Trade in Appliances, Household Production, and Labor Force Participation

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Abstract

We examine how trade influences female labor supply through reductions in the prices of household appliances that substitute for domestic labor. Using a comprehensive data set from 1981 to 2017, which includes four population censuses, household surveys, and customs records from Peru, we show that labor force participation rose at the same time that appliance import prices fell. We then develop and estimate a dynamic general equilibrium model of trade and household production, to quantitatively evaluate the aggregate impact of declining appliance prices. We find that the reduction in appliance prices during the sample period leads to an increase in female labor force participation that explains one tenth of the total rise in female labor participation in Peru over the past 30 years.

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1 Introduction

Globalization has increased rapidly during the past decades and the resulting competition from labor-abundant countries has transformed labor markets in rich and poor countries alike. This sweeping transformation has sparked a vast body of economic research trying to understand the effects of globalization across a wide range of outcomes, ranging from income inequality to health and marital outcomes.[1]

An overarching principle in much of the existing literature is that trade competition affects labor markets primarily through its impact on labor demand. We propose a complementary channel through which trade also reshapes labor supply. Increased trade reduces the prices of household appliances, such as refrigerators and washing machines, which substitute for labor in domestic production. Access to these appliances allows individuals to shift their time from home production to market activities, leading to higher labor force participation. Since women devote a larger share of their time to domestic tasks—twice as much as men, on average, in OECD countries (OECD, 2011)—this mechanism disproportionately affects female labor force participation.

To examine this new channel linking trade and labor markets, we focus on Peru, which like many developing countries relies heavily on international trade to access modern appliances. We begin by documenting four empirical facts that reveal the transformation of Peru's labor market and suggest a potential role of international trade in appliances in driving this process. To do so, we leverage a comprehensive dataset from 1981 to 2017 that comprises population censuses, detailed import and export records, and a time-use survey. We then develop a model to quantify the impact of an exogenous reduction in appliance prices brought about by a trade liberalization.

Our first fact shows a striking parallel development in Peruvian households. Female labor force participation among those aged 25-65 has risen by approximately 23 percentage points since 1993, while male participation has remained stable at about 90 percent. At the same time, household appliance adoption expanded rapidly. Prior work has shown that appliance ownership is closely linked to women's labor supply (Greenwood, Seshadri, and Yorukoglu (2005); de V. Cavalcanti and Tavares (2008)), and the Peruvian evidence is consistent with this relationship. Time-use surveys indicate that women in households with appliances spend less time on home production and exhibit both higher labor force participation and greater market hours.

Our second fact suggests that international trade played an important role in enabling

[1] See, for example, Autor, Dorn, and Hanson (2016) and Harrison, McLaren, and McMillan (2011) for surveys.

the adoption of these time-saving technologies. Beginning in the early 1990s, after a period of import substitution policies, Peru liberalized its economy and allowed households to access modern appliances produced abroad. The effects were substantial. From 1994 to 2017, import prices of time-saving appliances, relative to average national income, fell by about 70 percent, and total appliance imports increased more than tenfold. Importantly, these imports replaced the country's previously limited domestic production, suggesting that the price decline was largely an exogenous shock to appliance availability and highlighting the potential role of international trade in this labor market transformation.

Did appliance adoption enable this labor market transformation? Our third fact suggests this was the case, by exploiting geographic variation in access to utilities. Running water and electricity are preconditions for using modern appliances, and in 1993 there was wide dispersion in utility access across Peruvian regions. We find that regions with better baseline utility access experienced faster growth in both appliance ownership and female labor force participation, consistent with these regions being better positioned to benefit from declining appliance prices. This differential is particularly pronounced among married women, who typically bear greater responsibility for household chores and child-rearing.

Our fourth fact provides additional suggestive evidence by examining how ownership and labor force participation vary by age, depending on the timing of exposure to cheaper appliances. We divide regions into terciles based on baseline utility access and compare women aged 30-45 (prime working years) to those aged 50-65 (nearing retirement) across cohorts exposed to different appliance prices. For the younger group, the differential in appliance ownership and labor force participation between high- and low-access regions reaches 10 percentage points for cohorts observed after prices declined. Effects are substantially smaller for the older group. These patterns are consistent with younger households treating appliances as long-term investments, leading to differential adoption and labor market responses that persist over the life cycle.

These four facts are consistent with trade reducing the price of appliances, which then enabled women to reallocate time from home to market production, especially among those living in places where infrastructure allowed them to do so and among those who would benefit from long run investments.

These four facts also motivate our theoretical framework and guide our quantitative analysis of the mechanism. The second part of our paper develops a dynamic, quantitative model of household production in a small open economy. In the model, we analyze the households' decisions to adopt appliances for home production in the face of a price shock. The new technology embodied in appliances entails a sunk investment cost and an increase in labor productivity at home. We show that, at the extensive margin, the sunk cost of ownership is traded off against the improved continuation value of having appliances in the rest of the lifecycle, inducing an adjustment that takes years to unfold. At the intensive margin, the productivity gain induced by appliances leads to increases in hours worked when market and home goods are complementary. The strength of these responses is governed by the dispersion of an unobserved heterogeneity shock to preferences.

We calibrate the model and simulate the effects of reducing import prices of time-saving appliances in general equilibrium. Our strategy is to calibrate our parameters targeting a combination of macro and micro moments of the Peruvian economy before the shock, assuming it is in a steady state. Data on wages and hours worked inform household preferences; aggregate census data allow us to recover a small set of model fundamentals. To connect the model to data, we treat the country as a collection of small economies (provinces, the same as in our empirical section) that vary in their productivities and the share of households with access to utilities.

In our main quantitative exercise, we study a counterfactual scenario in which there is a permanent and unexpected drop in appliance prices (relative to average national income) of 70 percent—the magnitude we observe in the data. We find that appliance ownership increases in aggregate by about 8 percentage points, whereas female labor force participation increases by 2.2 percentage points. This corresponds to slightly below one tenth of the total change in female labor force participation observed in the data between 1993 and 2017, which demonstrates the importance of the labor supply channel of trade. A second quantitative exercise examines a broader notion of trade liberalization, in which tariff reductions lower the goods price index by one percent. Female labor force participation responds more strongly in this scenario, as the additional income effect allows households to invest more in appliances. All these effects take several years to unfold, as they require substantial adjustments across households of different ages.

We contribute to three main strands of the literature. First, we contribute to the large empirical literature examining the impacts of international trade on local labor markets. Early work, such as Topalova (2010), documents the distributional consequences of trade liberalization in India, while Autor, Dorn, and Hanson (2013) and Pierce and Schott (2016) study the effects of Chinese import competition on United States labor markets. Subsequent work has documented that these distributional impacts are present in both developing and advanced economies (e.g. Pierce and Schott, 2020, Traiberman, 2019, Hummels, Jorgensen, Munch, and Xiang, 2014, Costa, Garred, and Pessoa (2016), Greenland and Lopresti, 2016, Greenland, Lopresti, and McHenry, 2019). In addition, the adjustment to trade shocks and their consequences have been shown to be persistent (e.g. Dix-Carneiro, 2014, Dix-Carneiro and Kovak, 2017, Caliendo, Dvorkin, and Parro, 2019). More recently, attention has turned to gendered impacts. Autor, Dorn, and Hanson (2019) show that male employment in the United States was disproportionately affected by Chinese import competition, while Juhn, Ujhelyi, and Villegas-Sanchez (2014) find that Mexican exporters reduced gender gaps through labor-saving technologies. In Peru, Chong and Velásquez (2024) show that exposure to tariff cuts lower wages among men, but not women. Conversely, other studies find more limited or adverse effects for women. Gaddis and Pieters (2017) document no gains for women in Brazil due to male-dominated sectoral expansion, and Mansour, Medina, and Velasquez (2022) show substantial and persistent negative impacts on Peruvian women's employment in response to Chinese imports. While this literature focuses largely on labor demand channels and gendered sectoral differences, our work complements it by examining how trade also shapes women's labor supply through changes in the relative prices of market goods and home production.

Second, our work connects to the literature on electrification, household appliance adoption, and women's employment. Theoretically, we build on Greenwood, Seshadri, and Yorukoglu (2005), who examine how the diffusion of household appliances contributed to rising female labor force participation in the United States during the past century, and on Gertler, Shelef, Wolfram, and Fuchs (2016), who characterize household decisions regarding the acquisition of energy-using assets. Empirically, we relate to studies documenting the effects of electrification on women's employment such as Dinkelman (2011) and Vidart (2023), as well as research linking appliance ownership to labor force participation (Coen-Pirani, Leon, and Lugauer (2010); de V. Cavalcanti and Tavares (2008); Hackett and Marquez-Padilla (2022)). We extend this literature to developing countries, where the connection between trade and household technology adoption is particularly salient. Developing economies typically lack domestic appliance production and, during the 1970s-1980s, maintained trade barriers that made imports prohibitively expensive. Trade liberalization therefore played a crucial enabling role in household technology diffusion—a channel less relevant in the developed countries examined in prior work. We document how this trade-enabled appliance diffusion correlates with changes in time allocation and female labor supply, and evaluate its equilibrium and aggregate impacts through a quantitative model.

Finally, we contribute to the macro development literature on structural transformation, female labor force participation, and the division of labor across countries (Gottlieb, Doss, Gollin, and Poschke (2024); Chiplunkar and Kleineberg (2025); Ngai, Olivetti, and Petrongolo (2024); Ngai and Petrongolo (2017)), as well as work on household production and time allocation over the life cycle and across demographic groups (e.g Aguiar and Hurst, 2005, 2007a,b). Building on these contributions, our theoretical framework explicitly models women's market labor through the lens of home production. We show that trade can reshape the productive structure of the economy by altering the demographic composition of labor supply, a mechanism that is particularly salient in developing countries where female labor force participation remains relatively low.

2 Data

Our paper uses three primary sources from Peru. First, we draw from four population censuses conducted in 1981, 1993, 2007, and 2017. These censuses provide detailed data on labor force participation, employment status, demographic characteristics, and household appliance ownership, all at a fine geographic level. We use the census data for two purposes: to conduct individual-level regressions examining labor market outcomes and appliance ownership and to construct measures of regional exposure to the appliance availability shock based on baseline utility infrastructure. We harmonize provincial boundaries across census years to create a consistent panel based on the 1993 province definitions. To mitigate potential confounding effects related to college attendance and early retirement, our main sample comprises individuals aged 25-65. An individual is classified as part of the labor force if he or she reports being employed or actively seeking employment. We measure utility access at the household level as having running water, electricity, or both. The combined census data cover approximately 33 million individuals after applying sample restrictions.

Second, we use customs records from 1994 to 2017 to document the nationwide shock to appliance availability. These records provide detailed data on appliance imports and exports at the product level, including value, quantities, and unit prices. Our focus is on time-saving household appliances, specifically refrigerators and washing machines (including combined washing and drying machines, see Appendix Table A.1). With these data, we construct nationwide real appliance prices as import unit values relative to adjusted net national income per worker (from the World Bank WDI).

Third, we use the Peruvian Time Use Survey of 2010 to document the allocation of time by gender between labor market and household work. Finally, we supplement these primary data sources with the *Encuesta Nacional de Hogares* (ENAHO), a household survey spanning 1998 to 2017, which we use for additional robustness checks and supplementary analyses.

3 Stylized Facts

In this section, we document four stylized facts about the relationship between international trade in appliances and female labor force participation in Peru since 1993: (i) appliance ownership surged while female labor force participation rose by 23 percentage points, (ii) international trade enabled this expansion in appliance adoption, (iii) areas with better access to electricity and running water experienced larger increases in both appliance ownership and female labor force participation, particularly among married women, and (iv) these shifts were more pronounced among younger cohorts.

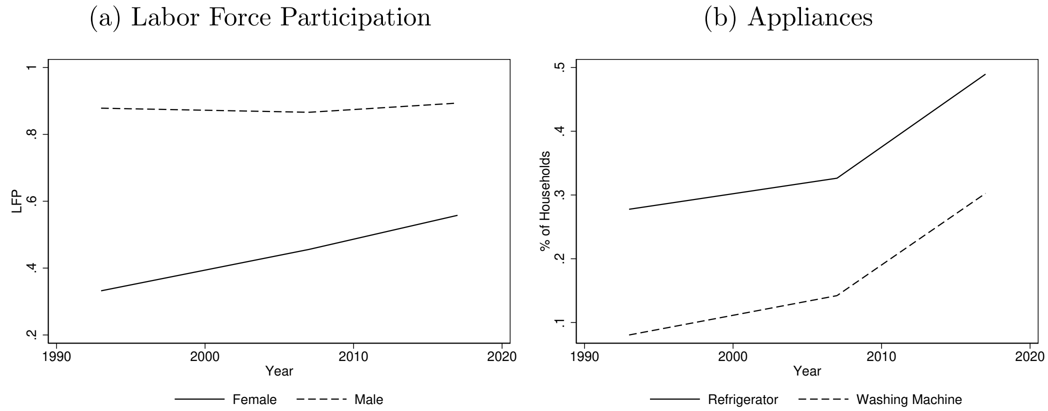
3.1 Fact 1: Appliance Use and the Transformation of Household Production and Female Labor Force Participation

Over the past few decades, female labor force participation has grown substantially across both developed and developing countries, while male labor force participation has remained relatively stable or declined. In Latin America and the Caribbean, for instance, female labor force participation among women aged 15 and older increased from 44 percent to 51 percent between 1993 and 2017, according to the International Labor Organization (ILO). At the same time, ownership of appliances such as washing machines and refrigerators increased globally by approximately 25 percentage points, marking a substantial shift in household technology adoption.[2]

In Peru, these global trends are mirrored by striking local patterns. Female labor force participation among women aged 25 to 65 rose dramatically from 33 percent in 1993 to 56 percent in 2017, according to our population census data. By contrast, male labor force participation remained steady at a bit below 90 percent during the same period (Figure 1a). At the same time, household ownership of time-saving appliances increased substantially, with ownership of washing machines growing from 8 to 30 percent and that of refrigerators from 27 to 49 percent (Figure 1b).

[2] Appendix B documents these trends.

Figure 1: The Evolution of Labor Force Participation and Appliance Ownership in Peru



Notes: Panel (a) shows labor force participation rates for women and men, aged 25-65. Panel (b) shows the share of all Peruvian households that own refrigerators and washing machines. Both panels are based on data from the Peruvian censuses of 1993, 2007, and 2017.

Increased availability of these household technologies has implications for the allocation of time in the household and, by extension, for labor markets. Our time-use data show that this is particularly true for women, who disproportionately bear the burden of household chores. Table 1 shows the mean hours per day allocated by women and men to household chores and labor markets according to the Peruvian Time Use Survey of 2010.[3] The average woman aged 25 to 65 spends four times as much time on household chores as her male counterpart. The ownership of time-saving appliances, however, alleviates this burden. Women in households with such appliances spend 13 percent less time on daily chores, reducing their mean from 6.8 to 5.9 hours per day. Appliance ownership is also associated with a 4.3 percentage point increase in female labor force participation and a 15 percent increase in average daily hours worked in the labor market, conditional on employment. In contrast, across all these measures, the time allocation of men is virtually unchanged with ownership of time-saving appliances.

[3]Unfortunately, Peru's time use survey was only conducted in 2010, when the transformation of labor markets was well underway. Data availability prevents us from exploiting time series variation for the analysis.

Table 1: Time Use, by Ownership of Appliance and Sex

Variable	Female		Male	
	With Appl.	W/o Appl.	With Appl.	W/o Appl.
HH Chores (hrs/day, mean)	5.9	6.8	1.9	2.3
	(0.10)	(0.08)	(0.06)	(0.05)
Labor Force Participation (%)	62.1	57.8	91.6	94.7
	(1.28)	(1.14)	(0.79)	(0.54)
Labor Market (hrs/day, mean)	5.1	4.5	9.6	9.4
	(0.13)	(0.10)	(0.12)	(0.09)
Labor Market (hrs/day, mean, cond. work)	7.9	6.9	10.4	9.7
	(0.12)	(0.12)	(0.10)	(0.09)

Notes: Household chores include cooking, cleaning, washing clothing, managing the household, shopping for the household, childrearing, and caring for a disabled, sick, or elderly household member. Labor market hours refer to the total time spent on both primary and secondary jobs for each individual. Appliance ownership indicates a refrigerator and/or a washing machine in the household. Standard errors are in parentheses.

The data show, therefore, that starting in the 1990s, Peruvian households experienced a substantial transformation in both household production and women's labor market participation. The time use evidence suggests that appliances reduce domestic workload for women, enabling them to reallocate time toward paid labor, while having much smaller effects for men. We next document how international trade enabled this transformation.

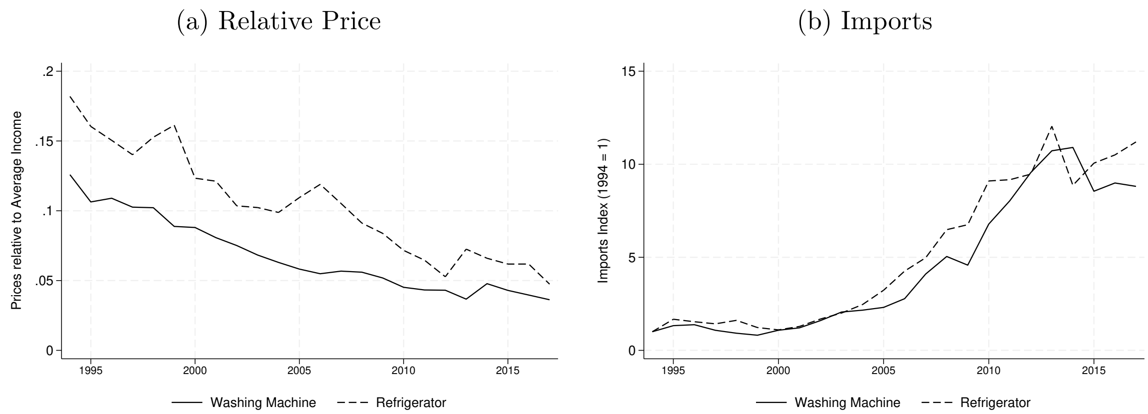
3.2 Fact 2: Ownership of Appliances Boosted by International Trade

Between 1994 and 2017, Peru saw a sharp increase in the imports of time-saving appliances. This surge can be traced back to economic reforms in the early 1990s, when the country shifted from import substitution policies to greater integration into international trade. These reforms enabled Peru to access modern appliances produced abroad, benefiting from global productivity gains and the integration of East Asian countries into global markets. Two key developments characterize this transformation. First, as shown in Figure 2a, the import prices of appliances—relative to national income per worker—declined significantly between 1994 and 2017, with refrigerator prices falling by approximately 74 percent and washing machine prices by 71 percent.[4] Second, as illustrated in Figure 2b, imports of refrigerators and washing machines surged during this period, each growing tenfold (against

[4]The early years of our imports data contain a few records in which quantities are measured with error and, therefore, unit values are mismeasured as well. We therefore present median import prices for each appliance.

population growth of only about thirty percent).

