Number of children under age 5 present in HH	0.27 (0.62)	0.24 (0.54)
Total number of children ever born	1.97 (1.76)	2.20 (1.82)
Education of the husband	10.11 (3.37)	11.43 (3.24)
Wage income of the husband	\$4,967.88 (\$2,574.41)	\$6,708.72 (\$3,669.49)
Total Household Income††	\$7,916.30 (\$3,727.99)	\$13,384.89 (\$6,503.47)
Housing Unit Ownership (dummy, 1=own)	0.65	0.69
Number of Observations	17,340	134,010

For 1960 Census: † Median Labor Income of Husband: \$4,850 - †† Median Total Household Income: \$7,450.
For 1970 Census: † Median Labor Income of Husband: \$6,383 - †† Median Total Household Income: \$12,350.

Third, the coefficients in front of the home appliances all increase to -0.2287, 0.1002, and 0.0098 in 1970.

Finally, the sign and magnitude of the coefficients for the control variables are consistent with the existing literature on women's participation (e.g., Eckstein and Wolpin (1989)). The likelihood that a married woman participates in the labor force is lower for whites, increases with the number of years of education and age (a proxy for work experience); it decreases with age^2, the number of children present in the household and especially the number of children under age five, and the husband's education and income. Note also that the coefficient in front of the number of years of schooling, an imperfect measure of the returns to schooling, increased substantially from 0.1061 in 1960 to 0.1172 in 1970.[5]

The negative sign in front of the appliances dummy can seem counterintuitive at first given the fact that there is a positive relationship between women's participation and the presence of appliances at the aggregate level. In what follows, we use a simple example to explain the negative sign for the coefficient in front of the washing machine. For ease of exposition, we ignore the control variables and assume that the probability of working only depends on whether women own home appliances. The probability of working is given by the following logistic function:

$$Prob(e_i = 1|\delta_i) = \frac{1}{1 + e^{-\alpha\delta_i}} \tag{7}$$

The log-likelihood function is given by:

$$\ln(L) = -f^{w,a}\ln(1 + e^{-\alpha}) - f^{nw,a}\ln(1 + e^{\alpha}) - (f^{w,na} + f^{nw,na})\ln(2) \tag{8}$$

[5]Card (2001) discusses the potential problems/solutions associated with using simple regression analysis to measure the returns to schooling.

Tab. 4: Logit Model Employment Decision - Estimate (Standard Error)

	1960	1970
Washing Machine	-0.2600 (0.03)	-0.2287 (0.01)
Dryer	0.0101†(0.03)	0.1002 ($9e^{-3}$)
Freezer	-0.0182†(0.02)	0.0098†($8e^{-3}$)
Dishwasher	-	-0.0282 (0.01)
Age	0.0874 ($8.5e^{-3}$)	0.0561 ($3e^{-3}$)
Age×Age	-$1.2e^{-3}$ ($1e^{-4}$)	-$9e^{-4}$ ($4e^{-5}$)
Race (dummy, 0=white)	0.4510 (0.03)	0.5610 (0.01)
Years of Education	0.1061 ($4.2e^{-3}$)	0.1172 ($1e^{-3}$)
Number of own children	-0.0922 (0.01)	-0.1198 ($4e^{-3}$)
Number of own children under age 5	-0.7078 (0.01)	-0.7745 ($7e^{-3}$)
Total Number of Children Ever Born	-0.0645 ($9.5e^{-3}$)	-0.0210 ($3e^{-3}$)
Education of the husband	-0.0418 ($3.6e^{-3}$)	-0.0376 ($1e^{-3}$)
Log(Husband's wage)	-0.4588 (0.02)	-0.4375 ($7e^{-3}$)
Housing Unit Ownership	0.0593 (0.02)	0.1437 ($9e^{-3}$)
Constant	1.8689 (0.20)	2.4888 (0.08)
-2log(L)	65,603.48	414,729.75
Number of Observation	51,263	301,915

