European Economic Review 87 (2016) 194–215

Contents lists available at ScienceDirect

European Economic Review

journal homepage: www.elsevier.com/locate/eer

Distortions, infrastructure, and female labor supply in developing countries

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ARTICLE INFO

Article history:
Received 12 September 2015
Received in revised form
20 May 2016
Accepted 23 May 2016
Available online 27 May 2016

JEL classification:
O11
O14
O33

Keywords:
Female labor force participation
Developing countries
Infrastructure
Policy distortions
Household appliances

ABSTRACT

In this paper I document cross-country gaps between gross domestic product (GDP) per capita and GDP per worker. The gaps are driven mostly by a lower female labor force participation (LFP) in developing countries. Females began to participate more in the labor markets of these countries when more households acquired access to basic infrastructure and when distortive policies affecting the prices of household appliances were partially removed. I use a model of home production with endogenous labor force participation to account for these facts. I find that the prices of household appliances and access to infrastructure are quantitatively important in explaining cross-country labor supply differences.

1. Introduction

The existing literature on development has focused on analyzing cross-country differences in output per worker. The consensus is that almost 50% of these differences are accounted for by total factor productivity (TFP) differences (see Hall and Jones, 1999; Caselli and Growth, 2005, and, for Latin American (LA, henceforth) countries, Restuccia, 2008). However, cross-country gaps between gross domestic product (GDP) per capita and GDP per worker, driven by differences in labor force participation (LFP) across countries, have not garnered much attention in existing work. In this paper I document that the gap between GDP per worker and GDP per capita is entirely driven by differences in female LFP.

I uncover a new mechanism through which female LFP and economic development are intimately related. Moreover, I analyze the effect of economic reforms and government infrastructure programs on female LFP. Specifically, infrastructure refers to electricity and running water and the lack of access to it combined with low income and relatively expensive household appliances, prevent households in developing countries from adopting time-saving household technologies and, thus, from participating in the surging rate of technological progress in the home durable goods sector in the developed world.

I focus on a set of LA countries due to the availability of rich micro-data for a period of reforms and high income growth. In my empirical analysis, I narrow my focus specifically to Brazil and Mexico, the largest countries in the sample. Three novel

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http://dx.doi.org/10.1016/j.euroecorev.2016.05.006
0014-2921/

aspects of the data motivate this study. First, LFP participation differences are due mainly to differences in the participation of women in the labor market. In the US, the female LFP rate was 69% by 1990, whereas in Brazil and Mexico it was 39% and 37%, respectively. More importantly, by performing an accounting exercise I find that differences in female LFP account for around 15% of the differences in GDP per capita between the LA countries and the US in the period 1980–1990. This observed gap in female LFP started to decrease in the early 1990s: in 2005, female LFP was 72% in the US and 66% and 48% in Brazil and Mexico, respectively. Interestingly, in the same period the survey data show substantial differences in the use of durable household goods across countries. For instance, 80% of US households used a washing machine in 1990, whereas in Brazil and Mexico only 24% and 36% of households used one, respectively.

Second, in almost all the LA countries in my sample the relative price of appliances was constant or increased until the beginning of the 1990s and then rapidly decreased in the period 1990–2005. LA countries constitute excellent laboratories to analyze the effects of changes in trade policy as import substitution policies were applied in these countries until the mid-1980s. The collapse of these economies sets the stage for trade reforms, and LA countries have drastically reduced their tariff and nontariff restrictions since the end of the 1980s. I provide data on the evolution of average tariff rates in this period that suggest a factual link between the evolution of these prices and the changes in the trade policy.

Third, I document substantial differences in the access to electricity and running water both across countries and within countries in the period analyzed. Almost all US households had access to running water (c. 1990), whereas in Brazil and Mexico only 78% and 81% of the households had access to this service, respectively.[1] Interestingly, most of the difference in access comes from poor households: in 1990, 97% and 92% of the households in the top-income quintile had access to these two services in Brazil and Mexico, but only 35% and 47% of the households in the bottom-income quintile had access to these infrastructure services, respectively. This unequal access to basic infrastructure dramatically changed in the post-reform period: between 1990 and 2005 access to electricity and running water for the bottom-income quintile increased by 94% and 53% in Brazil and Mexico, respectively.

According to this evidence, the relatively high prices of household appliances and the lack of access to infrastructure can be interpreted as barriers to technology adoption by LA households. These barriers were in place until approximately 1990 and then partially removed by 2005 after economic reforms were introduced in these countries. To analyze the impact of these reforms on the observed differences and evolution of the female LFP, in the second part of the paper I develop a quantitative model. Specifically, it is an overlapping-generations model with home production and endogenous LFP that builds on Greenwood et al. (2005) (GSY, henceforth) and incorporates these salient features of the data. Its key features are (i) heterogeneity in households' ability levels and (ii) access to the infrastructure needed to operate household durable goods. More critically, I specifically model the interplay between this type of heterogeneity and access to infrastructure services in determining the adoption of time-saving household technologies.

I then calibrate the model to the US and compute the steady-state predictions for each of the countries in my sample at two points in time: the pre-reform period (1990) and the post-reform period (2005). Using the calibrated model and data, I vary country-specific parameters to investigate how much of the observed differences in female LFP is accounted for by the model in both 1990 and 2005 for each of the countries considered. Specifically, I allow average human capital levels, household income inequality, access to basic infrastructure by income quintile, gender earnings gap, TFP, and the relative price of household appliances to be country specific.

For Brazil in its pre-reform (1990), I find that the model performs well in matching the observed level of female LFP (41% in the model versus 38% in the data). Furthermore, it also succeeds in predicting the observed female LFP in the post-reform period (70% in the model versus 66% in the data). Consequently, the model predicts a 78% increase in the female LFP (74% in the data). I also use the model for Mexico. In this case, I find that the model over predicts the levels of female LFP in both periods. However, it predicts a 15% increase in female LFP between these two periods, accounting for 50% of the increase observed in the data.

Finally, I conduct a counterfactual experiment in which I keep both the access to infrastructure and the change in the price of appliances in both Brazil and Mexico at their 1990 levels. This experiment can be viewed as a “policy” exercise since by eliminating the changes in these two variables, I am assessing the effect of the documented changes of trade policy and government infrastructure programs that took occurred in the study period. In these counterfactual economies the model accounts for just 7% of the observed increase in female LFP in Brazil and does not predict any change in female LFP in Mexico. Thus, access to infrastructure and the reduction in prices of household appliances are the main forces behind the observed increase in female LFP in these countries.

Related literature: Many authors (e.g. Prescott, 2004 and Rogerson, 2009, among others) have studied differences in the labor supply between developed countries, mostly between Europe and the US. Motivated by the fact that around 15% of the observed differences in GDP per capita between LA countries and the US is due to differences in LFP, I focus on the extensive margin of labor supply differences in the developing world.

In addition, most of the LFP differences are due to differences in the market work of females, and their connection with economic development has not received much attention in the macroeconomics literature. Specifically, two important aspects of my paper connect it with the development literature. The first is the analysis of the effect of the access to basic infrastructure, which has been a major concern for government policies aimed to measure the returns to public investment

[1] I use c. 1990 as a reference year because the Brazilian data are for year 1992, and Mexican data are for year 1989. Hereafter I use “1990” for simplicity.

in infrastructure programs. My analysis offers new evidence and a formal analysis through which an increase in access to infrastructure has a nontrivial positive effect on the supply of labor. Second, one strand of the development literature focuses on the differences in the relative price of investment goods to explain differences in observed investment rates of physical capital across countries (see Restuccia and Urrutia, 2001, among others). It is argued that these price differences reflect distortions to the accumulation of physical capital in poor countries. However, it has been difficult to identify the origin of such distortions or the policies that could explain this cross-country disparity in the price levels of investment goods. The novelty of my approach is that I focus on a specific type of investment goods (household appliances) and a particular channel through which they affect the labor supply of a particular country. Moreover, I provide evidence suggesting that trade barriers are the main distortions behind the observed cross-country differences in the price of household investment goods.

This paper also documents a rise in female LFP in developing countries. An extensive literature has investigated the increase and the possible causes of the increase in the female LFP: reduction in fertility (Angrist and Evans, 1998), the diffusion of oral contraceptives (Goldin and Katz, 2002; Bailey, 2006), changes in men's attitudes regarding the market work of women (Fernndez et al., 2004), the reduction in the gender wage gap (Smith and Ward, 1985; Jones et al., 2003; Gayle and Golan, 2006), the role of medical advances and the introduction of infant formula (Albanesi and Olivetti, 2007), the role of structural change (Rendall, 2010), changes in the intra-household game (Eckstein and Lifshitz, 2011) and, for LA countries, the work of Cruces and Galiani (2005).

