Durable Ownership and Time Allocation: Evidence from China's "Home Appliances to the Countryside" Rebate

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Abstract

We estimate the effect of labor saving household technologies on female labor force participation. To organize our empirical analysis, we formulate a model of home production which delivers testable predictions regarding the effect of durable price on adoption, and the impact of adoption on allocation of time between home and the market. Importantly, the model illustrates how changes in time use will be asymmetric for males and females in the household. In drawing the causal link between durable ownership and household time allocation, we exploit price shocks generated by the "Home Appliances to the Countryside" promotion, a durable goods rebate offered by the Chinese government to certain rural households for specific durables like fridges and washing machines. Results show that eligible households had higher ownership propensity in these categories and this leads to a large and significant reduction in housework, as well as a sizable increase in market work time, and a boost in female LFP. Also consistent with the model, we find the reallocation of time is driven by females, rather than males, in the household. Overall, the evidence points to durables as "engines of liberation" Greenwood et al. [2005] and suggests their rapid penetration in emerging markets could lead to substantial changes in time-use.

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1 Introduction

The marked rise in women's labor force participation over the twentieth century has been well-documented. Correlates of this change include economic factors (Goldin [1995]), socio-cultural norms and attitudes (Fernández et al. [2004]) and new technologies (Goldin and Katz [2000], Greenwood et al. [2005], de V. Cavalcanti and Tavares [2008], Coen-Pirani et al. [2010]). Much of our knowledge concerning the catalyst of increased female labor force participation (LFP) comes from studies based on data from developed countries. These insights may not be directly applicable to settings where market imperfections, social norms, or institutions moderate womens' incentives and constraints to enter the labor market.

In this paper, we turn to a developing country context to assess one particular hypothesis about the drivers of increased female work time– adoption of durable good technologies. Using panel data on Chinese households, we investigate whether increased ownership of home production technologies like fridge and washing machines reduced housework and boosted employment among Chinese women. This mechanism underlying increased female LFP is in the spirit of Greenwood et al. [2005] "engines of liberation" hypothesis where appliance adoption generates labor savings in home production and spurs an increase in market labor supply.

Identifying the impact of durable adoption of time allocation and labor force participation would typically be riddled with endogeneity problems. We circumvent these issues by exploiting plausibly exogenous variation to durable price generated by the Chinese government's "Home Appliances (Going) to the Countryside" (HAGC) rebate program. Starting in 2007, households residing in certain geographical areas were offered a thirteen percent rebate in specific durable goods categories. Over the next five years, different geographies and durable categories became eligible for the rebate. We exploit the cross-sectional and temporal variation created by the promotion as a shock to the price of appliances which boosted their ownership propensity among eligible or "treated" households. Using this price shock as an instrument for durable ownership, we then estimate its impact on home production and market work time.

We organize the evidence within a tractable theoretical framework. Building upon the

standard home production framework (surveyed in its various applications in Aguiar et al. [2012]), we formulate a model that allows us to obtain comparative statics predicting the effects of durable goods adoption on time allocation. We show that if the elasticity of substitution between home and market goods in the household's utility is sufficiently low, then appliance adoption leads to a reduction in home work. A second feature of the model is it allows us to distinguish between a wife's and husband's time use. We show that when the wife's labor is a closer substitute to household capital services than the husband's labor, she experiences a stronger labor-saving effect of appliance adoption, which in turn boosts her labor market supply.

Turning to the empirical results, we first confirm that the rebate had a significant effect on prices, ownership of appliances and time reallocations. Using the policy as a first-stage instrument, we test the prediction of the model regarding LFP of married female in the household. Consistent with the theoretical framework, the data reveals that following the rebate, appliance adoption significantly reduced home production time and increased market working time, as well as significantly increased the predicted probability of married women LFP [1].

The idea of durables as "engines of liberation" has been explored empirically in a limited way and with mixed results. Using aggregate country-level data from seventeen OECD countries, de V. Cavalcanti and Tavares [2008] finds that a twenty percent decrease in the relative price of appliances leads to an increase in participation of between two and three percent. Using U.S. Census data, Coen-Pirani et al. [2010] find the diffusion of household appliances accounts for about forty percent of the observed increase in married womens' labor force participation rates during the 1960s. In contrast to these two papers, Cardia [2010], using U.S. Census data and relying on fixed-effects estimation, finds evidence weighing in against durables as a significant drivers of womens' LFP again. We improve on these work methodologically by using panel data in conjunction with plausibly exogenous shocks to durable prices. Importantly, since we actually have micro, individual-level data on time-use, we are able to document the effects of durable-ownership on time allocations thus providing

[1] On average, ownership of a durable such as fridge, washing machine or motorbike decreased time spent in housework by 7 hours per week for the female. Time spent in market work increased by 19-20 hours per week for the female and 7 hours per week for the male.

direct evidence in support of the home production channel formalized in our model and underlying the model of Greenwood et al. [2005].

More generally, we also contribute to stream of literature highlighting various correlates of increased women's LFP. These include how technologies that lowered childbearing (Goldin [1995]) and infrastructural (Dinkelman [2011]), evolving social preferences (Fernandez et al. [2002]), economic factors (Goldin [1995]) as well as reduced social norms (Goldin [1995], Mammen and Paxson [2000]).

The rest of the paper is as follows. Section 2 specifies the home production model and presents the theoretical predictions. Section 3 introduces China's "Home Appliance to the Countryside" Rebate program. Section 4 describes the data and empirical strategy. Section 5 presents the empirical findings. Finally, section 6 concludes.

2 Theoretical Framework

In this section, we formulate a simple theoretical framework that illustrates how a reduction in the prices of home appliances induces households to invest in these technologies and generates a reallocation from home work time to market work time. We provide conditions under which this mechanism is especially important for female labor supply. The model belongs to a broader class of models first pioneered by Becker [1965] and Gronau [1976] where the household consumes both market-produced goods and home-produced goods and allocates time among market work, home work and leisure (see the recent survey by Aguiar et al. [2012]).

2.1 Model Setup

Consider a unitary household model where there are two household members: husband and wife, denoted $i \in \{H, W\}$. Household utility depends on household consumption c and the leisure time of each household member l_i:

$$U = \ln(c) + \sum_{i \in \{H,W\}} \ln(l_i) \tag{1}$$

As in recent models of home production (see Aguiar et al. [2012]), household consumption is a CES aggregate of market goods (x^m) and home goods (x^h):

$$c = \left[(x^m)^\theta + \left(x^h\right)^\theta \right]^{\frac{1}{\theta}} \tag{2}$$

where x^m represents goods purchased in the market and x^h represents goods produced at home (measured in the same units as market-purchased goods). The parameter $\theta \leq 1 (\theta \neq 0)$ is the elasticity of substitution between market consumption and home consumption. While this functional form nests the case of perfect substitution ($\theta = 1$) often studied in the earlier literature (see for example Gronau [1977]), the assumption that home and market goods are not perfect substitutes ($\theta < 1$) is important in explaining the time-saving effect of appliances, as we will discuss below.

