

# Household Technology: Was it the Engine of Liberation?

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## Abstract

Home production has dramatically changed during the course of the 20th century and labor saving technologies, from running water to modern appliances, have reduced the time demands of home production. This paper uses 1940 and 1950 US Census data to assess the impact of the increased diffusion of plumbing facilities and modern refrigeration (which presence nearly doubled during the decade) on female labor market supply and occupational choices. It finds that increased female labor force participation rates are strongly correlated with the increased adoption of indoor plumbing facilities but *not* with the increased adoption of modern refrigerators. For counties in the South however, there is a positive correlation between increases in female labor force participation rates and the adoption of modern refrigerators. One interpretation is that in these counties the benefits of modern refrigeration were higher - either because of the weather, because ice was not easily available and/or because of being further away from shopping areas. Despite the important increase in clerical occupations during these two decades, this study finds that neither clerical nor professional jobs (which were the best paid occupations) increased relatively to other occupations in counties which experienced higher adoption of modern refrigerators. The implications of these results are important to modelling technological changes to the household production function and suggest giving less weight to durables and the acquisition of modern appliances - or formal inclusion of substitutes - and more weight to improvements in the structure of the house.

*Key words:* Household Technology; Women Labor Force Participation; Home Production

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## 0.1 Introduction

The technological progress that permeated the late 19th century and the 20th century transformed household chores in a radical way. In 1890 in the United States only 24% of households had running water and only 8% had electricity. In 1950, these figures were 83% and 94%, respectively.<sup>1</sup> By 1950, a majority of households also had indoor bathrooms and modern appliances such as stoves, electric irons, vacuum cleaners, refrigerators and washing machines.

What are the implications of these changes on women's and men's allocation of time, and more particularly on women's decision to join the labor market? Women's labor force participation rates increased dramatically between the turn of the century and the late 20th century. In 1900, 20.6% of women were part of the labor force versus 50% in 1980. Most of this increase was due to married women entering the labor force; their participation rate increased from 5.6% in 1900 to 51% in 1980.

In an influential paper Greenwood, Seshadri and Yorukoglu (2005) examine the role of the household technology revolution in liberating women from household chores by simulating a general equilibrium model with home production. In their model, durables and hours are inputs in the household production function and the productivity of home technology is equal to the inverse of the price of durable goods. With a historical price decline of 8.3% a year during the 20th century they show that productivity growth in the durable sector alone can explain a large part of the increase in married women's labor participation in the US.

This paper examines how women responded to the modernization of home production, by using 1940 and 1950 US census data and two indicators of home production transformation: the presence of a bathtub or shower, and of a modern refrigerator inside the unit. The increase in the adoption of modern refrigerators during the 40s was dramatic: it went from 44% to 80% and affected all counties, urban and rural. The diffusion of indoor plumbing facilities (private toilets, baths and showers) was slower but improvements between these two decades were also important. This study uses information about the presence of a bath or shower for exclusive use as a measure of the modernity of plumbing facilities inside the home. Although per se a bath or a shower may not have been a crucial time-saver, they are proxies for the existence of other plumbing facilities, such as an indoor flush toilet and of bathroom facilities as

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<sup>1</sup> This revolution was faster in the US than in European countries. In France in 1954 running water was only available to 54% of the dwellings (see Prost and Vincent, 1991). The adoption of modern appliances was also slower in Europe than in the US. In Britain, for example, mass adoption of modern appliances started in the 50s where in the US began in the 20s (see Bowden and Offer, 1994).

modern as today's. For the country as a whole, 59% of occupied dwellings had a bath or shower in 1940 while 72%, had one of the two in 1950. The large number of counties in the US Census (3098 in 1940) and the large variability across counties in both the speed of adoption of labor saving appliances and women's labor force participation rates, make this sample important and unique in assessing the impact of labor saving technologies on women labor force decisions.<sup>2</sup> Ideally one would want household level information about home technology and women's labor decisions, but given the absence of these data, county level information can provide a second-best source of information.

Both refrigerators and plumbing facilities are endogenous and their adoption could be due to women working and/or to a common exogenous factor - such as urban density - that could explain the adoption of modern appliances, more modern homes and increased female labor force participation rates. In these cases, coefficient estimates would be inconsistent and therefore difficult to interpret. To address the endogeneity problem this paper uses several instruments. The challenge is to find instruments that are relevant in the sense that they can identify both endogenous variables. Fortunately the adoption of plumbing facilities and modern refrigerators followed different patterns and this can be exploited in searching for relevant instruments.

The presence of modern indoor plumbing/bathroom facilities is linked to major public works. During the middle of the 19th century increased urban density created health issues such as water contamination and disease outbreaks. It is during this period that water-supply systems were constructed and piped water made available to city dwellers. Big cities like New York and Boston underwent the excavation of underground sewage systems in the late 19th century and early 20th century (see *Scientific American*, 1892). Given that modern refrigerators appeared later (in 1930 only 14% of the households had a modern refrigerator), the urban density of the county in 1930 and changes in urban density between 1930 and 1940 are important identifying instruments for the presence and late adoption of indoor plumbing/bathroom facilities. Electricity - a condition for electrical appliances - was much more pervasive in less urban areas and urban density does not play a significant role in the explanation of the increased diffusion of modern refrigerators over the decade. Other important instruments associated with more modern plumbing facilities, but not necessarily with the acquisition of modern appliances, are the percentage of rural farm dwellings with water in 1940 and the percentage of dwellings owned rather than rented. To identify the diffusion of modern appliances, the most important instruments are the percentage of dwellings that had radios in 1940 (which measures both the feasibility and the likelihood that appliances like re-

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<sup>2</sup> Bailey and Collins (2006) use refrigerators and modern stoves as an indicator of the diffusion of modern appliances to assess the effects of home production technological advances on fertility rates.

frigerators are adopted), the percent of rural farm dwellings with lights in 1940, and the change in the presence of ice-boxes over the decade. Additionally, an important instrument for both endogenous variables - but not necessarily correlated positively to both - is the ratio of craftsmen to total male employment in 1940 and/or its increase over the decade. Male craftsmen were electricians, engineers, carpenters, inspectors, brickmasons, stonemasons...the best suited occupations for early home installation of new household technologies such as plumbing and electricity. A higher presence of craftsmen relative to total male employment is also an indicator of a higher demand of these occupations for home renovations as well as for public work. While one could worry about having male occupations as an instrument, because of concern of correlation with an omitted variable representing the change in family income, these are middle income occupations and the least likely to change the distribution of income into one with fewer poor individuals and more wealthier individuals. Tests of orthogonality of the errors are performed and the robustness of the results checked using different sets of instruments.

Once corrected for the endogeneity of the regressors, the results of this study suggest that the increased adoption of modern refrigeration during the 40s did not have a significant impact on female labor force decisions except for counties in the South. One interpretation is that refrigerators had substitutes (ice-boxes, daily milk delivery, can food, stores selling fresh produces ...) that made this innovation less crucial to female labor decisions. In contrast, for all counties outside the South, the increased diffusion of indoor bathroom facilities is significantly and positively correlated with increased female labor force participation rates, thus indicating that significant changes to home production - such as the introduction of indoor bathroom facilities - may have had important effects on female labor force participation decisions.

Although a 32% decrease in the number of domestics between the two decades suggests that for many households some of the benefits of labor saving technologies were crowded out by the decrease in hired help, the effects of the decrease on labor force decisions were probably not very important. This is because the families with domestic help in 1940 were mostly higher income families and/or with women working as professionals. If they substituted away, it was because household chores were easier and domestic help less needed. This is the group that gained the least from the household technological revolution. So it is not surprising that this study finds that professional jobs did not increase, relatively to other occupations, in counties which underwent more important progress in household technology.

It is for the households with limited or no domestic help that the revolution brought the most important improvements and contributed to the increase in female labor force participation. However, not all improvements provided the same benefits. Indoor plumbing and toilets had fewer substitutes than

modern appliances and their absence usually meant heavy work and backward home production technology. The results herein indicate that the diffusion of bathroom facilities have helped increase the presence of women in clerical occupations. The most important explanations for their increase, however, are the strong demand for clerical and desk jobs that started at the turn of the century and changed social norms that held married women back in the 30s (see Goldin, 2007)<sup>3</sup>

Modern appliances may have contributed to increased female labor force participation in the second part of the 20th century. However, the results reported below indicate that the transformation needed some other important changes in order that large numbers of married women - and women with children - enter the labor market as they did in the 60s, 70s and 80s. Recent empirical studies find evidence suggesting a positive effect of household technologies during the second half of the 20th century. Pirani, Leon and Lugauer (2008), use micro-data from the 1960 and 1970 US Census (not available for 1940 and 1950) and find that ownership of washing machines, dryers and freezers increased the presence of married women in the labor market. Cavalcanti and Tavares (2008) use data on the price of home appliances in OECD countries for the period 1975-1999 and find that a decrease in the relative price of appliances has a positive and significant effect on female labor force participation rates in OECD countries.

The paper is organized as follows: section 1 examines how home technologies evolved during the 40s; section 2 examines the relation between the adoption of modern refrigeration and of indoor plumbing facilities on female labor force; section 3 examines their impact on the composition of female occupations and section 4 concludes.

## 1 The Diffusion of Household Technologies

This section examines how household technology changed across US counties over the first half of the 20th century. Table 1 uses the census data to summarize the most important changes.<sup>4</sup>

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<sup>3</sup> A survey made by the National Education Association in 1931 revealed that 77% of the cities reporting did not hire married women as teachers and 63% dismissed teachers upon marrying (see Baxandall, Gordon and Reverby, 1995). See also Blau, Ferber and Winkler (2002) and Goldin (1990).