† Not Significant at the 10 percent level

where $(f^{w,a}, f^{nw,a}, f^{w,na}, f^{nw,na})$ denote the fraction of women who work and bought a washing machine, do not work and bought a washing machine, work and did not buy a washing machine, or finally do not work and did not buy a washing machine. It is easy to show that the optimal value of α that maximizes the log-likelihood function is equal to:

$$\hat{\alpha} = \ln(\frac{f^{w,a}}{f^{nw,a}}) \tag{9}$$

The sign of the estimated parameter $\hat{\alpha}$ is positive, equal to zero, or negative, when the ratio between (a) the fraction of women own a washing machine and work and (b) the fraction of women who own a washing machine but do not work is greater than one, equal to one, or less than one, respectively. In 1960, the fraction of women who work and own a washing machine is equal to 0.272, while the fraction of women who do not work but own a washing machine is equal to 0.5742 (see Tables 2 and 3). Since the ratio between the former and the latter is equal to 0.47, the estimated value for the coefficient α in equation (9) is negative and equal to -0.74, a lower value compared to the estimate of -0.26 in Table 4.[6]

Our simple example in equation (9) also allows us to understand why the coefficients in front of home appliances dummy variables increase from 1960 to 1970. As the participation rate of married women increased between 1960 and 1970, the measure of women who work and own home appliances increased compared to the measure of women who do not work and own home appliances. As a result, the ratio between the former and the latter increases, which implies that the estimated value for the coefficients $(\alpha_1, \alpha_2, \alpha_3)$ in equation (6) goes up.

We believe that, altogether, our results suggest a different interpretation of the impact of home appliances on the participation decision of married women. Consider a theory where (i) the

[6]Using equation (9) and the fraction of women who own a dryer and a freezer in Tables 2 and 3, the coefficient estimate for the dryer and freezer is equal to -0.87 and -0.71, respectively. In comparison, the coefficient estimate for the dryer and freezer from the regression model in equation (6) is equal to 0.01 and -0.02, respectively (see Table 4).

presence of home appliances has no impact on the participation decision of married women, (ii) the quantity demanded of home appliances increases when the price of home appliances goes down relative to the household median income, and (iii) the demand for home appliances shifts upward with household income and other variables related to the "family size".

The implications of this theory are consistent with the main facts both at the micro- and aggregate level. First, as technological progress in the household sector unfolds, the price of home appliances declines relative to the median household income, which implies that the fraction of households that buy the home appliances goes up. Second, as participation rates of married women increase, perhaps because of a reduction in the gender wage gap or a decrease in fertility, the price of home appliances and participation rates are negatively correlated as in CT, while the fraction of households that own the home appliances and women's participation rates are positively correlated as in GSY. Finally, and most importantly, the fraction of households that own the home appliances is slightly higher in households where women do not work compared to households where women work. This happens because the data shows that (i) the household median income is higher when women work and (ii) women who do not work tend to have a larger number of children both in the household and over the course of their life, and tend to live in larger homes.

The engines of liberation theory is consistent with the aggregate facts but fails to account for the microeconomic ones. If home appliances had a true quantitative impact on women joining the labor force, the fraction of households that own home appliances should be greater for women who work compared to women who do not. The data clearly shows that this is not the case.

3.3 Appliances Adoption

In this last section, we study the home appliances adoption decision at the household level. In Tables 5 and 6, we first present some descriptive statistics for households that own the home appliances versus those households who do not. There are four main differences between households who own home appliances and those who do not. First, the labor force participation rate of women is greater for households that do not own the home appliances. For example, among households that do not own a washing machine, forty-four percent of women work, while only thirty-two percent of women who own a washing machine work.

Second, households that own the home appliances are also more likely to own the housing unit where they live. For example, seventy-one percent of households that own a washing machine own the housing unit where they live, while, among households that do not own their housing unit, only thirty-one percent their own a washing machine.[7]

Third, families that own the home appliances are larger in size, as evidenced by a greater number of children (either present in the household or over the course of a life-time) or additional rooms and bedrooms. For example, the mean number of rooms and bedrooms is equal to 5.4 and 3.62 for households that own a washing machine compared to 4.08 and 2.82 for those who do not.

Finally, the mean (median) total household income is greater for households that buy home appliances. For example, the mean total household income is equal to $7,272 for households that own a dryer compared to $4,977 for those who do not, a difference in income of more than forty percent. Part of the large differences in income can be accounted for by differences in racial composition. For example, ninety-four percent of households that own a washing are whites, while among those households that do not own a machine machine, only seventy-nine percent are whites.