Figure 2: Relative Price and Imports



Notes: Panel (a) shows the relative price of appliances, defined as the ratio of the nominal import price to the national income per worker in Peru. Panel (b) shows an index of total imports of these appliances during the same time period (1994=1). Prices and imports are derived from customs data, while the average national income per capita is obtained from the World Bank.

This increase in imports of appliances was instrumental in expanding access to time-saving technologies for Peruvian households. Throughout this period, appliance imports entirely replaced local production, which was virtually non-existent to begin with. According to the Peruvian Statistical Institute (INEI) and our own calculations using customs data, in 1994, the quantity imported of washing machines was approximately 15 times greater than the number of domestically produced washing machines. This number is 2.2 for refrigerators.[5] Furthermore, the Peruvian Ministry of Production reports a 62.5 percent decline in the physical volume of production in the appliance manufacturing sector from 1994 to 2002. Coupled with the large increase we see in imports, these numbers suggest the vast majority of the supply into the country comes from abroad (Proexport-Colombia, 2003). This near absence of domestic manufacturing means that the large drop in import prices effectively acted as an exogenous shock that gave international trade a critical role in facilitating the adoption of time-saving technologies.

3.3 Fact 3: Ownership and Labor Force Participation

Did trade-enabled appliances drive the rise in female labor force participation? This fact provides suggestive evidence of this channel by examining how the transformation of Peru-

[5] In addition, it was a relatively unimportant industry within Peruvian manufacturing. According to the results of the 1994 Annual Manufacturing Statistical Survey, the household appliance industry in Peru accounted for just 0.76 percent of the country's total manufacturing output. It also represented only 0.99 percent of manufacturing employment and 0.56 percent of the total number of manufacturing establishments.

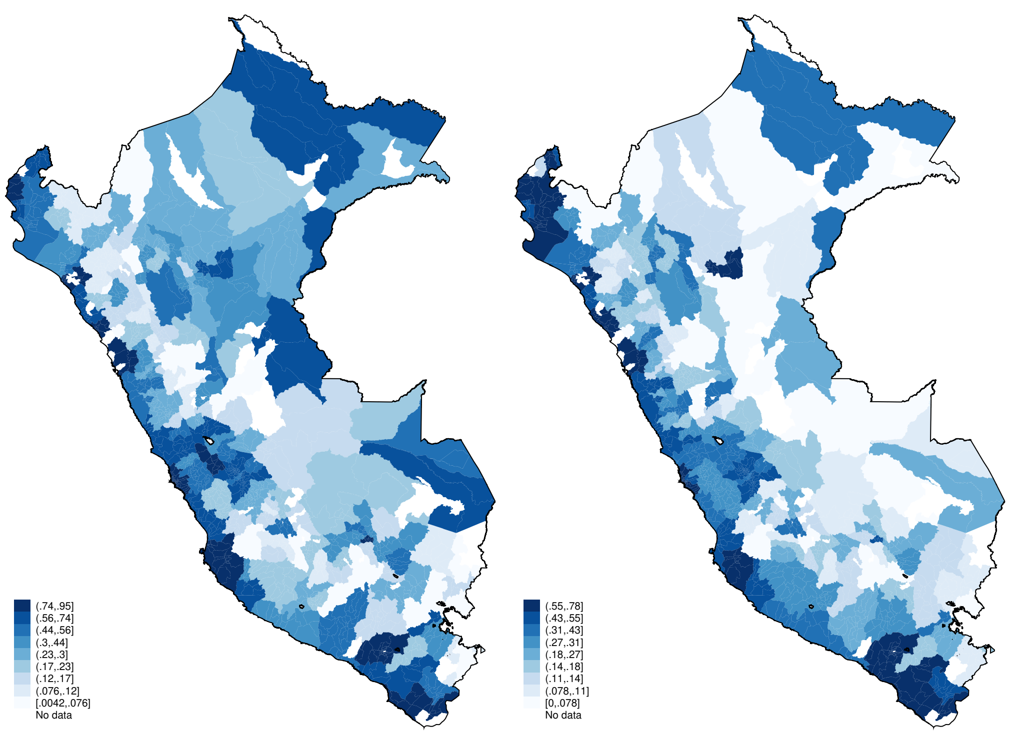
vian labor markets varied with access to running water and electricity, essential prerequisites for households to benefit from declining appliance prices. The idea is the following: in regions with better access to utilities, households were better positioned to adopt appliances as prices fell. We find that these regions indeed experienced faster growth in both appliance ownership and female labor force participation, supporting the mechanism whereby appliances reduce the time required for household production tasks and thereby enable more women to participate in the labor market.

We begin with Figures 3a and 3b, which illustrate the large baseline variation in utility coverage across regions (provinces) in Peru in 1993, just prior to the major waves of trade liberalization. At this time, electricity and water coverage ranged from nearly universal access in coastal and urban areas to almost complete absence in the interior regions. Nationally, only 39 percent of households had access to both electricity and running water. This regional disparity naturally separates households into those that could take advantage of declining appliance prices and those that could not.

Figure 3: Household Access to Basic Services in 1993

(a) Electricity

(b) Running Water



Notes: Panel (a) and Panel (b) display province-level access to electricity and running water, respectively, as recorded by the 1993 Peruvian population census.

If utility access determined regional exposure to the appliance price shock, regions with better baseline access should exhibit differential growth in appliance ownership. Moreover, if appliances disproportionately reduce women's household work, we should also observe differential growth in female labor force participation starting in 1993. To test this idea, we construct a variable that interacts the baseline average share of households with electricity and running water at the province level, $Access_{p,1993}$, with a linear time trend. We then estimate the following regression using individuals aged 25-65 from the 1993, 2007, and 2017 censuses:

$$\mathrm{y}_{ipg,t} = \beta_1 \left(Access_{p,1993} \times t\right) + \gamma_p + \gamma_t + \delta' X_{i,t} + \tau' \mathrm{Trade}_{gp,t} + \alpha' \left(W_{gp,1981} \times t\right) + \delta' \left(D_{p,1993} \times t\right) + \epsilon^{o}_{ipg,t}, \tag{1}$$

where an observation is denoted by individual i in province p of gender g in census year t. The dependent variable $\mathrm{y}_{ipg,t}$ represents either (i) appliance ownership (an indicator that equals one if the individual owns a refrigerator, washing machine, or both) or (ii) labor force participation (an indicator that equals one if the individual participates in the labor market and zero otherwise).

Our coefficient of interest, β_1, in equation (1), captures the differential evolution of outcomes between regions with full utility access and those with no access. In both specifications, we include an increasingly stringent set of controls to ensure that this coefficient isolates trends attributable specifically to initial differences in utility access, rather than other regional characteristics or time-varying factors. First, we include province and census year fixed effects, denoted by γ_p and γ_t, to absorb time-invariant regional differences and control for nationwide trends, respectively. Second, $X_{i,t}$ represents a set of individual-level characteristics, including age and age squared and indicators for different education levels, as well as indicators for characteristics of the residence of the individual such as an urban indicator, and access to electricity and running water at the dwelling, to isolate the regional exposure effect from individual household circumstances. Our third set of controls, denoted by $\mathrm{Trade}_{gp,t}$, controls for gender-specific shifts in labor demand induced by trade. While our focus is on the labor supply channel operating through appliances, trade liberalization also affects labor markets through changes in labor demand, as extensively documented in the literature. These controls capture the exposure of local labor markets to market access and import competition shocks, constructed using the baseline employment composition of each region. Specifically, we construct two controls for each gender: one capturing changes in labor demand due to increased exports and one due to increased imports.[6] Fourth, while

[6]We follow Autor, Dorn, and Hanson (2019) and calculate the weighted average of changes in imports and exports per worker for each province, where weights are the province's industrial employment shares for

we do not have a long time series, we aim to control for pre-existing trends in labor force participation across regions as well as differential trends based on average regional income. To do so, $W_{gp,1981} \times t$ represents the interaction of linear time trends with province-level covariates for individuals of gender g in 1981, including average labor force participation and average income. Fifth, to further distinguish the effect of utility access from broader regional development, we control for baseline regional characteristics interacted with time trends. Specifically, $D_{p,1993} \times t$ represents the population density in province p in 1993 interacted with a linear time trend, which helps separate the utility access effect from differential trends associated with urbanization or regional development more broadly. While this comprehensive set of controls allows us to isolate variation attributable to baseline utility access as much as the available data permit, we interpret the resulting patterns as suggestive evidence.

Table 2 presents our results when the dependent variable is appliance ownership, while Table 3 presents the findings for labor force participation, both estimated on the female subsample. In each table, Columns (1) through (6) report estimates of β_1 from equation (1) across specifications that progressively add the controls described above. Column (1) includes province fixed effects (γ_p), while Column (2) adds census year fixed effects (γ_t). Column (3) incorporates individual-level controls ($X_{i,t}$), and Column (4) adds controls for trade exposure effects ($\text{Trade}_{gp,t}$). Column (5) accounts for pre-trends by including interactions of 1981 gender-specific labor force participation and average income with time ($W_{gp,1981} \times t$). Column (6) adds baseline population density interacted with a time trend ($D_{p,1993} \times t$) to control for differential trends associated with regional development. To aid interpretation, we discuss the accumulated differences implied by β_1 over the 24-year period from 1993 to 2017.

Column (1) of Table 2 shows that appliance ownership increases by 34 percentage points between 1993 and 2017 for women in provinces with full utility coverage in 1993 compared to those in provinces without any utilities. This coefficient is remarkably stable across specifications. It remains robust to controls for labor demand changes due to trade exposure (37 percentage points), which guard against the possibility that high-utility regions also experienced larger export or import shocks. A potential concern is that these trade controls might capture household income effects that independently affect female labor supply. The stability of our coefficient when adding these controls suggests that such income channels do

gender g. The first control is defined as: $\Delta\text{Import exposure}_{gp,t} = \sum_j \frac{l_{jgp,93}}{l_{gp,93}} \frac{\Delta\text{Imports}_{j,t}}{L_{j,t}}$, where $\Delta\text{Imports}_{j,t}$ denotes the change in total imports of Peru in 2-digit industry j, between time t and 1993, and $l_{jgp,93}$ is total employment in that industry for gender g, province p, in 1993. The second control is defined analogously, but for exports: $\Delta\text{Export exposure}_{gp,t} = \sum_j \frac{l_{jgp,93}}{l_{gp,93}} \frac{\Delta\text{Exports}_{j,t}}{L_{j,t}}$.

Table 2: Appliance Ownership and Baseline Utility Access, Women

	(1)	(2)	(3)	(4)	(5)	(6)
Access Trend	0.0142	0.0054	0.0152	0.0154	0.0102	0.0144
	(0.0019)***	(0.0028)*	(0.0027)***	(0.0023)***	(0.0036)***	(0.0025)***
Mean Dependent	0.361	0.361	0.362	0.362	0.376	0.250
Province FE	X	X	X	X	X	X
Province + Year FE		X	X	X	X	X
Ind. Controls			X	X	X	X
Trade Controls				X	X	X
$W_{gp,81}$ x t					X	X
$D_{gp,93}$ x t						X
N.Provinces	192	192	192	192	154	150
N.Obs.	17,060,040	17,060,040	16,971,919	16,971,919	14,546,144	9,974,824

Notes: Appliances bundle is defined as a dummy variable that takes the value of 1 if the household owns a refrigerator or a washing machine. The unit of observation is women aged between 25 and 65. Column (1) includes province fixed effects (γ_p) and Column (2) adds census year fixed effects (γ_t). Columns (3) and (4) progressively add individual controls ($X_{i,t}$) and trade exposure controls ($Trade_{gp,t}$). Column (5) controls for pre-trends using 1981 gender-specific labor force participation and income interacted with time $\left(W_{gp,1981} \times t\right)$, while Column (6) adds baseline population density interacted with time $\left(D_{p,1993} \times t\right)$. Standard errors are shown in parentheses and clustered at the province level.

Table 3: Labor Force Participation and Baseline Utility Access, Women

	(1)	(2)	(3)	(4)	(5)	(6)
Access Trend	0.0149	0.0070	0.0075	0.0078	0.0064	0.0091
	(0.0008)***	(0.0009)***	(0.0009)***	(0.0009)***	(0.0015)***	(0.0015)***
Mean Dependent	0.329	0.329	0.329	0.329	0.333	0.296
Province FE	X	X	X	X	X	X
Province + Year FE		X	X	X	X	X
Ind. Controls			X	X	X	X
Trade Controls				X	X	X
$W_{gp,81}$ x t					X	X
$D_{gp,93}$ x t						X
N.Provinces	192	192	192	192	154	150
N.Obs.	17,060,040	17,060,040	16,971,919	16,971,919	14,546,144	9,974,824

Notes: Labor force participation is defined as a dummy variable that takes the value of 1 if the individual participates in the labor market and 0 if they do not. The unit of observation is women aged between 25 and 65. Column (1) includes province fixed effects (γ_p) and Column (2) adds census year fixed effects (γ_t). Columns (3) and (4) progressively add individual controls ($X_{i,t}$) and trade exposure controls ($Trade_{gp,t}$). Column (5) controls for pre-trends using 1981 gender-specific labor force participation and income interacted with time $\left(W_{gp,1981} \times t\right)$, while Column (6) adds baseline population density interacted with time $\left(D_{p,1993} \times t\right)$. Standard errors are shown in parentheses and clustered at the province level.

not drive our main results. The coefficient is also robust to controls for pre-trends in gender-specific labor force participation and income (Column (5)) as well as differential trends in regional development (Column 6). Our most stringent specification in Column (6) implies an accumulated difference of 35 percentage points.

The results in Table 3 examine the relationship between baseline utility access and female labor force participation. Starting with Column (2), the coefficient remains stable across specifications as we add our full set of controls. Column (6) implies that labor force participation grew by about 22 percentage points more between 1993 and 2017 in provinces with full utility access at baseline compared to those without.

The differential behavior between men and women reinforces this interpretation. As shown in Appendix Tables A.2 and A.3, the evolution of appliance ownership is quantitatively similar for men and women. However, the effects diverge for labor force participation, where the differential growth for men is about 60 percent of that for women. This pattern is consistent with appliances disproportionately reducing women's time spent on household production, as documented in Fact 1, thereby having a larger impact on female labor supply.

To provide additional evidence that appliances reduced time spent on household production and enabled increased female labor force participation, we examine how the effects vary by marital status. This distinction is important, as married women typically shoulder a larger share of household responsibilities, and thus we expect to observe larger effects among them if the appliance mechanism is at work. Appendix Table A.5 reports the results for appliance ownership, comparing single and married individuals, while Appendix Table A.6 focuses on labor force participation. Each column estimates equation (1) on a different sample, including all controls from our baseline specification.

As shown in Columns (1) and (2) of Appendix Table A.5, both single and married individuals experience similar increases in appliance ownership. However, Appendix Table A.6 reveals striking differences in how this translates to labor force participation. For women, the increase is 23 percentage points for married individuals compared to 18 percentage points for single individuals. In contrast, the effect for men is 14 percentage points regardless of marital status. This pattern is consistent with the appliance mechanism: marital status increases the differential effect for women but not for men, as expected if married women bear disproportionate household responsibilities and thus have more scope to reallocate time when appliances become available.

Robustness Checks. Our results are robust across several specifications. First, Appendix Table A.4 shows that our findings remain stable when restricting the sample to individuals aged 25-50, addressing potential concerns about early retirement patterns that may differ by gender. Second, one might worry that cheaper appliances may have fostered the migration of working age households, or those with a high propensity to work more generally, to regions with high access to utilities. If this were the case, our observed effects could reflect changes in population composition rather than shifts in household decisions. As shown in Appendix Table A.7, however, we find no evidence that access trends drive migration from low-access districts to areas with better access. In fact, it does not significantly influence migration overall, either from low-access districts or from high-access ones. Third, we do not observe the same patterns for appliances that do not save time on household chores. As a placebo test, Appendix Table A.8 examines television ownership. Unlike time-saving appliances, televisions should not systematically affect the time available for market work. Consistent with this, we find that baseline utility access has little to no effect on television ownership, with patterns that are muted and in some cases opposite to those for time-saving appliances. Importantly, the differential effect by marital status observed for refrigerators and washing machines does not appear for televisions, supporting the interpretation that our main results operate through the time-saving channel rather than reflecting general appliance consumption. Finally, we corroborate our results using data from the *Encuesta Nacional de Hogares* (ENAHO). This provides an important robustness check, as the levels and trends of labor force participation in the ENAHO differ from the census data. Notably, while ENAHO reports higher baseline levels of labor force participation, the increase during the overlapping period (1998-2017) is considerably more muted. As shown in Appendix Table A.9, the relationship of baseline utility access with appliance ownership is similar to our census-based estimates, as is the correlation with appliance purchases over the last year. The association with labor force participation is significant only for women, consistent with our main findings. Moreover, Appendix Table A.10 confirms our results regarding marital status: the labor force participation association is concentrated among married women, whereas the relationship with ownership is similar for both single and married individuals.

3.4 Fact 4: The Evolution of Ownership and Labor Force Participation across Cohorts

To complement the evidence we have presented so far, this fact exploits variation across birth cohorts in their exposure to declining appliance prices. The key insight is that women who experienced the price decline at younger ages had more time to benefit from the long-term labor market advantages of appliance adoption. We implement a cohort-based comparison: we hold age fixed and compare appliance ownership and labor force participation across birth cohorts within the 30-45 window, then replicate the same cohort comparison within the 50-65 window. Taken together, these two age-specific cohort comparisons allow us to assess whether earlier exposure to cheaper appliances generated persistent differences in both ownership and labor force participation later in life.

We frame this analysis as a difference-in-differences design. Both high- and low-access regions experienced general increases in appliance ownership and female labor force participation over time, consistent with the nationwide trends we have documented above. However, the identifying variation here comes from the additional increase in high-access regions relative to low-access regions, and how this differential varies between the two age groups. If appliances enabled this transformation, we should observe a larger differential for women aged 30-45, who were younger when appliance prices fell and could benefit from adoption over a longer time horizon, compared to women aged 50-65.