<sup>4</sup> Counties in the South are regions 5, 6 and 7 in the Census. In the paper, urban density is the percentage of the population of the county that resides in urban areas. "More urban" counties have 25%, or more, of the population residing in urban areas. "Less urban" counties have less than 25% of the population residing in urban areas. All information comes from the Census. Results reported use urban density for 1940,

## 1.1 *Electricity and Plumbing*

The first wave of innovations to home production came from the diffusion of electricity and piped water and by 1940 the majority of dwellings not in the south or in rural areas, had both. For the country as a whole, in 1940, 83% of the total number of dwellings had electrical lights and 74% had running water.<sup>5</sup>

A substantial improvement to home production was the introduction of private flush toilets, bathtubs or showers. In 1940 only 59% of occupied dwellings had a bath or shower inside their homes for exclusive use. By 1950 this percentage rose to 72%. The presence of a bath or shower inside the unit is an indicator for modern plumbing facilities. Although this series does not include information on whether the dwelling also had a flush toilet, this was usually the case. In 1940, 59% of the dwellings had a bath or shower inside their unit, while 58.9% had a flush toilet inside the unit for exclusive use (Table P, Census 1950). Therefore although the addition of a bath or shower may not be a crucial time-saver for the purpose of home production, it indicates the presence of a modern bathroom.

From the point of view of the infrastructure of the house, Table 1 shows that there is an important dichotomy between the south and less urban counties and the rest of the country, with the formers lagging behind the household technology revolution in an important way. In 1950, for example, only 52% of the dwellings in the counties in the South and 43% of the dwellings in less urban counties had a bathtub or shower inside their unit.

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but results are similar when urban density for 1950 is used. There are 1829 "Less Urban" counties in 1940, for a total of 30.5 million people ( 23% of the population). Counties in the South represent 32% of the total population. All data used in the tables, figures and regressions come from 1930, 1940 and 1950 Census volumes. They have been downloaded from the Haines data bank. The only exceptions are the series "bath or shower" for 1950 and "ice-box" for 1940 and 1950, which were not available in the Haines data bank and come directly from the CENSUS 1940 and 1950 pdf files. Unless specified, series describing housing conditions are percentages with respect to the total number of dwellings in a county. Refrigerators and ice-boxes are the percentages of dwellings reporting a modern refrigerator or a ice-box over the total number of dwellings reporting either refrigerators, ice-boxes, other methods or none.

<sup>5</sup> Most of the dwellings without indoor running water were located in rural-nonfarm and rural-farm areas. In most cases dwellings had access to some source of water near by and some had a hand-pump in their dwelling.

## 1.2 Modern Appliances

Modern electric appliances started to appear at the turn of the century and rapidly penetrated the market (electric irons, vacuum cleaners, stoves, washing machines, dishwashers, modern refrigerators...) with few others (clothes dryers, freezers, and microwave ovens) entering the market in the second half of the century. Washing machines had a rapid initial diffusion but took time to reach full absorption; their diffusion was hampered by the fact that they needed running water in addition to electricity. In 1940, already 61% of the wired households had a washing machine, in 1952, 75% (see Bowden and Offer, 1994) had one in their home.<sup>6</sup>

The modern refrigerator, for which Census county data for 1940 and 1950 is available, was an important appliance.<sup>7</sup> It replaced the ice-box, a large wood box lined with insulating materials (cork, mineral wool...) and about the size of a refrigerator; this required frequent delivery of ice, emptying of melted ice and supervision of the temperature to ensure that it would remain at a desirable and constant level.<sup>8</sup> Vanek (1973, p. 112) reports that food preparation was the most time intensive activity, the one which also had the most drastic decline between 1940 and 1950. Bryant (1996) also reports that the largest decline in time spent on household chores between 1925 and 1968 was in the preparation of meals and cleanup, which went from 2.93 hours a day to 2.02 hours a day. Total housework chores occupied 7.35 hours in 1925 and 6.31 in 1968 (Bryant, 1996, Table 6, p. 371), most of the savings were therefore in the preparation of meals and cleanup to which modern refrigeration in addition to modern stoves have contributed importantly.

The first refrigerators were a luxury. Vanek (1978) documents that their price in 1919 measured in 1963 dollars was \$1660 which most families could not

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<sup>6</sup> The penetration of electric irons began in 1910, of vacuum cleaners in 1913, of washing machines in 1916, of dishwashers in 1922, of modern refrigerators in 1925, of clothes dryers in 1950, of freezers in 1947, of microwave ovens in 1973 and of blenders in 1948 (source: Bowden and Offer, 1994, Table 1, p.729).

<sup>7</sup> Goodwin, Grennes and Craig, 2002, call it "one of the great inventions" which contributed importantly to the "spatial and temporal integration of perishable markets" and to improving the standards of living (p. 155). Gordon (2000) puts modern refrigeration among the first great inventions.

<sup>8</sup> A good description of the ice-box is found in Frederick, 1919, p.54. She suggests that the refrigerator be built in the wall space and accessible from the outside of the house for ice-delivery, saving thus "the tracking of ice delivery into the kitchen" and making "it possible to use very little ice or none in winter months." As well "if the refrigerator is perfectly insulated and made, the modern kitchen temperature will not affect it."

afford. Their price declined fast, to \$170 in 1939 and to \$150 in 1949.<sup>9</sup> In 1930 only 14% of the dwellings had a modern refrigerator, in 1940 the ratio rose to 44% and by 1950 the ratio almost doubled to 80% (to 86%, in urban counties). The increase was important in both urban and rural counties.

During the 40s many other improvements affected the efficiency of home production. New houses in the late 40s included a finished kitchen with built-in cabinets, stoves, a washer. In mid-19th century with Catharine Beecher (1845) and later Christine Frederick's publications in the 1910s, the kitchen underwent considerable improvements in its design and functionality.<sup>10</sup> Food shopping also became easier with self service stores expanding rapidly during the 30s and 40s and with modern refrigeration which had important effects on the production, storage and distribution of food (see Goodwin, Grennes and Craig, 2002).

Despite these important changes to home production which made the majority of urban households by 1950 almost as efficient as today's, many households in the south and in less urban areas were still in the throw of the revolution. Modern refrigerators and modern appliances were not at the forefront of the revolution. Figures 1 and 2 show that while in 1940 many counties had a modern bathroom but no modern refrigerator, just a decade after the situation was reversed and modern refrigerators were more common than modern bathrooms in many counties. Innovations that required only electricity were adopted fairly quickly while indoor plumbing was slow to penetrate and par-

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<sup>9</sup> See Miller, 1960, p. 200. The Fair Labor Standard Act in 1938 established the minimum wage to be 30 cent per hour in 1939 and 75 cent per hour in 1949 (see Costa, 2000b). With this in mind, a minimum wage worker in 1939 had to work 14 weeks full time (40 hours a week) to buy a refrigerator and in 1950 had to work 5 weeks. In 1936 Vanek (1973) reports that a washing machine could be bought for as low as \$29.95.

<sup>10</sup> In the early part of the century, Frederick was an editor in several home magazines and was credited with encouraging the design of more efficient kitchens; she set up and directed a model kitchen, the Applecroft Home Experiment Station (see Frederick, 1919). Architects of the Bauhaus schools and Frank Lloyd Wright in the U.S. introduced the "L" or "U" shaped kitchen. These features, and the idea of a continuous counter as work surface, became popular for american kitchens by 1930 (see Vanek, 1973). But other labor-savings devices as simple as ready-made clothing and linoleum floors, were important time savers (see Baxandall R. F., Gordon L. and Reverby S., 1995).



ticularly slow to penetrate less urban areas and southern counties.<sup>11</sup>

## 2 Labor Force Participation Rates and Household Technologies

During this decade women's labor force participation rate<sup>12</sup> went from 25.3% to 28.8%. Some counties witnessed much sharper increases than others: 1167 counties witnessed increases higher than 30% and 745 counties above 40%; in 400 counties women's labor force participation actually decreased in 1950 relatively to 1940. Among the 3089 counties in 1940, 2648 are counties with a population smaller than 50 thousand inhabitants and 1405 are in the south of the United States. Low populated counties tended to have lower labor participation rates and also a lower percentage of dwellings with modern appliances.

### 2.1 1940

Figure 3 plots women labor force participation rates against the ratio of dwellings with bathrooms in each county for 1940. There is a clear positive relation between women labor force participation rates and indoor bathroom facilities. A similar correlation (not reported) is found between the presence of refrigerators and female labor force participation rates. This correlation could be spurious and due to a common factor such as early industrialization and high income levels that explain a higher female labor demand, better infrastructures (electricity and plumbing) and higher rates of adoption of modern appliances. Figure 4 illustrates that there is a strong relation between urban density and women labor force participation rates. High labor force participation rates are also found in counties which have fewer dwellings with indoor bathroom facilities (see left side of Figure 3). In these cases poverty and hardship may explain women's decision to work. When counties with 10% or more of the population which is non-white are excluded, the high labor participation rates for less modern counties disappear (see Figure 5).

A comprehensive specification of the female labor supply equation would have as arguments, among other things, demand side factors representing opportu-

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<sup>11</sup> Baxandall R. F., Gordon L. and Reverby S. (1995), p. 227, notes "A single home may be operated in the twentieth century when it comes to ownership of automobile and vacuum cleaner, while its lack of a bathtub may throw it back to another era and its lack of sewer connection and custom of pumping drinking-water from a well in the same backyard with the family 'privy' put it on a par with life in the 'Middle-Ages'."

<sup>12</sup> The labor force includes persons 14 years or and over, who had a job or were seeking one during a specified week.

nities, the female-men earning gap, the husband's income, home technologies and a measure of education. Unfortunately the data set poses strong restrictions on the side of the regressors that can be included. In particular, women's wages, men/women earning gap and income data are not available at county level. This may create an omitted variable bias. The only indicator that proxy for income is the ratio of white population as a percentage of the total population in the county. In 1940, this regressor is consistently negative and strongly significant. This indicates that in 1940 a significant portion of women worked because of low family incomes and poverty.

For the specification of the female labor force regression in 1940, the following regressors, in addition to the ratio of white population to total population (white 1940), were included: the percentage of women 25 years or older, with one or more years of college (education) and as indicators of opportunities, the sales in the retail sector (retail sales 1940), the value added of the manufacturing sector (man va 1940) and the degree of urban density in 1940 (urban 1940). Technologies that can reduce time spent on home production are modern refrigerators (refrig 1940), the presence of a bath or shower (bath 1940) and of the ice-box (ice-box 1940). Ice-boxes are assumed exogenous. It was a relatively inexpensive technology and its adoption depended on whether regular delivery of ice was feasible. In 1940 an important fraction of households had neither refrigerators nor ice-boxes, so its inclusion does not create a problem of near-collinearity. To examine the effects of the adoption of modern refrigerators and indoor bathroom plumbing facilities, both endogenous variables, appropriate instrumental variables must be used. The instruments used are several indicators of the feasibility of the adoption of the modern technology (described in the introduction) and are listed in the footnote to Table 2.