Home goods are produced by the household using labor and capital. We describe the home production process by using a parsimoniously parameterized function of the three inputs: labor inputs including home production time for both husband and wife (h_H and h_W), and capital input, the household stock of appliances k.[2] The standard modeling choice in the literature is a Cobb-Douglass specification (as in most of the models surveyed by Aguiar et al. [2012]). However, in order to explain the differential impact of appliance adoption on the household members' labor supply, it is necessary to allow the elasticity of substitution between labor and capital to differ across different labor inputs. Therefore we consider the following nested CES technology:

$$x^h = \left[(h_W)^\sigma + (h_H^\rho + k^\rho)^{\frac{\sigma}{\rho}} \right]^{\frac{1}{\sigma}} \tag{3}$$

where σ and ρ give the elasticity of substitution between husband's home production time, wife's home production time and durable appliance. Both σ and ρ are in $(-\infty, 1)$. If either σ or ρ equals zero, the corresponding nesting is Cobb-Douglas. Values of σ or ρ greater than zero indicate greater substitutability than in the Cobb-Douglas case. Note that the elasticity of substitution between durable appliance and the wife's home work is $\frac{1}{1-\sigma}$, and the elasticity of substitution between durable appliance and the husband's home work is $\frac{1}{1-\rho}$. With this

[2] To simplify we consider only one single appliance in our model and treat it as a continuous variable, $k \in \mathbb{R}^+$. Qualitatively similar results obtain from the model with a discrete appliance variable, $k \in \{0, 1\}$, and are available from the authors upon request.

formulation, we allow different degrees of substitutability between household capital and male labor and female labor respectively. Specifically, when $\sigma > \rho$ household capital is a closer substitute for the wife's labor relatively to the husband's labor.

The household uses labor and non-labor income to purchase market consumption goods and appliances. The household faces a budget constraint given by:

$$\sum_{i \in \{H,W\}} w_i n_i + v = x^m + pk \tag{4}$$

where n_i is market work hours of household member i. Prices are expressed in real terms, i.e. they are relative to the price of market consumption goods: w_i is the real wage of member i, p is the real rental price of household capital and v is real non-labor income.

In addition, each household member faces a time allocation constraint:

$$l_i + n_i + h_i = 1 \quad i \in \{H, W\} \tag{5}$$

2.2 Predictions of the Model

We use this home production model to obtain predictions about the effects of a reduction in appliance prices on household time allocation. To generate the predicted comparative statics, we solve the model numerically. Appendix provides the first-order conditions of the model that we use to compute the optimal solution. First, we look at the case where there are no differences between household members. The parameters for this exercise are: $\theta = 0.2$, $\sigma = \rho = 0.7$ $w_H = w_W = 1.15$, $v = 0$. The main conclusion is robust to changes in the parameters as long as an interior solution exists. Figure 2 plots the optimal amount of household capital as a function of the appliance price. Figure 2 depicts a clear negative relation and indeed for a large range of parameter values household capital behaves as a normal good. Thus the model predicts that as appliance prices drop households invest in more appliances.

Figures 3a and Figures 3c illustrate how time use is affected by the appliance price. As the price of appliances falls and household capital increases, time is reallocated from home work to market work. To understand the underlying mechanism, first note that this result is different from what standard production theory would suggest: since labor and capital are generally not perfect substitutes in production of home goods, one would expect that

capital and labor input are positively related. This is certainly the case when home goods and market goods are perfect substitutes: $\theta = 1$. In this case, the optimality condition (12) reduces to:

$$\frac{\partial x^h}{\partial h_i} = w_i \; i \in \{H, W\} \tag{6}$$

since under perfect substitution we have $\frac{\partial c}{\partial x^h} = \frac{\partial c}{\partial x^m}$. Equation (6) is the standard home work supply rule from the earlier home production literature (see for example Gronau [1977]) and it states that home work hours are chosen so that its marginal product is equal to the given real wage. Because labor and capital are not perfect substitutes, an increase in the capital stock raises labor productivity: $\frac{\partial^2 x^h}{\partial h_i \partial k} > 0$. Then the law of diminishing marginal product of labor implies that when the household capital stock increases, labor input in home production also has to go up in order to satisfy (6). In this environment, appliance adoption induces an increase in home work.

To explain the time-saving effect of household capital, it is necessary that home goods and market goods have a sufficient degree of complementarity, i.e. θ has to be sufficiently low (unlike the previous case where $\theta = 1$). When home goods and market goods are not close substitutes, it is optimal for the household to consume a mix of both. In this case, when the household capital stock increases and home work becomes more productive, it is optimal to reallocate some of the time saved from home production to market work. This adjustment allows both home consumption and market consumption to increase at the same time, maximizing household utility.

More importantly, the model allows for a differential effect on the household members' labor supply. To see this, we solve the model when the wife's labor is a closer substitute to household capital services than the husband's labor:

$$\sigma > \rho \tag{7}$$

In order to reproduce a more realistic situation we also assume a gender gap in wages, although this is not necessary to generate differential responses of home work to appliance adoption. Thus the new parameters chosen are: $\theta = 0.2$, $\sigma = 0.8$, $\rho = 0.6$ $w_H = 1.3$, $w_W = 1$, $v = 0$. Figures 3b and 3d illustrate how the appliance price differentially affects time use for the two household members. Figure 3b shows that there is a sharper decrease in the wife's

home work time as the appliance price falls. In Appendix B we provide a general proof of the result that condition (7) implies a sharper decrease in the wife's home work time without resorting to numerical methods (in particular, see equation (22)). As before, the reduction in home work time spurs an increase in market work for each individual, as shown by Figure 3d. Again, the wife's market work increases more as the appliance price falls while the husband's market work curve is flatter.

To summarize, the model makes the following theoretical predictions:

1. *A reduction in appliance prices induces an increase in appliance adoption.*
2. *If the elasticity of substitution between home goods and market goods is sufficiently low, adoption causes a reduction in house work and an increase in market work for at least some of the household members.*
3. *When the wife's labor is a closer substitute to household capital services than the husband's labor, then the wife experiences a larger decrease (increase) in home work (market work) than the husband.*

3 Background: China's "Home Appliance to the Countryside" Rebate

The model in the previous section predicts that adoption will change time allocation in the household. We seek to establish causality and the key to our identification strategy is to leverage the exogenous price variation generated by the "Home Appliances Going to the Countryside" (HAGC) rebate. HAGC was a five-year, government-sponsored promotion aimed at stimulating consumption of home appliances in rural China. Households were entitled to rebates of thirteen percent when they bought certain categories of durable goods. Each household could buy up to two products within each category. In December 2007 the policy was first introduced in Shandong, Henan, Sichuan provinces and the eligible categories were television sets, refrigerators, mobile phones or washing machines. One year later (December 2008) the program was extended to Inner Mongolia, Liaoning, Dalian, Heilongjiang, Anhui, Hubei, Hunan, Guangxi, Chongqing, and Shanxi. Finally in February 2009, the policy was extended to the whole country, and the number of subsidized products was increased

to include motorcycles, computers, water heaters, and air conditioners. Each province could choose two of these four extra products to promote ("4+2 Policy"). [3] Figure 1a and Figure 1b show the timeline of rebates across provinces and categories. In the empirical analysis, we focus on three durables that came under the purview of HAGC– washing machine, fridge (both part of Phase 1) and motorbike (Phase 2).