Our specification using data aggregated at the province-by-cohort level is as follows:

$$y_{c,p} = \beta\,[\text{Access Bin}_p \times \text{Cohort}_c] + \text{Cohort}_c + \text{Province}_p + \phi' X_{c,p} + \varepsilon_{c,p} \tag{2}$$

where c stands for cohort, and p for province. We divide provinces into terciles based on baseline access to water and electricity, denoted by Access Bin_p. Cohort_c represents groups of consecutive birth cohorts (which vary depending on the age group of analysis), and Province_p refers to province fixed effects. $X_{c,p}$ is a set of controls at the cell c, p level, including the share of urban population, gender-specific exposure to imports and exports, $\text{Trade}_{gp,t}$, as well as the number of people in the cell. Finally, $y_{c,p}$ is the cell share of either (i) appliance ownership (washing machine, refrigerator, or both) or (ii) labor force participation. The coefficient β captures our difference-in-differences estimator: it measures how the relationship between cohorts and outcomes varies by baseline access level. Specifically, β tells us the differential change in each outcome across cohorts, in high-access regions compared to low-access regions.

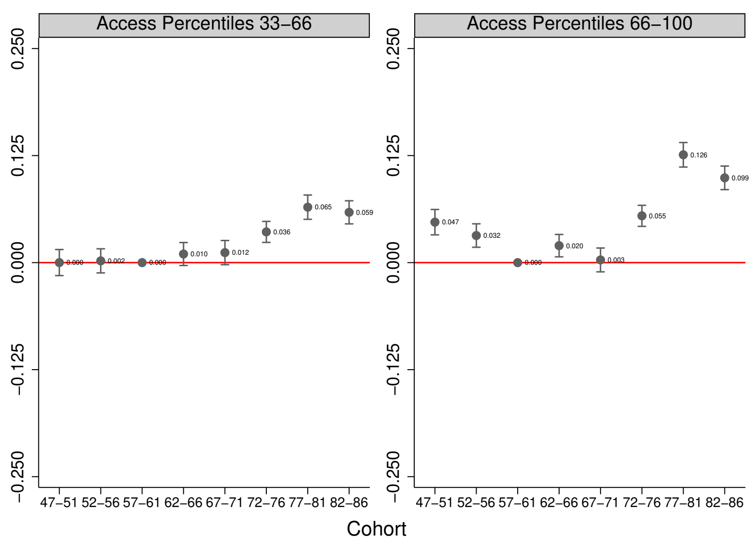
For the remainder of this section, we focus on married women, for whom our previous findings suggest the relationship between appliance ownership and female labor force participation is most pronounced.

Women aged 30 to 45. We begin our analysis with women aged 30 to 45, a critical period in the life cycle for labor market attachment and household formation. The key to our identification is comparing women in this age range observed at different points in time: those in the 1993 census faced high appliance prices throughout their prime working years, while those in the 2007 and 2017 censuses experienced the price decline during these formative years. If appliances enable female labor force participation, the differential between high-and low-access regions should be larger for cohorts exposed to cheaper appliances during their prime working years.

We frame this comparison as follows. Cohorts born between 1947 and 1961 were aged 30-45 in 1993, before appliance prices declined substantially. These cohorts serve as our baseline, having made their long-term labor market decisions in an environment of expensive appliances. In contrast, cohorts born between 1962 and 1986 were aged 30-45 in either 2007 or 2017, after appliances had become considerably cheaper. These younger cohorts could incorporate cheaper appliances into their labor market decisions from early in their careers. Appendix Table A.11 details the construction of these cohort groups.

Figure 4 shows the results of estimating equation (2) using ownership as the dependent variable. The figure shows the differential rate of appliance ownership for each cohort relative to our omitted category (the 1957-61 cohort in low-access provinces). The results reveal a clear pattern: younger cohorts exhibit larger differentials, which are particularly pronounced in high-access provinces. For example, appliance ownership is 9 percentage points higher for women aged 30-45 observed in 2017 in high-access provinces, compared to those observed in 1993 in low-access provinces.

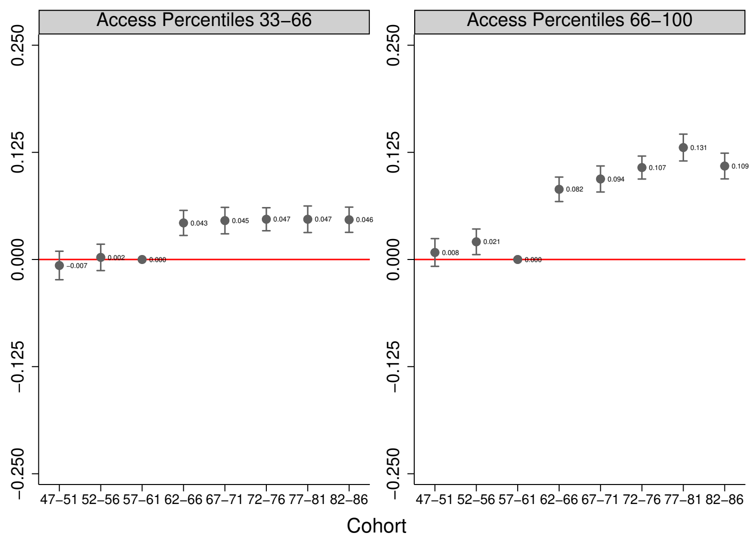
Figure 4: Cohort Analysis - Appliance Ownership 30-45-year-olds



Notes: This figure shows the results of the estimation of equation (2) where the dependent variable is ownership of appliances (refrigerator or washing machine). The x-axis denotes the cohort (birth year) while the y-axis refers to the estimated effect. The panels are divided by percentiles of baseline utilities at the province level. All the effects are evaluated for individuals within 30-45 years old.

Figure 5 repeats our analysis, but considering female labor force participation as the dependent variable. The differential in female labor force participation, relative to the 1957-61 cohort in low access regions, mirrors the trends in ownership. The differential is particularly large for cohorts residing in areas with good access to services, where labor force participation was up to 10 percentage points larger.

Figure 5: Cohort Analysis - Female Labor Force Participation 30-45-year-olds

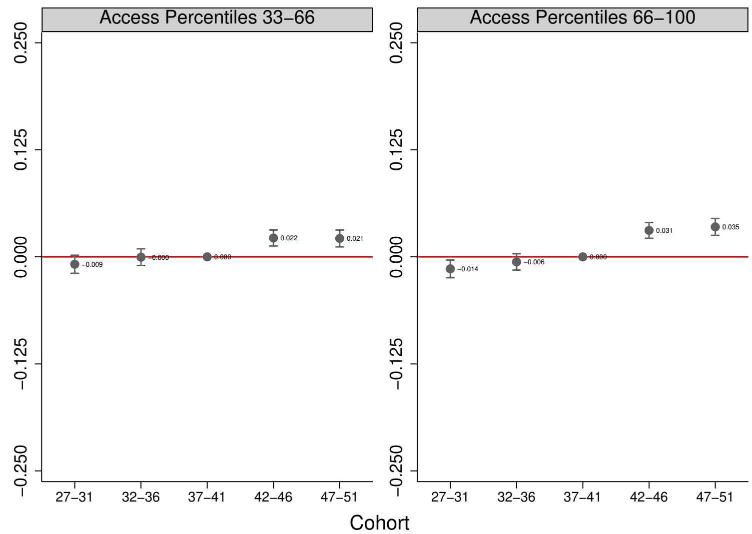


Notes: This figure shows the results of the estimation of equation (2) where the dependent variable is labor force participation. The x-axis denotes the cohort (birth year) while the y-axis refers to the estimated effect. The panels are divided by percentiles of baseline utility coverage at the province level. All the effects are evaluated for individuals within 30-45 years old.

Women aged 50 to 65. Second, we investigate whether these patterns differ by age. We use a similar specification, now focusing on women aged 50-65, who are nearing retirement. The key difference is that these women, regardless of when they are observed, were older when appliance prices declined and thus had less time to benefit from cheaper appliances over their working lives.

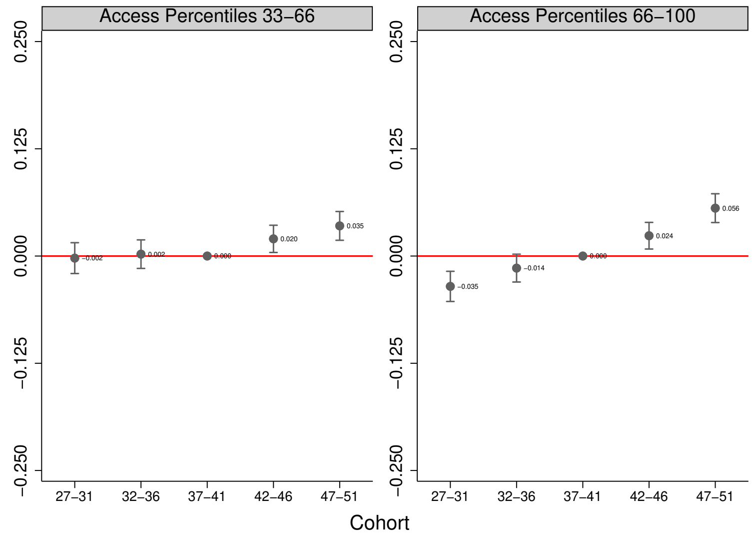
The baseline cohorts comprise women born between 1927 and 1941, who were aged 50-65 in 1993. The comparison cohorts include those born between 1942 and 1951, who were aged 50-65 in 2007. Figures 6 and 7 present the results. We find smaller effects for both appliance ownership and labor force participation compared to the 30-45 age group. This pattern is consistent with our interpretation: women who experienced the price decline later in their careers had less scope to adjust their long-term labor market attachment and household technology adoption, even when exposed to the same price changes.

Figure 6: Cohort Analysis - Appliance Ownership 50-65-year-olds



Notes: This figure shows the results of the estimation of equation (2) where the dependent variable is ownership of appliances (refrigerator or washing machine). The x-axis denotes the cohort (birth year) while the y-axis refers to the estimated effect. The panels are divided by percentiles of baseline utility coverage at the province level. All the effects are evaluated for individuals within 50-65 years old.

Figure 7: Cohort Analysis - Female Labor Force Participation 50-65-year-olds



Notes: This figure shows the results of the estimation of equation (2) where the dependent variable is labor force participation. The x-axis denotes the cohort (birth year) while the y-axis refers to the estimated effect.The panels are divided by percentiles of baseline utility coverage at the province level. All the effects are evaluated for individuals within 50-65 years old.

Moreover, we do not observe these cohort patterns for appliances that do not save household production time. Appendix Figures A.1 and A.2 show no significant differential effects for television ownership, mirroring the placebo results from Fact 3.

In summary, the evidence presented in this section provides suggestive support for a channel linking trade to female labor supply through household appliances. We document that female labor force participation and appliance ownership surged simultaneously in Peru, driven by trade-induced price declines that made imported appliances accessible. Regions with better baseline utility infrastructure experienced larger increases in both appliance ownership and female labor force participation, with effects concentrated among married women. These patterns are strongest for cohorts who experienced the price decline earlier in their working lives, consistent with appliances being durable investments with long-term labor market consequences. While these correlations do not establish definitive causality, they point to international trade as an important enabling factor for female labor supply in developing countries where domestic production of such technologies is limited. Building on these insights, the next section develops a model to quantify the potential aggregate impact of this mechanism.

4 Model

In this section, we present a model to quantify the aggregate effects of a reduction in the import prices of appliances. In describing the model and in taking the model to the data, we focus on households consisting of a man and a woman residing in a small open economy.

4.1 Environment

The model features a collection of small open economies that are isolated from one another, each trading only with the rest of the world. For ease of exposition, we describe a single representative region, though the full quantitative analysis features all such regions operating independently. This structure allows us to take the prices of certain goods, particularly appliances, and the interest rate as given.[7] Time is discrete and indexed by t, but we omit this index when it does not introduce confusion.

Demography and Household Composition. Each generation lives J periods, and at any given time, there are J generations alive. Households consist of a man and a woman, and at each time there is a mass ν of households, equally distributed across generations.

Preferences, States, and Budget Constraints. There are three types of goods: market goods m, home goods g, and household appliances. Throughout, we use the price of market goods as the numeraire, and set it to one.

A household's state each period is denoted by $(j, a, d, \ell) \in \mathcal{J} \times \mathcal{A} \times \mathcal{D} \times \mathcal{L}$, where j represents the household's age, a denotes the household's assets in units of the market good, d indicates the appliance ownership status (where $d = 0$ if the household does not own an appliance, $d = 1$ if the household purchases an appliance in the current period (paying the sunk cost), and $d = 2$ if the household already owns an appliance (having paid the sunk cost in a previous period)), and ℓ indicates whether the woman works in the labor market ($\ell = 1$), or stays at home ($\ell = 0$). We assume that men are employed in the labor market in every state.

The period utility function for the household is given by:

$$u(m, g) = \left[\mu^{\frac{1}{\eta}} m^{\frac{\eta-1}{\eta}} + (1-\mu)^{\frac{1}{\eta}} g^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}, \tag{3}$$

[7] The home economy is the limit when the population size goes to zero relative to that of the rest of the world, as shown in Alvarez and Lucas (2007). Appendix C.1 shows how we obtain this limit, starting from a standard quantitative model with many countries.

where μ measures the preference for market goods and η is the elasticity of substitution in consumption between market and home goods. The utility function does not depend on the household's state.

Time Allocation. Each household member is endowed with one unit of time. The time men spend in the household is fixed at zero, and their time in the labor market is fixed at one. The household jointly decides whether the woman participates in the labor market or stays at home. If the woman in a household devotes h_f units of time to the labor market, the household income is

$$w_m + w_f \cdot h_f,$$

where w_m and w_f are wages for men and women, respectively. The total time devoted to household production is $l_f = 1 - h_f$.

If the woman stays at home ($\ell = 0$), she devotes no time to the labor market ($h_f = 0$) and all her time to household production ($l_f = 1$), yielding total household income of w_m.

The Household's Problem. The following Bellman equation represents the dynamic problem of a household in state (j, a, d, ℓ) at the beginning of the period

$$V_{jk}(a) = \max_{m,g,a' \geq 0} \left\{ \ln u(m,g) + \beta \mathbb{E}_{\varepsilon} \max_{k' \in \mathcal{K}_k} \left[V_{j+1,k'}(a') + \varepsilon_{k'} \right] \right\}, \tag{4}$$

subject to the budget constraint

$$a' = Ra + w_m + w_f h_f - m - \mathbb{I}_k . f, \tag{5}$$

the home production technology

$$g_k = b_k \cdot l_f, \tag{6}$$

and the time constraint $1 \geq l_f \geq 0$, with $h_f = 1 - l_f$.

In the period budget constraint (5), R is the gross interest rate that households get on the assets a that they carry over from the previous period, a' is the choice of assets for the next period, and $\mathbb{I}_k$ is an indicator for whether the household purchases an appliance this period, which requires paying f units of market goods. In turn, home goods are produced according to equation (6), where l_f is time in home production and b_k is labor productivity in home production.

We highlight four important features of our formulation of this problem. First, in the expression above, we use the shorthand $k \in \mathcal{K} = \{1, \ldots, 6\}$ to denote discrete states (e.g.

own appliance and work).[8] Second, a household's state k is predetermined at the beginning of the period, so the household first makes a decision of how much to save or borrow going into the next period, a'. After that, it draws a vector of taste shocks $\{\varepsilon_{k'}\}$ i.i.d, from a Type-I Extreme Value distribution with parameters (G_k, ρ). Conditional on that draw, the household decides its state for next period, k'.[9] Third, we assume that individuals who are born in a given period start with zero assets, and choose optimally the state k in which to begin. Fourth, we normalize the terminal values for age $J+1$ to zero and impose that households must keep positive assets at all times, $a \geq 0$.

In addition, note that transitions are only possible to states $k' \in \mathcal{K}'_k$, a function of the current state k, reflecting that (i) when the household purchases an appliance ($d = 1$), it necessarily moves to $d = 2$ in the next period, and (ii) if the household does not have an appliance ($d = 0$), it cannot transition to $d = 2$.

Market-goods Technology. Market goods are produced by an aggregate technology, given by

$$Y_t = Z_t H_t, \tag{7}$$

where Z_t is an aggregate productivity shifter and H_t is a constant-elasticity index of time supplied by men and women:

$$H_t = \left(\alpha^{1/\sigma} H_{t,m}^{\frac{\sigma-1}{\sigma}} + (1-\alpha)^{1/\sigma} H_{t,f}^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}. \tag{8}$$

In equation (8), $H_{t,m}$ and $H_{t,f}$ represent aggregate hours worked by men and women, and σ is the elasticity of substitution between male and female labor supply.

4.2 Aggregation

To describe the equilibrium, we begin by aggregating household decisions to derive the population's law of motion. Using the properties of Type-I shocks, we can rewrite the Bellman equation (4) as follows:

$$V_{jk}(a) = \max_{a' \geq 0, 1 \geq h_f \geq 0} \left\{ \ln u\left(Ra + w_m + w_f h_f - a' - \mathbb{I}_k f, b_k l_f\right) + \beta\rho \log \Psi_{j+1,k}(a') \right\},$$

[8] The set $\mathcal{K}$ lists the elements of the set $\mathcal{D} \times \mathcal{L}$ in order. That is, the state $k = 1$ denotes (no appliance, no labor force participation), $k = 2$ denotes (no appliance, labor force participation), $k = 3$ denotes (purchasing an appliance, no labor force participation), $k = 4$ denotes (purchasing an appliance, labor force participation), $k = 5$ denotes (ownership, no labor force participation) and $k = 6$ denotes (ownership, labor force participation).

[9] The timing assumption is useful for tractability, since the choice of assets is independent of the shock ε_k, which makes the savings policy function depend only on the current state a, j, k.

where

$$\Psi_{j+1,k}\left(a'\right) \equiv \sum_{k'\in\mathcal{K}_k} \exp\left(\frac{1}{\rho}G_{k'}\right) \exp\left(\frac{1}{\rho}\left(V_{j+1,k'}\left(a'\right)\right)\right)$$

captures the expected value of having decided to keep a' assets for the next period.

For a given asset choice, denoted by $x_{j,k}\left(a\right)$, the household's probability to choose state k' for age $j+1$, if currently in state k is given by

$$\lambda_{j+1,kk'}\left(a\right) = \frac{\psi_{j+1,k'}\left(x_{j,k}\left(a\right)\right)}{\Psi_{j+1,k}\left(x_{j,k}\left(a\right)\right)}, \tag{9}$$

where

$$\psi_{j+1,k'}\left(x_{j,k}\left(a\right)\right) = \exp\left(\frac{1}{\rho}G_{k'}\right) \exp\left(\frac{1}{\rho}V_{j+1,k'}\left(x_{j,k}\left(a\right)\right)\right). \tag{10}$$

In expressions (9) and (10), the dispersion parameter ρ serves as an inverse measure of the sensitivity of transitional probabilities to future values, given the optimal choice of assets as determined by the policy function $x_{j,k}\left(a\right)$.