One important issue with multiple endogenous regressors is whether the instruments are relevant to identify the endogenous regressors. In these cases the first stage F-statistics is not sufficient to establish the relevance of the instruments for both endogenous variable. The Shea partial r-square reveals the contribution of an instrument without the inclusion of the contributions of other instruments or regressors and its values together with the values of the standard partial r-square (which includes the contributions of other instruments) are reported together with the p-values of the F-statistics of joint significance of the instrumental variables (first-stage F-statistic). When the Shea standard partial r-square is large for one endogenous variable but small for the other one, it indicates that the instruments are not capable to distinctively explain both endogenous variables, which could bias the estimates. The Stock-Yogo test of weak instruments is also reported. It tests the null hypothesis that a given set of instruments is weak against the alternative that they are strong. There are two sets of critical values for the Stock-Yogo test that are reported here: the 5% relative bias and the 10% nominal bias (two stage least squares and limited information likelihood). If the Stock-Yogo minimum

eigenvalue is greater than the 5% relative bias it means that the relative bias of TSLS is less than 5% of the endogeneity bias of simple OLS estimation and one can conclude that the instruments are strong. If the Stock-Yogo minimum eigenvalue is smaller, one can conclude that the instruments are weak.

GMM, which is consistent in presence of heteroskedasticity, is used to estimate regressions with instrumental variables. In the context of GMM, the test statistics used to evaluate the orthogonality of the instruments with respect to the error term is the Hansen-J test of overidentifying restrictions. The Hansen-J test, tests the joint hypothesis of the orthogonality condition and of correct model specification and a rejection of the null hypothesis can be due to the failure of any of these two hypothesis. It is distributed as a  $\chi^2$  with degrees of freedom equal to the number of overidentifying restrictions (the number of instruments minus the number of endogenous variables). Its p-values are reported at the end of the tables. As a robustness check, all the regressions reported were also estimated using two stage least squares (and the Sargan test of orthogonality, instead of the Hansen-J test, was used) and results were robust to estimation methods.

Table 2 reports the OLS regressions for female labor force participation rates in 1940. Each observation represents a county. Given the important differences found in the penetration of modern household technologies, a distinction between urban and less urban counties and between counties in the south and not in the south is made. Each subsample required a different subset of instrumental variables for the correct specification and orthogonality condition not to be rejected by the Hansen-J test. In many cases several subsets of instrumental variables passed the requirements and in all the cases where the null hypothesis was not rejected the results were similar to the ones presented in Table 2. Poor exogeneity of the instrument was not a problem as all the p-values of the Hansen-J test are fairly high, but on the ground of the relevance of the instruments the Shea partial r-square is in many cases much lower than the standard partial r-square. The choice of instruments was tied to the availability of data - with almost no data for 1930. The results for the sample containing counties not in the South are not reported as the Hansen-J test failed to reject the null hypothesis of orthogonality and/or correct model specification in all cases tried. In all cases the Stock-Yogo tests reject the hypothesis of weak instruments.

The results reported in Table 2 show a positive correlation between female labor force participation rates and the presence of a bath or a shower for regressions 1-IV and 4-IV, but not for the other subsamples. In all cases female labor force participation is not correlated with the presence of modern refrigerators. If the instruments correctly identify the two endogenous variables, the implication is that in 1940 modern refrigerators were the consequence of higher incomes and did not significantly increase the presence of women in the work

force. Interestingly, a strong positive correlation is found between the presence of ice-boxes (the old technology) and female labor force for the sample including all counties and for the sample including only the more urban counties. The strong significance of the ice-box in these equations indicates that this technology was important for working women and that old technologies and market substitutes to modern appliances should be included in a model of home production. What is surprising is that for counties in the South both the regressors refrigerators and ice-boxes are not significant. This may indicate that in 1940 in the South, most female participation to the labor market had less to do with home production and more to do with low family income.

### *2.1.1 1940-1950*

Figure 6 plots the change in women’s labor force between the two decades in each county against the percentage of dwellings with modern bathrooms facilities (with a bath or shower) in 1940. It shows increases in labor force participation rates that are most important in counties which were less modern in 1940 and which underwent important changes in home production technologies over the decade.

Table 3 reports the OLS regressions used to examine the relation between changes in household technology and women’s labor force participation rates between 1940 and 1950. The specification is similar to the one used to explain the level of female labor participation rates in 1940, but exploits information for both 1940 and 1950. The regressors are: the change over the decade (1940-1950) in the percentage of dwellings with modern refrigerators ( $\Delta$  refrig) and with a bath or shower ( $\Delta$  bath), changes in population ( $\Delta$  pop), the percentage of the white population in each county in 1940 (white 1940) and the female labor force rate in 1940 (wlf 1940). It also includes as regressors the change over the decade in the percentage of women 25 years or older, with one or more years of college ( $\Delta$  education) and as indicators of opportunities, the sales in the retail sectors (retail sales 1940), the value added of the manufacturing sector (man va 1940) and the degree of urban density in 1940 (urban 1940). As for Table 2, the results for different subsample (South, w/o South, More Urban and Less Urban) are reported together with the results of the regressions that use the whole sample.

The list of instruments used in each of the regressions called IVa in Table 3 is reported in a footnote to the table (at the end of the tables) and was described in the introduction. The instruments used in IVb are the ones used in IVa with the addition of the change in the presence of ice-boxes over the decade. Their decline is a strong predictor of the increased adoption of modern refrigerators. The set of instruments used in IVc is the same as in IVa but also includes the change in population over the decade (1940 to 1950) when

it is a nonsignificant regressor in the equation. This was included as a regressor to capture the effects of industrialization on female labor force but with other more appropriate regressors included (retail sales and the value added in the manufacturing sector) it is most often non-significant. Population changes instead are a relevant instrument as they are strongly negatively correlated with changes in the adoption of refrigerators and positively correlated with changes in plumbing/bathroom facilities. Migration usually is towards richer counties where modern appliances were adopted early and their increase over the decade not as important as for counties which were late adopter. Migration also implies urban development and more housing outfitted with modern plumbing/bathroom facilities.

The specifications reported in Table 3 do not include as regressors the percentage of dwellings with a bath or shower and/or with a refrigerator in 1940. Their inclusion as regressors in the samples South and w/o South was rejected by the Hansen-J test. In all other samples they were non-significant and their inclusion did not change the results presented in Table 3. This suggests that early adopters did not respond with a lag to the adoption of modern home technologies. Because of that, a broader set of instruments which also include the percentage of dwellings with a bath or shower and refrigerators is reported in Table 3 under IVd.

As Table 3 shows, the 1940 labor force participation rate is negative and significant which indicates that the counties with lower participation rates were the ones that witnessed the largest changes. Education is positive and significant in all samples but for counties in the South and in less urban areas. Both retail sales and manufacturing value added are significant and positive in all samples.

With the exception of the sample that only includes counties in the South, the variable refrigerator is not significant and the results robust to the different subsets of instruments. When only the set of states which are in the southern part of the US are included (which excludes some states in the northern part of the South and includes Arizona and New Mexico) the coefficient attached to the change in refrigeration increases to .1 and is significant, all other results remain the same. Important differences for counties in the south and counties not in the south are to be expected: refrigerators were most crucial in counties which were warmer and had shorter winters. Ice may have been more difficult to deliver, food more likely to spoil and shops with fresh produce farther apart. As a sign that ice-boxes may have not been as useful in the South, Table 1 shows that the percentage of reporting dwellings with ice-boxes in 1940 is the same for counties in the South and not in the South. In most samples but for the South, the change in bath or shower is significant and positive. Using GMM or IV methods did not make a difference to the results except for regression 6-IVa where the regressor bath or shower is not significant

with IV but significant with GMM.

All regressions pass the Hansen-J test with p-values that range from .08 to .82. For the samples South and w/o South, fewer sets of instruments passed the test. For the sample which only includes counties in the South, the sets of instruments that passed the test were limited to the ones reported, which makes it more difficult assessing the robustness of the results. The Shea partial r-square and the standard partial r-square indicate that the instruments are less relevant in explaining changes in the adoption of bathroom/plumbing facilities (except for the sample with counties in the South). Higher Shea's values are found with the regressions that use the broader set of instruments (IVd). The Stock-Yogo test rejects the null hypothesis of weak instruments in all cases except for the regressions that include counties not in the South where the minimum eigenvalue is smaller than the 2sls size of the nominal bias (but passes the test for the relative bias and for the nominal bias with limited information likelihood).

Several authors have suggested that modern appliances have not significantly decreased time spent on household chores. Vanek (1973) argued that in general improvements to household technology did not translate in a substantial reduction in housework because they substituted away from paid help, or market services and the standard for hygiene and cleanliness increased (see also Ramey and Francis, 2005 and Mokyr, 2000). This is not incompatible with Lebergott (1993), who argued that housework decreased importantly over the course of the century, from 58 hours a week in 1900 to 18 hours in 1975 as these figures include the gains accrued from having electricity, indoor plumbing and flush toilets in the premises which, in most counties, occurred in the first half of the century.<sup>13</sup>

The period between 1940 and 1950 covers the entrance of the US in the Second World War. Females labor force increased substantially between 1942 and 1945; the question is whether these increases lead to a shift in the labor supply which persisted over time by changing the social norm that married women should not work and/or by creating new opportunities. Acemoglu, Autor and Lyle (2004) show that in states with greater war mobilization of men, women worked more in 1950 than in 1940. Fernández, Fogli and Olivetti (2004) find that the effects of the war were persistent and also affected the next generation of women. Goldin (1991) uses a special sample of 4350 women (the Palmer Survey) and finds that the overall effect of the war on female labor force participation was not very important and that "the majority exited after 1944

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<sup>13</sup> Lebergott (1993) was criticized because he based his calculations on the average workload of domestic servants. Several authors in addition to Vanek (1973) argued that time spend on household chores decreased modestly even when comparing the early 20th century with the late 20th century. Bryant (1996) calculated that the decline between the mid-1920 and the mid-1960 was around 14%.

but before 1950" (page 741). When a dummy for the states with high enlisting is used in regression 1-IVc, the dummy is non-significant and the results presented in Table 3 unchanged.<sup>14</sup>

### 3 Occupations and the Diffusion of Household Technologies

Information about where women were working during the two decades is important to understand the impact of home technology on women's labor force decisions. Which occupations did the household technology revolution affect the most? Did it contribute to the massive increase in female labor market force participation of the second half of the century by changing the types of jobs women had?