The work most closely related to mine is that is that of GSY. The authors argue that the diffusion of home appliances played an important role in liberating women from time-consuming housework, encouraging them to participate more in the labor market. Specifically, GSY find that the observed decline in the relative price of home appliances can explain about 50% of the increase in female LFP between 1900 and 1980 in the US. Their paper motivated many studies that analyze the economic forces at work that corroborate this hypothesis.

Examples of empirical tests for the GSY explanation are de V. Cavalcanti and Tavares (2008) and, more recently, Coen-Pirani et al. (2010). Although it also provides evidence in favor of the GSY hypothesis by using a different data set, my goal, however, goes beyond such independent empirical tests. It extends the analysis by adding new features to the quantitative theory proposed by GSY motivated by salient features of the data, some specific to developing countries. Specifically, these features are access to basic infrastructure – such as running water and electricity – and cross-country differences in the prices of appliances, inequality, and TFP. The use of a richer model allows me to extract conclusions regarding the effect of the documented policy changes implemented in these countries during the study period-specifically, the effect of the removal of trade barriers and infrastructure programs on the labor supply of women.

2. Facts

In this section, I document differences in the labor supply at the extensive margin between a set of developing countries and the US by uncovering new comparable data on LFP from country surveys. In addition, I argue that these differences are important in explaining observed differences in GDP per capita in the period 1980–2005. All data sources are described in the Data appendix.

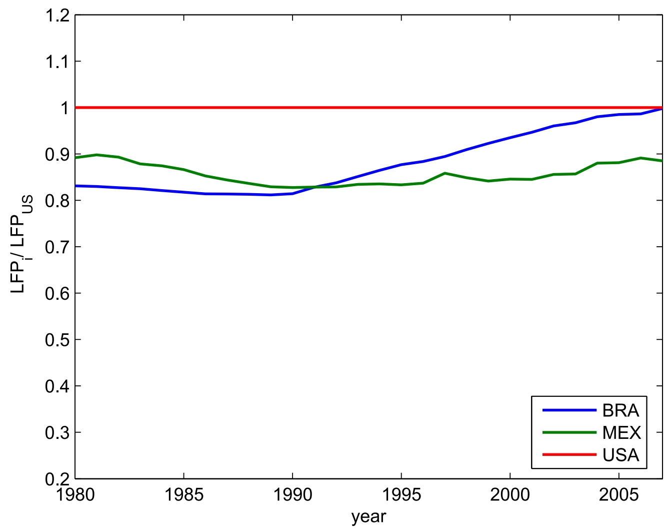

Fig. 1. Total labor force participation relative to the US. The *y*-axis is the ratio of total LFP of a country relative to the US. The countries represented in the figure are Brazil (BRA), Mexico (MEX) and United States of America (USA).

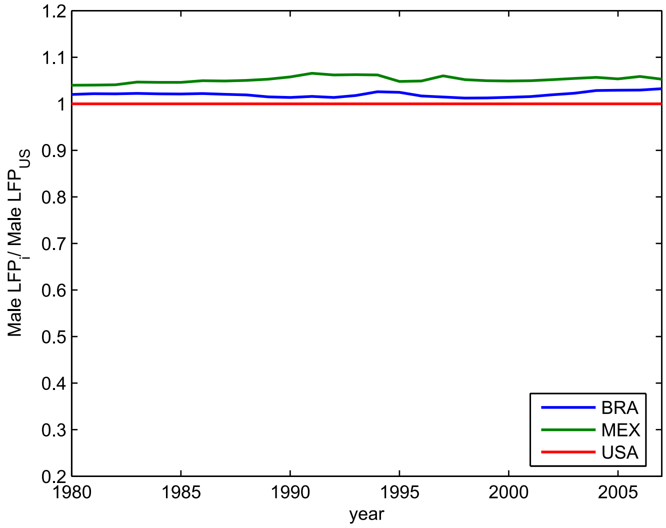

Fig. 2. Male labor force participation relative to the US. The *y*-axis is the ratio of male LFP of a country relative to the US. The countries represented in the figure are Brazil (BRA), Mexico (MEX) and United States of America (USA).

2.1. Labor force participation

Fig. 1 shows the evolution of total LFP for Brazil and Mexico relative to the US in the period 1980–2005. In 1980, total LFP in Brazil was around 80% of the US level. In Mexico, it was around 90% of the US level. Interestingly, in both countries total LFP participation decreased or remained constant relative to the US until the early 1990s when it started to increase. For instance, total LFP in Brazil caught up to the US level by 2005.

More importantly, decomposing the participation rates by gender shows that the observed cross-country differences in total LFP are the result of differences in the *female* LFP. As Fig. 2 shows, there are no substantial changes in the US male LFP during the period. However, Fig. 3 shows increased female LFP accounts for the entire difference in total LFP. A clear break about 1990 marks the evolution of the female LFP in these developing countries. Note that in the period 1980–1990 participation of women in the labor market decreased in Mexico and remained constant in Brazil. In the period 1990–2005 it substantially increased in both countries.

Table 1 shows the stunning differences in the participation of women in the labor markets in 1990 between Brazil and Mexico and the US and the substantial increase observed between 1990 and 2005. For instance, Brazil's female LFP was 39% in 1990 and 66% in 2005, an increase of almost 70% in just 15 years.

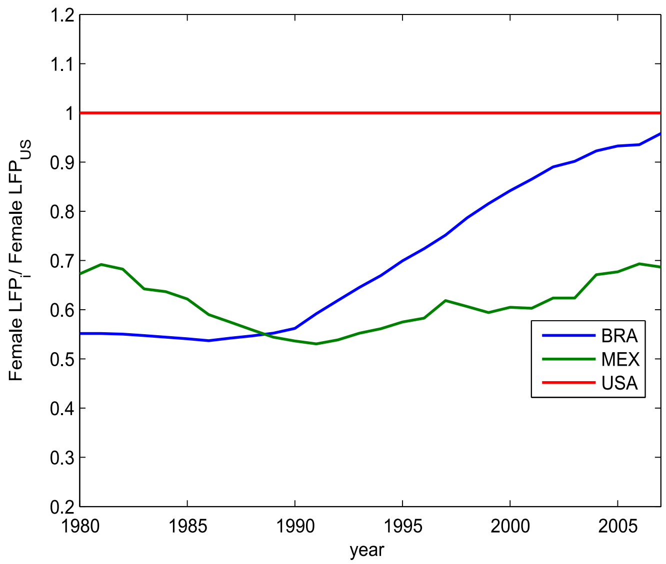

Fig. 3. Female labor force participation relative to the US in Brazil and Mexico. The *y*-axis is the ratio of female LFP of a country relative to the US. The countries represented in the figure are Brazil (BRA), Mexico (MEX) and United States of America (USA).

Table 1
Female LFP levels.

Country	1990 (%)	2005 (%)
Brazil	39	66
Mexico	37	48
United States	69	72

I focus my exposition on these two countries (the largest of the LA region) due to the availability of price data (see below), but the same pattern is observed in the majority of LA countries in the period analyzed as shown in Figs. 4–6. As clearly shown in Fig. 6, by 2005 several countries still lagged the US (Argentina, Chile, Ecuador, Mexico, and Venezuela) but others caught up and even exceeded the US (Bolivia, Brazil, Colombia, Paraguay, Peru, and Uruguay).

2.2. Labor force participation and economic development

I propose the following accounting exercise to assess the importance of differences in labor supply in the development process. For a particular year or period, we can compare the GDP per capita of country i relative to country j and decompose this ratio between the ratio of GDP's per worker and LFP.

By definition,

$$\frac{GDP_{pw,i}}{GDP_{pw,j}} = \frac{\frac{GDP_i}{LF_i}}{\frac{GDP_j}{LF_j}}, \tag{1}$$

where GDP_i is the GDP in country i, $GDP_{pw,i}$ is the GDP per worker of country i, and LF is the labor force or number of workers of country i.