Meanwhile, the optimal asset choice satisfies the Euler equation given below:

$$\frac{1}{u\left(m,g\right)} \frac{\partial u\left(Ra + w_m + w_f h_f - x_{j,k}\left(a\right) - \mathbb{I}_k f, b_k l_f\right)}{\partial m} = \beta\rho \frac{1}{\Psi_{j+1,k}\left(x_{j,k}\left(a\right)\right)} \frac{\partial \Psi_{j+1,k}\left(x_{j,k}\left(a\right)\right)}{\partial a'},$$

which states that the household chooses savings to equate the marginal utility of consuming market goods today with the expected marginal utility of saving for the next period. The expectation is taken over the distribution of shocks ε_k, which are unknown to the household at the time of the decision.

When the woman participates in the labor market, this Euler equation is coupled with an optimal static choice of h_f, which equates the benefit of working an additional hour, in terms of purchasing additional market goods, with the cost in terms of home goods

$$\frac{\partial u\left(Ra + w_m + w_f h_f - x_{j,k}\left(a\right) - \mathbb{I}_k f, b_k l_f\right)}{\partial m} \cdot w_f = \frac{\partial u\left(Ra + w_m + w_f h_f - x_{j,k}\left(a\right) - \mathbb{I}_k f, b_k l_f\right)}{\partial g} \cdot b_k,$$

but recall that if the state k is such that the woman does not work in the labor force, the household time choice is restricted to $l_f = 1$, $h_f = 0$.

Aggregate Law of Motion. To characterize the law of motion for the aggregate population, let $n_{jk,t}\left(a\right)$ denote the share of individuals in year t, aged j, in state k, and owning assets a.

The law of motion is then given by

$$n_{jk,t}(a) = \int_{\mathcal{A}} \sum_{k'} \lambda_{j,k'k,t}(z)\, \gamma_{j,k',t}(a,z)\, n_{j-1k',t-1}(z)\, dz + \bar{n}_{jk,t}(a), \tag{11}$$

where $\gamma_{j,k,t}(a,z)$ is an indicator equaling one if $x_{j,k,t}(z) = a$ and $\bar{n}_{jk,t}(a)$ represents the flow of households, capturing age-1 individuals, who are born in period t.

Labor Markets. Given the population $n_{jk,t}(a)$, we can derive the optimal labor supply in each period by aggregating across households in each state. Accordingly, the total supply of hours for men and women is given by:

$$H_{m,t} = \sum_j \sum_k \int_{\mathcal{A}} 1 \cdot n_{jk,t}(a)\, da \tag{12}$$

$$H_{f,t} = \sum_j \sum_k \int_{\mathcal{A}} h_{f,jk,t}(a) \cdot n_{jk,t}(a)\, da. \tag{13}$$

Demand for Appliances and Aggregate Savings. We can compute the total demand for new appliances as

$$D_t = \sum_j \sum_{k \in \mathcal{K}_{d=1}} \int_{\mathcal{A}} n_{jk,t}(a)\, da,$$

where $\mathcal{K}_{d=1}$ denotes the states in which appliances are purchased, and aggregate assets carried from period $t-1$ to period t as

$$A_t = \sum_j \sum_k \int_{\mathcal{A}} x_{jk,t-1}(a)\, n_{jk,t-1}(a)\, da.$$

Recall that under the assumption of a small open economy, the interest rate R is given, and the current account adjusts accordingly.

4.3 Equilibrium

We begin by defining a static equilibrium, followed by a dynamic equilibrium, for our small open economy. Appendix C explains in detail how we obtain this system as the limit of a quantitative model in which the size of the country, ν, goes to zero (see e.g. Alvarez and Lucas, 2007). Because this is a small open economy equilibrium, all aggregate quantities in the definition below, $H_{t,m}$, $H_{t,f}$, and H_t are scaled as a fraction of ν.

4.3.1 Static Equilibrium.

Given aggregate labor supply choices $\{H_{m,t}, H_{f,t}\}$, a static equilibrium at time t consists of wages $\{w_{m,t}, w_{f,t}, W_t\}$ and an hours aggregator, H_t, such that labor markets clear:

$$W_t = B_t \left(H_t\right)^{-1/\theta}, \tag{14}$$

$$H_{t,m} = \alpha \left(\frac{w_{m,t}}{W_t}\right)^{-\sigma} H_t \tag{15}$$

$$H_{t,f} = (1-\alpha) \left(\frac{w_{f,t}}{W_t}\right)^{-\sigma} H_t \tag{16}$$

and the aggregator H_t satisfies (8). In equation (14), B_t represents an aggregate demand shifter, defined in Appendix equation (C.11).

4.3.2 Dynamic Equilibrium.

Given initial conditions n_0, exogenous inflows of young people $\{\bar{n}_t\}_t$, the total number of households ν_t, pricing functions $\{w_{m,t}, w_{f,t}, W_t\}_t$, and external forces $\{B_t, p_t, f_t\}$, a dynamic equilibrium consists of paths for household counts $\{n_t\}_t$, and labor supplies by gender $\{H_{t,m}, H_{t,f}\}_t$ such that the law of motion (11) holds and the hour aggregations are satisfied.

4.4 Characterizing Household Behavior

Next, we examine how a household responds to a permanent, unexpected change in the price of appliances, which takes effect in period t. To show transparently the key mechanisms, as well as the key parameters and data moments that inform this response, we analyze a model in which households live for two periods and there are no savings. Appendix C.2 contains the proofs and further details.

We begin by defining the labor force participation rate, φ_t, which is the share of households in which the woman works in the labor market:

$$\varphi_t = \sum_j \underbrace{\sum_{k \in \mathcal{K}_{\ell=1}} n_{jk,t}}_{\equiv n_{j,t} \cdot \varphi_{j,t}}, \tag{17}$$

where $\mathcal{K}_{\ell=1}$ is the set of states in which the woman works, i.e., $k = 2, 4, 6$, and $\varphi_{j,t}$ is the participation rate in households of age j at time t.

4.4.1 Effects on Impact

Age-1 Households. We begin by characterizing labor force participation of age-1 households which, under our assumptions on entry, is given by[10]

$$\varphi_{1,t} = \sum_{k \in \mathcal{K}_{\ell=1}} \lambda_{j,1k,t}, \tag{18}$$

i.e., all those young households that decide to start life working.

Consider next the impact of a change in appliance prices, f. The household's response will reflect three main forces: (i) changes in lifetime utility, (ii) initial shares across states, and (iii) the elasticity ρ. In particular,

$$\frac{\partial \varphi_{1,t}}{\partial f} = \frac{1}{\rho}\left[\left(\sum_{k=2,4} \lambda_{1,1k,t} \partial_f V_{1k,t}\right) - \left(\sum_{k=2,4} \lambda_{1,1k,t}\right) \cdot \left(\sum_{k'=1,2,3,4} \lambda_{1,1k',t} \partial_f V_{1k',t}\right)\right], \tag{19}$$

Recall that $\lambda_{j,k'k,t}$ denotes the transition probability of a household of age j, currently in state k', to state k, at time t. Recall as well that states $k = 3$ and $k = 4$ are those in which the household purchases an appliance this period.

Consider first the role of the changes in lifetime utility, captured by the derivatives $\partial V_{1k,t}/\partial f$. These changes denote how incentives respond to a change in appliance prices. Households where the woman does not work, yet purchase appliances ($k = 3$), have lower incomes; but households that purchase an appliance while the woman works ($k = 4$) also benefit directly. All other states, $k = 1, 2$, do not experience a benefit at t, but at $t + 1$, and thus the incentives to transition to those states tend to respond more weakly. Second, consider the role of the initial observed shares. The baseline continuation value of having an appliance and working is larger, given the substantial productivity gain that appliances entail. This is especially true for young and low-wealth households, in which the marginal value of additional income is large.[11] Such forces are captured in the differences in the initial shares, $\lambda_{1,1k,t}$, which reflect precisely those continuation values (see equations (9) and (10)). The balance of changes in lifetime utility and the initial observed shares determines whether this derivative is positive. For example, equation (19) shows that the derivative $\partial\varphi_{1,t}/\partial f$ is more likely to be positive when $\lambda_{1,k_0 3,t}$ is small (i.e., the continuation value of having appliances and not working is relatively low) or when $\partial V_{13,t}/\partial f$ is small in absolute

[10]Recall we assume all households start life with not owning appliances nor working, and choose their initial state k for $j = 1$ optimally.

[11]Note that as households accumulate wealth, the value of working decreases and households value home production relatively more. This behavior is absent in this analysis, but present in our quantification.

value.[12] Third, note that given initial shares and changes in lifetime utility, the impact on labor force participation is scaled by $1/\rho$, the inverse measure of dispersion of idiosyncratic Type-I shocks.

Age-2 Households. To characterize households in their second period of life, note first that female participation rate is now

$$\varphi_{2,t} = \sum_{k'} \sum_{k \in \mathcal{K}_{\ell=1}} \lambda_{2,k'k,t} \cdot n_{1k',t-1}, \tag{20}$$

where $n_{1k',t-1}$ is predetermined at the time of the shock. Then,

$$\frac{\partial \varphi_{2,t}}{\partial f} = \left\{ \sum_{k'=1,2} n_{1k',t-1} \left(\frac{1}{\rho} \left[\lambda_{2,k'4,t} \frac{\partial V_{24,t}}{\partial f} - (\lambda_{2,k'2,t} + \lambda_{2,k'4,t}) \left(\lambda_{2,k'3,t} \frac{\partial V_{23,t}}{\partial f} + \lambda_{2,k'4,t} \frac{\partial V_{24,t}}{\partial f} \right) \right] \right) \right\}, \tag{21}$$

where the term in square brackets is analogous to that in equation (19), and it is positive—and thus the change in labor force participation following the shock is positive—when the share of households who buy appliances, $\lambda_{2,k'3,t}$, without working is low or when the direct impact on those households utility at the time of the shock, $\partial V_{23,t}/\partial f$, is small.

4.4.2 Effects Following the Shock

Although the shock is a permanent reduction in the price of appliances, its effects accumulate over time, due to the cohort structure of the model. To understand why, note first that in equation (18), labor force participation of age-1 households only depends on contemporaneous decisions (i.e., there are no lagged variables given that the initial asset allocation is exogenous and fixed at zero). Equation (20), in contrast, shows that age-2 participation rates depend on the choices made in the previous period, captured by the term $n_{1k',t-1}$. In particular, an increase in participation at age 1 in period $t = T$ will show up as increased participation at age 2 in all periods $t > T$, if those households that purchase appliances tend to remain in the labor force (i.e., if $\lambda_{j,k4,t} > \lambda_{j,k3,t}$). Thus, the effects of the permanent shock accumulate over time as younger cohorts make their way through the age distribution, after having made different decisions while young.

[12] In fact, in the extreme case when $\lambda_{1,1k,t} = 0$ for $k = 1, 3$ (i.e, the value of not working is quite low), the derivative in equation 19 is always positive.

4.4.3 Intensive and Extensive Margins of Labor Force Participation

Finally, our model allows for separate response of the extensive and intensive margins of labor force participation. We have already discussed the extensive margin decisions and the conditions under which appliance ownership is complementary with labor force participation. We now discuss the response of the intensive margin of hours worked when a household acquires an appliance.

The response of hours worked depends crucially on the degree of complementarity between household and market goods, measured by the elasticity η in the period utility (3). In our model, hours worked are given by

$$h_{f}^{*}, = 1 - \frac{(1-\mu)^{1/\eta}}{b_k} \left(\frac{w_f/b_k}{P}\right)^{-\eta} \frac{w_f + y_k}{P} \tag{22}$$

where $y_k = w_m + Ra - a'$ is cash at hand for the household, and the denominator, P, is the household price index

$$P = \left[\mu + (1-\mu)\left(w_f/b_k\right)^{1-\eta}\right]^{\frac{1}{1-\eta}},$$

where we have used that the price of market goods is normalized to 1.

It is straightforward to show that, in equation (22), the amount of hours worked increases in b_k, labor productivity in home production (conditional on state k), if $\eta < 1$. The reason is that appliance ownership increases the household's productivity in the production of home goods. When home and market goods are complements, the household wants to increase consumption of both, which requires releasing labor to the market.

Before moving on to the quantification, note that the analytical characterization we provide in this section abstracts from general equilibrium forces, such as reductions in the aggregate wage that might shift some women to drop out of the market. Having established the analytical properties of our model, as well as what are the key parameters that govern the response to changes in appliance prices, we turn to evaluating quantitatively the shock that Peru experienced between 1993 and 2017.

5 Quantification

To calibrate the model, we use data from the 1993 census, replicating the sample and variation we use in Section 3. We thus focus on households consisting of a man and a woman, in which the woman is aged 25 to 65 years old. We bring the model to 187 regions, which are provinces in the Peruvian data. We calibrate the model with a yearly frequency and a household lifespan of 40 years, assuming that the economy was in a steady state in 1993. Beginning in 1994, we introduce a permanent, unexpected 70 percent reduction in appliance prices relative to average national income. We describe the procedure briefly below, and relegate details to Appendix D.

Our quantitative model departs in two main respects from the simple model described in Section 4. The first is that we allow for some households in each region i to have access to utilities, while others do not. Households that have access to utilities behave as described above; households that do not have access face a reduced state space, as they must always satisfy $d = 0$ (i.e., they cannot own appliances). The second difference is that we allow for productivity to differ across regions in a parametric way. Specifically, we allow for the aggregate demand shifter to take the following form, $B_i = \bar{B}\left(\nu_i / \sum_{i'} \nu_{i'}\right)^{\varepsilon}$, where $\bar{B}$ is defined as in Appendix equation C.11 and $\nu_i / \sum_{i'} \nu_{i'}$ refers to regional population as a share of Peru's total.[13] Both regional characteristics are exogenous and taken directly from the data, aligning the quantitative model with our empirical strategy by capturing cross-regional variation in baseline utility infrastructure and economic development.

5.1 Calibration Procedure

This section outlines our calibration approach. We divide the parameters to be calibrated into two groups. The first group includes those parameters that we calibrate externally, with guidance from the literature. We describe these parameters in Panel A of Table 4. The second group consists of parameters that we identify by matching moments from the Peruvian data. These moments and parameters are listed in Panel B of Table 4.

A few parameters in Table 4 require a more detailed explanation.

Appliance Productivity. We set the value of b to 10, striking a balance between capturing the substantial productivity gains from appliances documented in the literature and maintaining conservative estimates given the lack of direct calibration targets for this parameter.[14] We examine the sensitivity to this parameter choice in Section 5.4.

[13]This formulation has a long tradition in the spatial economics literature (see, for example, Allen and Arkolakis, 2014). In the case of Peru, De la Roca, Parkhomenko, and Velásquez-Cabrera, 2023, have documented it provides a good fit to the data.

[14]Unfortunately, we lack sufficient moments to calibrate this parameter directly from our data. Greenwood, Seshadri, and Yorukoglu (2005) document substantial labor productivity gains in home production from appliances and, based on their calibration, we interpret labor-augmenting technological progress as increasing by a factor of 28 when households adopt appliances. However, because their model structure differs from ours, we do not directly adopt this value and instead set $b = 10$ as a more conservative benchmark.

Table 4: Calibrated Parameters

Panel A. External Calibration			
Parameter	**Notation**	**Source**	**Value**
Discount factor	β	Greenwood et al. (2005)	0.95
EoS between men and women	σ	Johnson and Keane (2013)	5
Agglomeration economies	ε	De la Roca, Parkhomenko, and Velasquez (2023)	0.1
Returns on assets	R	Greenwood et al. (2005)	1.05
EoS between market and non-market goods	η	Comin et al. (2021)	0.5
Labor productivity w/ appliance	$b\,(d>0)$	See discussion in text	10
Labor productivity w/o appliance	$b\,(d=0)$	See discussion in text	1
Panel B. Calibration in Steady State			
Fundamentals	**Notation**	**Target**	**Value**
Price of appliances	f	Choice of units	0.392
Goods prices	p	Choice of units	1
Exogenous TFP	$\bar{B}$	$f/\bar{W}_t = 0.392$ in 1993 (trade and income data)	1.51
Initial distribution	$\bar{n}_{0,t}{}^*$	Population Census in 1993	-
Relative male labor productivity	α	Ratio of wages by gender, 1998	0.917
Location of EV shocks	G_k	Census 1993 Agg Ownership and LFP rates	$G_{own} = -2.20$, $G_{lfp} = -4.01$
Preference for market goods	μ	Share of market goods in "full income" (Lima)	0.71
Shape parameter of EV shocks	ρ	Variance of odds ratios	0.10

Preferences for Market Goods. We calibrate $\mu = 0.71$ to target the share of expenditure on market goods in households with utility access in Lima during the baseline year. This parameter governs how households allocate "full income"—defined as the income that would accrue if both partners worked full time—between market and home goods. We focus on Lima because prior work using living standard measurement surveys (Yamada, 2005) has measured hours and wages there with reasonable precision, allowing us to construct reliable estimates of expenditure shares.[15]

Average Taste Shifters. Although the model features heterogeneity across ages and regions, we opt to target only countrywide aggregates—overall labor force participation and appliance ownership rates—by calibrating two location parameters of the taste shock distribution: G_{work} (governing labor force participation) and G_{own} (governing appliance ownership).[16]

Elasticity of Substitution. In our formulation, the household combines goods produced in the market (and in our small open economy formulation, traded goods produced abroad) with services produced at home. Our preferences, therefore, resemble those in the structural change literature , and following this literature, we set the elasticity of substitution $\eta = 0.5$(e.g. Comin, Lashkari, and Mestieri, 2021) .

Dispersion of Type-I Shocks. We calibrate ρ using the fact that the cross-sectional variance in appliance ownership observed in the baseline calibration is decreasing in ρ. Specifically, we compute, across provinces, the varianceof the log-odds of appliances ownership among households conditional on labor force participation. Note that, since we target only average ownership and FLFP at the country level, this moment is available as a guide to calibration.[17]

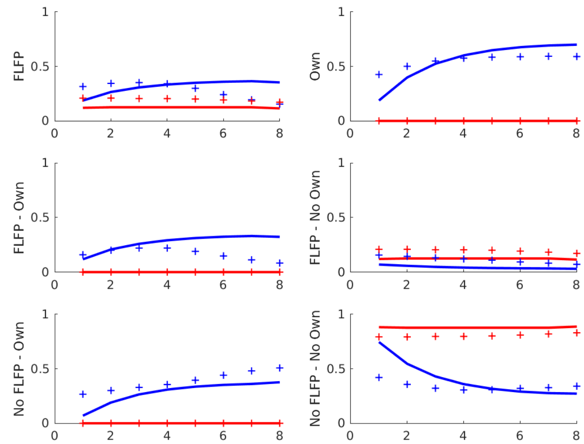
Savings. The computational burden of solving the model with savings, many states, and many regions is large. For this reason, we consider only a savings grid ranging from 0 to a maximum of 20% of average national income.