[7]The fact that households that own the housing unit where they live are more likely to own home appliances does not necessarily imply that households that rent lack access to the use of a washing machine. For example, rental buildings often have a common laundry room with a washing machine and dryer.

Altogether, these facts suggest that the probability of buying home appliances significantly increases with total household income and variables related to family size.

Tab. 5: Households which do not own home appliances: Descriptive Statistics 1960 Census - Mean (Standard Deviation)

	Washing Machine	Dryer	Freezer
Labor Force Participation	0.44	0.35	0.34
Ownership (dummy, 1=own)	0.31	0.59	0.61
Number of Rooms	4.08 (1.37)	4.97 (1.39)	5.04 (1.40)
Number of Bedrooms	2.82 (0.87)	3.37 (0.85)	3.42 (0.85)
Age	36.37 (11.47)	37.62 (10.30)	37.14 (10.18)
Race (dummy, 0=white)	0.21	0.11	0.09
Years of Education	10.11 (3.04)	10.09 (2.94)	10.38 (2.96)
Number of children	1.23 (1.58)	1.77 (1.62)	1.82 (1.60)
Number of children under age 5	0.46 (0.82)	0.53 (0.84)	0.59 (0.88)
Total Number children ever born	1.77 (1.97)	2.33 (1.93)	2.32 (1.87)
Husband's wage†	\$4,417.52 (\$2,834.87)	\$4,977.10 (\$2,664.61)	\$5,360.72 (\$3,009.49)
Household Total Income††	\$6,199.03 (\$3,797.38)	\$6,562.50 (\$3,466.28)	\$6,956.14 (\$3,762.25)
Number of Observation	7978	38085	40481

† Median Labor Income of Husband: \$4,050; \$4,850 ; \$5,050.

†† Median Total Household Income: \$5,550; \$6,050 ; \$6,250.

To quantify the impact of variables related to family size and total household income on the probability that a household buys home appliances, we run three logistic regressions where the dependent variables are equal to the conditional probability that a household owns a washing machine, a dryer, or a freezer, respectively:

$$\begin{aligned} Prob(\delta_{1i} = 1|X) &= \frac{1}{1 + e^{-\alpha_{10} - \alpha_{11}' X}} \\ Prob(\delta_{2i} = 1|X) &= \frac{1}{1 + e^{-\alpha_{20} - \alpha_{21}' X}} \\ Prob(\delta_{3i} = 1|X) &= \frac{1}{1 + e^{-\alpha_{30} - \alpha_{31}' X}} \end{aligned} \tag{10}$$

where $(\delta_{1i}, \delta_{2i}, \delta_{3i})$ is equal to one when household i own a dishwasher, a dryer, and a freezer, respectively, and X is a vector of control variables that includes not only the usual demographic and economic characteristics (race, age, total household income, schooling of wife and husband) but also information about ownership of the housing unit, the number of children in the household, and the number of rooms and bedrooms.

The results for this model are presented in Table 7. We find that variables related to the "family size" and total household income have a positive and significant impact on the probability that a household owns a home appliance. For example, the probability that a household decides to buy home appliances increases by three (four) percent for each additional room (bedroom) in the house and by two and a half percent for each children under age five.

Tab. 6: Households which own home appliances: Descriptive Statistics 1960 Census - Mean (Standard Deviation)

	Washing Machine	Dryer	Freezer
Labor Force Participation	0.32	0.30	0.33
Ownership (dummy, 1=own)	0.71	0.84	0.83
Number of Rooms	5.40 (1.34)	5.84 (1.33)	5.78 (1.39)
Number of Bedrooms	3.62 (0.78)	3.86 (0.71)	3.82 (0.76)
Age	37.75 (9.63)	37.29 (8.85)	39.01 (8.88)
Race (dummy, 0=white)	0.06	0.01	0.04
Years of Education	10.54 (2.93)	11.56 (2.72)	10.83 (2.93)
Number of children	1.99 (1.58)	2.16 (1.51)	2.08 (1.61)
Number of children under age 5	0.58 (0.87)	0.66 (0.90)	0.48 (0.79)
Total Number children ever born	2.49 (1.82)	2.54 (1.63)	2.62 (1.80)
Husband's wage†	\$5,779.10 (\$3,273.76)	\$7.272.59 (\$4,072.10)	\$6,342.39 (\$3,919.91)
Household Total Income††	\$7,407.66 (\$4006.47)	\$9,118.50 (\$4,756.42)	\$8,208.56 (\$4,652.13)
Number of Observation	43285	13178	10782

† Median Labor Income of Husband: \$5,250; \$6,250 ; \$5,550.