Table 4 shows the types of jobs women and men had and how they changed over the decade, in the country, in the South and in less urban counties.<sup>15</sup> About 50% of employed women worked in sectors that required heavy work, long hours and were not well paid; they worked as operatives, in the service sector and as domestics. The most important employers in the operatives and kindred sector were the manufacturing industries, with the highest percentage of women working in the textile and food industry. A smaller percentage of women worked as seamstresses, dressmakers and laundresses (except in private families). About 10% of the women worked in the service sector as cooks, servants (but not for private families), beauticians and waitresses. It is unclear how women working in these sectors were affected by the transformations in home production but they, as well as women working as domestics, were the least likely to be early adopter. The ratio of female operatives to total employment is positively correlated with the increased adoption of modern refrigeration and the coefficients in OLS regressions positive and significant (not reported). Valid instruments could not be found but Figures 7 and 8 suggest that the positive correlation with the increased adoption of modern refrigerators is likely to be spurious as it captures the growth of employment in the manufacturing sector that occurred in counties with fewer bathroom facilities, where likely the women working in these occupations were not the ones acquiring the modern appliances.

The next three subsections examine the importance and the effects of the decrease of domestic help and how the best occupations women had access

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<sup>14</sup> The list of states with high enlisting comes from Acemoglu, Autor and Lyle (2004).

<sup>15</sup> This is the list of most important female occupations. For men, other important occupations not included here were those of laborers and craftsmen, foremen, and kindred workers (blacksmiths, carpenters, electricians....).

to - professional and clerical and sales occupations - responded to the household technology revolution. The definition of "professional" occupations used here is an aggregate of three categories: professional (teachers, trained nurses, lawyers...), semiprofessional (technicians, dancers,...) and managerial positions (public officials, managers...).

### 3.1 *Domestics*

Figure 9 shows that modern counties tended to have a lower percentage of women employed as domestics than less modern counties. A high ratio of domestics to female employment in less modern counties makes sense as household chores were a lot heavier without indoor bathroom facilities. The majority of the dwellings in these counties did not even have indoor piped running water (see Table 1), they were located in less urban areas and had a higher ratio of the population that was non-white. The same figure shows a drastic decline in domestics between 1940 and 1950. In absolute numbers and on average, female domestics declined by 32% (see Table 4). The percentage of male domestics was low and it halved during the decade.

This is the picture that emerges by examining the ratio of female domestics to total female employment in each county, but because of the low labor force participation rates of less modern counties, the picture is quite different for the ratio of female domestics to the total number of females age 25 or older. Less modern counties did not have a much higher ratio of domestics to the number of females age 25 and over, than modern counties (see Figure 10). If one excludes counties which have 10% or more of the population that is non-white, the difference is even less remarkable (see Figure 11). This means that most women in less modern counties were overburdened by household chores, not just because of cooking and keeping their house clean but because of more basic and hard chores: getting the water to the house, doing the wash without running water and not having indoor bathrooms.

The decline affected almost all counties, but OLS regressions show a negative correlation with modern refrigeration and a positive correlation with the increase in modern bathrooms (see Table 5). The results are similar when instrumental variables are used (not reported) or when the ratio of domestics to total females rather than to total employed females is used. The negative correlation with refrigerators could indicate that households adopting modern refrigerators substituted away from domestic help and decreased the demand of domestics in these counties. Better opportunities and higher education may have also shifted their labor supply towards jobs in the manufacturing sector or in the expanding clerical and sales sector which usually required just completion of high school.



How common was it to have domestic help? Who lost the benefits of domestic help? These are difficult questions to answer with county data, but some hypothesis can be advanced. Figure 12 plots the ratio of domestics to women working as professionals in 1940 and shows that less modern counties tended to have a ratio above 1 (but mostly in counties with a higher ratio of non-white population) and modern counties, a ratio below 1. This means that in more modern counties if every woman working as professional employed a full-time domestic, that would more than completely exhaust the supply of domestics (see also Table 4).

Of course some professional women may have not needed domestics as in modern counties they already had many benefits of the household technology revolution and were likely to have been early adopters. Many were not married and may have required very little domestic help; in 1940 only 43% were either married, widowed or divorced. As well, domestics could work part time and be presents in more than one household and also in households where women did not work. Many well off families with no working women used to hire domestics. In 1940 the ratio male professionals to female domestics is 2.7 (see Table 4) - an indication that already in 1940 the most important use of domestic help was made by men and women working in professional occupations. Figure 15 illustrates the importance of the decline in domestic help between 1940 and 1950. In 1950, the ratio female domestics to male professionals is 5.6 (from Table 4) and for counties with more than 50% of the dwellings with a bathtub or shower, the ratio is 7. Many families had reduced or substituted away from domestic help to rely on modern household technologies.<sup>16</sup>

### 3.2 Professionals

Women working as professionals were more likely to be a higher percentage of total female employment in less urban and less modern counties (see Figure 14). This may have been due to several reasons, but lower female labor force participation rates and the demand of certain services like teaching and nursing may have been important contributing factors.<sup>17</sup> For the country as a whole, the total number of women employed in professional occupations increased by

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<sup>16</sup> Services like laundering, cleaning and drying expanded during the decade to accommodate working women and the decrease in domestic help. In 1950 a total of 316.923 women and of 361.529 men were working in this sector, with an increase of 40% and 67%, respectively, over the previous decade (see Census 1950, Table 134).

<sup>17</sup> Teachers in primary and secondary school were most often women, in 1920 for example there were 6 times more female teachers than there were male teachers. In 1940, out of 1.877 mil. women working as professionals, 41% were teachers, 18% trained nurses, 23% proprietors and managers and the rest were musicians, music teachers, college presidents or professors, artists, etc.

38% (see Table 3a) but as a ratio to total employment their presence did not increase.

In most counties other less well paid occupations were growing faster and there is no indication of a positive effect of modern technologies on the presence of women in professional occupations. The OLS regressions reported in Table 5, show a negative correlation with both modern refrigeration and bathroom facilities. Exogenous and relevant instruments were difficult to find and this makes sense as professional women were first adopters and the endogeneity effects more difficult to disentangle.

Why did professional women not increase their presence in the labor market? Not only professional women had the highest salaries, but also more likely to come from families with higher incomes, be married to men in higher paid occupations and to be early adopters. This means that by 1950 they likely had all the modern conveniences that could be bought at the time, and these were comparable to what was available to women in the late 20th century (barring microwaves, freezers and new materials that made ironing less taxing, from the list of the essential innovations). They could also hire some domestic help. It is difficult to think that home production was stopping them to join the labor force.<sup>18</sup>

Differently from women, the ratio of men working in professional occupations is higher the more modern the counties are (see Figure 15). This indicates that potentially there were jobs for women too. Interestingly in most counties, more women than men had one to three years of college but fewer women than men had four years or more of college education. Figures 16 and 17, respectively, illustrate this by reporting the ratio of women to men who have 1 to 3 years or 4 years or more of college. In addition even fewer women graduated.<sup>19</sup> In 1950, the number of men graduating with a bachelor degree or a first professional degree was three times the number of women graduating.<sup>20</sup>

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<sup>18</sup> It is unlikely that professional women could not afford domestics in 1950, while they could in 1940. Marshall and Paulin (1987) report the median year's earnings for women in different sectors in 1946 (Table 6, p. 18). Lebergott (1948) calculates the median full time earnings in 1939 (Table 5, p. 80). In 1939 and 1946, these figures were \$1450 and \$1671, for female proprietors and managers (a subset of the definition of professional occupations used in this paper) and \$373 and \$400, for female domestics. While not strictly comparable, these figures indicate that women in professional occupations could still afford domestics and suggest that the decline was the result of more efficient home production.

<sup>19</sup> On average for the US, 6% of women 25 or older had 1 to 3 years of college in 1940 and 4.85% of men had 1 to 3 years of college. For 1950 the percentages were 7.46% and 6.77%, respectively. Fewer women than men had 4 years or more of college: in 1940 3.69% and 5.34%, respectively. For 1950 these figures were 5% and 7%.

<sup>20</sup> See the Historical Statistical Abstracts, 1950, Table 149. For a discussion of the

These facts suggest that neither house chores, nor education per se was constraining women to participate in the labor market in the better paid positions. The large number of women who attended college, did it for fewer years than men, were much less likely to graduate and had made no substantial changes to their educational choices. The demand for these professions (teaching, nursing...) could not match the expansion in the various educational and professional choices and options men had in more modern counties.<sup>21</sup> Even with time freed from household chores, married women were responsible for raising children - an important part of home production which was not importantly affected by the household technology revolution - and exiting the labor market to re-enter later was not an option in many of the professional occupations men could choose from.

### *3.3 Clericals and sales*

During this decade, women's employment in the clerical and sales sector increased by 78% while men's, increased by 19%.<sup>22</sup> The increases are even more important in the South and in counties with lower urban density, where the total number of women working in the clerical and sales sector more than doubled (see Table 4 and Figures 18 and 19).

Several instruments used in the GMM estimations reported in Table 3 were valid instrument here as well and are used in the regressions reported in Table 7. The ratio of male craftsmen to total male employment and its change over the decade, however, failed the test. One instrument that was considered suitable and did not fail the Hansen-J test is the change in the median rent over the decade. While in the regressions for the female labor force this instrument could proxy for an omitted variable correlated with family income or be a reason in itself for women to work, for clerical and sales females worker this is likely not the case. This is because clerical workers tended to be young (since they only needed high school for most clerical jobs) and therefore they were either single or married without young children and to men more likely to be at the beginning of their career. They were therefore likely to be renting a small apartment, with a rent below the median value, or to still be living with their families. All these reasons make them unlikely to have been affected by median rents. Median rents are strongly positively correlated with improvements to the infrastructure of the house and the presence of modern infrastructure like

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college gender gap, see Goldin, Katz and Kuziemko (2006).

<sup>21</sup> In fact, women's college educational choices had not changed much throughout the 40s. In 1950, women graduating from college were mostly in education (30%), nursing (8.5%), home economics (7.5%), 24% in sociology, history, english etc.