HAGC has been regarded to have boosted sales considerably, with over 300 million units sold over the five-year period and sales recording double-digit growth. In 2011, the cumulative sales of HAGC commodities reached 405 billion yuan (about US$64 billion) and the total amount of subsidies were 46 billion yuan (about US$7.3 billion).

4 Methodology and Data

4.1 Data

The data are drawn from the *China Health and Nutrition Survey* (CHNS)[4]. The survey has a detailed document on time use at individual level and durable appliance ownership at household level. Observations are across nine provinces that vary substantially in geography, economic development, and public resources. This survey was conducted in 1989, 1991, 1993, 1997, 2000, 2004, 2006 and 2009. Our sample is drawn from five waves of the CHNS data, namely wave 2000, 2004, 2006 which are before-rebate periods, and wave 2009 and 2011 which are after-rebate period. Our sample includes both urban and rural households, though urban areas are not included by the promotion, it serves as a great control group in our experiment. Our baseline analysis involves a sample of households with household heads who are urban or rural residents, married, between age 25 to age 59, not students, and not retired.[5] We drop

[3] The price ceilings for these products were RMB3500 for color TVs, RMB2500 for refrigerators (including freezers), RMB1000 for cell phones, RMB2000 for washing machines, RMB3500 for computers, RMB2500 for wall-mounted air-conditioners and RMB4000 for floor-stand air-conditioners.

[4] The survey is a collaborative effort between the Carolina Population Center at the University of North Carolina at Chapel Hill and the National Institute of Nutrition and Food Safety at the Chinese Center for Disease Control and Prevention. Details are at http://www.cpc.unc.edu/projects/china

[5] One reason to exclude retired individuals in our sample is that older individuals or retired individuals tend to have very different patterns in time allocation: spend significantly more time in home work than working individuals, possibly due to their low opportunity cost. Another reason is that since retired individuals' time share for market work is essentially zero, it would create biased estimation if we intend to investigate the time-reallocation margin from home to the market.

the small number of households reporting zero or missing household income, or with missing education or age information. We include households in all five waves in which they appear in the survey and satisfy all our requirements. To limit the effects of extreme observations, we also drop some outlier observations on time use and individual annual income. Therefore, our final sample is an unbalanced panel consisting of 4056 households.[6]

Table 1 provides key descriptive statistics of the sample. The sample contains individuals between 25 and 60 years old. The median size of the household is two people. The majority of individuals (70%) are from rural areas. There is considerable heterogeneity in the level of education, income and working status in the population. The data provide information on household durable goods. In particular, we look at whether the household owns a fridge, a washing machine and one or more motorcycles. There is substantial variability in these variables. To measure household capital, we construct an index given by the sum of these three variables.[7]

We study how individuals allocate their time by computing the number of hours per week that a person spends in different activities and classify them in three categories: market work, home work and leisure. Home production time is calculated as hours per week spent on taking care of children, cleaning the house, doing laundry, cooking, and doing grocery shopping. Market time is defined as hours per week spent on primary occupation. Leisure time is defined as the sum of hours spent per week on sedentary activity and physical activity. The average individual in the sample spends 42 hours per week in market work, 6 hours per week in home work and 10 hours per week in leisure activities. Around one tenth of the individuals are engaged in childcare at home.

4.2 Estimation Strategy

OLS estimation of the effect of household durable ownership on female labor participation can be plagued by endogeneity since there could be numerous omitted variables like culture or technological-sophistication affecting both female labor participation and household appli-

[6]The sample is unbalanced also because of new respondents introduced into the survey, old respondents moved out of the survey, and transitions of household members into retirement or aging.

[7]Our choice for the three appliances are based on both the rebate program coverage and the consideration of its usage related to home production productivity.

ances ownership. We address these issues by using the HAGC rebate as an exogenous variation to appliance price which in turn should affect ownership. We undertake to approaches to forge plausibly causal connections between the rebate, price, ownership, time allocation and female labor participation. First, we estimate several reduced-form relationships, which include the relationship between the rebate and price, the rebate and ownership, the rebate and time allocation respectively. Among these reduced-form estimations, the relationship between the rebate and ownership is also the basis of our second approach– instrumental variable– which tells us the causal effect of ownership on female labor participation.

4.2.1 Difference-in-Differences (OLS)

In the first stage, we apply the differences-in-differences (DID) estimation strategy, which compares changes in prices of durables that are covered by rebate and not covered by rebate. The specification is as follows:

$$p_{it} = \text{Fixed effects} + \lambda(d_t \times Treat_i) + \mu_{it} \tag{8}$$

In the equation above, our main interest in on the parameter λ which estimates the effect of the rebate $(d_t \times Treat_i)$ on durable price p_{it}. d_t is a dummy which is equal to 1 if the observation is from wave 2009 (post). $Treat_i$ is a dummy which is equal to 1 if the appliance is covered by the rebate program.

The second reduced-form relationship we examine is the effect of rebate on durable ownership. Applying a similar DID estimation strategy, we compare the changes in durable ownerships for affected households pre-rebate (2000, 2004 and 2006) and after-rebate (2009 and 2011) to unaffected households controlling for time and household fixed effects as well as other time-varying covariates. The specification is as follows:

$$k_{it} = \text{Fixed effects} + X'_{it}\beta + \delta(d_t \times Treat_i) + \epsilon_{it} \tag{9}$$

In the equation above, our main interest in on the parameter δ which estimates the effect of the rebate $(d_t \times Treat_i)$ on k_{it} (household capital/durable ownership). k_{it} will be an "index" which is the sum of all three durables (so, maximum is 3 if fridge, washing machine and motorcycle are all owned and minimum is 0 if none is owned). d_t is a dummy which is equal

to 1 if the observation is from wave 2009 (post). $Treat_i$ is a dummy which is equal to 1 if the observation resides in certain rural area that is covered by the rebate program. X_{it} is a vector of all the control covariates, including age, education and household income. The identification assumption here is that there are no systematic difference in the control (no rebate) and treated (rebate) groups prior to treatment. Later, we will provide support for this assumption.

The third relationship that is of great interest is to test the differential impact of the rebate on time allocation for wife and husband. We run the following OLS regression for home work hours for wife and husband separately:

$$h_i = \text{Year Fixed effects} + X'_{it}\beta' + \delta'(d_t \times Treat_i) + \upsilon_{it} \tag{10}$$

Our main interest is in estimating the parameter δ', that captures the effect of the rebate program on home work time. A similar regression is estimated for which market work is the dependent variable[8].

4.2.2 Instrumental Variables

Using a instrumental variables framework, we would like to estimate the causal effect of durable adoption on female labor force participation (LFP). A candidate for an instrument would be a variable that is i) strongly correlated with ownership and ii) only affects hours through ownership. The DID specification shows support for i) and although it is not possible to directly test ii), arguably, one would not expect eligibility for the rebate to affect hours directly. An example may be if money saved by the rebate leads to reduction in work hours due to a wealth effect. However, it is doubtful whether the one-time savings would be sufficient to generate this type of wealth effect. Assuming the identification assumptions hold, we can use the rebate as instrument for ownership and run the following two-stage regression:

$$Pr(work = 1) = \text{Fixed effects} + X'_{it}\beta'' + \delta''(d_t \times Treat_i) + \tau\hat{k}_i + \varepsilon_{it} \tag{11}$$

[8]We also try to trace the direct impact of ownership on time allocation by doing an instrumental variables analysis where endogeneity problem is taken care of by using the HAGC rebate as a natural experiment. The direction of the estimates is similar to the OLS analysis but the magnitudes differ considerably. We report the IV results in Appendix, see Table10 and Table 11.