Since

$$LF_i = LFP_i \times POP_i, \tag{2}$$

where LFP_i and POP_i represent the labor force participation and total population of country i, respectively. Substituting (2) into (1) yields

$$\frac{GDP_{pw,i}}{GDP_{pw,j}} = \frac{\frac{GDP_i}{LFP_i \times POP_i}}{\frac{GDP_j}{LFP_j \times POP_j}}. \tag{3}$$

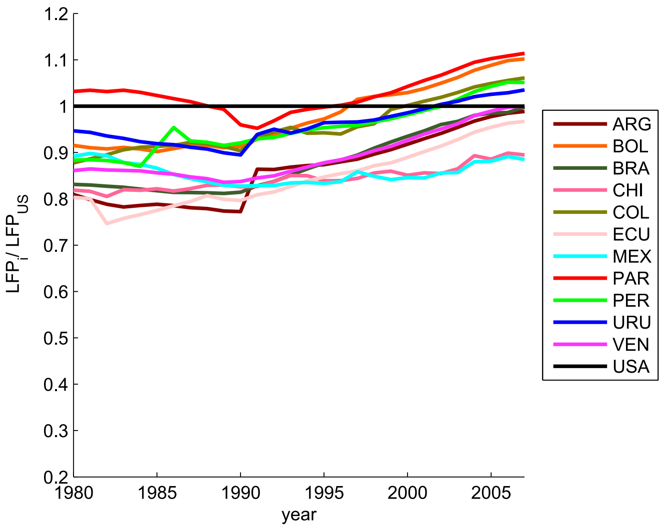

Fig. 4. Total labor force participation relative to the US in Latin American countries. The y-axis is the ratio of total LFP of a country relative to the US. The countries represented in the figure are Argentina (ARG), Bolivia (BOL), Brazil (BRA), Chile (CHI), Colombia (COL), Ecuador (ECU), Mexico (MEX), Paraguay (PAR), Peru (PER), Uruguay (URU), Venezuela (VEN) and United States of America (USA).

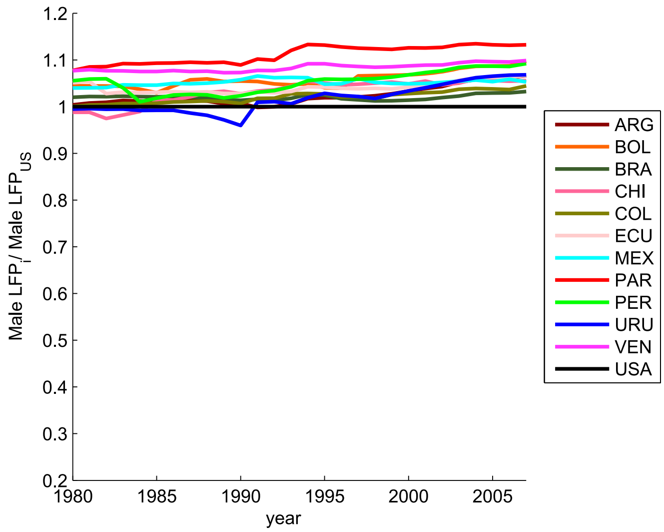

Fig. 5. Male labor force participation relative to the US in Latin American countries. The *y*-axis is the ratio of male LFP of a country relative to the US. The countries represented in the figure are Argentina (ARG), Bolivia (BOL), Brazil (BRA), Chile (CHI), Colombia (COL), Ecuador (ECU), Mexico (MEX), Paraguay (PAR), Peru (PER), Uruguay (URU), Venezuela (VEN) and United States of America (USA).

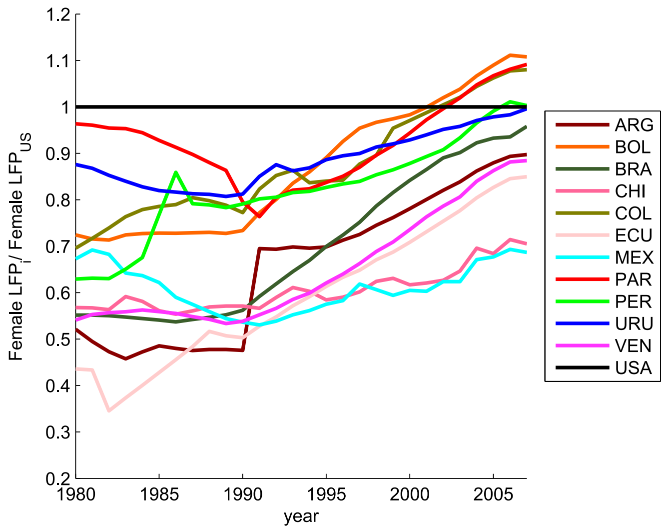

Fig. 6. Female labor force participation relative to the US in Latin American countries. The *y*-axis is the ratio of female LFP of a country relative to the US. The countries represented in the figure are Argentina (ARG), Bolivia (BOL), Brazil (BRA), Chile (CHI), Colombia (COL), Ecuador (ECU), Mexico (MEX), Paraguay (PAR), Peru (PER), Uruguay (URU), Venezuela (VEN) and United States of America (USA).

Using the definition of GDP per capita and rearranging terms,

$$\frac{GDP_{pw,i}}{GDP_{pw,j}} = \frac{GDP_{pc,i}}{GDP_{pc,j}} \times \frac{LFP_j}{LFP_i}, \tag{4}$$

or

$$\frac{GDP_{pc,i}}{GDP_{pc,j}} = \frac{GDP_{pw,i}}{GDP_{pw,j}} \times \frac{LFP_i}{LFP_j}. \tag{5}$$

The previous literature on developing accounting has focused on the observed differences in GDP per worker across countries (the first term of the right hand side [RHS] of (5)) and very little on LFP differences (the second term of the RHS of (5)). By using (5) to compare the average of LA with that of the US in the study period, we have

$$\frac{GDP_{pc,LA}}{GDP_{pc,US}} = \frac{GDP_{pw,LA}}{GDP_{pw,US}} \times \frac{LFP_{LA}}{LFP_{US}}. \tag{6}$$

Table 2
Households with washing machines.

Country	c. 1990 (%)	2005 (%)
Brazil	24	36
Mexico	36	64
United States	76	82

Table 3
Households with access to electricity.

Country	c. 1990 (%)	2005 (%)
Brazil	90	97
Mexico	91	99
United States	100	100

Table 4
Households with access to running water.

Country	c. 1990 (%)	2005 (%)
Brazil	78	90
Mexico	81	91
United States	100	100

Taking logarithms on both sides of (6) allows us to determine the contribution of the documented differences on LFP in explaining the observed differences in GDP per capita in that period. Interestingly, in both Brazil and Mexico, differences in LFP explain around 20% of the differences in GDP per capita between these countries and the US in 1990. Given the dramatic increase in LFP since the early 1990s, by 2005 LFP differences explain only 1% and 10% of the GDP per capita differences between Brazil and Mexico and the US, respectively.[2] As argued below, this study provides a detailed explanation for this nontrivial portion of the observed cross-country differences in income per capita.

2.3. *Differences in household technology across countries*

I explore compiled data from household surveys to document cross-country differences in the technologies used at the household level. The available data start about 1990, which is the year in which all the major changes in female LFP began in the region. I have access only to data on the percentage of households with washing machines in 1990 and 2005, which can be considered as a good approximation of the adoption of time-saving devices.

Table 2 shows the adoption of washing machines for Brazil, Mexico, and the US. Around 1990, 76% of US households operated a washing machine, but 36% and 24% of Mexican and Brazilian households, respectively, had one. The adoption of washing machines substantially increased during the period. From 1990 to 2005, the percentage of households with washing machines increased by 50% (from 24% to 36%) in Brazil and by 77% (from 36% to 64%) in Mexico.

2.4. *Barriers to technology adoption*

In this section, I provide evidence on barriers to the adoption of new technologies at the household level in a set of LA countries. I first show differences in the access to basic infrastructure across countries. In addition, I provide unique data on the evolution of the prices of household appliances for these developing countries that present an interesting pattern that can be connected to the observed differences regarding the adoption of new technologies by LA households. Finally, I provide data on average tariff levels before and after the reforms in the early 1990s, which I argue could be one reason behind the particular evolution of prices reflected in the data.

Infrastructure: In order to adopt the technology embodied in new appliances, the proper infrastructure needs to be available to the household: electricity and/or running water, depending on the specific appliance. Table 3 shows the mean access to electricity for Brazil, Mexico, and the US in 1990 and 2005. In the period analyzed, access to this basic service substantially increased. In Brazil access increased from 90% to 97% and, in Mexico from 91% to 99%. I later argue this factor has a nontrivial effect on the increase in the female LFP in these countries. Table 4 shows the mean access to running water. Again, Brazil and Mexico experienced a substantial expansion in the access to this basic service: the percentage of households with access to running water increased by 15.4% and 12.3% in Brazil and Mexico, respectively.

[2] For the average LA country, differences in the LFP explain more than 15% of the ratio of GDP per capita between LA and the US in 1990.

Table 5
Brazil: access to infrastructure by income quintile.

Income quintile	c. 1990 (%)	2005 (%)	Change (%)
Top	97	99	2.2
Second	84	94	12.3
Third	72	89	23.3
Fourth	57	82	43.7
Bottom	35	67	92.6

These figures refer to the mean access to these basic infrastructure services, but exploring data on the access to infrastructure by income quintile provides a better picture of the substantial changes in this margin experienced by the households of these countries. Table 5 presents the percentage of households with access to both electricity *and* running water by income quintile in Brazil in 1990 and 2005. The high inequality in access to infrastructure is clearly evident in 1990: while almost all households at the top of the income distribution had access to these services, only 35% of the poorest households could use these infrastructure services. In other words, for the majority of poor households, even if they could afford new durable goods, they could not use the new technologies due to the lack of access to the infrastructure needed to operate them. The picture dramatically changed in 2005. As the third column in Table 5 shows, by 2005, there was much less inequality in access to infrastructure, providing major improvements in access to these services for poor households. The access rates increased by 41% and 94% for the households in the bottom two income quintiles.