†† Median Total Household Income: \$6,550; \$7,950 ; \$7,050.

4 Concluding Remarks

In this paper, we proposed a simple theoretical model of home appliances and labor force participation decisions. We used cross-sectional data rather than aggregate data to test the predictions of the model and presented new evidence on the relationship between the labor supply of married women and the presence of appliances.

Our main findings are as follows. First, our choice-theoretic model shows that not all women who buy home appliances decide to work. As the price of home appliances declines, two groups of women decide to buy the home appliances but do not alter their work decision. Second, using individual data from two cross-sections of the US census for the 1960 and 1970 decades, we found that the increase in home appliances ownership between 1960 and 1970 is similar for women who work and women who do not work. Third, we estimated a simple logistic model of women's employment for both censuses. We find that (i) the sign of the coefficients in front of the appliances dummy are negative for the 1960 and 1970 decades and (ii) the coefficients in front of all home appliances dummy variables increase between 1960 and 1970. Finally, we estimated a simple logistic model of home appliances adoption and found that the probability of buying home appliances significantly increases with variables related to family size and total household income.

We see two ways to improve our analysis. First, using panel data rather than two consecutive cross-sections would shed even more light on the relationship between home appliances and women's labor supply because we could directly observe whether women who adopt the home appliances alter their work decision. Second, we only studied the impact of the washing machine, dryer, dishwasher, and freezer because there is no available information in the 1970 US Census on other important appliances such as the vacuum cleaner or the microwave. It would be worthwhile to check whether our results hold true when more appliances such as the microwave or the vacuum cleaner are included in the set of appliances. We leave these two avenues for future research.

Tab. 7: Logit Model - Appliances Adoption Decision 1960 Census - Estimate (Standard Deviation)

	Washing Machine	Dryer	Freezer
Ownership (dummy, 1=own)	1.0744 (0.03)	0.7977 (0.29)	0.7811 (0.03)
Number of Rooms	0.3766 (0.02)	0.1610 (0.01)	0.1741 (0.01)
Number of Bedrooms	0.3973 (0.03)	0.2041 (0.02)	0.1293 (0.02)
Age	0.1282 (0.01)	0.0873 (0.01)	0.114 (0.01)
Age×Age	-0.0017 ($1e^{-4}$)	-0.0013 ($1e^{-4}$)	-0.0013 ($1e^{-4}$)
Race (dummy, 0=white)	-1.1946 (0.04)	-1.771 (0.08)	-0.6147 (0.05)
Years of Education	-0.0254 ($5e^{-3}$)	0.0940 ($4e^{-3}$)	0.0196 ($4e^{-3}$)
Number of own children	0.1215 (0.02)	0.0025†(0.01)	0.0344 (0.01)
Number of own children under age 5	0.2228 (0.02)	0.2698 (0.01)	-0.0977 (0.02)
Total Number children ever born	0.0262 (0.01)	0.0342 (0.01)	0.0403 (0.01)
Log(Household Total Income)	0.0774 (0.02)	0.9545 (0.02)	0.0858 (0.02)
Constant	-4.8176 (0.2844)	-14.2525 (0.29)	-6.5367 (0.27)
-2log(L)	44327.10	58436.35	52738.33
Number of Observation	51263	51263	51263

† Not Significant at the 10 percent level

5 The Appendix

The utility of work and non-work given the adoption decision is given by:

$$U^{w,a} = w_m + w_f - pa + v(1 - t_w - \frac{t_k}{\eta^a}n) \tag{11}$$

$$U^{nw,a} = w_m - pa + v(1 - \frac{t_k}{\eta^a}n) \tag{12}$$

It is easy to show that women work if the wage offer is greater than a reservation wage $w^*(a)$.