Again, our main interest is in parameter τ, which explains the effect of household appliances on the predicted probability of female LFP for married women. We test the effect on three appliances separately as well as the appliance index.

5 Results

5.1 DID Evidence and Assumption Revisited

Firstly we use a panel of differences-in-differences tables to show raw comparison of means for the effect of the rebate on durable ownership[9]. Table 2 shows that there is an increase in mean household durable ownership, and the increase is around 0.17 units. On the time allocation aspect, wife's home production time for those affected households before and after the rebate has dropped 2.88 hours per week compared to unaffected households shown by Table 8 upper panel. In contrast, husband's home production time for those affected households has dropped only 0.22 hours per week as shown by Table 8 lower panel. Similar comparisons for market work time are shown by Table 9. Wife's market work time for those affected households before and after the rebate has increased 1.44 hours per week compared to unaffected households. In the meanwhile husband's market work time for those affected households has dropped by 0.81 hours per week.

A key identifying assumption for the DID specification is that there are no differing ownership trends between control and treated groups prior to the rebate. Figure 4 graphs average ownership for eligible and ineligible households in the years before and after the rebate. We see that prior to 2006 control and treated households have a parallel trend in durable ownership and afterwards there is an uptick in ownership for families who got the rebate [10].

5.2 The Impact of Rebate on Durable Prices

A direct test to the effect of the HAGC policy is to use durable price as an outcome variable and examine the different responses of durable prices for those under rebate and not covered

[9] We do a similar analysis for hours, results are in the Appendix. See Table 8 and 9.

[10] We can also look at evolution of ownerships for all the appliances and the chosen three particular appliances separately, see Figure 5, 6, 7 and 8 in the Appendix.

by rebate. Table 3 shows the effect of the HAGC policy on prices of different durable categories. As expected, prices fall significantly for the durables that were subject to the policy (Table 3a) and eligible durables remain unaffected (Table 3b). Results are significant at 1%, 5% and 10% level.

5.3 The Impact of Rebate on Durable Ownerships

The DID estimates from estimation equation (9) are presented in Table 4. The probability that a household owns a washing machine increases significantly by 6% if the household receives a price rebate (columns (1)). The probability of owning a fridge or a motorcycle also increases significantly, by about 8% (columns (2) and (3)). Overall, the rebate seems to have a positive and significant causal effect on durable ownerships (shown in columns (4) and (5)).

5.4 The Impact of Rebate on Time Allocation

Turning to the OLS estimates of the effect of the HAGC policy on time allocation between home work and market work, we find that the rebate does significantly reduced home work time and significantly increase market work time for both wife and husband, but the magnitude is quite different. The estimates are significant at 1% level. Table 5 reproduces the results for home work, obtained from estimating equation (10). Comparing estimates from column (1) and (2), home appliance rebate has a much stronger effect on reducing wife's home work time. This may imply that wife's labor is a closer substitute to household appliance than the husband's labor, which is consistent with our theory prediction. Table 6 presents the OLS estimates of the effect of household appliances rebate on hours of market work. Again, we control for province fixed effects and year fixed effects, and a number of observables. Results show that with appliances rebate, wife's market hour increases more than the husband's, which coincides with the previous finding that the greater reduction in wife's home work has been reallocated to market work.

5.5 The Effect of Appliance Ownership on LFP

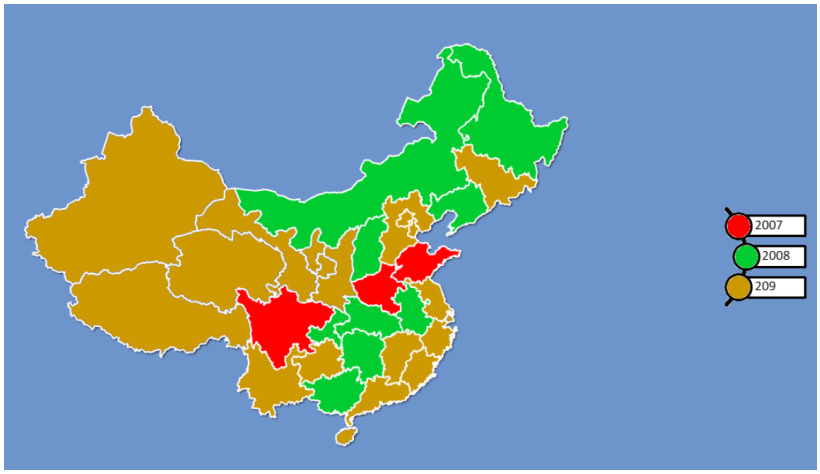
The IV probit test results on female LFP are reported in Table 7. The coefficients on household appliances are positive and significant at 1% level, which indicates an increase in the ownership of home appliance leads to a significant increase in the predicted LFP probability for married women. Results hold for each appliance as well as the appliance index. We also find significant positive correlation between college education and female LFP, and significant negative effects of age, middle school education, high school education, and household income on female LFP.

6 Conclusions

In our analysis, we find durable goods such as washing machine, fridges and motorbikes led to considerable reductions in home production time and boosts to market work time, particularly for female household members. Moreover the adoption of household durable appliances increases female labor force participation. Given the rapid penetration of labor-saving appliances among the burgeoning middle-classes in emerging and developing markets, this particular channel is particularly relevant for policymakers and researchers interested in the drivers of female labor-force participation. Reductions in time-consuming housework for females also have implications for welfare-enhancing outcomes like female literacy and schooling (Ilahi and Grimard [2000], Nauges and Strand [2011], Sekhri [2013] as well as better health and education for children (Mokyr [2000], Lewis [2012]).

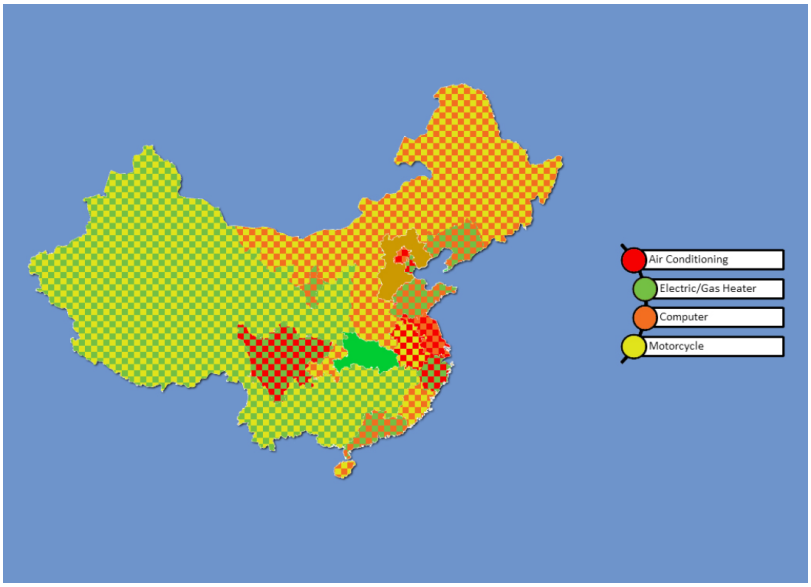
Figures and Tables

Figure 1: China's Home Appliances to the Countryside Rebate



(a) Timing of Phase 1 Rebate (TV, WM, Fridge, Cellphone)