[15]We condition on utility access because this ensures a monotonic mapping between the targeted moment and the parameter μ.

[16]Keeping a low resolution in our calibration—i.e., not targeting all observable shares by household state, age, and province—allows us to assess the fit of the model at the baseline and estimate the parameter ρ.

[17]We perform a grid search over ρ, as described in Appendix D. At our preferred value of $\rho = 0.1$, the variance of the log-odds of appliances ownership is 0.8, whereas the target moment is about 2.6. At a value of $\rho = 0.04$ the model matches this variance. However, because the model abstracts from many economic incentives for appliance ownership and labor force participation, we prefer not to match this moment exactly to avoid overstating our quantitative results. In addition, $\rho = 0.1$ is the lowest value for which our model is numerically well behaved.

Figure 8: Baseline Fit of Aggregate Shares by Age



Notes: Each panel corresponds to an observable cell in the data. Within each panel, the blue crosses correspond to the data, while the red line corresponds to the model simulation.

5.2 Untargeted Moments

Our calibration explicitly targets a number of outcomes, as described above. A moment we do not target directly is the ratio of hours in the household for women who have appliances, relative to those who do not. As described in Table 1, these savings are about 13 percent in the data (1 - 5.9/6.8). Our calibration delivers time savings of about 31 percent. Although this moment is larger than in the data—a bit above twice as large—given our simple calibration, we consider it a demonstration that the model delivers plausible behavior. The fact that there are time savings in the model, moreover, responds to the complementarity of market and home goods in preferences.

The model also does a reasonable job of capturing the average choices of households over the lifecycle. Figure (8) shows that the model captures relatively well all the observable cells formed by combinations of the states defined by ownership and labor force participation.[18]

In addition, as we discuss below, when looking at our counterfactual scenarios in Section (5.3), our model also delivers empirical moments associated with responses to the shock that are comparable to the data.

[18] Note that we underestimate the share of households in the (FLFP, No Ownership) cell. Equation 19 shows that the larger the share of households in this cell, the smaller the impact of reducing appliance prices on female labor force participation. The reason is that ownership may increase in response to the shock among those who were already working, which would not count as an increase in FLFP. Therefore, by slightly underestimating this cell, we end up overstating the impacts. We also overestimate the share of old households in the (FLFP & Ownership) cell which, in turn, implies, we overestimate the impact on labor force participation among older women.

5.3 Quantitative Results

We now present our main quantitative results. We focus on two types of counterfactual scenarios. The first type considers only reductions in appliance prices, thus evaluating the mechanism of appliance availability in isolation. The second considers, in addition, a reduction in tariffs, thus providing a broader view of the impacts of trade on female labor force participation.

5.3.1 The Impact of a Reduction in Appliance Prices

We model the shock as an unexpected reduction, starting in 1994, of appliance prices of 70 percent relative to average national income. We emphasize that we keep constant all other fundamentals in the model in this exercise, so as to isolate the impact of cheaper appliances on appliance ownership and female labor force participation.[19]

Figure 9 shows the aggregate impacts of introducing this change in appliance prices, keeping all other fundamentals constant. Panel (a) shows the evolution of appliance ownership, i.e., the fraction of households that own appliances. The price reduction leads to an approximately 8 percentage point increase in ownership. Relative to the observed increase in ownership in the data, the reduction in the price of appliances accounts for more than one-third of the observed increase in ownership (which was 22 percentage points).

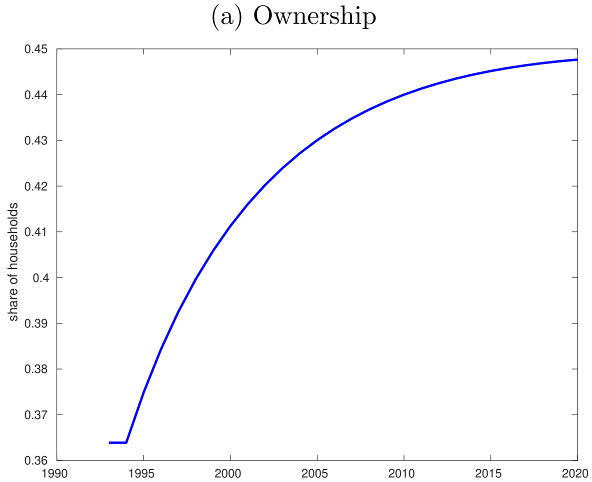
Panel (b) shows that aggregate female labor force participation increases by about 2.2 percentage points, which is about one-tenth of the observed increase in female labor participation. Female hours in the market conditional on working, in turn, increase by about 3 percent. These two results mean that women engage more in the labor market and work longer hours per person than before the shock.[20]

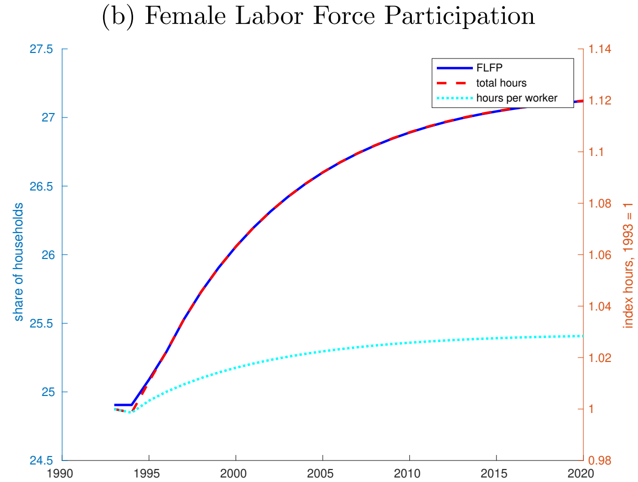
The reduction in the price of appliances contributes only a fraction of the overall increase in female labor force participation we observe in the data, reflecting the fact that many other

[19]Note that in all our simulations, the baseline rate of ownership in the aggregate is 36 percent and that of labor force participation is slightly below 25.5. In contrast, when we present our data in Section 3, the corresponding rates are about 25 percent and 35 percent. The main difference comes from the samples we use. In Fact 1, we aim at presenting the transformation of Peruvian households with a broad sample, which includes non-married women. In our calibration, the structure of the model requires us to retain only married women.

[20]The fall in the price of appliances shifts out the supply of female labor. Holding all else constant, this shift puts downward pressure on female wages. This prediction follows from our model because we do not incorporate other channels through which appliances might increase female productivity (for example, by enabling better job search) or increase demand for female workers (for example, through structural change toward services). As shown in Appendix Figure E.5, the predicted wage effect is quantitatively small at around 2 percentage points. We explore this mechanism empirically using ENAHO household survey data, which includes wage information, and find that baseline utility access is associated with a widening of the gender wage gap over time, consistent with the model's prediction (Appendix Table A.12).

Figure 9: Counterfactual Response of Appliance Ownership and FLFP





Notes: Panel (a) shows the aggregate share of households that own an appliance in the counterfactual scenario in which the price of appliances drop. In Panel (b), in the same scenario, the solid blue line shows the aggregate share of households where the woman participates in the labor market (left axis), while the dotted line shows average hours conditional on work and the red dashed line shows total hours worked by women in the economy (the latter two in the right axis).

forces, such as changes in gender norms and the rise of services, had an impact as well. At the same time, note that our simulation uses information only on household utility access at baseline. The mechanism we study in this paper is bound to interact strongly with the observed increases in access to utilities that occurred since 1993—which would render our results a lower bound of the total impact of the shock—but such interaction is not part of our results.[21]

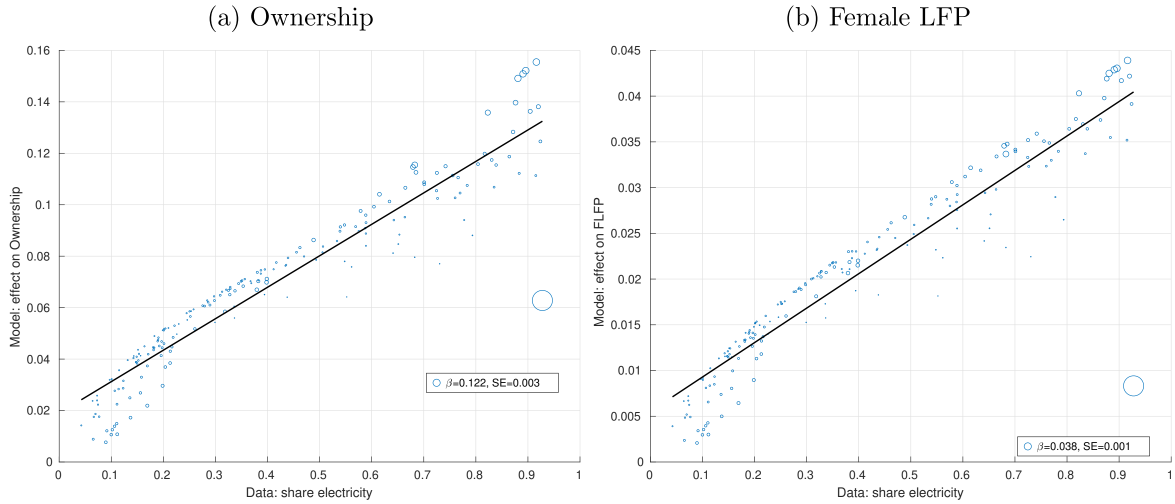
Although the shock is immediate it takes several years to unfold. The key to the slow evolution of the household responses lies in the demography of the model (see Appendix Figure E.6, which traces the response for households of a given age over time). The response is initially strongest among young households which stand to benefit the most from the availability of appliances (especially those between 35 and 40 years old). The expansion in the FLFP proceeds as these households age and remain on the labor market.

Regional Heterogeneity. Given that we calibrate the model with parameters that are constant across provinces, our model generates cross-sectional variation in the baseline and in the response to the shock, based only on the observable differences across provinces (e.g. access to utilities).

Figure 10 plots the responses in these variables, against the baseline share of households

[21] Access to utilities increased by 30 percentage points between 1993 and 2017 according to own calculations using Census data.

Figure 10: Counterfactual Responses and Baseline Shares



Notes: The figure plots the counterfactual responses of ownership (Panel a) and female labor force participation (Panel b) against baseline shares of access to utilities.

with access to utilities.[22] Just like in motivating Fact 3 (Tables 2 and 3) there is a positive correlation between the magnitude of the response and the baseline share of households with access to utilities.[23] This occurs in the model because only the households with access to utilities can reap the benefits of lower appliances prices. Utilities are a necessary precondition. Thus, the larger the share of households with utilities, the larger the aggregate response of a given province. Note, however, that there is also variation around these lines, as regions differ in their productivity.

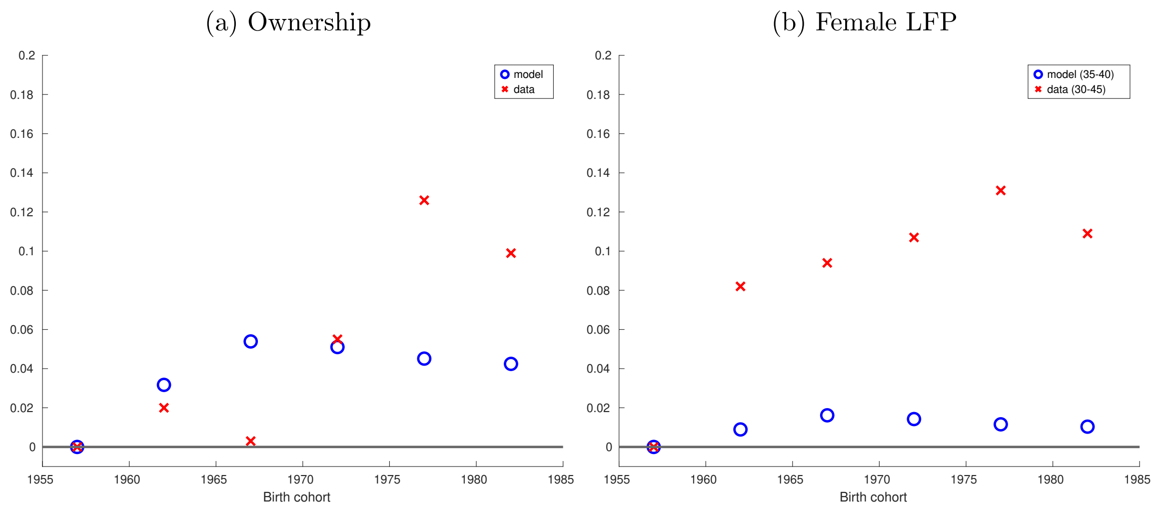
Cohort Effects. Our model also allows for the possibility that, along the transition path, each cohort respond differentially to the shock. The reason is that the lifetime value of cheaper appliances is larger for younger cohorts, so they may respond more strongly. We now compare these responses to the cohort effects we estimated above.

Figure 11 displays our cohort effects for ownership, in Panel (a), and for female labor force participation, in Panel (b). In the case of ownership, our model generates, on average, cohort responses of the same magnitude as we documented in our Fact 4 (Section 3). In the

[22] Appendix Figure E.4 shows how the model fits labor force participation and ownership across regions in the baseline. The model captures very well the variation in appliance ownership across regions; at the same time, the model does less well in capturing the share of households in which women work, reflecting that, in reality, there are incentives to work that are not captured in our model.

[23] The magnitudes are also comparable between simulation and data. Table 2 for example, implies that a province which, at baseline, had 100 percent of households with access (relative to one with 0 percent) had a 34 percentage point difference over our 24-year period. For female labor force participation, Table 2 implies a growth of about 22 percentage points. Comparing steady-state to steady-state, Figure 10 suggests a difference of about 12 percentage points for ownership and 3.8 percentage points for FLFP.

Figure 11: Cohort Analysis: Data vs Simulation



Notes: The figure compares the cohort effects we estimate in the data (red crosses) against those in simulated in the model (blue circles). Each dot is a cohort.

case of labor force participation, the model generates a more muted response, of on average one-tenth of the cohort effects that we see in the data. This is to be expected, since in reality many factors other than appliance prices might have differentially increased the labor force participation of women in provinces with high baseline access to utilities.[24][25]

5.3.2 The Impact of a Joint Reduction in Appliance Prices and Tariffs

We next assess the impact of joint reductions in appliance prices and import tariffs—the two mechanisms through which trade operates in our model—with the goal of understanding how trade affects labor force participation more broadly (although we abstract from other mechanisms studied in the literature). In this scenario, besides making appliances cheap, trade lowers the price of goods relative to local wages. In particular, we study a scenario in which the price of appliances drops by 70 percent relative to the average national wage

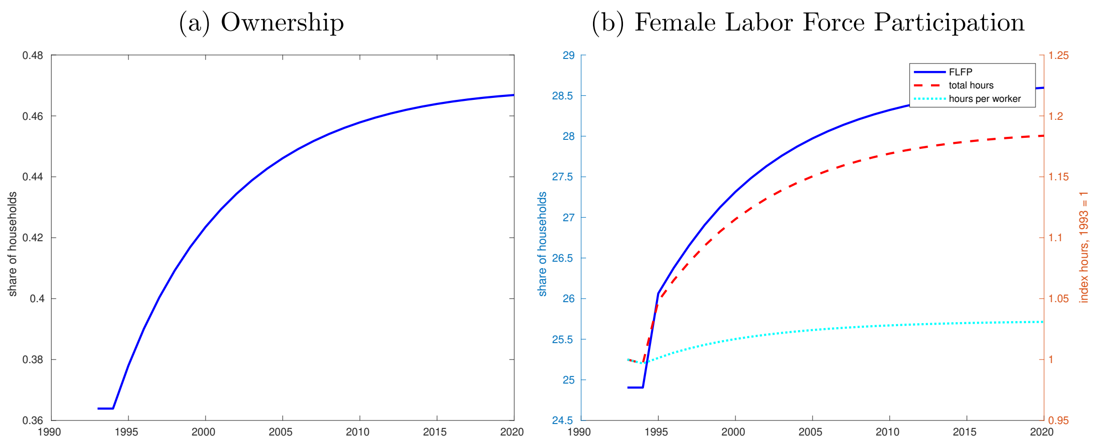
[24]Our empirical cohort effects strike the following balance. On the one hand, they include a broad range of women (of age 30-45) to have precise estimates. On the other hand, because census years are unevenly distributed over time, each observation contains only part of this age range, which means that the age-composition changes across observations. In consequence, our cohort effects also reflect some permanent differences in ages in both ownership and labor force participation. To clean out this effect in our simulation—in which differences in these outcomes are more stark across ages—we present a uniform comparison including only women aged 35-40 in each observation.

[25]To place these quantitative results in context, note that Greenwood, Seshadri, and Yorukoglu (2005) find that the price reduction of appliances can account for virtually all the increase in female labor force participation in the US, during the 19th century. Looking at a different shock, Vidart (2023) studies electrification in the US and finds that it increased the employment of young women with post-secondary education by 3-4 percentage points more than those without post-secondary education.

index, as above, while additionally the price of the market good drops by 1 percent.[26]

Figure 12 shows that, relative to our previous exercise, doing so produces a stronger response of ownership, labor force participation, and female market hours. These outcomes are the balance of two new effects. First, market goods are now cheaper which, everything else constant, will increase the desire to spend time in home production, due to the complementarity between market and home goods. Second, households are now richer, which means they can afford to purchase appliances and increase labor force participation. As Figure 12 shows, the second effect dominates, as it drives larger increases in both ownership and labor force participation, as compared to our simulation in which only the price of appliances changes.

Figure 12: Counterfactual Response of Appliance Ownership and Female LFP: Broad Trade Shock



Notes: Panel (a) shows the aggregate share of households that own an appliance in the counterfactual scenario in which the price of appliances drops together with the international price of goods. In Panel (b), in the same scenario, the solid blue line shows the aggregate share of households where the woman participates in the labor market (left axis), while the dotted line shows average hours conditional on work and the red dashed line shows total hours worked by women in the economy (the latter two in the right axis).

5.4 Robustness

In this section we study the robustness of our results to our choice of $b\,(d>1)$. For these exercises, we return to our main counterfactual in which we only reduce the price of appliances.

[26]In a one-sector quantitative trade model of the type studied in Arkolakis, Costinot, and Rodriguez-Clare (2012), with a trade elasticity of four, this is the change in real wages implied by an 8 percent reduction in Peru's domestic trade share since 1993. Unfortunately, we lack the data to compute domestic trade shares for this period, but note that this number is not out of line with evidence for other countries (Costinot and Rodriguez-Clare, 2014).