The same pattern is observed for Mexico. Table 6 shows that in 1990, 92% of households in the top-income quintile had access to electricity and running water, whereas only 45% of the households in the bottom quintile had access to these basic services. Again, a more equal distribution in the access to infrastructure is observed in 2005: access rates increased by 53% for the households in the bottom income quintile.

Prices of household appliances: To explore the possible reasons for the different adoption pattern across countries observed in the labor participation data, I examine the evolution of the relative prices of household appliances for each of the countries analyzed. The idea is to use relative prices as indicators of distortions that vary across countries and time. A large literature focuses on the differences in the relative price of a generic investment good to explain differences in investment rates of physical capital across countries observed in the data (see Restuccia and Urrutia, 2001, among others). Here I focus on a specific type of investment goods (household appliances) and a particular channel through which they affect the labor supply of a particular country.

I uncover new data from national statistical agencies for some countries in the sample to observe the particular dynamics of the relative prices of appliances. Figs. 7 and 8 present the evolution of the relative price of household appliances, constructed as the ratio between a price index of appliances and a consumer price index, for Brazil and Mexico, respectively. For the US, the seminal work by GSY shows that the observed declining path of the prices of household appliances is the main force that spurred the adoption of new durable goods by households and explains most of the increase in the female LFP in the US during the 20th century. Interestingly, in LA countries the relative prices of household appliances show an upward or constant trend until the end of the 1980s, when they start to decline rapidly until the end of the study period (see Figs. 7 and 8). In Brazil, the relative price declined 60% between 1990 and 2005 and in Mexico by 26% in the same period. Note that the prices of home appliances started to decline in the early 1990s; this coincides with the increase in the female LFP documented above and depicted in the figures. Also note that these prices are not adjusted by quality, which surely improved after the trade reforms, so the documented decline is a lower bound of the real decrease in prices.

Why is a different pattern observed in the evolution of appliance prices in LA countries? The timing of the break in the trend of the price of household appliances in LA countries coincides with the timing of the trade liberalization period, which was characterized by the removal of trade policies that introduced distortions in the prices of imported goods in the study period. Among them are the import substitution policies in place until the early 1990s. These policies sought to promote and develop a domestic manufacturing industry through the application of tariffs and para-tariff barriers on imported goods. To provide some evidence in this direction, Table 7 shows the average effective applied tariff rates in Brazil and Mexico in the period preceding the reforms (1990) and in the post-reform period (2005). The average tariff levels around 1990 show that, on average, Brazilian consumers had to pay an extra 43% when purchasing imported goods. In Mexico, the average tariff rates are lower, since the trade reforms were initiated earlier than in Brazil. Yet, in both countries tariff rates were reduced

Table 6
Mexico: access to infrastructure by income quintile.

Income quintile	c. 1990 (%)	2005 (%)	Change (%)
Top	92	97	5.4
Second	86	95	10.7
Third	80	93	16.3
Fourth	64	87	35.3
Bottom	45	74	66.2

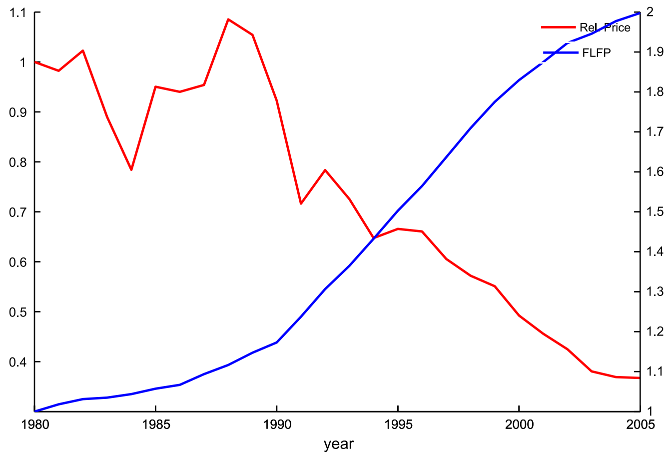

Fig. 7. Relative price of appliances and female LFP in Brazil. The *y*-axis on the left-hand side represents the relative price of household appliances (Rel. Price) and it is 1 for the year 1980. The *y*-axis on the right-hand side represents the female LFP (FLFP) where 1 is its value for the year 1980.

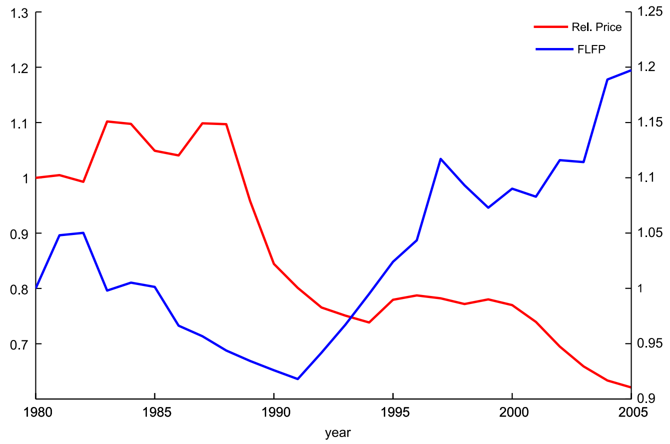

Fig. 8. Relative price of appliances and female LFP in Mexico. The *y*-axis on the left-hand side represents the relative price of household appliances (Rel. Price) and it is 1 for the year 1980. The *y*-axis on the right-hand side represents the female LFP (FLFP) where 1 is its value for the year 1980.

Table 7
Average applied tariff levels.

Country	All products		Manufactured products	
	c. 1990 (%)	2005 (%)	c. 1990 (%)	2005 (%)
Brazil	34	12	35	13
Mexico	14	9	14	9

between these two periods. In Brazil, average tariff rates decreased by 70%. This value is close to the observed reduction in the price of household appliances between the same two periods (60%). In Mexico, tariffs were reduced by 30% and the price of appliances declined 26%. The changes in tariff rates are similar for manufactured goods (also depicted in Table 7). To my knowledge, there are no available data on tariffs for specific products in the period analyzed, but there is some evidence that the level of protection for consumer durables was even more aggressive (see Table 8 in Cole et al. (2005)). For instance, the average nominal tariff applied to durables was 266% in Argentina in 1960. In addition, it is well known that measures of tariff rates are only an approximate indicator of trade restrictions since they do not take into account para-tariff barriers (duties and custom fees) and quantitative restrictions such as import quotas. Other measures of trade restrictions in the pre-reform and post-reform periods are documented by Loayza and Palacios (1997), who show a similar pattern of changes in trade restrictions.

This evidence suggests that the removal of these distortive policies may be the main reason for the break in the pattern of relative prices observed in the figures and might contribute to explain the rise in the adoption of appliances by LA households observed in the data. A home production model (described in the next section) introduces the link suggested by (i) the presented facts on adoption of household technologies, (ii) the relative price of household appliances and its evolution (which may reflect distortions/barriers), and (iii) access to infrastructure (which also acts as a barrier).

3. The model

A stationary description of the model environment is provided below.

3.1. Environment

Preferences, endowments and heterogeneity: Time is discrete.

Time is discrete. Each period, an overlapping generation of heterogeneous agents is born into an economy that lives for J periods. At each point in time there is a continuum of agents with unit mass, belonging to one of J generations. Death is certain at age J; hence, the fraction of agents of age $j \in J$ is equal to $1/J$.

Households are born with no assets and are heterogeneous in their ability levels (efficiency units of labor) denoted by h, which is realized at the beginning of their life. Ability is drawn from the exogenous distribution $\pi(h)$ and is fixed over its life.

A household is composed of a male and a female, each endowed with one unit of time. They also share the same ability level h. The male splits his time between market work and leisure, whereas the female can spend her time in market work, housework, and leisure. It is assumed that labor is indivisible, and the portion of time allocated to market work is fixed and given by ω. Males always supply labor to the market and their income is given by $w\omega h$, with w being the wage rate. For females, if they work in the market they obtain $\phi w\omega h$, where ϕ is a parameter denoting the gender earnings gap. Households derive utility from the consumption of market goods, home goods, and leisure time.