<sup>22</sup> In 1940, one third of the women working as clericals were stenographers, the rest were in sales or bookkeepers, cashiers, accountants and telephone operators.

modern plumbing and bathrooms. Additional instruments are: the ownership of the house, the urban density in 1930, the percentage of dwellings with a radio in 1940 and the size of the county (2-IV and 3-IV, do not include the last instrument). For the adoption of modern refrigerators, the most relevant instrument is the percentage of dwellings with radio in 1940.

The results of the estimations indicate that the increased adoption of modern refrigerators had non-significant effects on female labor force except for counties not in the South. Robustness checks showed this result to depend on a number of counties with declining population and a declining ratio of clerical to total female employment. These counties also witnessed less important increases in the adoption of modern refrigerators. Once this subsample is taken out (about 100 counties), the coefficient on modern refrigerators is non-significant. All instruments passed the Hansen-J test with p-values ranging from .169 to .538 and the Stock-Yogo test. The Shea partial is higher for refrigerators, but close to the standard partial for both endogenous variables.

The increase in the demand of clerical and sales jobs together with the increase in the percentage of women who finished high school have been important determinants of the increase in the presence of women in the clerical and sales sector at the turn of the century, when it became the first important occupation - beside teaching - that required some education (Goldin, 1990). It was better paid and less hard than factory or farm work (see also Costa, 2000a). Goldin (2002) reports that women occupied 20.2% of all clerical and sales jobs in 1900 and 40.4% in 1930. This was much before modern appliances became common. Small changes in home production due to the availability of electricity, electrical lights and indoor piped water could have allowed children, boys and girls, to stay in school longer and a higher percentage to finish high school. The important changes in clerical and sales may have therefore been both the direct effect of less housework for young married women and the indirect effect of home technology on children's education.<sup>23</sup>

## 4 Conclusions

The evidence presented in this paper suggests that the dramatic diffusion of modern refrigeration during the 40s had a significant impact on female labor force in the South but not in the rest of the country. It is the penetration of indoor plumbing facilities that is most significantly linked to higher increases in female labor force and to the rise of clerical and sales occupations.

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<sup>23</sup> As well "in the 1920s a new norm was forged" and women in white-collar occupations could remain employed after marriage until they had their first child (see, Goldin, 2002, p. 12)

The household technology revolution reduced the need for domestics, whose absolute number declined by 38%. Their use, though, was limited to higher income households - most households benefited importantly from better indoor plumbing, which had few substitutes.

The negative correlation between professional jobs as a percentage of total employment and the increased adoption of modern refrigeration suggests that women in middle-upper income households, who most likely were early adopters, did not join the work force as a result of the time freed from home production. This is consistent with what one would expect since women in this group, by definition, could always hire domestic help and choose to work, before or after the household technology revolution. The revolution made little difference. The most important part of home production for women with education and higher family income, was not keeping the house clean and cooking, but raising children.

It is women with some education and little or no domestic help that benefitted the most from the household revolution; they either devoted more time to the care of their house and children, or joined the labor force. Women in clerical and sales occupations could start to work at a very young age, just after high school and even before, and leave the labor market to raise children without losing human capital, and later re-enter when the children are older.

The increase in clerical jobs did not imply fundamental changes in female labor decisions - such as observed in the 70s and 80s - with many women remaining in the labor force while raising young children. In 1950 only 8% of women with children 10 years or younger were in the labor force. Therefore, although the effects of the household technology revolution were important, they were not by themselves sufficient to change the way most women were viewing their jobs; for most it was still a transitory situation. The constraints imposed by raising children are more important and binding than cooking or cleaning a house, since the tasks surrounding children could not be concentrated in a day, nor postponed to the evenings or weekends.

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**Table 1**

Sample Characteristics of US Counties in 1940 and 1950 (mean values)

	All Counties		More Urban <sup>2</sup>		Less Urban <sup>2</sup>		High Urban <sup>2</sup>		South <sup>1</sup>		w/o South <sup>1</sup>	
	1940	1950	1940	1950	1940	1950	1940	1950	1940	1950	1940	1950
number of counties	3086		1264		1822		496		1405		1681	
fem. lab. part. <sup>3</sup>	.2530	.2880	.2746	.3059	.1684	.2097	.294	.320	.2403	.2695	.2577	.2957
electrical lights <sup>4</sup>	.83	-	.92	-	.48	-	.98	-	.56	-	.94	-
refrigerators <sup>4</sup>	.44	.80	.50	.84	.21	.64	.54	.86	.30	.67	.50	.85
water <sup>5</sup>	.74	-	.85	-	.33	-	.93	-	.47	-	.85	-
bath/shower	.59	.72	.69	.79	.22	.43	.77	.84	.33	.52	.69	.80
ice-box <sup>4</sup>	.27	.11	.29	.10	.18	.13	.31	.10	.27	.18	.27	.07
radio 1930 <sup>6</sup>	.40	-	.46	-	.21	-	.50	-	.16	-	.50	-
radio 1940 <sup>6</sup>	.83	-	.88	-	.62	-	.92	-	.61	-	.91	-
total population (mil)	132	151	102	120	30.5	30.9	7.56	9.1	41.7	47.2	90.5	104



**Table 2**

OLS results: female labor force participation rates 1940 <sup>1</sup>								
	All counties		South		Less Urban		More Urban	
	1	1-IV <sup>2</sup>	2	2-IV	3	3-IV	4	4-IV
regression	1	1-IV <sup>2</sup>	2	2-IV	3	3-IV	4	4-IV
refrig 1940	-.004	-.015	.006	.07	-.0026	.081	.0086	-.11
	(-.34)	(-.45)	(.2)	(1.16)	(-.13)	(1.67)	(.53)	(-2.46)
bath 1940	.056	.048	.067	.012	.084	.007	.046	.09
	(5.2)	(2.56)	(2.57)	(.24)	(4.6)	(.21)	(3.52)	(3.7)
white 1940	-.21	-.20	-.21	-.21	-.18	-.177	-.278	-.27
	(-40.3)	(-29)	(-27.2)	(-23.8)	(-30.18)	(-20.8)	(-30.4)	(-23.3)
urban 1940	.088	.09	.127	.129	.07	.072	.093	.1
	(16.0)	(16.7)	(11.1)	(9.64)	(5.91)	(5.97)	(9.7)	(8.96)
education 1940	.13	.14	.179	.156	.15	.144	.105	.16
	(4.5)	(3.9)	(2.89)	(1.86)	(3.49)	(3.12)	(2.7)	(3.46)
retail sales 1940	.064	.07	.038	.039	.043	.058	.072	.084
	(5.58)	(5.8)	(1.51)	(1.49)	(2.5)	(3.3)	(4.8)	(5.12)
man va 1940	.00008	.00008	.0001	.0001	.00007	.00007	.00008	.0001
	(5.79)	(5.47)	(9.2)	(3.61)	(5.76)	(2.63)	(8.9)	(6.15)
ice-box	.053	.05	-.014	-.006	-.003	.003	.085	.074
	(6.87)	(6.4)	(-1.1)	(.24)	(-.13)	(.29)	(7.8)	(5.7)
R <sup>2</sup>	.6471	.6466	.6377	.6350	.4915	.4822	.6556	.6406
observations	2311	2311	1041	1041	1178	1178	1133	1133

**Table 2 Tests**

OLS results: female labor force participation rates 1940 <sup>1</sup>				
	All counties	South	Less Urban	More Urban
regression	1-IV	2	3-IV	4-IV
HJ p-value	.208	.225	.8304	.235
$\Delta$ refrig: Shea P/Standard P	.168/.377	.294/.581	.138/.381	.145/.33
$\Delta$ bath: Shea P/Standard P:	.288/.652	.265/.524	.243/.670	.284/.648
F- $\Delta$ refrig - F - $\Delta$ bath	234-718	285-226	143.6-474	91.99-343
Stock-Yogo test: min eigenvalue	76.94	66.68	37.4	31.73
2sls relative bias 5%	15.72	13.97	13.97	15.72
2sls size of nominal bias 10%	21.68	19.45	19.45	21.68
LIML size of nominal bias 10%	4.06	4.32	4.32	4.06
# instruments	6	5	5	6

**Table 3**

OLS results: changes in female labor force participation rates <sup>1</sup>												
regression	All Counties						South			w/o South		
	1	2	2-IVa	2-IVb	2-IVc	2-IVd	3	3-IVa	3-IVc	4	4-IVa	4-IVb
$\Delta$ refrig	.027 (2.7)	.018 (1.79)	.012 (.37)	-.016 (-.6)	-.027 (-1.02)	-.0003 (-.02)	.029 (1.64)	.089 (2.53)	.09 (2.78)	-.001 (-.12)	-.05 (-1.66)	-.046 (-1.58)
$\Delta$ bath	.049 (3.9)	.055 (3.96)	.10 (2.55)	.13 (3.3)	.161 (4.57)	.126 (4.99)	.054 (2.17)	.056 (1.1)	.045 (1.17)	.03 (1.89)	.175 (2.92)	.16 (2.95)
$\Delta$ pop	.099 (3)	.011 (3.39)	.009 (1.99)	.007 (1.51)	- (-)	- (-)	.0002 (.05)	-.0005 (-.09)	- (-)	.018 (4.63)	.010 (2)	.01 (2.13)
white 1940	-.006 (-.96)	-.013 (-2)	-.015 (-1.56)	-.008 (-.91)	-.007 (-.76)	-.0118 (-1.6)	-.01 (-2.07)	-.029 (-2.99)	-.03 (-3.1)	.062 (2.48)	.09 (2.86)	.081 (2.70)
wlf 1940	-.32 (-19.6)	-.32 (-16.1)	-.31 (-16)	.14 (3.12)	-.31 (-15.8)	-.31 (-15.86)	-.30 (-10.8)	-.29 (-10.3)	-.29 (-10.4)	-.385 (-15.4)	-.33 (-9.3)	-.337 (-9.9)
urban 1940	.0001 (.04)	.002 (.5)	.99 (2.89)	.005 (.95)	.006 (1.08)	.044 (.87)	-.001 (-.15)	-.007 (-.75)	-.008 (-.8)	.01 (1.87)	.015 (2.63)	.0149 (2.64)
$\Delta$ education	.168 (4.32)	.136 (3.1)	.128 (2.89)	.14 (3.12)	.146 (3.33)	.144 (3.35)	.18 (2.3)	.11 (1.37)	.103 (1.28)	.10 (2.19)	.11 (2.2)	.118 (2.33)
retail sales 1940	.072 (9.5)	.057 (6.39)	.053 (4.74)	.047 (4.43)	.047 (4.19)	.0555 (5.77)	.07 (4)	.086 (4.72)	.084 (4.68)	.056 (5.74)	.04 (3.2)	.043 (3.71)
man va 1940	.00005 (8.4)	.00004 (4.87)	.00004 (5.18)	.00005 (5.1)	.00005 (5.77)	.00005 (5.77)	.00007 (4.7)	.00007 (4.8)	.00007 (4.88)	.00003 (5.2)	.00003 (5.5)	.00003 (5.5)
south dummy	- (-4.34)	-.88 (-4.34)	-.91 (-3.98)	-1 (-4.74)	-1 (-4.44)	-.91 (-4.38)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
R <sup>2</sup>	.3074	.3161	.31	.3049	.2937	.3046	.2510	.2402	.2398	.2287	.1772	.1869
observations	2312	2312	2312	2312	2312	2312	1381	1030	1030	1282	1282	1267