We consider the impact of using different values for the productivity gain coming from appliance adoption, $b\,(d > 1)$. Our central value is $b\,(d > 1) = 10$, which as we have argued, delivers plausible behavior of some untargeted moments. We next compare what happens when we shut down this channel, setting $b\,(d > 1) = 1$, and when we double the productivity of appliances to $b\,(d > 1) = 20$.

Doing so has two effects. The first effect is to distort the initial fit of the model relative to the data and produce employment shares that stray from the data.[27] The second effect is to change the way incentives respond to changes in the price of appliances: muted, for $b\,(d > 1) = 1$ and strongly for $b\,(d > 1) = 20$.

The first effect can be seen in Appendix Figure E.7, which shows that relative to our baseline, low appliance productivity leads to too low labor force participation, while high appliance productivity leads to too high labor force participation. The total effect is shown in Figure 13, which shows that with low appliance productivity, there is no incentive to join the labor force in the aftermath of the shock. The figure also shows that with high appliance productivity the effects are mitigated: More women are already working and own appliances at the baseline, which means that the scope for increases in labor force participation are smaller. We relegate to Appendix Figure E.8 the corresponding comparisons for ownership, but we note that the patterns are consistent with our interpretation.

6 Conclusion

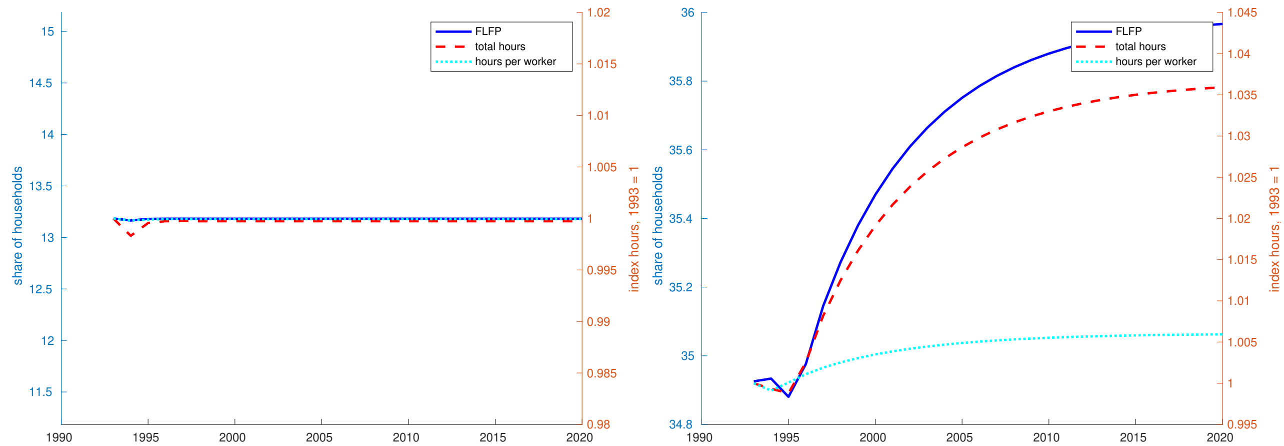
We study the relation between household production—which continues to be carried out mostly by women in the developing world—, participation in labor markets, and international trade. A productive research agenda has studied the ways in which international trade impacts labor demand, either reducing it through import competition or increasing it via new trade opportunities. We focus instead on how international trade affects labor supply decisions, as well as time use within and outside of the household.

Trade policy is often designed with the goal of protecting certain groups from foreign competition, whether those groups are workers or firms exposed to international trade or industries whose growth the government wants to foster. Although due to data limitations our empirical and quantitative results are far from definitive, they do point out to an overlooked impact of trade policy, namely, encouraging labor force participation by making appliances

[27] In this exercise, we do not recalibrate the model to fit the initial targets. The reason is that our mechanism operates through the value of $b\,(d > 1)$, which has a direct impact on these outcomes. For example, demanding that the model fit the appliance ownership data for a value of $b\,(d > 1) = 1$, would require high exogenous preferences for a states that are dominated by every other state in the model, as ownership entails a cost but brings no benefits.

Figure 13: Counterfactual Response of Appliance Ownership and Female LFP: Alternative Calibration of $b\,(d > 0)$

(a) Female Labor Force Participation (b) Female Labor Force Participation



Notes: Both panels show the aggregate share of households where the woman participates in the labor market, in the scenario where the price of appliances drops. Panel (a) shows the case of $b\,(d > 1) = 1$ and Panel (b) shows the case of $b\,(d > 1) = 20$.

that substitute for household labor more accessible. Understanding this mechanism is particularly important in countries where domestic appliance production is limited and female labor force participation is low, a prevalent scenario in many middle- and low-income countries.

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A Appendix Figures and Tables

A.1 Data and Measurement

Table A.1: Appliance Definition

APPLIANCE	6-DIGIT HTS CODES	DESCRIPTION
Refrigerators	841810	Refrigerators and freezers; combined refrigerator-freezers, fitted with separate external doors, electric or other
	841821	Refrigerators; for household use, compression-type, electric or other
	841829	Refrigerators; household, electric or not, other than compression-type
	841830	Freezers; of the chest type, not exceeding 800l capacity
	8418540	Freezers; of the upright type, not exceeding 900l capacity
	841850	Furniture incorporating refrigerating or freezing equipment; for storage and display, n.e.c. in item no. 8418.1, 8418.2, 8418.3 or 8418.4 (chests, cabinets, display counters, show-cases and the like)
Washing/Drying Machines	845011	Washing machines; household or laundry-type, fully-automatic, (of a dry linen capacity not exceeding 10kg)
	845012	Washing machines; household or laundry-type, with built-in centrifugal drier, (not fully-automatic), of a dry linen capacity not exceeding 10kg
	845019	Washing machines; household or laundry-type, not fully-automatic, without built-in centrifugal drier, of a dry linen capacity not exceeding 10kg
	845020	Washing machines; household or laundry-type, of a dry linen capacity exceeding 10kg
	845090	Washing machines; parts for household or laundry-type
	845110	Dry-cleaning machines
	845121	Drying machines; of a dry linen capacity not exceeding 10kg
	845129	Drying machines; of a dry linen capacity exceeding 10kg

A.2 Stylized Facts

Table A.2: Appliance Ownership and Baseline Utility Access, Men

	(1)	(2)	(3)	(4)	(5)	(6)
Access Trend	0.0151	0.0069	0.0169	0.0169	0.0113	0.0153
	(0.0017)***	(0.0024)***	(0.0025)***	(0.0022)***	(0.0034)***	(0.0024)***
Mean Dependent	0.328	0.328	0.329	0.329	0.343	0.226
Province FE	X	X	X	X	X	X
Province + Year FE		X	X	X	X	X
Ind. Controls			X	X	X	X
Trade Controls				X	X	X
$W_{gp,81}$ x t					X	X
$D_{gp,93}$ x t						X
N.Provinces	192	192	192	192	154	150
N.Obs.	15,876,548	15,876,548	15,808,418	15,808,418	13,451,628	9,278,775

Notes: Appliances bundle is defined as a dummy variable that takes the value of 1 if the household owns a refrigerator or a washing machine. The unit of observation is men aged between 25 and 65. Column (1) includes province fixed effects (γ_p) and Column (2) adds census year fixed effects (γ_t). Columns (3) and (4) progressively add individual controls ($X_{i,t}$) and trade exposure controls ($Trade_{gp,t}$). Column (5) controls for pre-trends using 1981 gender-specific labor force participation and income interacted with time $(W_{gp,1981} \times t)$, while Column (6) adds baseline population density interacted with time $(D_{p,1993} \times t)$. Standard errors are shown in parentheses and clustered at the province level.

Table A.3: Labor Force Participation and Baseline Utility Access, Men

	(1)	(2)	(3)	(4)	(5)	(6)
Access Trend	0.0021	0.0051	0.0053	0.0055	0.0046	0.0060
	(0.0002)***	(0.0006)***	(0.0006)***	(0.0007)***	(0.0010)***	(0.0010)***
Mean Dependent	0.876	0.876	0.877	0.877	0.875	0.874
Province FE	X	X	X	X	X	X
Province + Year FE		X	X	X	X	X
Ind. Controls			X	X	X	X
Trade Controls				X	X	X
$W_{gp,81}$ x t					X	X
$D_{gp,93}$ x t						X
N.Provinces	192	192	192	192	154	150
N.Obs.	15,876,548	15,876,548	15,808,418	15,808,418	13,451,628	9,278,775

Notes: Labor force participation is defined as a dummy variable that takes the value of 1 if the individual participates in the labor market and 0 if they do not. The unit of observation is men aged between 25 and 65. Column (1) includes province fixed effects (γ_p) and Column (2) adds census year fixed effects (γ_t). Columns (3) and (4) progressively add individual controls ($X_{i,t}$) and trade exposure controls ($Trade_{gp,t}$). Column (5) controls for pre-trends using 1981 gender-specific labor force participation and income interacted with time $(W_{gp,1981} \times t)$, while Column (6) adds baseline population density interacted with time $(D_{p,1993} \times t)$. Standard errors are shown in parentheses and clustered at the province level.

Table A.4: Appliance Ownership, Labor Force Participation and Baseline Utility Access, for ages 25-50

	Women		Men	
	(1)	(2)	(3)	(4)
	App. Ownership	LFP	App. Ownership	LFP
Access Trend	0.0141	0.0091	0.0156	0.0054
	(0.0024)***	(0.0015)***	(0.0024)***	(0.0010)***
Mean Dependent	0.253	0.318	0.223	0.893
Province FE	X	X	X	X
Province + Year FE	X	X	X	X
Ind. Controls	X	X	X	X
Trade Controls	X	X	X	X
$W_{gp,81}$ x t	X	X	X	X
$D_{gp,93}$ x t	X	X	X	X
N.Provinces	150	150	150	150
N.Obs.	7,624,918	7,624,918	7,035,220	7,035,220

Notes: Appliance ownership is defined as a dummy variable that takes the value of 1 if the household owns a refrigerator or a washing machine. Labor force participation is defined as a dummy variable that takes the value of 1 if the individual participates in the labor market and 0 if they do not. The unit of observation is individuals aged between 25 and 50. Columns (1) and (2) refer to appliance ownership and labor force participation effects for women, while Columns (3) and (4) replicate these regressions for men. All specifications include province and time fixed effects, $\gamma_p + \gamma_t$, individual controls $X_{i,t}$, as well as controls for gender-specific exposure to exports and imports, pre-trends ($W_{gp,1981} \times t$) and baseline population density interacted with time $\left(D_{p,1993} \times t\right)$. Standard errors are shown in parentheses and clustered at the province level.

Table A.5: Appliance Ownership and Baseline Utility Access, by Marital Status

	Women (1) Single	(2) Married	Men (3) Single	(4) Married
Access Trend	0.0137	0.0150	0.0146	0.0158
	(0.0026)***	(0.0025)***	(0.0023)***	(0.0025)***
Mean Dependent	0.291	0.237	0.258	0.218
Province FE	X	X	X	X
Province + Year FE	X	X	X	X
Ind. Controls	X	X	X	X
Trade Controls	X	X	X	X
$W_{gp,81}$ x t	X	X	X	X
$D_{gp,93}$ x t	X	X	X	X
N.Provinces	150	150	150	150
N.Obs.	2,799,760	7,175,064	2,312,768	6,966,007

Notes: Appliance ownership is defined as a dummy variable that takes the value of 1 if the household owns a refrigerator or a washing machine. Columns (1) and (2) of the table examine the impact on appliance ownership for single and married women, respectively, while Columns (3) and (4) replicate this analysis for men. All specifications include province and time fixed effects, $\gamma_p + \gamma_t$, individual controls $X_{i,t}$, as well as controls for gender-specific exposure to exports and imports, pre-trends ($W_{gp,1981} \times t$) and baseline population density interacted with time ($D_{p,1993} \times t$). Standard errors are shown in parentheses and clustered at the province level.

Table A.6: Labor Force Participation and Baseline Utility Access, by Marital Status

	Women (1) Single	(2) Married	Men (3) Single	(4) Married
Access Trend	0.0073	0.0094	0.0062	0.0060
	(0.0015)***	(0.0016)***	(0.0010)***	(0.0011)***
Mean Dependent	0.447	0.247	0.806	0.892
Province FE	X	X	X	X
Province + Year FE	X	X	X	X
Ind. Controls	X	X	X	X
Trade Controls	X	X	X	X
$W_{gp,81}$ x t	X	X	X	X
$D_{gp,93}$ x t	X	X	X	X
N.Provinces	150	150	150	150
N.Obs.	2,799,760	7,175,064	2,312,768	6,966,007

Notes: Labor force participation is defined as a dummy variable that takes the value of 1 if the individual participates in the labor market and 0 if they do not. Columns (1) and (2) of the table examine the impact on labor force participation for single and married women, respectively, while Columns (3) and (4) replicate this analysis for men. All specifications include province and time fixed effects, $\gamma_p + \gamma_t$, individual controls $X_{i,t}$, as well as controls for gender-specific exposure to exports and imports, pre-trends ($W_{gp,1981} \times t$) and baseline population density interacted with time ($D_{p,1993} \times t$). Standard errors are shown in parentheses and clustered at the province level.

Table A.7: Migration Rates and Baseline Utility Access

	Women		Men	
	(1)	(2)	(3)	(4)
	Low Access	High Access	Low Access	High Access
Access Trend	0.0032	-0.0018	0.0050	-0.0014
	(0.0038)	(0.0018)	(0.0051)	(0.0020)
Mean Dependent	0.0981	0.173	0.130	0.198
Province FE	X	X	X	X
Province + Year FE	X	X	X	X
Ind. Controls	X	X	X	X
Trade Controls	X	X	X	X
$W_{gp,81}$ x t	X	X	X	X
$D_{gp,93}$ x t	X	X	X	X
N.Provinces	75	75	75	75
N.Obs.	2,425,779	7,549,045	2,357,403	6,921,372

Notes: Migration is defined as a dummy variable that takes the value of 1 if the individual migrated over the last 5 years and 0 if they do not. Columns (1) and (2) refer to the effects for women living in low-access districts (below nationwide median) and high-access districts (above nationwide median), while Columns (3) and (4) replicate these regressions for men. All specifications include province and time fixed effects, $\gamma_p + \gamma_t$, individual controls $X_{i,t}$, as well as controls for gender-specific exposure to exports and imports, pre-trends ($W_{gp,1981} \times t$) and baseline population density interacted with time ($D_{p,1993} \times t$). Standard errors are shown in parentheses and clustered at the province level.

Table A.8: Television Ownership and Baseline Utility Access

	Women		Men	
	(1)	(2)	(3)	(4)
	Single	Married	Single	Married
Access Trend	0.0073	0.0027	0.0055	0.0023
	(0.0020)***	(0.0019)	(0.0017)***	(0.0019)
Mean Dependent	0.291	0.247	0.258	0.892
Province FE	X	X	X	X
Province + Year FE	X	X	X	X
Ind. Controls	X	X	X	X
Trade Controls	X	X	X	X
$W_{gp,81}$ x t	X	X	X	X
$D_{gp,93}$ x t	X	X	X	X
N.Provinces	150	150	150	150
N.Obs.	2,799,760	7,175,064	2,312,768	6,966,007

Notes: TV is defined as a dummy variable that takes the value of 1 if the individual owns a television and 0 if they do not. Columns (1) and (2) refer to television ownership for single and married women, respectively, while Columns (3) and (4) replicate these regressions for single and married men. All specifications include province and time fixed effects, $\gamma_p + \gamma_t$, individual controls $X_{i,t}$, as well as controls for gender-specific exposure to exports and imports, pre-trends ($W_{gp,1981} \times t$) and baseline population density interacted with time ($D_{p,1993} \times t$). Standard errors are shown in parentheses and clustered at the province level.

Table A.9: Appliance Ownership, Labor Force Participation and Baseline Utility Access, ENAHO sample

	App. Ownership		App. Purchase		LFP	
	(1)	(2)	(3)	(4)	(5)	(6)
	Women	Men	Women	Men	Women	Men
Access Trend	0.0152	0.0162	0.0021	0.0025	0.0066	0.0008
	(0.0033)***	(0.0028)***	(0.0008)**	(0.0007)***	(0.0019)***	(0.0007)
Mean Dependent	0.353	0.299	0.0189	0.0174	0.767	0.966
Province FE	X	X	X	X	X	X
Province + Year FE	X	X	X	X	X	X
Ind. Controls	X	X	X	X	X	X
Trade Controls	X	X	X	X	X	X
$W\_gp, 93$ x t	X	X	X	X	X	X
N.Provinces	188	188	188	188	188	188
N.Obs.	303,390	311,841	303,390	311,841	306,724	314,702

Notes: Appliance ownership is defined as a dummy variable that takes the value of 1 if the individual owns a refrigerator or a washing machine. Appliance purchase takes a value of 1 if the individual purchased a refrigerator or a washing machine in the past year. Labor force participation is defined as a dummy variable that takes the value of 1 if the individual participates in the labor market and 0 if they do not. The unit of observation is individuals aged between 25 and 65. Columns (1) and (2) refer to appliance ownership, Columns (3) and (4) refer to appliance purchases over the last year, and Columns (5) and (6) refer to labor force participation, for women and men, respectively. All specifications include province and time fixed effects, $\gamma_p + \gamma_t$, individual controls $X_{i,t}$, which include age, age squared, education level, and log of income, as well as controls for gender-specific exposure to exports and imports, and pre-trends ($W_{gp,1993} \times t$). These pre-trends include gender-specific measures of 1993 labor force participation interacted with time as well as 1993 population density interacted with time. Observations are weighted by the survey weights. Standard errors are shown in parentheses and clustered at the province level.