The objective of a household is to maximize

$$\sum_{j=1}^{J} \beta^{j-1} \left[\lambda \ln c_m(j) + \nu \ln c_n(j) + (1-\lambda-\nu) \ln l(j)\right],$$

where $c_m(j)$ is the consumption of market goods at age-j, $c_n(j)$ is the consumption of home goods at age-j, and $l(j)$ is leisure at age-j. β is the discount factor, λ is the weight of market goods, and ν is the weight of home goods.

Technologies: The technology for producing home goods is given by

$$c_n = \min\{d, \zeta \times n\}, \tag{7}$$

where c_n denotes the quantity of home goods produced and consumed in the household; d represents the durable good, which is assumed to be lumpy; ζ is the level of the technology to produce home goods; and n is the home labor performed by the female, which is indivisible. This assumption is convenient when mapping the model with data since we observe only adoption rates (i.e., the extensive margin) for the adoption of home production technologies. In addition, the specification is more general than it appears since, as discussed in GSY, in the presence of indivisibility in the arguments, the Leontief specification is equivalent to the constant elasticity of substitution (CES) technology. In addition, as shown in Section 6 in GSY, the predictions of the model do not hinges on the indivisibility assumptions.

Two technologies are available for the household to produce home goods. When households are born, they are endowed with the *old* technology, which we can interpret as the one used to produce handmade home goods (for instance, washing clothes by hand). The *new* technology requires the purchase of a durable good at the price q. I abstract from modeling the production of the durable good and assume that its price is exogenous. Once the household purchases the durable good, it will use the new technology for its entire life.

In order to map the model to the data, following GSY and Vandenbroucke (2009), a convenient way to parameterize the home production technology is as follows. If the household operates the old technology, the amount of durable goods is given by

$$d = \delta, \tag{8}$$

and when it operates the new technology, it is given by

$$d' = \kappa\delta > d, \quad \text{with } \kappa > 1. \tag{9}$$

Regarding the amount of labor, n, required to produce home goods with the new technology, assume that

$$n' = \eta, \tag{10}$$

and when it operates the old technology it is given by

$$n = \rho\eta, \quad \text{with } \rho > 1, \tag{11}$$

that means $n > n'$.

Combining these four equations, the productivity to produce home goods with the old technology is given by

$$\zeta = \frac{\delta}{(\rho\eta)}, \tag{12}$$

and when it operates the new technology it is given by

$$\zeta' = \frac{\kappa\delta}{\eta} = \kappa\rho\zeta > \zeta. \tag{13}$$

Given the Leontief specification for the production of home goods, this implies that the quantity of home goods produced with the old technology is

$$c_n = \min\{d, \zeta n\} = \delta, \tag{14}$$

and with the new technology

$$c_n' = \min\{d', \zeta' n'\} = \kappa\delta > c_n. \tag{15}$$

In addition, adopting the new technology requires the household to have access to the basic infrastructure needed for that purpose. For instance, running water and electricity are necessary to operate a washing machine. The access to infrastructure is given to the household when it is born, and it is introduced in the model as a discrete exogenous variable $\gamma \in 0, 1$. If $\gamma = 1$, the household has access to infrastructure, and if $\gamma = 0$, it does not.

There is a standard Cobb–Douglas technology that describes the production of market goods by competitive firms, given by

$$y = zK^{\alpha}(L)^{1-\alpha}, \tag{16}$$

where y is total output, K is the aggregate stock of physical capital, L represents the labor input, z is the TFP parameter, and α is the share of physical capital in output.

Capital is accumulated according to

$$K' = (1-\chi)K + i, \tag{17}$$

where χ describes the depreciation rate and i the investment done by firms operating in competitive markets.

The resource constraint reads

$$y = c_m + i + qd. \tag{18}$$

3.2. Household decision problem

A recursive description of the household decision problem is presented below.

For an age-j household, optimization consists of choosing the amount of assets to carry to the next period a' and two discrete choices: (i) whether the female participates in the market or stays at home and (ii) whether it purchases the durable good or not. In addition to its age j, the following are relevant to the household's decisions: the assets it carries into the period, a; the efficiency units with which it is endowed, denoted by h, which together with the wage rate w will determine both the income of the male and the female (if she works in the market); if it has adopted the new technology in the past or not; and if it has access to infrastructure, since without access to basic infrastructure, the household cannot adopt the new technology in any period. Thus, the state of a household is summarized by the vector $x = (a, h, \gamma, \tau, j)$; τ is the state variable describing the adoption of technologies by the age-j household. It takes the values $\{0, 1\}$, where $\tau = 0$ indicates the household has adopted the new technology in the past and $\tau = 1$ indicates the household has not adopted the new technology in the past.

Define the participation of the female in the market by the indicator function I_P, which takes the value 1 if the household chooses for the female to work in the market and 0 if she stays at home. In the same way, whether to continue operating the old technology (with which she is already endowed) or purchase the durable good at the exogenous price q and operate the new technology is described by the indicator function I_A, which takes the value 1 if the household purchases the durable good and 0 if not. Also, let $V(a, h, \gamma, \tau, j)$ define the lifetime utility of age-j household.

To illustrate the household decision, consider first the case of an age-j household that is born with access to infrastructure (i.e., $\gamma = 1$) and has adopted the new technology sometime in the past (i.e., $\tau = 0$). This household chooses the level of assets it will carry to the next period and whether the female participates in the market or stays at home. Its budget constraint reads

$$c_m = w\omega h + (\phi w\omega h)I_P + ra - a', \tag{19}$$

where r is the interest rate and $\phi < 1$ is the parameter that represents the gender wage gap.

The value function obeys the following recursion:

$$V(a,h,1,0,j)=\max_{a',I_P\in\{0,1\}}\left[\lambda\ln(w\omega h+(\phi w\omega h)I_P+ra-a')+\nu\ln(\kappa\delta)+(1-\lambda-\nu)\ln\left(2-(1+I_P)\omega-\eta\right)+\beta[V(a',h,1,0,j+1)]\right]. \tag{20}$$

Now consider the age-j household that is born with access to infrastructure (i.e., $\gamma=1$) and has *not* adopted the new technology in the past (i.e., $\tau=1$). This household chooses whether or not it will purchase the durable good (adopt the new technology) in the current period, the asset level to carry to the next period, and whether or not the female participates in the labor market. Its budget constraint is given by

$$c_m=w\omega h+(\phi w\omega h)I_P+ra-a'-qI_A. \tag{21}$$

given our specification for the home production technology, its value function reads

$$\begin{aligned}V(a,h,1,1,j)=\max_{a',I_P\in\{0,1\},I_A\in\{0,1\}}&\left[\lambda\ln(w\omega h+(\phi w\omega h)I_P+ra-a'-qI_A)+\nu\ln\left(I_A(\kappa\delta)+(1-I_A)\delta\right)\right.\\&+(1-\lambda-\nu)\ln\left(I_A(2-(1+I_P)\omega-\eta)+(1-I_A)(2-(1+I_P)\omega-\rho\eta)\right)+\beta[I_AV(a',h,1,0,j+1)\\&\left.+(1-I_A)V(a',h,1,1,j+1)]\right].\end{aligned} \tag{22}$$

Finally, there are households born without access to infrastructure (i.e., $\gamma=0$). It is assumed that such households need access to infrastructure to operate modern technologies. Therefore, without access to infrastructure they cannot purchase the durable good at any time in their life. In this case,

$$I_A=0\quad\text{for } j=1,..,J. \tag{23}$$

Each period the household chooses its asset level to carry to the next period and whether or not the female works in the labor market. The value function reads as follows:

$$V(a,h,0,1,j)=\max_{a',I_P\in\{0,1\}}\left[\lambda\ln(w\omega h+(\phi w\omega h)I_P+ra-a')+\nu\ln(\delta)+(1-\lambda-\nu)\ln\left(2-(1+I_P)\omega-\rho\eta\right)+\beta[V(a',h,1,1,j+1)]\right]. \tag{24}$$

Abusing notation somewhat, denote the optimal decision rules for assets by $a'(x)$, the female participation function by $I_P(x)$, and the adoption function by $I_A(x)$.

Aggregates: For aggregation purposes it necessary to specify the position of households across states.

Let $\psi_j(B,H;\gamma,\tau)$ be the mass of households, with asset position $a\in B$, efficiency units $h\in\mathcal{H}$, $j\in\mathcal{J}$, access to infrastructure γ, and adoption state τ. The measure ψ is defined for all $B\in\mathcal{B}$, the class of Borel subsets of $\mathbb{R}$, all Borel subsets $H\subset\mathcal{H}$, all $j\in\mathcal{J}$, $\gamma\in\{0,1\}$, and $\tau\in\{0,1\}$. The dynamic evolution of the mass of households reads as follows.

The realization of γ determines the mass of newborns without access to infrastructure:

$$\psi_1(B,H;0,1)=\frac{1}{J}\int_{\mathbb{R}\times H}I_{\{\gamma=0\}}z(h)dh\quad \textit{if}\ 0\in B,$$

where $I_{\{\cdot\}}$ is an indicator function.