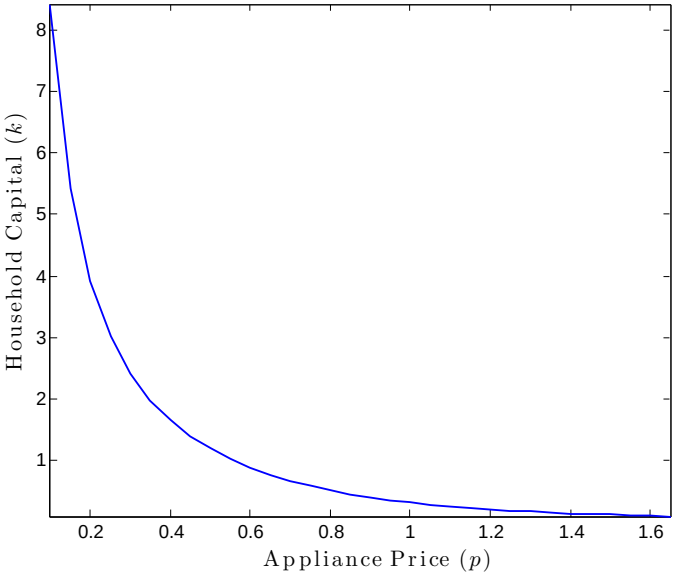
Notes: Phase 1 refers to rebate on four appliances (TV, washing machine, fridge, cellphone) from 2007 to 2009 across difference provinces.



(b) Phase 2 Rebate: Two appliances chosen per province in 2009

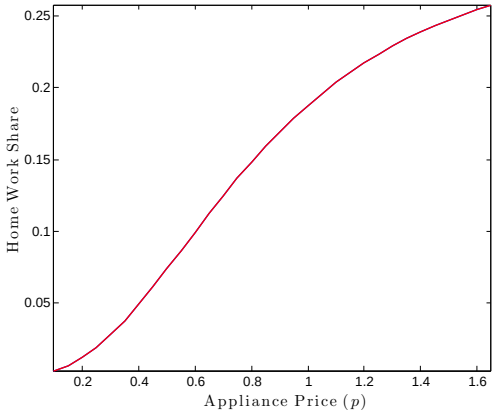
Notes: Phase 2 refers to rebate on two appliances chosen by each province from motorcycles, computers, water heaters, and air conditioners in 2009.

Figure 2: Appliance Price and Household Capital

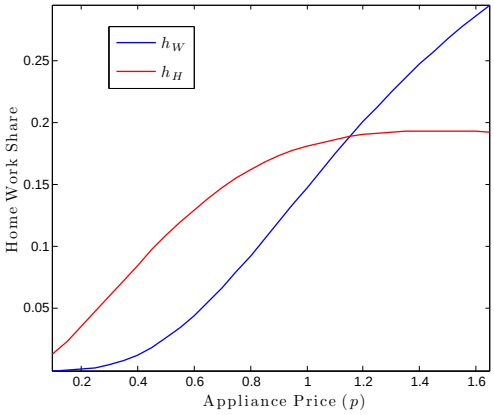


Notes: Figure 2 shows a clear negative relation between the optimal amount of household capital and the appliance price.

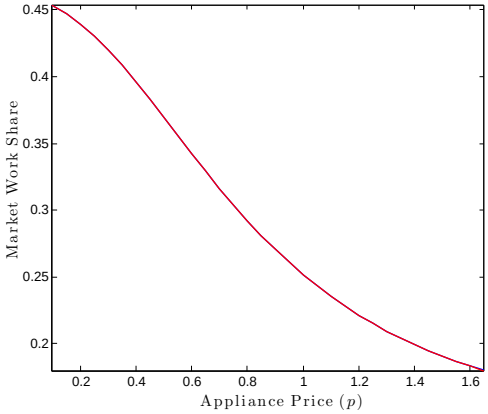
Figure 3: Appliance Price and Time Allocation



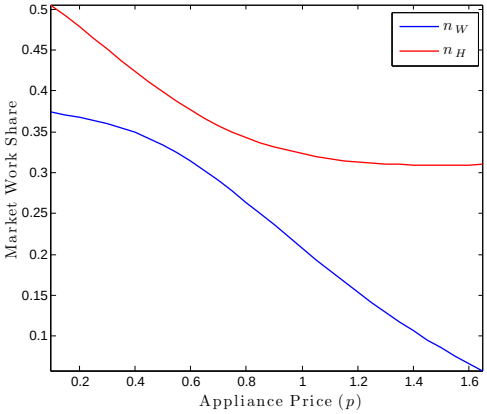
(a) Appliance price and home work time: Baseline Case – No gender difference



(b) Appliance price and home work time: With gender difference

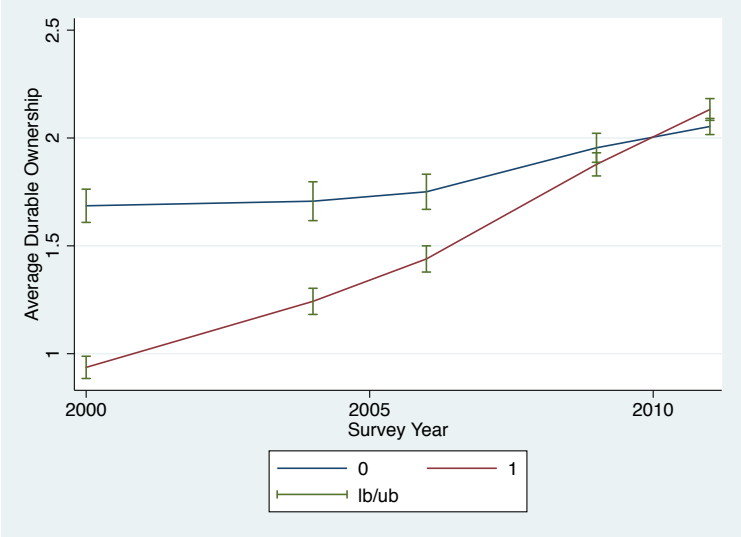


(c) Appliance price and market work time: Baseline Case – No gender difference



(d) Appliance price and market work time: With gender difference

Figure 4: Trends in Durable Ownership for Control and Treated Groups



Notes: Average durable ownership refers the durable index which include all three appliances (washing machine, fridge, and motorbike). The graph represents the arithmetic mean of durable ownership based on 95% CI by "treatment group".