Table A.10: Appliance Ownership, Labor Force Participation and Baseline Utility Access, ENAHO sample, by Marital Status

	App. Ownership		App. Purchase		LFP	
	(1)	(2)	(3)	(4)	(5)	(6)
	Single	Married	Single	Married	Single	Married
Access Trend	0.0157	0.0151	0.0018	0.0021	0.0008	0.0074
	(0.0060)***	(0.0027)***	(0.0010)*	(0.0008)***	(0.0028)	(0.0020)***
Mean Dependent	0.375	0.345	0.375	0.345	0.374	0.345
Province FE	X	X	X	X	X	X
Province + Year FE	X	X	X	X	X	X
Ind. Controls	X	X	X	X	X	X
Trade Controls	X	X	X	X	X	X
$W\_gp, 93$ x t	X	X	X	X	X	X
N.Provinces	188	188	188	188	188	188
N.Obs.	89,843	213,529	89,843	213,529	91,122	215,584

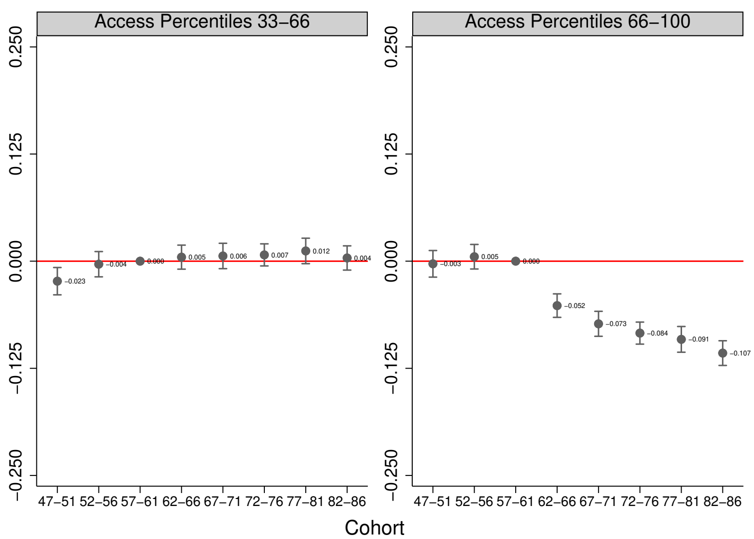
Notes: Appliance ownership is defined as a dummy variable that takes the value of 1 if the individual owns a refrigerator or a washing machine. Appliance purchase takes a value of 1 if the individual purchased a refrigerator or a washing machine in the past year. Labor force participation is defined as a dummy variable that takes the value of 1 if the individual participates in the labor market and 0 if they do not. The unit of observation is women aged between 25 and 65. Columns (1) and (2) refer to appliance ownership, Columns (3) and (4) refer to appliance purchases over the last year, and Columns (5) and (6) refer to labor force participation, for single and married women, respectively. All specifications include province and time fixed effects, $\gamma_p + \gamma_t$, individual controls $X_{i,t}$, which include age, age squared, education level, and log of income, as well as controls for gender-specific exposure to exports and imports, and pre-trends ($W_{gp,1993} \times t$). These pre-trends include gender-specific measures of 1993 labor force participation interacted with time as well as 1993 population density interacted with time. Observations are weighted by the survey weights. Standard errors are shown in parentheses and clustered at the province level.

Table A.11: 30-45 Year Old Cohorts

Cohort	1993	2007	2017
1942-1946	47-51	61-65	71-75
1947-1951	42-46	56-60	66-70
1952-1956	37-41	51-55	61-65
1957-1961	32-36	46-50	56-60
1962-1966	27-31	41-45	51-55
1967-1971	22-26	36-40	46-50
1972-1976	17-21	31-35	41-45
1977-1981	12-16	26-30	36-40
1982-1986	7-11	21-25	31-35
1987-1991	2-6	16-20	26-30

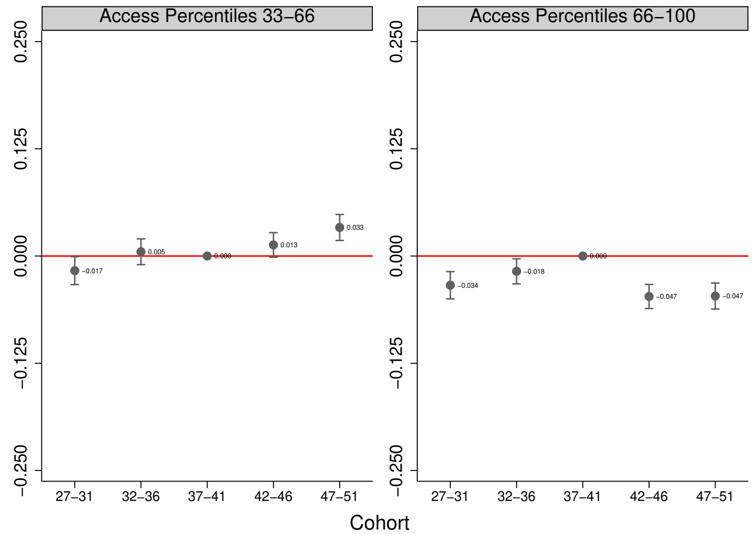
Notes: Cohorts, in rows, are defined by birth year. Census years are in columns. Numbers in each cell are the age range of the cohorts at each observed census (1993, 2007, and 2017).

Figure A.1: Cohort Analysis - TV Ownership 30-45 year-olds



Notes: This figure shows the results of the estimation of equation (2) where the dependend variable is ownership of televisions. The x-axis denotes the cohort (birth year) while the y-axis refers to the estimated effect. The panels are divided by percentiles of baseline utilities at the province level. All the effects are evaluated for individuals within 30-45 years old.

Figure A.2: Cohort Analysis - TV Ownership 50-65 year-olds



Notes: This figure shows the results of the estimation of equation (2) where the dependend variable is ownership of televisions. The x-axis denotes the cohort (birth year) while the y-axis refers to the estimated effect. The panels are divided by percentiles of baseline utilities at the province level. All the effects are evaluated for individuals within 50-65 years old.

Table A.12: Wages and Baseline Utility Access

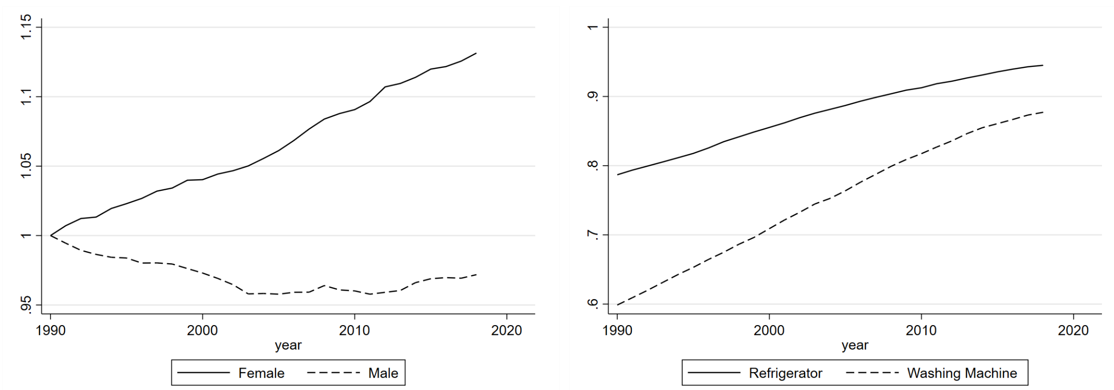
Notes: Dependent variable is the log of hourly wages. All specifications include province and time fixed effects, $\gamma_p + \gamma_t$, individual controls $X_{i,t}$, as well as controls for gender-specific exposure to exports and imports, pre-trends $(W_{gp,1981} \times t)$ and baseline population density interacted with time $\left(D_{p,1993} \times t\right)$. Standard errors are shown in parentheses and clustered at the province level.

B International Trends

Over the last 30 years, global female labor force participation has increased substantially. Panel (a) of Figure B.3 illustrates that average cross-country female labor force participation has increased by 15 percentage points between 1990 and 2020, while male participation appears to have slightly decreased and stagnated during the same period. Although not depicted in the figure, this trend in female labor force participation has been primarily driven by low- and middle-income countries. Moreover, this inflow of women into the labor force has coincided with a widespread adoption of household appliances that substitute for time spent on household production. Panel (b) of Figure B.3 shows a surge in ownership of refrigerators and washing machines over the past 30 years.

Figure B.3: Overall Trends

(a) Labor Force Participation (b) Ownership of Appliances



Notes: In Panel (a) each series is an index (base year is 1990). Source: ILO. In panel (b), each series shows the fraction of households who report owning the appliance. Source: Euromonitor's Passport Consumer Appliances Data

C Model Derivations

C.1 Obtaining the Small Open Economy (SOE) Limit in the Static Equilibrium

We begin by stating the environment and equilibrium in the N-country economy.

C.1.1 Environment

Preferences. The household maximizes the bellman equation given by

$$V_{i,jk}(a) = \max_{m,g,a'\geq 0} \left\{ \ln u(m_i, g_i) + \beta \mathbb{E}_{\varepsilon} \max_{k' \in K_k} \left[V_{i,j+1,k'}(a') + \varepsilon_{k'} \right] \right\}, \tag{C.1}$$

with

$$a' = Ra + w_m + w_f h_f - m - \mathbb{I}[d=1] f,$$

where

$$u(m_{it}, g_{it}) = \left[\mu^{\frac{1}{\eta}} m_{it}^{\frac{\eta-1}{\eta}} + (1-\mu)^{\frac{1}{\eta}} g_{it}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}, \tag{C.2}$$

and

$$m_{it} = \left[\sum_{i'} (m_{i'it})^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}}$$

$$h_f = 1 - l_f.$$

Technology. Home goods are produced according to the following technology:

$$g_{it} = b(d) \cdot l_{it,f}. \tag{C.3}$$

Market goods are produced according to

$$Y_{it} = Z_{it} H_{it},$$

where Z_{it} is a country-specific productivity and H_{it} is a constant-elasticity index of labor supply of men and women:

$$H_{it} = \left(\alpha^{1/\sigma} H_{it,m}^{\frac{\sigma-1}{\sigma}} + (1-\alpha)^{1/\sigma} H_{it,f}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}. \tag{C.4}$$

Appliances are produced using market goods as input, with a constant productivity Z_{it}^{d}, and differentiated according to their region of origin, with elasticity θ.

C.1.2 Aggregation

Populations evolve according to

$$n_{it,jk}(a) = \int_{\mathcal{A}} \sum_{k'} \lambda_{ij,k'k}(z)\, \gamma_{it,j-1k'}(a,z)\, n_{it-1,j-1k'}(z)\, dz + \bar{n}_{it,jk}(a), \tag{C.5}$$

where $\sum_j \sum_k \int_{\mathcal{A}} n_{it,jk}(a)\, da = \nu_i, \forall t$, and $\lambda_{ij,k'k}(z)$ is the transition probability that a household in country i who is in state k (with capital z) moves into state k' when it enters cohort j,

and labor supplies are given by

$$H_{it,m} = \sum_j \sum_k \int_{\mathcal{A}} 1 \cdot n_{it,jk}(a)\, da, \tag{C.6}$$

$$H_{it,f} = \sum_j \sum_k \int_{\mathcal{A}} h_{it,jkf}(a) \cdot n_{it,jk}(a)\, da. \tag{C.7}$$

Aggregate Savings and Demand for Appliances. At each point in time, we can compute the total demand for new appliances as

$$D_{it} = \sum_j \sum_{k \in \{3,4\}} \int_{\mathcal{A}} n_{it,jk}(a)\, da,$$

and total assets carried between periods t and $t-1$ as

$$A_{it} = \sum_j \sum_k \int_{\mathcal{A}} x_{it,jk}(a)\, n_{it-1,jk}(a)\, da. \tag{C.8}$$

where $x_{it,jk}(a)$ is the policy function for assets.

C.1.3 Equilibrium

Static Equilibrium. At time t, given the workers choices of labor supply, $\{H_{it}\}$ and asset holdings $\{A_{it}\}$, a static equilibrium is a set of wages $\{W_{it}\}$, a world interest rate, R, such that labor and capital markets clear:

$$W_{it} H_{it} = \sum_{i'} \pi^m_{ii't} X^m_{i't} + \frac{1}{Z^a_{it}} \sum_{i'} \pi^a_{ii't} X^a_{i't}, \tag{C.9}$$

$$0 = \sum_i A_{i,t} - R A_{i,t-1} \tag{C.10}$$

and the aggregator $\{H_{it}\}$ satisfies equation (8), and where $\pi^s_{ii',t}$ is the standard Armington expenditure share for sector $s = m, a$. In this definition, country i's total expenditure in market goods and in appliances is given by

$$X^m_{it} = \sum_j \sum_k \int_{\mathcal{A}} P_{it} m_{it,jk}(a)\, n_{it,jk}(a)\, da,$$

and

$$X^a_{it} = f_{it} D_{it},$$

and the price indices of market goods and appliances are given by

$$P_{it} = \left(\sum_{i'} \left(W_{i't} \tau_{i'i,t} / Z_{i't} \right)^{1-\theta} \right)^{\frac{1}{1-\theta}},$$

and

$$f_{it} = \left(\sum_{i'} \left(\frac{W_{i't} \tau^a_{i'i,t}}{Z_{i't} Z^a_{i't}} \right)^{1-\theta} \right)^{\frac{1}{1-\theta}}.$$

Dynamic Equilibrium. Given initial conditions, $\{A_{i,0}\}$, and optimal pricing functions for $\{W_{i,t}\}$ and R_t, defined by the static equilibrium, a dynamic equilibrium is a path of labor supplies and assets $\{H_{i,t}, A_{i,t}\}$, for $t = 1, 2, \ldots$ such that the law of motion of population and asset holdings hold.

C.1.4 The SOE Limit

In our quantification and analysis, we exploit the notion of a small open economy, a limiting case of the economy described above (Alvarez and Lucas, 2007). To this end, suppose (i) the home country does not produce appliances, $Z^a_{i,t} = 0$, (ii) the home country is small in the sense that $\kappa_{it} \equiv \lim Z^{\theta-1}_{it} / \nu_{it}$ as $\nu_{it} \to 0$, where ν_{it} is the population size in country i.

With these assumptions we can rewrite the labor market clearing condition C.9 for country i as:

$$W_{it} = \underbrace{\left(\frac{\tau^{1-\theta}_{iF}}{P^{1-\theta}_{Ft}} \kappa_{it} X^m_{Ft} \right)^{1/\theta}}_{\equiv B_{it}} \left(\frac{H_{it}}{\nu_{it}} \right)^{-1/\theta}, \tag{C.11}$$

where the second term, H_{it}/ν_{it} is a rate of participation in the labor market. The world capital market equilibrium given in equation (C.10) boils down to

$$0 = \sum_{j \neq i} A_{j,t} - RA_{j,t-1},$$

which means that the SOE takes the interest rate as given. Equation (C.8), in turn, determines the SOE's asset holdings, for any interest rate.

C.2 Characterizing the Ownership and Labor Participation Rates

We show in this Appendix how to characterize the response on impact of an economy with (i) $J = 2$, (ii) no assets and (iii) all individuals "born" in state $k_0 = 1$. To simplify notation in this section, we suppress the country index i.

C.2.1 Ownership

We begin by characterizing the aggregate ownership rate, ω, which is defined as

$$\omega_t = \sum_j \underbrace{\sum_{k \in \mathcal{K}_\omega} n_{t,jk}}_{n_{t,j}\omega_{j,t}}$$

We characterize this rate in our two-period model, starting with age-1 households:

$$\omega_{1,t} n_{t,1} = \sum_{k \in \mathcal{K}_\omega} \lambda_{1,1k,t},$$

Noting that only households that are currently purchasing the appliance are directly affected in period t by the price reduction, we obtain

$$\begin{aligned}
\frac{\partial \omega_{1,t}}{\partial f} &= \sum_{k \in \mathcal{K}_\omega} \partial_f \lambda_{1,1k,t} \\
&= \sum_{k=3,4} \left[\lambda_{1,1k,t} \frac{1}{\rho} \partial_f V_{1k,t} - \lambda_{1,1k,t} \sum_{k'=1,2,3,4} \lambda_{1,1k',t} \frac{1}{\rho} \partial_f V_{1k',t} \right] \\
&= \left[\sum_{k=3,4} \lambda_{1,1k,t} \frac{1}{\rho} \partial_f V_{1k,t} - \sum_{k=3,4} \lambda_{1,1k,t} \left(\sum_{k'=1,2,3,4} \lambda_{1,1k',t} \frac{1}{\rho} \partial_f V_{1k',t} \right) \right] \\
&= \left(1 - \sum_{k=3,4} \lambda_{1,1k,t} \right) \left(\sum_{k'=3,4} \lambda_{1,1k',t} \frac{1}{\rho} \partial_f V_{1k',t} \right)
\end{aligned}$$

where we use the shorthand $\partial_x y = \partial y/\partial x$, and $\frac{1}{\rho}\partial_f V_{1k',t} = 0$, for $k \in \{5, 6\}$, because at age 2, those states do not have a future where f matters. Also note that, in contrast, $\partial_f V_{j,11,t} = \partial_f V_{j,12,t} = \beta\rho\partial_f \log \Psi_{2,2}$.

Given that the baseline shares $\lambda_{1,k_0 3,t} + \lambda_{1,k_0 4,t}$ add up to less than one, and assuming that $\lambda_{1,11,t} = \lambda_{1,12,t} = 0$, this shows that ownership rate for age-1 households rises on impact, with a strength governed by $1/\rho$.

For age-2 households, we have

$$\omega_{2,t} n_{2,t} = \sum_{k' \in \{1,2,3,4\}} \sum_{k \in \mathcal{K}_\omega} \lambda_{2,k'k,t} \cdot n_{t-1,1k'}$$

$$\frac{\partial \omega_{2,t}}{\partial f} = \sum_{k' \in \{1,2,3,4\}} \sum_{k \in \{3,4,5,6\}} \partial_f \lambda_{2,k'k,t} \cdot n_{t-1,1k'}$$

because n does not change on impact. Further

$$\frac{\partial \omega_{2,t}}{\partial f} = \sum_{k' \in \{1,2\}} \sum_{k \in \{3,4\}} \partial_f \lambda_{2,k'k,t} \cdot n_{t-1,1k'} + \sum_{k' \in \{3,4\}} \sum_{k \in \{5,6\}} \partial_f \lambda_{2,k'k,t} \cdot n_{t-1,1k'}$$

Note next that the second term on the right-hand side is zero: conditional on being in state $k' = 3$ in age one, the household can only move to states that are not affected directly by the price of appliances; the same is true for $k' = 4$. Therefore:

$$\begin{aligned}
\frac{\partial \omega_{2,t}}{\partial f} &= \sum_{k' \in \{1,2\}} n_{t-1,1k'} \sum_{k \in \{3,4\}} \partial_f \lambda_{2,k'k,t} \\
&= \frac{1}{\rho} \sum_{k' \in \{1,2\}} n_{t-1,1k'} \left[[1 - (\lambda_{1,k'3,t} + \lambda_{t,1k',4})] \left[\lambda_{1,k'3,t} \partial_f \log u_{t,1k'3} + \lambda_{1,k'4,t} \partial_f \log u_{t,1k'4} \right] \right].
\end{aligned}$$

C.2.2 Participation Rate

We proceed analogously to characterize the labor force participation rate:

$$\varphi_t = \sum_j \underbrace{\sum_{k \in \mathcal{K}_{\ell=1}} n_{t,jk}}_{\equiv n_{t,j} \cdot \varphi_{j,t}}, \tag{C.12}$$

Using again our two period model, starting with age-1 households:

$$\varphi_{1,t} = \sum_{k \in \mathcal{K}_{\ell=1}} \lambda_{1,1k,t},$$

Noting that only households that are currently purchasing the appliance are directly affected in period t by the price reduction, we obtain

$$\frac{\partial \varphi_{1,t}}{\partial f} = \frac{1}{\rho} \sum_{k=2,4} \lambda_{j,1k,t} \partial_f V_{1k,t} - \left(\sum_{k=2,4} \lambda_{j,1k,t} \right) \left(\sum_{k'=1,2,3,4} \lambda_{j,1k',t} \frac{1}{\rho} \partial_f V_{1k',t} \right),$$

where $\partial_f V_{j,11,t} = \partial_f V_{j,12,t} = \beta \rho \partial_f \log \Psi_{2,2}$, as before.