Recall that the no access to infrastructure status for households remains constant for their entire lifetime, which prevents such households from adopting the new technology. For $1<j\le J$, we need to consider the mass of households without access to infrastructure for which $a\neq 0$. That means

$$\psi_{j+1}(B,H;0,1)=\frac{1}{J}\int_{\mathbb{R}\times H}I_{\{a'(a,0,1)\in B\}}d\psi_j(a,h;0,1),$$

where $I_{\{\cdot\}}$ is an indicator function.

Similarly, the mass of households with access to infrastructure is denoted by

$$\psi_1(B,H;1,1)=\frac{1}{J}\int_{\mathbb{R}\times H}I_{\{\gamma=1\}}z(h)dh\quad \textit{if}\ 0\in B.$$

Note that here I use the assumption that a newborn is endowed with the old technology and so has not adopted the technology in the past ($\tau=1$).

Since all households die at J, we have that

$$\psi_{J+1}(B,H;\gamma,\tau)=0.$$

For $1<j\le J$, ψ obeys the following recursion.

For the case of past adopters (i.e., $\tau=0$),

$$\psi_{j+1}(B,H;1,0)=\frac{1}{J}\int_{\mathbb{R}\times H}I_{\{a'(a,1,0,j)\in B\}}d\psi_j(a,h;1,0)+\frac{1}{J}\int_{\mathbb{R}\times H}I_{\{a'(a,1,1)\in B\}}I_A(a,1,1,j)d\psi_j(a,h;1,1).$$

In words, the mass of past adopters in $j+1$ is equal to the mass of past adopters in j (first term on the RHS) plus the mass of new adopters (second term on the RHS).

In the same way, the mass of no adopters in $j+1$ is given by

$$\psi_{j+1}(B,H;1,1)=\frac{1}{J}\int_{\mathbb{R}\times H} I_{\{a'(a,1,1,j)\in B\}}(1-I_A(a,1,1,j))d\psi_j(a,h;1,1).$$

We now have all the elements to provide an equilibrium definition.

Equilibrium: In this economy, a stationary competitive equilibrium consists of value functions $V(x)$; decision rules $a'(x)$, $I_P(x)$, and $I_A(x)$; aggregate variables K and L; a measure ψ; and a set of prices w, r, and q, such that

1. Optimal decision rules $a'(x)$, $I_P(x)$ and $I_A(x)$ solve the household's dynamic problem given w, r, and q, and $V(x)$ are the resulting value functions.
2. Factor prices are competitive:

$$w=(1-\alpha)z(L/K)^{-\alpha}$$
$$r'=\alpha z(L'/K')^{(1-\alpha)}+(1-\chi)$$

3. Labor and capital markets clear:

$$L=\sum_{j=1}^{J}\frac{1}{J}\omega\int_{\mathbb{R}\times H} hd\psi(x)+\phi\omega\sum_{j=1}^{J}\frac{1}{J}\int_{\mathbb{R}\times H} hI_P(x)d\psi(x),$$

and

$$K=\sum_{j=1}^{J}\frac{1}{J}\int_{\mathbb{R}\times H} ad\psi(x).$$

4. The measure of agents is generated as described above.

3.3. A simple case

To illustrate the effect of the price of durable goods on the adoption of the new home technology and on female LFP and their interaction with TFP and ability levels I resort to a simple version of the general model described above. Specifically, I consider a small open economy version of the overlapping-generations economy described above in which individuals live for only two periods (young and old), they work in the first period and retire in the second. I focus on the technology adoption and female labor participation decisions of the young with access to infrastructure. Assuming the same technology for the production of home goods, the young's household optimization problem is given by

$$\begin{aligned}\max_{a,I_P\in\{0,1\},I_A\in\{0,1\}} & \lambda\ln\left[w\omega h+(\phi w\omega h)I_P-a-qI_A\right]+\nu\ln\left[I_A(\kappa\delta)+(1-I_A)\delta\right]+(1-\lambda-\nu)\ln\left[I_A(2-)1+I_P)\omega-\eta)\right.\\ & +(1-I_A)(2-(1+I_P)\omega-\rho\eta)\big]+\beta\ln(ar)+\beta\ln\left[I_A(\kappa\delta)+(1-I_A)\delta\right]+\beta(1-\lambda-\nu)\ln\big[I_A(2-(1+I_P)\omega-\eta)\\ & \left.+(1-I_A)(2-(1+I_P)\omega-\rho\eta)\right]\end{aligned} \tag{25}$$

The Euler equation for consumption of the market good is given by

$$c_m^o=\beta r c_m^y \tag{26}$$

where c_m^y and c_m^o are the consumption of market goods when young and old, respectively.

We can now easily obtain the expressions for consumption when young and old, which are given by

$$c_m^y=\frac{w\omega h+(\phi w\omega h)I_P-qI_A}{1+\beta} \tag{27}$$

and

$$c_m^o=\frac{r\beta}{1+\beta}\left[w\omega h+(\phi w\omega h)I_P-qI_A\right]. \tag{28}$$

Once again, assuming that the output is produced according to (16) by competitive firms and that there is full depreciation of the physical capital stock. Thus, it transpires that the rental rate of capital is going to be given by r and that

$$r=\alpha z K^{\alpha-1}(L)^{1-\alpha} \tag{29}$$

and

$$w=(1-\alpha)zK^{\alpha}(L)^{-\alpha}. \tag{30}$$

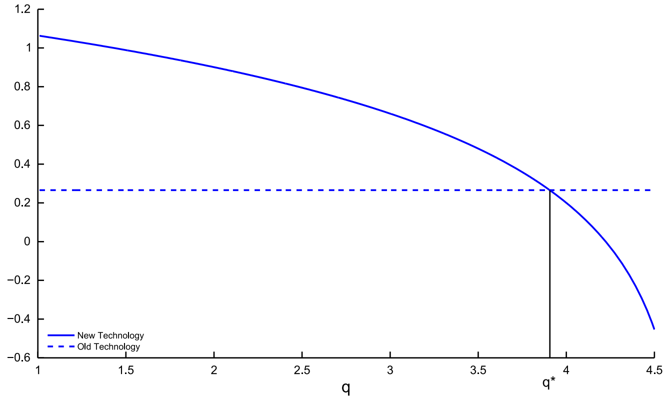

Fig. 9. Adoption decision and the price of the durable good: benchmark. This figure plots the value functions when the young household adopts the new technology (solid line) and when it continues to operate the "old" one (dashed line) for a given value of ability level *h*.

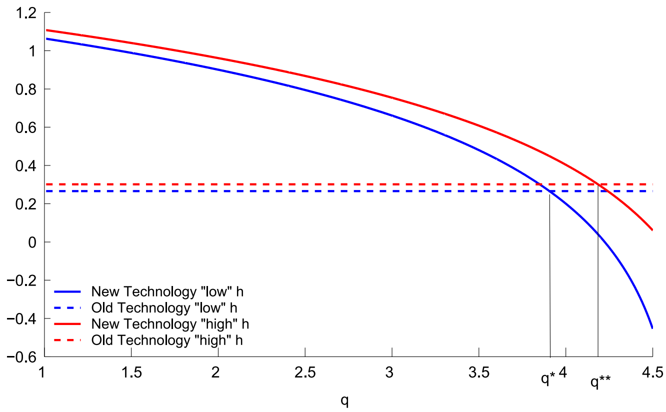

Fig. 10. Adoption decision and the price of the durable good: "Low" and "High" ability levels. This figure plots the value functions when the young household adopts the new technology (solid line) and when it continues to operate the "old" one (dashed line) for a given "low" (blue) and "high" (red) values of ability levels *h* for different values of the price of the appliance *q*. The values q^* and q^{**} are the threshold level prices for "low" and "high" *h*, respectively. (For interpretation of the references to color in this figure caption, the reader is referred to the web version of this paper.)