**Table 3 Tests**

OLS results: changes in female labor force participation rates <sup>1</sup>								
regression	All Counties				South		w/o South	
	2-IVa	2-IVb	2-IVc	2-IVd	3-IVa	3-IVc	4-IVa	4-IVb
HJ p-value	.5196	.16	.194	.355	.085	.145	.10	.160
$\Delta$ refrig: Shea P/Standard P	.195/.22	.14/.26	.183/.239	.471/.478	.22/.28	.253/.29	.17/.27	.208/.296
$\Delta$ bath: Shea P/Standard P:	.07/.15	.07/.15	.13/.1698	.218/.22	.19/.24	.226/.26	.058/.092	.064/.091
F- $\Delta$ refrig - F - $\Delta$ bath	155-82.6	158.6-67.7	144.3-94	262.4-81.2	58.6-47.5	52.2-44.8	93.4-25.7	87.8-20.9
Stock-Yogo test: min eigenvalue	34.2	33.5	66.4	77.1	32.04	35.7	15.49	14.29
2sls relative bias 5%	11.04	13.97	13.97	17.7	16.88	17.7	13.97	15.72
2sls size of nominal bias 10%	16.87	19.45	19.45	25.64	23.72	25.64	19.45	21.68
LIML size of nominal bias 10%	.4.72	4.32	4.32	3.78	3.9	3.78	4.32	4.06
# instruments	4	5	5	8	7	8	5	6

**Table 3cont**

OLS results: changes in female labor force participation rates										
regression	Less Urban					More Urban				
	5	5-IVa	5-IVb	5-IVc	6-IVd	6	6-IVa	6-IVb	6-IVc	6-IVd
$\Delta$ refrig	.015 (.97)	-.011 (-.27)	-.02 (-.53)	-.045 (-1.24)	.005 (.21)	.013 (1)	.0008 (.02)	-.043 (-1.4)	-.08 (-.55)	-.007 (-.46)
$\Delta$ bath	.06 (2.7)	.12 (1.74)	.13 (1.81)	.20 (3.33)	.157 (3.3)	.034 (1.98)	.087 (1.55)	.11 (2.1)	.11 (2.2)	.11 (3.52)
$\Delta$ pop	.02 (3.35)	.014 (1.87)	.013 (1.7)	- (-)	- (-)	.0054 (1.3)	.0036 (.63)	.0001 (.03)	- (-)	- (-)
white 1940	-.034 (-3.8)	-.030 (-2.5)	-.027 (-2.4)	-.023 (-1.96)	-.033 (-3.22)	.027 (2.73)	.028 (2.22)	.037 (3.23)	.032 (2.8)	.03 (3.05)
wlf 1940	-.375 (-11.2)	-.378 (-11.2)	-.378 (-11.1)	-.374 (-10.86)	-.36 (-10.8)	-.256 (-12.9)	-.245 (-10.5)	-.240 (-10.5)	-.244 (-10.8)	-.241 (-11.4)
urban 1940	.028 (2.44)	.033 (2.66)	.032 (2.65)	.035 (2.82)	.032 (2.68)	-.008 (-1.1)	-.0035 (-.41)	-.005 (-.58)	-.003 (-.43)	-.0025 (-.35)
$\Delta$ education	.098 (1.54)	.083 (1.25)	.091 (1.36)	.090 (1.31)	.083 (1.26)	.16 (3.1)	.158 (2.99)	.18 (3.38)	.16 (3.2)	.166 (3.27)
retail sales 1940	.066 (4.35)	.056 (3.1)	.055 (3.87)	.047 (2.5)	.05 (3.05)	.046 (4.56)	.044 (3.47)	.035 (3.0)	.042 (3.39)	.45 (4.38)
man va 1940	.00007 (4)	.00007 (4)	.00007 (3.87)	.00007 (4.38)	.00008 (5.10)	.00003 (5.31)	.00003 (5.4)	.00003 (4.9)	.00003 (5.49)	.00004 (5.95)
south	-1.3 (-3.81)	-1.3 (-3.76)	-1.39 (-4)	-1.37 (-3.62)	-1.18 (-3.35)	-.45 (1.77)	-.6 (-1.76)	-.79 (-2.7)	-.7 (-2.2)	-.65 (-2.44)
R <sup>2</sup>	.2828	.2767	.2741	.2513	.2648	.4141	.408	.3985	.4026	.4029
observations	1182	1182	1169	1182	1182	1130	1130	1121	1130	1130

**Table 3cont-Tests**

OLS results: changes in female labor force participation rates								
regression	Less Urban				More Urban			
	5-IVa	5-IVb	5-IVc	5-IVd	6-IVa	6-IVb	6-IVc	6-IVd
HJ - p value	.5248	.4872	.1943	.1496	.376	.3978	.7741	.825
$\Delta$ refrig: Shea P/Standard P	.1545/.236	.173/.278	.20/.24	.358/.363	.114/.146	.19/.22	.203/.20	.67/.63
$\Delta$ bath: Shea P/Standard P	.0946/.145	.094/.15	.147/.176	.196/.199	.073/.09	.085/.098	102/.10	.25/.23
F- $\Delta$ refrig - F - $\Delta$ bath	120-66	111-51	92-62.6	83.12-36.21	48-29	61-24	55.7-25	234.2-42.8
Stock-Yogo test: min eigenvalue	39.4	29.16	49.49	34.75	21.57	20.54	24.67	42.27
2sls relative bias 5%	na	11.04	11.04	17.70	11.04	13.97	13.97	17.7
2sls size of nominal bias 10%	13.43	16.87	16.87	25.64	16.87	19.45	19.45	25.64
LIML size of nominal bias 10%	5.44	4.72	4.72	3.78	4.72	4.32	4.32	3.78
# instruments	3	4	4	8	4	5	5	8

**Table 4**

Occupations Totals (millions)												
	All counties						South					
	females			males			females			males		
	1940	1950	%	1940	1950	%	1940	1950	%	1940	1950	%
professionals	1.89	2.59	+38%	5.22	7.34	+40%	.468	.690	+47%	1.22	1.78	+46%
cleric. & sale	3.1	5.53	+79%	4.37	5.22	+19%	.593	1.26	+113%	.923	1.23	+33%
operatives	2.0	3.01	+46%	6.23	8.14	+31%	.487	.733	+50%	1.52	2.17	+43%
service	1.27	1.99	+57%	2.22	2.38	+3%	.304	.534	+76%	.531	.554	+4%
domestics	1.94	1.31	-32%	.144	.072	-100%	.831	.614	-35%	.074	.027	-63%
farmers <sup>1</sup>	.151	.116	-23%	4.20	4.99	+19%	.095	.061	-56%	2.47	1.95	-27%
employed	11	15.5	+41%	33.8	40.2	+19%	3.13	4.3	+37%	10.3	11.7	+14%
total	50	56.6	+13%	50.0	54.9	+10%	14.9	16.7	+12%	14.7	16.2	+10%

**Table 4cont**

Occupations Totals (millions)						
	Less Urban					
	females			males		
	1940	1950	%	1940	1950	%
professionals	.140	.161	+15%	.324	.368	+12%
cleric. & sale	.086	.186	+116%	.137	.190	+38%
operatives	.045	.102	+126%	.298	.471	+58%
service	.057	.103	+81%	.085	.083	-2.3%
domestics	.143	.091	-57%	.088	.004	-95%
farmers	.044	.029	-52%	1.51	1.27	-16%
employed	.619	.836	+35%	3.61	3.63	+0.05%
total	4.79	4.6	-4%	5.18	4.83	-6.7%

**Table 5**

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OLS results:  $\Delta$  female domestics (as a % of employment)

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regressors	All Counties	South	w/o South	More Urban	Less Urban
$\Delta$ refrig	-.049 (-6.6)	-.034 (-2.29)	-.046 (-6.7)	-.08 (-8.7)	-.038 (-3.5)
$\Delta$ bath	.078 (8.4)	.11 (6.4)	.03 (3.3)	.053 (4.8)	.085 (6.2)
$\Delta$ pop	-.004 (-1.5)	-.017 (-3.6)	.007 (3.1)	-.004 (-1.5)	-.005 (-1.4)
white 1940	-.164 (-40.8)	-.161 (-27.8)	-.045 (-4.6)	-.140 (-24.2)	-.172 (-31.7)
domestics 1940	-.62 (-82)	-.60 (-49.4)	-.74 (-68.5)	-.60 (-63.2)	-.62 (-56.9)
urban 1940	.015 (5.9)	.015 (3)	.006 (2.5)	.002 (.5887)	.012 (1.28)
R <sup>2</sup>	.71	.673	.804	.79	.6784
observations	3048	1382	1666	1229	1819