Note that when $\lambda_{j,13,1} = \lambda_{j,11,1} = 0$,this reduces to

$$\begin{aligned} \frac{\partial \varphi_{1,t}}{\partial f} &= \frac{1}{\rho} \sum_{k=2,4} \lambda_{j,1k,t} \partial_f V_{1k,t} - \left(\sum_{k=2,4} \lambda_{j,1k,t} \right) \left(\sum_{k'=2,4} \lambda_{j,1k',t} \frac{1}{\rho} \partial_f V_{1k',t} \right), \\ &= \left(1 - \sum_{k=2,4} \lambda_{j,1k,t} \right) \left(\sum_{k'=2,4} \lambda_{j,1k',t} \frac{1}{\rho} \partial_f V_{1k',t} \right), \end{aligned}$$

which is always positive.

To characterize age-2 households, we proceed analogously as with ownership above.

$$\begin{aligned} \frac{\partial \varphi_{2,t}}{\partial f} = &\sum_{k' \in \{1,2,3,4\}} \sum_{k \in \{2,4,6\}} \partial_f \lambda_{2,k'k,t} \cdot n_{t-1,1k'} \\ &\sum_{k' \in \{1,2\}} \sum_{k \in \{2\}} \partial_f \lambda_{2,k'k,t} \cdot n_{t-1,1k'} + \sum_{k' \in \{1,2\}} \sum_{k \in \{4\}} \partial_f \lambda_{2,k'k,t} \cdot n_{t-1,1k'} + \sum_{k' \in \{4\}} \sum_{k \in \{6\}} \partial_f \lambda_{2,k'k,t} \cdot n_{t-1,1k'}, \end{aligned}$$

where now the third term is zero. where now the first term is zero because for state $k = 2$, f has no bearing on present utility (and there is not future at $j = 2$), and the third term is also zero, because for state $k = 6$, f has no impact either. Then it becomes

$$\frac{\partial \varphi_{2,t}}{\partial f} = \sum_{k' \in \{1,2\}} \sum_{k \in \{2,4\}} \partial_f \lambda_{2,k'k,t} \cdot n_{t-1,1k'},$$

so

$$\frac{\partial \varphi_{2,t}}{\partial f} = \sum_{k' \in \{1,2\}} n_{t-1,1k'} \sum_{k \in \{2,4\}} \left[\lambda_{2,k'k,t} \partial_f V_{2k,t} - \lambda_{2,k'k,t} \sum_{m=\{1,2,3,4\}} \lambda_{2,k'm,t} \partial_f V_{2m,t} \right],$$

Finally, noting that when $j = 2$, $\partial V_{2m,t} = 0$ for $m = 1, 2$, we obtain

$$\frac{\partial \varphi_{2,t}}{\partial f} = \sum_{k' \in \{1,2\}} n_{t-1,1k'} \left\{ \left[-\lambda_{2,k'2,t} \sum_{m=\{3,4\}} \lambda_{2,k'm,t} \partial_f V_{2m,t} \right] + \left[\lambda_{2,k'4,t} \partial_f V_{24,t} - \lambda_{2,k'4,t} \sum_{m=\{3,4\}} \lambda_{2,k'm,t} \partial_f V_{2m,t} \right] \right\}$$

which simplifies to the expression in the main body of the paper.

D Calibration Procedure

In this section we explain in detail our calibration procedure. We proceed in the following steps:

1. Assume the census year 1993 is a steady state of the economy, before the reduction of the price of appliances.

2. Using the data, calculate the population shares in each cell, $\hat{n}_{it,jk}$, $t = 1993$, aggregating states $k = 3, 5$ and $k = 4, 6$ together. Calculate wages $w_{m,it}$ and $w_{f,it}$ from time surveys. Because there are no surveys available for 1993, we use the numbers calculated by Yamada (2005).

3. For each guess of ρ

   (a) Guess values of B,α, and G_{own} and G_{work}, that is

$$G_k = \begin{cases} 0 & \text{if } k = 1 \\ G_{\text{work}} & \text{if } k = 2 \\ G_{\text{own}} & \text{if } k = 3, 5 \\ G_{\text{work}} + G_{\text{own}} & \text{if } k = 4, 6 \end{cases}$$

      i. Pick μ so that the model replicates the expenditure share in market goods for Lima, implied by market hours and wages in Yamada (2005).

   (b) Update based on the difference to the targets of W, w_m/w_f, ownership and labor force participation in the aggregate, respectively.

4. Pick the value of ρ that best replicates the variance of the log odds of ownership rates across provinces.

D.1 Discretizing the Space of Assets

To solve the model computationally, we discretize the asset space into a grid with I points, denoted a^{ι}. We let $a^1 = 0$ and $a^I = 0.20 \times \bar{w}_{1993}$.[28] We call this grid A. The state space then becomes $\mathcal{S} = \mathcal{K} \otimes A$, with with $|\mathcal{S}| = S$.

[28] In practice, our simulations never reach this upper limit.

Let $\Lambda_{j,t}$ be a S by S matrix, that collects the transition probabilities $\lambda^{\iota}_{jkk',t} = \lambda_{jkk',t}(a^{\iota})$. In particular,

$$\Lambda_{j,t} = \begin{bmatrix} \lambda^1_{j11,t} & \lambda^1_{j12,t} & \dots & \lambda^1_{j1K,t} \\ \lambda^2_{j11,t} & \lambda^2_{j12,t} & \dots & \lambda^2_{j1K,t} \\ \vdots & & & \\ \lambda^I_{j11,t} & & & \lambda^I_{j11,t} \\ \lambda^1_{j21,t} & \lambda^1_{j22,t} & & \lambda^1_{j2K,t} \\ \vdots & & & \\ \lambda^I_{j21,t} & \lambda^I_{j22,t} & & \lambda^I_{j2K,t} \\ \vdots & & & \\ \lambda^I_{jK1,t} & \dots & & \lambda^I_{jKK,t} \end{bmatrix} \otimes \mathbf{1}_{1\times I},$$

and let $\tilde{\Pi}_{j,t}$ be a S by S transition matrix for assets that collects the decisions to transition from asset state ι to ι', conditional on starting on state k,

$$\Gamma_{j,t} = \mathbf{1}_{1\times K} \otimes \begin{bmatrix} \mathbb{I}_1[1,1] & \mathbb{I}_1[1,2] & \dots & \mathbb{I}_1[1,I] \\ \vdots & & & \\ \mathbb{I}_1[I,1] & \mathbb{I}_1[I,2] & \dots & \mathbb{I}_1[I,I] \\ \vdots & & & \\ \mathbb{I}_K[I,1] & \mathbb{I}_K[I,2] & \dots & \mathbb{I}_K[I,I] \end{bmatrix},$$

where

$$\mathbb{I}_{jk}[\iota,\iota'] = \begin{cases} 1 & if \quad x_{jk}(a^{\iota}) = a^{\iota'} \\ 0 & \text{otherwise} \end{cases}.$$

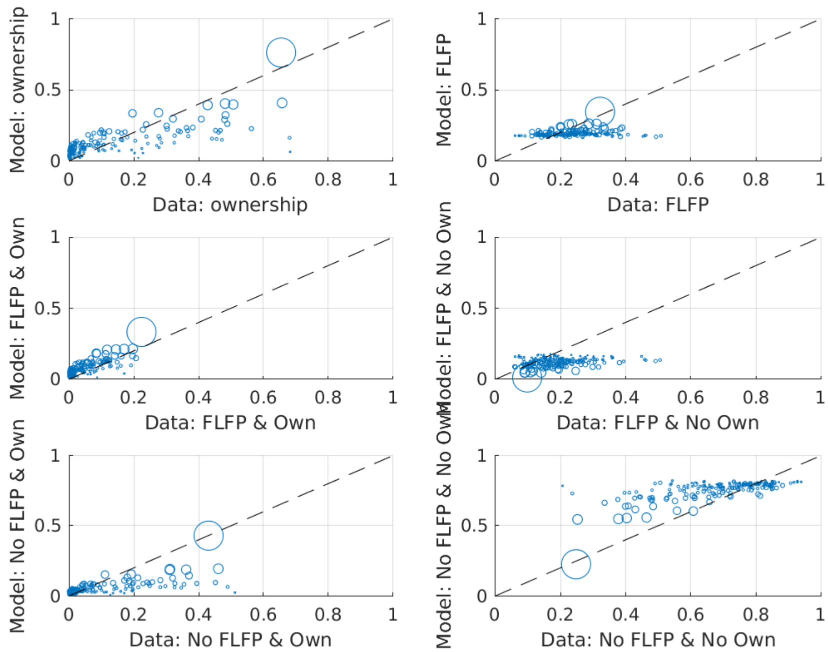
Finally, letting $\tilde{\Pi}_{j,t} = \Gamma_{j,t}\Lambda_{j,t}$, the discretized version of the law of motion in equation 11 is given by:

$$n_t = \Pi_t n_{t-1} + \bar{n}_t,$$

where

$$\Pi_t = \begin{bmatrix} 0 & \dots & & & & 0 \\ \tilde{\Pi}^T_{t,1} & & & & & \\ \vdots & \tilde{\Pi}^T_{t,2} & & & & \\ & & \tilde{\Pi}^T_{t,3} & & & \\ & & & \ddots & & \\ 0 & \dots & & & \tilde{\Pi}^T_{t,J-1} & 0 \end{bmatrix}.$$

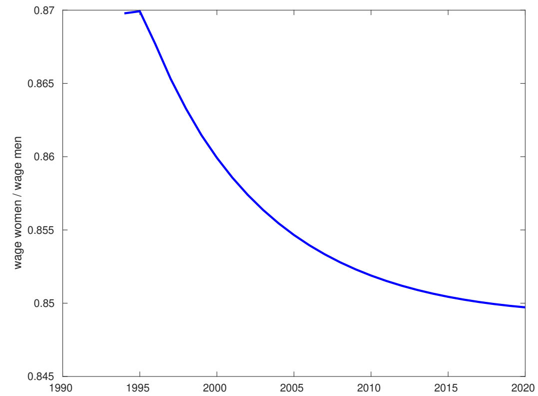
Figure E.4: Data vs Baseline Calibration



Notes: Each panel corresponds to an observable cell in the data, and each observation is a province. Within each panel, the horizontal axis plots the data and the vertical axis plots the simulation.

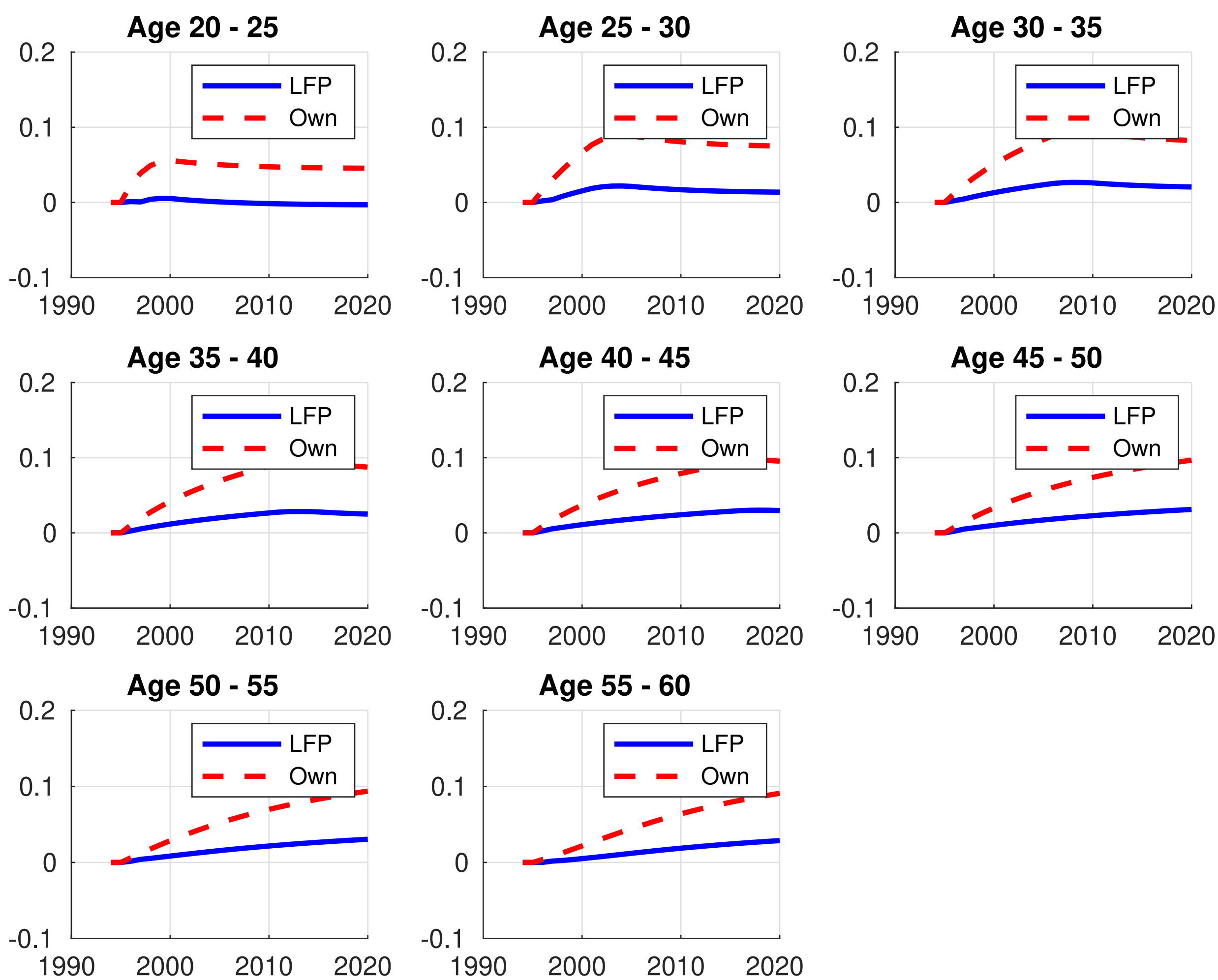
E Robustness and Additional Quantitative Results

Figure E.5: Counterfactual Response of Wages: Appliance Price Shock



Notes: The figure shows the aggregate wage of women, relative to men, in the counterfactual scenario in which the price of appliances drop.

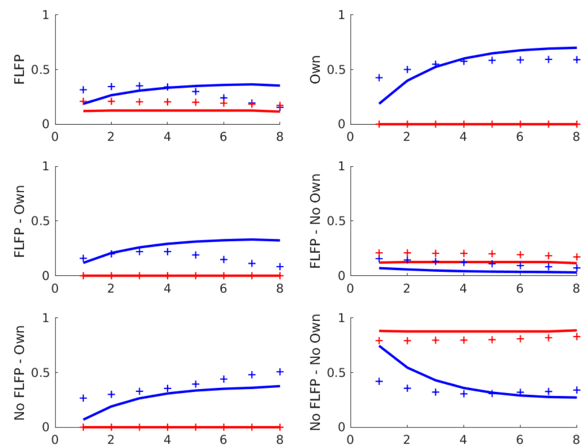
Figure E.6: Evolution of Ownership and FLFP by Age



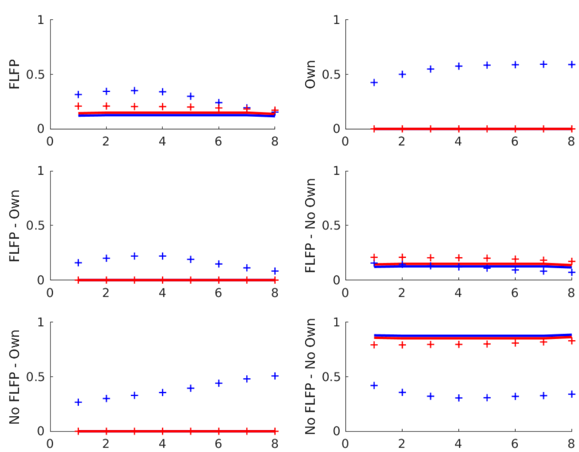
Notes: Each panel is an age group in a given year after the shock. The figure plots the evolution of the share of households owning an appliance (red) and the share of households (blue).

Figure E.7: Baseline Fit of Aggregate Shares by Age (Robustness to Appliance Productivity)

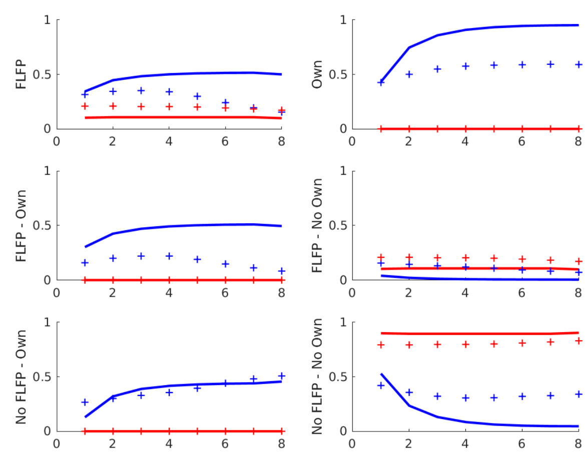
(a) Baseline Calibration



(b) Calibration $b\,(d > 0) = 1$



(c) Calibration $b\,(d > 0) = 20$



Notes: Subfigure (a) repeats our baseline calibration. Subfigure (b) shows the baseline fit when we set $b\,(d > 1) = 1$. Subfigure (c) shows the baseline fit when we set $b\,(d > 1) = 20$. Within each subfigure, each panel corresponds to an observable cell in the data. The blue crosses correspond to the data, while the red line corresponds to the model simulation.

Figure E.8: Counterfactual Response of Appliance Ownership (Robustness to Appliance Productivity)