The reservation wage is such that women are indifferent between working and not-working, $U^{w,a} = U^{nw,a}$. It is equal to:

$$w^*(a) = v(1 - \frac{t_k}{\eta^a}n) - v(1 - t_w - \frac{t_k}{\eta^a}n) \tag{13}$$

Let $f(x) = v(1-x) - v(1-t_w-x)$. We have $f^{'}(x) = -v^{'}(1-x) + v^{'}(1-t_w-x)$. Since the function v is increasing and concave, we have $f' > 0$. This implies that $f(t_k n) > f(\frac{t_k n}{\eta})$, i.e. $w^*(1) < w^*(0)$.

Next consider the adoption decision given work. The utility of adopting versus non-adopting given the labor supply decision is given by:

$$U^{e,a} = w_m + w_f e - p + v(1 - t_w e - \frac{t_k}{\eta}n) \tag{14}$$

$$U^{e,na} = w_m + w_f e + v(1 - t_w e - t_k n) \tag{15}$$

It is easy to show that households adopt the home appliances if the price of home appliances is smaller than a reservation price $p^*(e)$. The reservation price is such that households are indifferent between adopting and non-adopting, $U^{e,na} = U^{e,a}$. It is equal to:

$$p^*(e) = v(1 - t_w e - \frac{t_k}{\eta}n) - v(1 - t_w e - t_k n) \tag{16}$$

Let $g(x) = v(x - \frac{t_k}{\eta}n) - v(x - t_k n)$. We have $g^{'}(x) = v^{'}(x - \frac{t_k}{\eta}n) - v^{'}(x - t_k n)$. Since the function v is increasing and concave, we have $g' < 0$. This implies that $g(1 - t_w) > g(1)$, i.e. $p^*(1) > p^*(0)$.

Given the thresholds functions, $w^*(a)$ and $p^*(e)$, we can derive the optimal joint decisions of households which are summarized in Proposition 1 and Figure 1.

Determining the optimal work/adoption is not immediate when $w^*(1) \leq w_f \leq w^*(0)$ and $p^*(1) \leq p \leq p^*(0)$. In this case, agent's utility for each option is equal to:

$$\begin{aligned}
U^{e=1,a=1}(w_f, p) &= w_m + w_f - p + v(1 - t_w - \frac{t_k}{\eta}n) \\
U^{e=1,a=0}(w_f, p) &= w_m + w_f + v(1 - t_w - t_k n) \\
U^{e=0,a=1}(w_f, p) &= w_m - p + v(1 - t_w - \frac{t_k}{\eta}n) \\
U^{e=0,a=0}(w_f, p) &= w_m + v(1 - t_w - t_k n)
\end{aligned} \tag{17}$$

By definition of the thresholds, the following is true for any price $p^*(1) \leq p \leq p^*(0)$.

$$\begin{aligned}
U^{e=1,a=1}(w^*(1), p) &= U^{e=0,a=1}(w^*(1), p) \\
U^{e=1,a=0}(w^*(0), p) &= U^{e=0,a=0}(w^*(0), p)
\end{aligned} \tag{18}$$

As a result, for any wage $w^*(1) \leq w_f \leq w^*(0)$, we have:

$$\begin{aligned} U^{e=1,a=1}(w_f, p) &> U^{e=0,a=1}(w_f, p) \\ U^{e=1,a=0}(w_f, p) &< U^{e=0,a=0}(w_f, p) \end{aligned} \tag{19}$$

Hence, we only need to compare $U^{e=1,a=1}$ to $U^{e=0,a=0}$ to determine the agent's optimal choice in the rectangle.

Fix $p \in [p^*(1), p^*(0)]$. There exists a unique $\tilde{w}(p)$ such that $U^{e=1,a=1}(\tilde{w}(p), p) = U^{e=0,a=0}(\tilde{w}(p), p)$. The threshold function is equal to:

$$\tilde{w}(p) = p + v(1 - t_k n) - v(1 - t_w - \frac{t_k n}{\eta}) \tag{20}$$

Finally, it is easy to show that $\tilde{w}(p^*(0)) = w^*(1)$ and $\tilde{w}(p^*(1)) = w^*(0)$. As a result, the agent's optimal choice in the rectangle is work and adopt when $w_f \geq \tilde{w}(p)$ and do not work, do not adopt when $w_f \leq \tilde{w}(p)$.

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