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**Table 6**

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OLS results: $\Delta$ female professional (as a % of employment)					
regressors	AllCounties	South	w/o South	MoreUrban	LessUrban
$\Delta$ refrig	-.10 (-10.5)	-.099 (-6.3)	-.079 (-5.9)	-.086 (-8.6)	-.10 (-7.2)
$\Delta$ bath	-.017 (-1.39)	-.041 (-2.24)	.008 (0.4)	-.008 (-.59)	-.017 (-.93)
$\Delta$ pop	.005 (1.58)	.005 (1.06)	.007 (1.44)	.01 (3.6)	.005 (.2)
non white 1940	.007 (1.2)	.026 (3.6)	-.055 (-2.98)	-.011 (-1.7)	.015 (1.84)
prof 1940	-.47 (-42.7)	-.48 (-26.4)	-.46 (-30.1)	-.44 (-35.8)	-.50 (-30.4)
urban 1940	-.01 (-3)	-.012 (-2.2)	.002 (.42)	-.001 (-.19)	-.034 (-2.4)
R <sup>2</sup>	.5742	.50	.5221	.6882	.5333
observations	3048	1382	1666	1229	1819

**Table 7**

OLS results: $\Delta$ female clerical & sales employment (as a % of employment) <sup>1</sup>										
	All Counties		South		w/o South		Less Urban		More Urban	
regression	1	1-IV	2	2-IV	3	3-IV	4	4-IV	5	5-IV
$\Delta$ refrig	-.051	-.069	-.004	.029	-.04	.10	-.03	-.066	-.085	-.08
	(-4.4)	(-2.56)	(-.25)	(.5)	(-2.72)	(2.99)	(-1.79)	(-2.08)	(-5.59)	(-2)
$\Delta$ bath	.08	.066	.06	.003	.07	-.026	.08	.05	.079	.11
	(5.8)	(2.13)	(2.66)	(.06)	(3.66)	(-.44)	(3.2)	(.85)	(4.33)	(2.45)
$\Delta$ pop	.046	.044	.041	.043	.043	.056	.052	.051	.039	.037
	(12.5)	(10.3)	(7)	(5.8)	(9.0)	(9.18)	(8.39)	(7.66)	(8.9)	(6.2)
white 1940	.0058	.011	.002	-.004	-.04	-.137	.008	.019	-.0008	-.26
	(.87)	(1.16)	(.33)	(-.25)	(-1.6)	(-4.09)	(.93)	(1.61)	(-.08)	(-.3)
cleric & sales 1940	-.176	-.17	-.07	-.068	-.22	-.194	-.198	-.2	-.164	-.16
	(-10.2)	(-9.4)	(-2.79)	(-2.1)	(-9.91)	(-8)	(-6.44)	(-5.79)	(-8.59)	(-7.13)
urban 1940	.021	.02	.0022	.0033	.02	.0178	.029	.033	.015	.021
	(4.3)	(3.8)	(.26)	(.34)	(3.23)	(2.26)	(2.16)	(2.3)	(2.08)	(1.37)
$\Delta$ education (hs)	.021	.036	.08	.076	.147	.125	.0003	.030	.06	.057
	(.8)	(1.2)	(2.2)	(1.7)	(3.35)	(2.5)	(.01)	(.7)	(1.77)	(1.37)
retail sales 1940	.0036	.005	.027	.036	.04	.059	.0084	.016	.0014	.0003
	(.42)	(.53)	(1.53)	(1.78)	(3.67)	(4.89)	(.58)	(1)	(.13)	(.28)
man va 1940	-.00001	-.00001	-.00001	-.00001	-.00003	.00005	-.00003	-.00007	-.00001	.00001
	(-1.85)	(-2.44)	(-1.8)	(-1.9)	(-.37)	(.06)	(-.28)	(-.73)	(-2.46)	(1.94)
R <sup>2</sup>	.1702	.1680	.1080	.102	.1716	.1075	.13	.1237	.25	.246
observations	2310	2310	1028	1028	1282	1282	1182	1180	1130	1130

**Table 7 Tests**

OLS results: $\Delta$ female clerical & sales employment (as a % of employment) <sup>1</sup>					
	All Counties	South	w/o South	Less Urban	More Urban
regression	1-IV	2-IV	3-IV	4-IV	5-IV
HJ p-values	.169	.2672	.344	.538	.346
$\Delta$ refrig: Shea P/Standard P	.21/.266	.122/.163	.199/.26	.247/.27	.19/.2
$\Delta$ bath: Shea P/Standard P	.15/.187	.112/.15	.139/.18	.135/.148	.155/.158
F- $\Delta$ refrig - F - $\Delta$ bath	163-105	49.77-45	90-56.97	86-40	56-42
Stock-Yogo test: min eigenvalue	76.7	29.29	47.87	36.31	39.8
2sls relative bias 5%	13.97	11.04	11.04	13.97	13.97
2sls size of nominal bias 10%	19.45	16.87	16.87	19.45	19.45
LIML size of nominal bias 10%	4.32	4.72	4.72	4.32	4.32
# instruments	5	4	4	5	5

## Footnotes to the Tables.

### Table 1

<sup>1</sup>The census divides the US into 9 regions and the South is made of regions 5, 6 and 7. The column w/o South includes all other regions. <sup>2</sup> "More Urban" are counties with 25% or more of the population living in urban areas, "Less Urban", with less than 25% living in urban areas and "High Urban", with 50% or more living in urban areas. <sup>3</sup>Female labor force participation rates. <sup>4</sup> Census, Housing General Characteristics, 1940, Table 23 and 1950, Table 27. "refrigerator" is the percentage of reporting dwellings with a mechanical refrigerator; Ice-box: is the percentage of reporting dwellings with a ice-box. <sup>5</sup> Water: "running water in dwelling unit" Census, Housing General Characteristics, 1940, Table 22 and 1950, table 27. <sup>6</sup> Percentage of dwellings reporting a radio. .

### Table 2

<sup>1</sup> Dependent variable: women labor force participation rate in 1940.  $\Delta$  indicates the difference of the indicated variable between 1940 and 1930. The instruments used for refrig 1940 and bath 1940 in 1-IV are the percentages of rural farms with lights in 1940, the percentage of rural farms with water in 1940, the number of dwellings owned in 1940, the percentage with radios in 1940, the percentage of men employed as craftsmen in 1940 and of the percentage of the population living in urban areas in 1930. In 2-IV only the last five are used. 3-IV uses the same instruments as 1-IV except for the ratio of men working as craftsmen (which is not included). 4-IV uses the same set of instruments as 1-IV. The results reported use GMM. <sup>2</sup>  $\Delta$  refrig: Shea P/Standard P shows the Shea's partial  $r^2$  in the numerator and the Standard partial  $r^2$  in the denominator for the endogenous variable  $\Delta$  refr.  $\Delta$  bath: Shea P/Standard P, is the same but for the variable bath or shower. H J p-values are the p-values for the Hansen-J test.

### Table 3

<sup>1</sup> The dependent variable is the change in female labor force rates between 1950 and 1940.  $\Delta$  indicates the difference of the indicated variable between 1950 and 1940. IVa, IVb and IVc are instrumental variable estimations (using GMM) where instruments have been used for both  $\Delta$  refrig and  $\Delta$  bath. IVb contains the same instruments as in IVa but with the addition of the change over the decade in the percentage of reporting dwellings with ice boxes. IVc contains the same instruments as in IVa but with the addition of the change in population over the decade (1950-1940). For 2-IVd, 5-IVd and 6-IVd in addition to the instruments described in IVa, the following instruments are used: the percentage of dwellings with a bath or shower in 1940, the percentage of dwellings with a refrigerator, the percentage change in the population between 1950 and 1940, the change in the number of dwellings between 1940 and 1930 and the percentage of the population living in urban areas in 1930.

Common instruments for regressions under IVa are: dwellings owned in 1940, the percentage of dwellings with radios in 1940 and the change in the percentage of men employed as craftsmen (to total male employment) between 1940 and 1950. These are exactly the instruments used for 5-IVa, the sample that only includes the less urban counties. For 2-IVa (all counties together) the change in the urban density between 1940 and 1930 was also included (excluding it does not change the results but it is a relevant instrument). For 3-IVa (counties in the South only) the instruments also include the percentage of rural farms with water in 1940, the area of the county, the change in the urban density between 1940 and 1930 and the ratio of male craftsmen to total male employment in 1940. For 4-IVa (counties not in the South), the set of instruments also include: the percentage of rural farms with electrical lights and the percentage of rural farms with water in 1940. For 6-IVa (counties in more urban areas), the additional instrument is the change in urban density between 1940 and 1930.

Table 4

<sup>1</sup>These are farm owners and tenants and farm managers and do not include farm laborers. In 1950 there were 1.95 mil. male farm laborers and .448 millions female farm laborers.

Table 7

<sup>1</sup> The dependent variable is the change in female clerical and sales workers over total female employment between 1950 and 1940.  $\Delta$  indicates the difference of the indicated variable between 1950 and 1940. The instrumental variables used for  $\Delta$  refrig and  $\Delta$  bath are: dwellings owned in 1940, the percentage of dwellings with radios in 1940, the change in the median rent between 1940 and 1950, the percentage of the population living in urban areas in 1930 and the size of the counties. 2-IV and 3-IV only include the first four instruments. The results reported use GMM, but similar results were obtained when using IV and/or different subsets of the instruments.