Table 1: Descriptive Statistics - CHNS

Variables	Obs	Mean	Std. Err.	Min	Max
A. Demographic Variables					
Age	8345	45.88	7.77	24.04	58.99
Middle school edu	8345	0.61	0.49	0	1
High school edu	8345	0.17	0.38	0	1
College edu	8345	0.07	0.24	0	1
Household size	8318	3.57	1.17	1	11
Fraction urban	8345	0.29	0.45	0	1
B. Income Variables					
Annual income	3602	21.72	30.55	0.14	580
Household income	8290	36.31	42.89	0	780
Number of earners	8345	2.04	0.81	1	7
C. Durable Ownership					
Fridge	8311	0.57	0.49	0	1
Washing machine	8313	0.70	0.46	0	1
Motorcycle	8306	0.34	0.47	0	1
Total Index	8345	1.61	0.99	0	3
D. Time Allocation					
Market hours	6857	42.75	18.74	1	119
Home hours	8345	6.35	12.04	0	119
Leisure hours	8345	10.06	13.85	0	116
Childcare dummy	5290	0.13	0.35	0	1

Note: Total index refers to the sum of three home appliances ownership for: washing machine, refrigerator and motorbike. Annual income and household income are rescaled by 1000.

Table 2: Effect of Rebate on Average Durable Ownership

	Households by Rebate		
			Difference
	Control	Treat	Treat-Control
Variable	(1)	(2)	(3)
Durable Ownership (pre)	1.58	1.16	-0.42
Durable Ownership (post)	2.02	1.77	-0.25
Change in Mean Ownership	0.44	0.61	0.17

Note: Durable ownership refers to the sum of ownerships of three household durable appliances: refrigerator, washing machine and motorcycle. It is a variable between 0 and 3.

Table 3: HAGC Rebate and Durable Appliance Price

(a) Effect of Rebate on Chosen Durable Appliance Price

	Prices of Durable Appliances (CHOSEN for rebate)			
	Washing Machine	Fridge	Motorcycle	Cell Phone
HAGC	-161.07**	-222.03*	-2526.83***	-652.78***
	(77)	(132)	(746)	(172)
Year Fixed Effects	Yes	Yes	Yes	Yes
Household Fixed Effects	Yes	Yes	Yes	Yes
Observations	6275	5121	9244	9244

Note: All the above four appliances belong to the HAGC rebate, either in phase1 or phase 2.

(b) No Effect on Non-chosen Durable Appliance Price

	Prices of Durable Appliances (NOT chosen for HAGC rebate)				
	VCR	Microwave	Electrical Fan	Sewing Machine	Rice Cooker
HAGC	1978.67	-102.45	-17.25	-35.95	24.06
	(1914)	(156)	(90)	(25)	(33)
Year FE	Yes	Yes	Yes	Yes	Yes
Household FE	Yes	Yes	Yes	Yes	Yes
Observations	456	1901	6850	3347	6633

Note: The above appliances don't belong to the HAGC rebate categories.

Table 4: Regression Results: Effect of Rebate on Durable Ownerships

Dependent Variables: Durable Ownership					
	Washing Machine	Fridge	Motorcycle	Durable Index 1	Durable Index 2
Explanatory Variable	(1)	(2)	(3)	(4)	(5)
Post × Treat	0.057**	0.081***	0.131***	0.261***	0.132***
	(0.025)	(0.030)	(0.031)	(0.057)	(0.043)
Household Fixed Effects	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	9205	9201	9196	9244	9244

Note: All standard errors are clustered at the household level and are reported in parentheses. Post = 1 for observations from 2009 and 2011. Durable Index 1 is the sum of durable ownerships of washing machine, fridge and motorcycle. Durable Index 2 is the sum of durable ownerships of washing machine and fridge. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Effect of Appliance Rebate on Home Production - OLS

Dependent Variables: Home Hours		
	Wife Home	Husband Home
Explanatory Variable	(1)	(2)
Rebate	-3.141***	-1.366***
	(0.686)	(0.378)
Urban	0.551	1.208***
	(0.473)	(0.328)
Province	-0.097***	0.008
	(0.017)	(0.011)
Age	-0.085***	-0.030**
	(0.029)	(0.016)
Some Middle School	-0.365	-0.522
	(0.439)	(0.348)
High School Equiv.	-2.087***	0.248
	(0.604)	(0.421)
Some College	-4.717***	0.976*
	(0.959)	(0.566)
Household Income	0.405**	0.554***
	(0.222)	(0.134)
Year Fixed Effects	Yes	Yes
Observations	8290	8290

Note: All standard errors are clustered at the household level and are reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 6: Effect of Appliance Rebate on Market Work - OLS

Dependent Variables: Market Hours		
	Wife Market	Husband Market
Explanatory Variable	(1)	(2)
Rebate	5.408***	2.746***
	(0.930)	(0.750)
Urban	2.214***	6.672***
	(0.706)	(0.622)
Province	0.035	-0.148***
	(0.025)	(0.023)
Age	-0.426***	-0.141*****
	(0.040)	(0.033)
Some Middle School	-1.078*	-0.162
	(0.987)	(0.685)
High School Equiv.	2.625***	1.815**
	(0.604)	(0.812)
Some College	11.479***	-2.293***
	(1.086)	(0.841)
Household Income	2.518***	3.345***
	(0.320)	(0.293)
Year Fixed Effects	Yes	Yes
Observations	8290	8290

Note: All standard errors are clustered at the household level and are reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 7: Effect of Home Appliance Ownership on Female LFP –IV Probit

Dependent Variables: Female LFP				
	Washing Machine	Fridge	Motorcycle	Durable Index
Explanatory Variable	(1)	(2)	(3)	(4)
Post × Treat	1.879***	1.387***	1.251***	0.551***
	(0.324)	(0.322)	(0.308)	(0.143)
Age	-0.008	-0.196***	-0.016***	-0.017***
	(0.006)	(0.003)	(0.004)	(0.004)
Some Middle School	-0.232***	-0.273***	-0.257***	-0.292***
	(0.040)	(0.035)	(0.037)	(0.035)
High School Equiv.	-0.501***	-0.592***	-0.225***	-0.458***
	(0.045)	(0.062)	(0.058)	(0.058)
Some College	0.257	0.329*	0.927***	0.606***
	(0.191)	(0.180)	(0.098)	(0.128)
Household Income	-0.122***	-0.112***	-0.022	-0.092**
	(0.038)	(0.045)	(0.028)	(0.043)
Household Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Observations	8274	8272	8267	8290

Note: All standard errors are clustered at the household level and are reported in parentheses. Post = 1 for observations from 2009 and 2011. Durable Index is the sum of durable ownerships of washing machine, fridge and motorcycle. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Appendix A: Figures and Tables