Combining (29) and (30) we obtain that the wage rate is $w=(1-\alpha)\alpha^{\frac{\alpha}{(1-\alpha)}}z^{\frac{1}{(1-\alpha)}}r^{\frac{-\alpha}{(1-\alpha)}}$, which depends on the interest rate and the TFP level. We can now use this simple framework to illustrate the household decisions with respect to the adoption of the new technology and the female LFP. For that purpose, I rely on a numerical example by using some of the values of the parameters obtained on the quantitative analysis in the next section.[3] It is easy to show, that in this case and given the parameter values, if the household adopts the technology then it is optimal for the household for the female to participate in the market. Thus, I concentrate the analysis on the adoption decision when the price q varies. Fig. 9 shows the lifetime utility of the young household when it adopts and operate the new technology (solid line) and when it does not adopt the technology and keeps operating the old one (dashed line). It is easy to show that there is a single crossing point between both lines that represents the threshold price q^* of the household durable good given its ability level h as represented in the figure. If the price is less than q^*, then the household adopts the new technology, otherwise it continues to operate the old one. More interesting, by increasing the ability level to $h' > h$ we can see that, everything else equal, the threshold price is higher, $q^{**} > q^*$ as shown in Fig. 10. That is, the higher the ability level of the household, the higher price of the technology it can afford. In the same way, given a price q, in this economy the adopters are high-ability (high-income) households. This effect can be reinforced if, in addition of having higher ability levels, many of these households are also the ones with access to infrastructure. The framework is rich enough to analyze the effect of changes in the TFP level z. Similarly, if we increase the level of TFP ($z' > z$), the threshold price is higher ($q^{***} > q^*$), as shown in Fig. 11. That is, given its ability level h, the higher the productivity of the economy, everything else equal, the higher the price the household can afford to adopt the new technology.

[3] Specifically, in the benchmark case I set $\alpha=1/3$, $\omega=0.36$, $\lambda=0.33$, $\phi=0.74$, $\nu=0.1$, $\delta=1$, $\rho=3.25$, $\eta=0.16$, $\beta=0.56$, $z=14.5$, $\kappa=8$, $r=1.3$, and $h=0.7$.

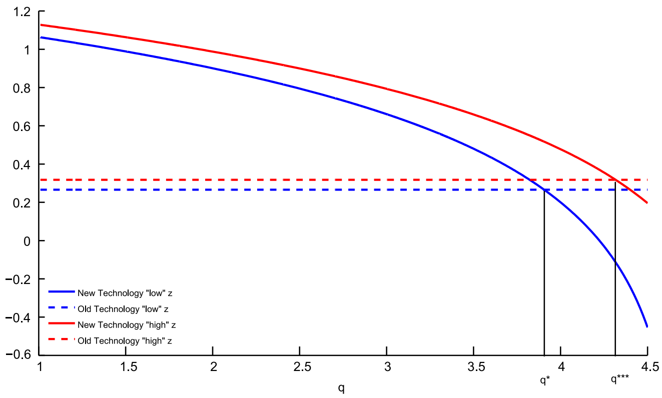

Fig. 11. Adoption decision and the price of the durable good: "Low" and "High" TFP levels. This figure plots the value functions when the young household adopts the new technology (solid line) and when it continues to operate the "old" one (dashed line) for a given "low" (blue) and "high" (red) TFP levels z for different values of the price of the appliance q. The values q^* and q^{***} are the threshold level prices for "low" and "high" TFP, respectively. (For interpretation of the references to color in this figure caption, the reader is referred to the web version of this paper.)

Table 8
Calibration: targets.

Target	Model	Data	Data source
Female LFP in 1990 (%)	70.3	69.0	ILO
Nondurables consumption/GDP	0.56	0.56	NIPA
Adoption of washing machines in 1990 (%)	76.0	76.0	Census Bureau
Access to electricity and water in 1990 (%)	100	100	Census Bureau
Capital–output ratio	2.8	2.8	NIPA
Gini income	0.48	0.46	BLS
Female earnings/male earnings	0.73	0.73	BLS

Note: This table presents the results of the calibration exercise when the model is calibrated to the US in 1990. BLS, Bureau of Labor Statistics; ILO, International Labour Organization; NIPA, National Income and Product Accounts.

Table 9
Model mechanics.

Experiments	Adoption (%)	Female LFP (%)	Gini index	Output
Benchmark	76	70	0.48	100
Average efficiency units	46	59	0.56	69
Dispersion of efficiency units	66	65	0.53	99
Price of appliances	52	64	0.49	99
Access to infrastructure	24	56	0.49	98
TFP	52	64	0.48	72

Note: This table presents the results of the experiments to explore the model mechanics. It presents the value of the variables of interest for the benchmark economy (first row) and resulting from the experiments (second through the sixth rows).

4. Quantitative analysis: the benchmark economy

4.1. Parameterization

I calibrate the model to the US economy in 1990. The model period is 13 years with $J=4$. The first three periods are working periods and the last one is a retirement period in which members of the household do not work. In the model, households start life at the age of 25, retire at the age of 64 (which is consistent with the age of the workers in the data I target), and they die when they are 77 years old. The parameter that represents the technology in market production, z, is normalized to 1.

There are seven parameters, $\alpha, \chi, \omega, \eta, \rho, \kappa$, and δ, that I take directly from data. The share of capital in market production, α, is set to 0.3. The depreciation rate, χ, is set to 10%, which is the estimated depreciation rate of physical capital (not including durable goods) by the U.S. Bureau of Economic Analysis. The remaining five parameters relate to the production of home goods. ω is set to 0.36 by assuming that a market worker works in the market 40 h a week of her 112 h of non-sleeping time. η and ρ set the allocation of time a female performs household chores with and without household appliances. According to Lebergott (1993), females who use household appliances spend on average 18 h a week to produce home goods; therefore, $\eta = 18/112 = 0.16$. However, when they do not have access to these durable goods, they spend 58 h a week; therefore, $\rho \times \eta = 58/112 = 0.52$, which means $\rho = 3.25$. κ and δ control the aggregate relative stock of appliances before and after the adoption of the durable goods, respectively. Following GSY, the stock of appliances when households adopt the new technologies is eight times the one observed when very few households use these durable goods; thus, after fixing $\delta = 1$, $\kappa = 8$.

For the efficiency units, I assume that h are distributed $\log(h) \sim N(\mu_h, \sigma_h)$. I normalize the US distribution by setting $\mu_h = 0$. In the US, the proportion of households with access to electricity *and* running water is close to 100%, so I set $\gamma = 1$ for all households.

It remains to determine values for $\phi, \sigma_h, \beta, \lambda, \nu$, and q. These are chosen together to match the following moments of the data: (i) the observed Gini coefficient for household income, (ii) the female LFP rate, (iii) the percentage of nondurable goods consumption over GDP, (iv) the percentage of households with washing machines, (v) female earnings as a percentage of male earnings reported by the U.S. Bureau of Labor Statistics, and (vi) the capital-output ratio; all in 1990. The parameter values are as follows: $\phi = 0.74$, $\sigma_h = 0.82$, $\beta = 0.96$, $\lambda = 0.33$, $\nu = 0.2$, and $q = 0.23$. Table 8 shows the fit of the model to the targets in detail.

5. Model mechanics: steady-state effects

In this section, I explore the long-run consequences of a number of changes in the calibrated parameters of the benchmark economy. The aim of these experiments is to highlight the role of different forces at work in various countries to facilitate the understanding of the cross-country analysis performed in the next section. Specifically, I consider the following departures from the benchmark case that apply to the evidence for LA countries: a decrease in the average efficiency units of labor, an increase in income inequality, a decrease in the price of household appliances, a decrease in the access to infrastructure, and a decrease in TFP. I consider each of the changes in isolation.

The motivation for the experiments that follow is straightforward. As documented in Section 2, there are both substantial cross-country and within-country differences in the price of household appliances between 1990 and 2005. In addition, there are both cross-country and within-country variations in the access to infrastructure. Finally, the variation in TFP and in the parameters controlling the efficiency units of labor contributes to the assessment of the relative importance of observed cross-country differences in the level and concentration of income in determining the observed differences in the adoption of household technologies and female LFP.

The effects of changing the average level of efficiency units of labor: In the first experiment, I change only the parameters that govern the distribution of efficiency units of labor. Specifically, I lower μ_h to -0.56 and raise σ_h to 1.036 such that the average level of efficiency units in this hypothetical economy is 70% of the one in the benchmark economy, but the variance of the efficiency units (the log-normal distribution) remains constant across these two economies. The goal of the experiment is to analyze the effects of reducing the average income of households through the efficiency units channel. Since my study focuses on the population 25 years of age and older, this change in efficiency units of labor could be interpreted as an exogenous change in average human capital levels across different economies, an issue addressed below. The second row in Table 9 summarizes the results. The percentage of households with durable goods decreases significantly: from 76% to 46%. As a result, female LFP declines (from 70% to 59%).

There is a cutoff level of efficiency units that divides households between those for which it is optimal to purchase the durable good and those for which it is not. The fact that the average efficiency units of labor in this economy is reduced and the price of household appliances remains constant, prevents a large percentage of households (the poorer ones) from purchasing the durable good or adopting the new technology. As a result, fewer females are able to participate in the labor market. Also interesting to note is the fact that the reduced number of females participating in the market, who are also the poorer ones in the income distribution, makes the economy more unequal, as observed in the increase in the Gini coefficient for income, which goes from 0.48 to 0.56.