Figure 1: Refrigerators 1940

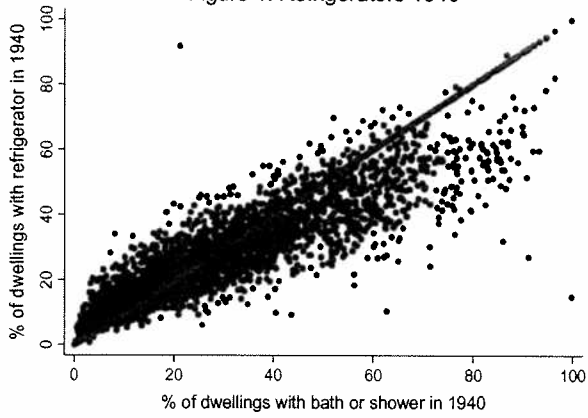


Figure 2: Refrigerators 1950

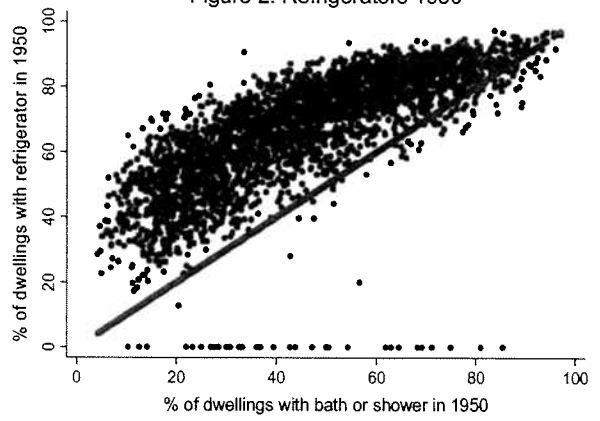


Figure 3: Female Labor Force Participation Rate 1940

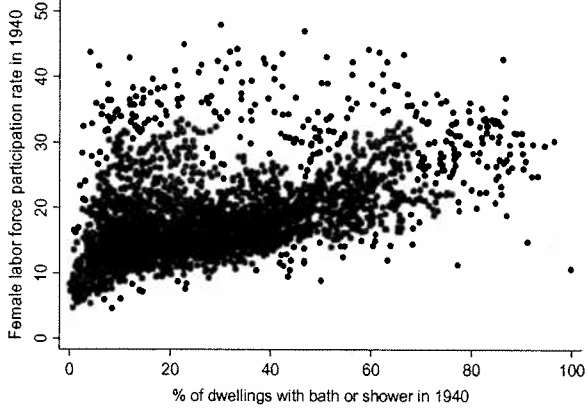


Figure 4: Urban Density 1940

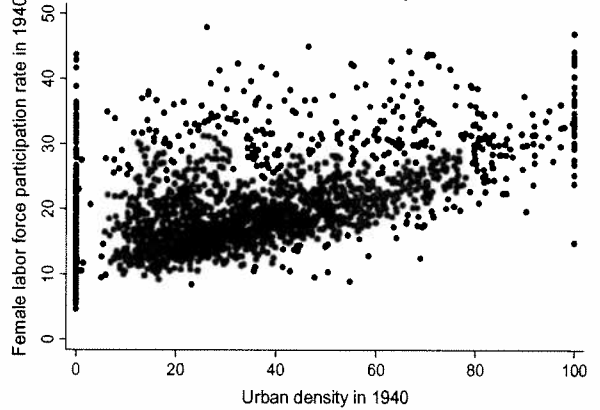


Figure 5: Female Labor Force Participation rate 1940  
w/o counties with more than 10% of non white population

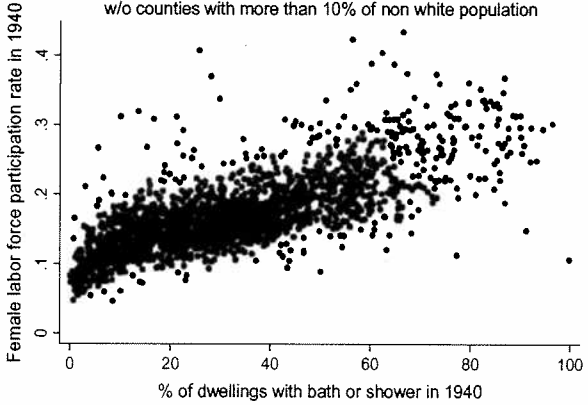
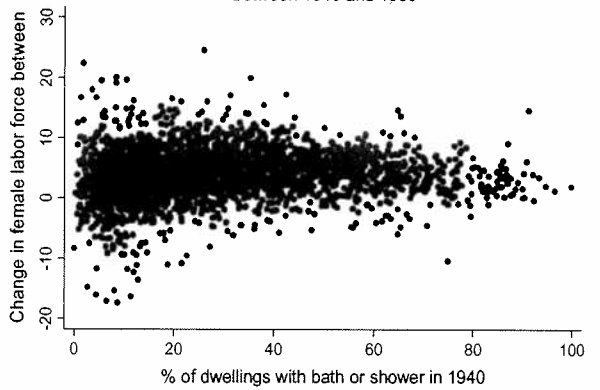


Figure 6: Change in Female Labor Force  
between 1940 and 1950



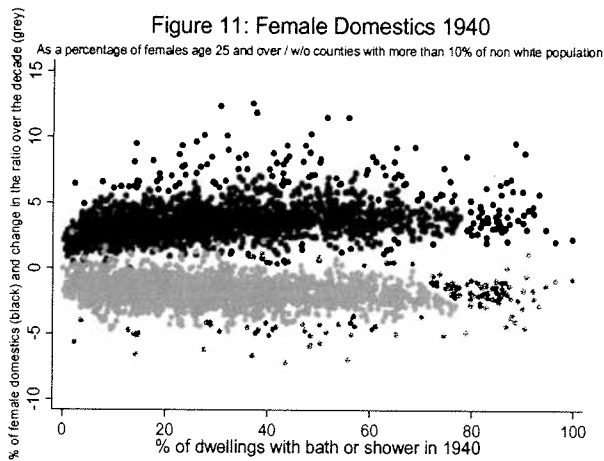
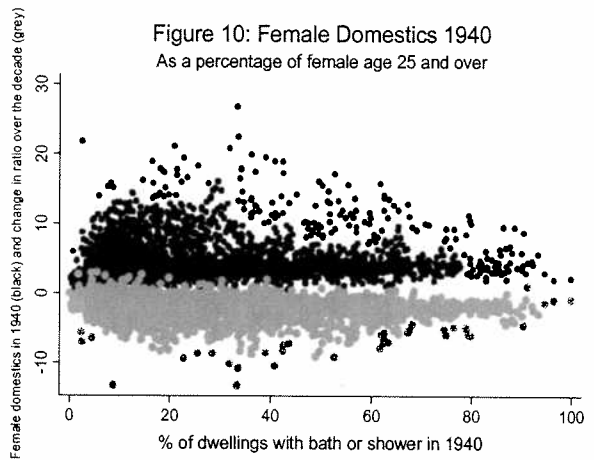
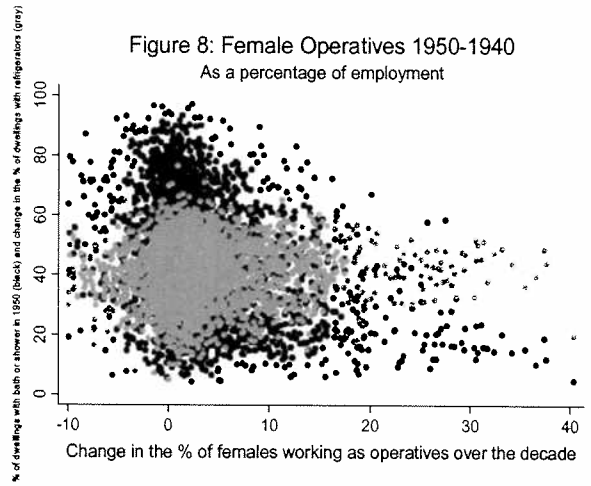
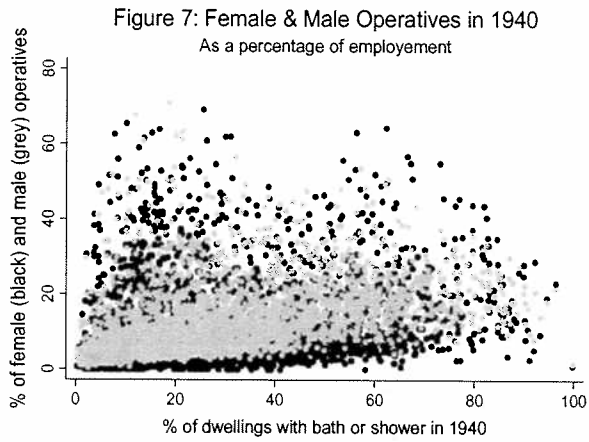


Figure 12: Female Domestics to female Professionals 1940

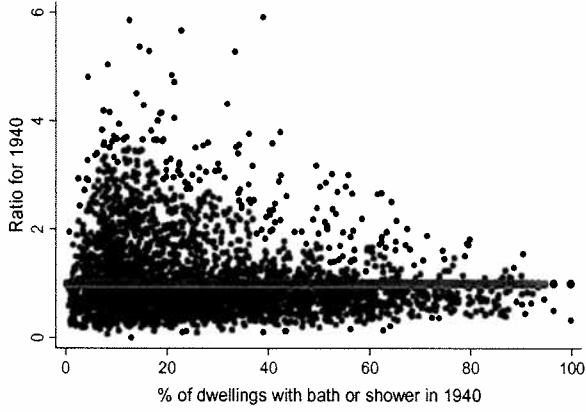


Figure 13: Female Domestics to Female Professionals in 1950

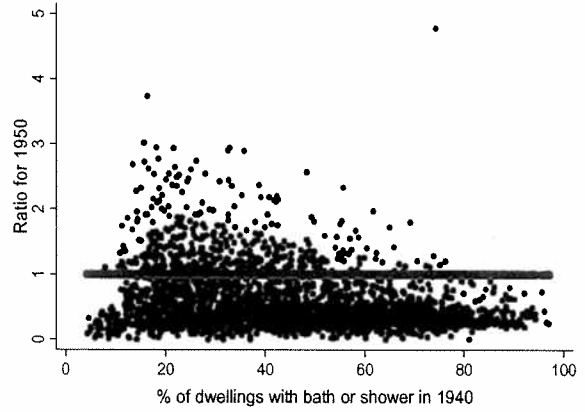


Figure 14: Female Professionals 1940  
As a percentage of female employment

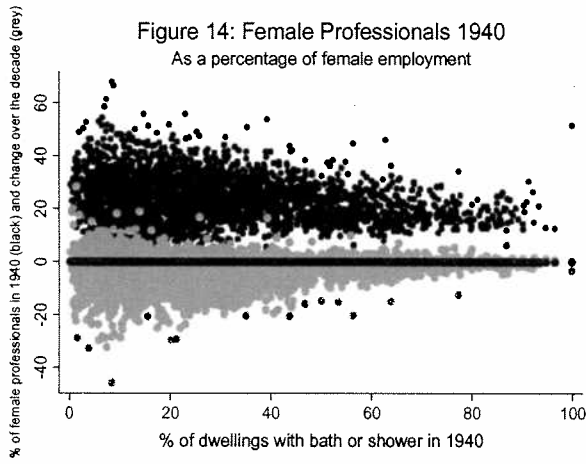


Figure 15: Male Professionals 1940  
As a percentage of male employment