Figure 5: Trends in Durable Ownership: Control vs. Treated Group

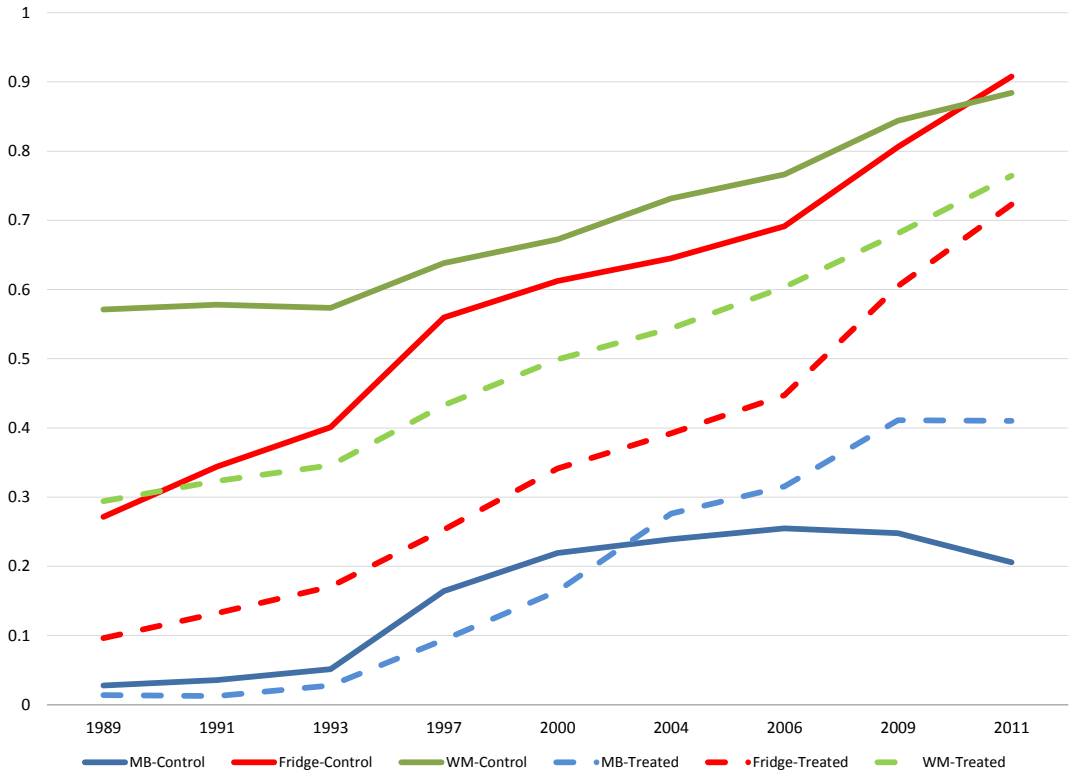
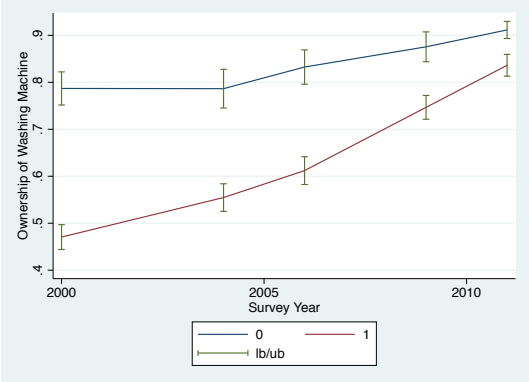
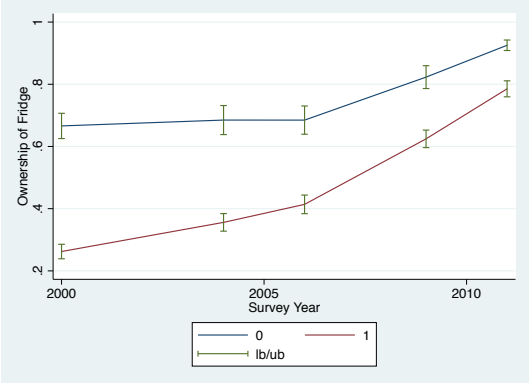


Figure 6: Trends in Washing Machine Ownership for Control and Treated Groups



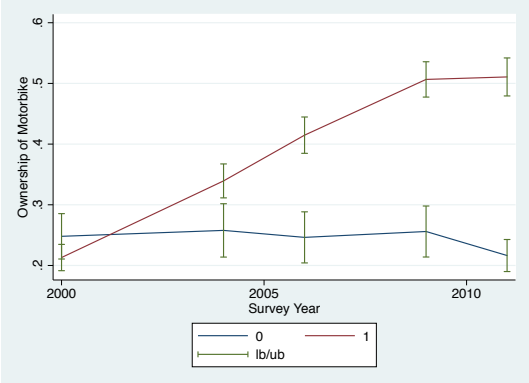
Notes: The graph represents the arithmetic mean of washing machine ownership based on 95% CI by "treatment group".

Figure 7: Trends in Fridge Ownership for Control and Treated Groups



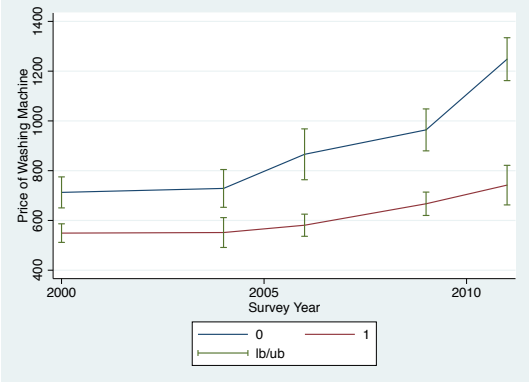
Notes: The graph represents the arithmetic mean of fridge ownership based on 95% CI by "treatment group".

Figure 8: Trends in Motorbike Ownership for Control and Treated Groups



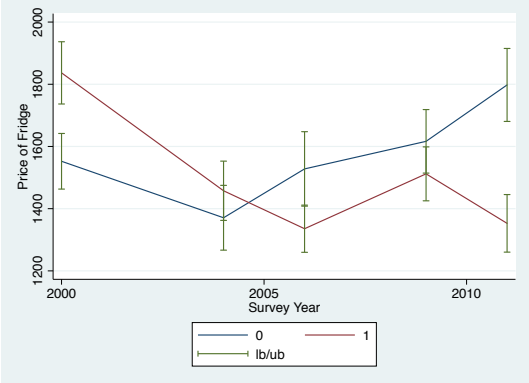
Notes: The graph represents the arithmetic mean of motorbike ownership based on 95% CI by "treatment group".

Figure 9: Trends in Washing Machine Price for Control and Treated Groups



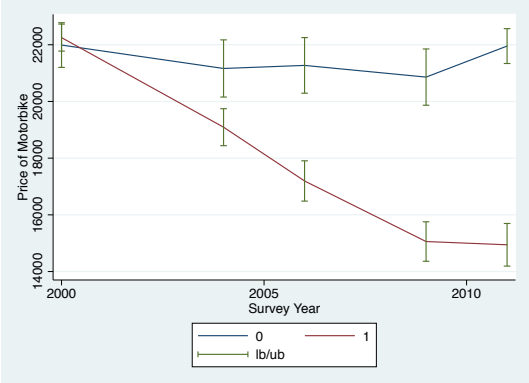
Notes: The graph represents the arithmetic mean of washing machine price based on 95% CI by "treatment group".

Figure 10: Trends in Fridge Price for Control and Treated Groups



Notes: The graph represents the arithmetic mean of fridge price based on 95% CI by "treatment group".

Figure 11: Trends in Motorbike Price for Control and Treated Groups



Notes: The graph represents the arithmetic mean of motorbike price based on 95% CI by "treatment group".

Table 8: Effect of Rebate on Wife's and Husband's Home Production Time

	Households by Rebate		
			Difference
	Control	Treat	Treat-Control
Variable	(1)	(2)	(3)
Wife's Home Hours (pre)	14.93	16.64	1.71
Wife's Home Hours (post)	15.89	14.72	-1.17
Change in Mean Hours	0.96	-1.92	-2.88
Husband's Home Hours (pre)	9.60	8.33	-1.27
Husband's Home Hours (post)	5.80	4.31	-1.49
Change in Mean Hours	-3.80	-4.02	-0.22

Table 9: Effect of Rebate on Wife's and Husband's Market Work Time

	Households by Rebate		
			Difference
	Control	Treat	Treat-Control
Variable	(1)	(2)	(3)
Wife's Market Hours (pre)	24.21	24.07	-0.14
Wife's Market Hours (post)	22.77	24.07	1.30
Change in Mean Hours	-1.44	-0.00	1.44
Husband's Market Hours (pre)	40.77	39.89	-0.88
Husband's Market Hours (post)	42.78	41.09	-1.69
Change in Mean Hours	2.01	1.20	-0.81

Table 10: The Effect of Durable Appliance Ownership on Home Production - IV Regression

Dependent Variables: Home Hours				
	Wife Home		Husband Home	
Explanatory Variable	(1)	(2)	(3)	(4)
Durable Ownership	-7.067**	-7.308*	3.178	3.036
	(3.729)	(6.024)	(2.301)	(2.438)
Age		0.049		0.270
		(0.091)		(0.266)
Some Middle School		-0.190		-0.367
		(0.912)		(0.613)
High School Equiv.		-0.044		-0.813
		(1.444)		(0.966)
Some College		-1.632		-1.506
		(2.069)		(1.677)
Household Income		0.559		0.012
		(0.431)		(0.226)
Household Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Observations	6459	6411	6459	6411

Note: All standard errors are clustered at the household level and are reported in parentheses. Post = 1 for observations from 2009 and 2011. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 11: The Effect of Durable Appliance Ownership on Market Work - IV Regression

Dependent Variables: Market Hours				
	Wife Market		Husband Market	
Explanatory Variable	(1)	(2)	(3)	(4)
Durable Ownership	19.490***	20.557***	7.642*	7.030
	(6.012)	(6.438)	(4.550)	(4.809)
Age		0.122		-0.156
		(0.144)		(0.320)
Some Middle School		0.647		1.802
		(1.601)		(1.460)
High School Equiv.		-0.515		1.502
		(2.468)		(1.706)
Some College		6.678***		-3.458
		(2.804)		(2.249)
Household Income		0.314		1.118**
		(0.672)		(0.560)
Household Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Observations	6459	6411	6459	6411

Note: All standard errors are clustered at the household level and are reported in parentheses. Post = 1 for observations from 2009 and 2011. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Appendix B: Model Details

The household utility maximization problem gives the following optimality conditions with respect to h_i, n_i and k, for $i \in \{H, W\}$:

$$\begin{cases} h_i: & \dfrac{\partial U}{\partial c}\dfrac{\partial c}{\partial x^h}\dfrac{\partial x^h}{\partial h_i} = \dfrac{\partial U}{\partial l_i} \\ n_i: & \dfrac{\partial U}{\partial c}\dfrac{\partial c}{\partial x^m} w_i = \dfrac{\partial U}{\partial l_i} \\ k: & \dfrac{\partial U}{\partial c}\dfrac{\partial c}{\partial x^m} p = \dfrac{\partial U}{\partial c}\dfrac{\partial c}{\partial x^h}\dfrac{\partial x^h}{\partial k} \end{cases}$$

These imply the following:

$$\frac{\partial c}{\partial x^h}\frac{\partial x^h}{\partial h_i} = w_i \frac{\partial c}{\partial x^m} \quad i \in \{H, W\} \tag{12}$$

$$\frac{\partial c}{\partial x^h}\frac{\partial x^h}{\partial k} = p\frac{\partial c}{\partial x^m} \tag{13}$$

Combining equation (12) and (13), we obtain:

$$\frac{\partial x^h}{\partial k} \Big/ \frac{\partial x^h}{\partial h_i} = \frac{p}{w_i} \quad i \in \{H, W\} \tag{14}$$

Evaluating (12) for both household members, we have:

$$\frac{\partial x^h}{\partial h_H} \Big/ \frac{\partial x^h}{\partial h_W} = \frac{w_H}{w_W} \tag{15}$$

These conditions state that the marginal rate of technical substitution between any two home production inputs is equal to the ratio of the input prices.

To further illustrate the implications of this theory for our main research question, we study the comparative statics of the model when the appliance price changes. We assume that there is a reduction in p, while other exogenous variables, such as wages, are fixed.

With the nested CES production functional form, equation (14) and (15) can be written as follows (where we evaluate (14) for $i = H$):

$$\left(\frac{k}{h_H}\right)^{\rho-1} = \frac{p}{w_H} \tag{16}$$

$$\left[\left(\frac{k}{h_H}\right)^{\rho} + 1\right]^{\frac{\sigma}{\rho}-1}\left(\frac{h_H}{h_W}\right)^{\sigma-1} = \frac{w_H}{w_W} \tag{17}$$

Log-linearizing the expressions (16) and (17) yields:

$$(\rho-1)\ln k-(\rho-1)\ln h_h \simeq \ln p-\ln w_h$$
$$\ln w_h-\ln w_w \simeq \frac{\sigma-\rho}{\rho}\Big(\frac{k}{h_h}\Big)^{\rho}+(\sigma-1)\ln h_h-(\sigma-1)\ln h_w$$

After total differentiating the above two expressions and denoting the percentage change of variable x by g_x, we obtain, after some algebra,

$$g_p-g_{w_h}=(1-\rho)(g_{h_h}-g_k) \tag{18}$$
$$g_{h_h}-g_{h_w}=\frac{1}{1-\sigma}(\sigma-\rho)(\frac{k}{h_h})^{\rho}(g_k-g_{h_h}) \tag{19}$$

Since $g_{w_h}=0$, equation (18) implies:

$$g_k-g_{h_h}=-\frac{g_p}{1-\rho} \tag{20}$$

Then equation (19) gives:

$$g_{h_h}-g_{h_w}=-\frac{(\sigma-\rho)g_p}{(1-\rho)(1-\sigma)}(\frac{k}{h_h})^{\rho} \tag{21}$$

and using equation (16) we get:

$$g_{h_h}-g_{h_w}=-\frac{(\sigma-\rho)g_p}{(1-\rho)(1-\sigma)}(\frac{p}{w_h})^{\frac{\rho}{1-\rho}} \tag{22}$$

These equations are important since they provide a simple way of using our model to understand how changes in the durable appliance ownership affect the changes (in percentage terms) of home production hours of husband and wife separately. Since $g_p<0$ and $\rho<1$, equation (21) implies $g_{h_H}<g_k$. If $\sigma>\rho$, equation (22) implies $g_{h_W}<g_{h_H}$. Thus when household capital is a closer substitute for the wife's labor relatively to the husband's labor, the percentage change in the wife's home work induced by a fall in the appliance price is smaller than the percentage change in the husband's home work. In particular (22) implies that the saving in home work time generated by an investment in household capital (if any) is stronger for the wife when her labor is a relatively closer substitute to household capital.

Since the total time constraint for a person is bounded to be one, any reduction of home production time due to durable adoption would lead to an increase in labor supply in the market or leisure time. Thus the model allows for a differential response of home work and market work across different household members.

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