The effects of changing the dispersion of efficiency units of labor: Now I consider a hypothetical economy with a higher dispersion of the efficiency units of labor or ability levels compared with the benchmark economy. To perform this experiment, I change the parameters of the distribution of efficiency units of labor so the log-normal distribution of the hypothetical economy has a variance 50% higher than its counterpart in the benchmark economy but both share the same average level of efficiency units. Specifically, I set $\mu_h = -0.11$ and $\sigma_h = 0.94$. The third row in Table 9 shows the results. In this case, the adoption levels decrease (from 76% to 66%). This change in the adoption level causes fewer females to participate in the market; their participation decreases (from 70% to 65%). The changes in the parameters of the distribution generate a higher variance in the efficiency units of labor. This generates a larger mass of households of both at the lower and higher levels of efficiency units. In this experiment, the first force dominates, so there is a higher concentration of low-ability households compared with the benchmark economy. Therefore, a smaller mass of households can adopt the new technology which causes fewer females to participate in the labor market. However, the changes are not as large as in the previous case when the movement in the distribution of ability was more significant. As expected, income inequality increases, as is evident from the Gini coefficient shown in the table.

Table 10
Model predictions for Brazil.

Year	Female LFP (%)		Adoption (%)	
	Data	Model	Data	Model
1990	39	41	24	2
2005	66	70	36	17

The effects of changes in the price of household appliances: In this experiment, I consider an economy in which households face a higher relative price of household appliances, which could discourage the adoption of new household technologies. For that purpose, I increase q such that the price of appliances is 40% higher than in the benchmark economy (see the fourth row of Table 9 for the results of this experiment). As the price of household appliances increases, there is a smaller mass of households for which it is optimal to adopt the new household technology. As a result, the proportion of households that adopts the new technology decreases (from 76% to 52%), and fewer females participate in the labor market (from 70% to 64%). Again, the fact that fewer females are working in the market slightly raises income inequality.

The effects of changes in access to infrastructure: Next I consider that the effect of access to basic infrastructure could also operate as a barrier to the adoption of new technologies by households. Motivated by household survey data, I set the proportion of households with access to infrastructure depending on their location in the income distribution. Specifically, as discussed below in the cross-country analysis, I use data on access to electricity and running water by income quintile. The data show that richer households have more access to infrastructure than the poor ones. Therefore, I set different proportions of households with access to infrastructure by income quintile. In this experiment, I consider a case where 95% of the households in the top income quintile have access to infrastructure, 83% of the households in the fourth quintile, 78% of the households in the third quintile, 73% of the households in the second quintile and 53% of the households in the bottom income quintile. The fifth row of Table 9 shows the results. This experiment is the one that shows the major effects. Note that adoption is reduced by almost 70% (it goes from 76% to 24% in both cases). This dramatic change in the adoption of new technologies reflects the infrastructure restrictions faced by households in this hypothetical economy. Since access to infrastructure is a necessary condition for the adoption of the new technology (e.g., 53% of the households in the lowest income quintile cannot adopt the new technology), this affects households decisions regarding female LFP. Note that female LFP decreases (from 70% to 56%).

The effects of total factor productivity: Finally, I analyze the effect of changes in TFP. In the model, TFP enters as a technology parameter, z, which was set to 1 for the benchmark economy. In this experiment, I lower z to 0.8. The sixth row of Table 9 shows these results. As expected, through changes in TFP, the marginal product of labor is much lower than in the benchmark economy (the wage rate decreases from 0.36 to 0.27). This lowers the labor income of households, and for the same price of the durable good, there are fewer households for which it is optimal to adopt the new technology (adoption decreases from 76% to 52%). The change in technology adoption lowers the female LFP, which is also affected by the change in the wage rate since it makes the labor market less attractive for females.

6. Cross-country analysis

In this section, I investigate the extent to which the forces in the model can account for (i) the observed levels and evolution in the adoption of new household technologies and (ii) female LFP in each of the countries considered. The analysis consists of computing two different steady states for each of the economies, 1990 and 2005, and then confronting the model predictions with data. Each of the steady states explicitly accounts for the documented country-specific levels and evolution in the efficiency units of labor, output, gender earnings gaps, access to infrastructure, and prices of household appliances.

6.1. Model predictions for Brazil

I now use the model for the Brazilian case. I first compute a steady state for Brazil in 1990, which is done as follows. I use the 1985 benchmark of the Penn World Tables (PWT) to determine relative price data that are comparable across countries. Specifically, by using PWT benchmark data, I compute the price of specific consumption goods, such as washing machines, relative to the price of an aggregate consumption good for both Brazil and the US. Then I compute the ratio of the Brazilian relative price to the US relative price.[4] I already have the calibrated value of this price for the US in 1990 (q^{US}_{1990}), and according to the data I set q^{BRA}_{1990} such that $q^{BRA}_{1990}/q^{US}_{1990} = 0.82$, which gives $q^{BRA}_{1990} = 0.18$.

There is a set of parameters that are also specific to Brazil. Although the parameters are chosen together to reproduce a set of moments, each is linked to a particular moment in the data. Regarding the distribution of abilities, I set $\sigma_h = 1.15$ to

[4] A similar procedure is followed in Restuccia and Urrutia (2001) for the case of an aggregate investment good.

Table 11
Change in female LFP 1990 (=100) versus 2005 for Brazil.

Year	Data	Model
1990	100	100
2005	169	171

reproduce a Gini coefficient of Brazil in 1990 of 0.56 (it is 0.59 in the data). In addition, I set $\mu_h = -1.02$ so that the mean of h in Brazil over the mean of h in the US is 0.50, which corresponds to the ratio of average human capital levels between Brazil and the US in 1990 computed by using data on the average years of education of people aged 25 and older and the Mincerian returns as calculated in Hall and Jones (1999).[5]

As is clear in the data, access to infrastructure varies across countries. In addition, access varies within each of the developing countries according to the position of households in the income distribution. Recall that this is relevant into my computation providing that, by construction, households without access to basic infrastructure cannot purchase the durable good and so adopt the new technology. Therefore, when computing the steady state for Brazil in 1990, I assign to each household in the model a value of $\gamma=1$ or $\gamma=0$ such that, in the steady-state equilibrium, 33% of Brazilian households in the first income quintile have access to electricity *and* running water (35% in the data), 60% in the second income quintile (57% in the data), 73% in the third quintile (72% in the data), 85% in the fourth quintile (84% in the data), and 100% in the fifth quintile (97% in the data).

Differences in the gender earnings gaps are also observed across countries. This is an endogenous object in the model that depends on the mean ability levels of the females that participate in the market in equilibrium and the wage rate gap ϕ. For Brazil, I change ϕ to match female earnings as a percentage of male earnings observed in the data – that is, 0.65. Finally, according to the PWT data (version 6.2), the output per worker in international dollars in Brazil was 40% of that in the US; therefore, I lower the technology parameter z to 0.78 to match this observed output difference. The remaining parameters are not specific to Brazil, and so I use the values obtained when I calibrate the model for the US in 1990.

The second row of Table 10 depicts the levels of female LFP and adoption predicted by the model and their data counterparts. Note that these two variables were not targeted in either 1990 or 2005. The model performs well in explaining the observed level of female LFP in 1990 (41% versus 39% in the data). Consequently the model also accounts for the observed gap in female LFP between the US and Brazil in 1990. This suggests that the theory proposed is quantitatively important in accounting for observed differences in the female labor supply between these two countries. However, exploring the adoption levels in Table 10 shows that the model falls quite short in accounting for the levels of adoption of durable goods. This is not surprising considering that the adoption levels in the data are for only washing machines; in the theoretical framework, household technology enters in the home goods production function as a composite durable good for which we have no comparable data. Yet the model qualitatively succeeds in predicting a much lower adoption rate in Brazil compared with the US, as observed in the data.

I now compute a steady state for Brazil in 2005. I set the relative price of durable goods, q_{2005}^{BRA}, to be consistent with the 60% decline in this price observed in the data between 1990 and 2005 (see Section 2.4). In addition, according to the data, in 2005 the relative earnings of females with respect to males are 0.87, so I change ϕ_{2005} accordingly. I also set $\mu_h = -0.59$ so that the relative human capital level (computed as before) of Brazil with respect to that of the US in 2005 is 0.63, higher than its level in 1990. Furthermore, I set $\sigma = 1.0$ to resemble a lower observed Gini coefficient for income in 2005, that is, 0.54.

Additionally, I assign to each household a value of $\gamma = 1$ or $\gamma = 0$ such that in the steady-state equilibrium 65% of Brazilian households in the first income quintile have access to electricity and running water (in the data it is 67% in 2005 and 35% in 1990), 83% in the second income quintile (82% in 2005), 90% in the third quintile (89% in 2005), 93% in the fourth quintile (94% in 2005), and 100% in the fifth quintile (99% in 2005). Finally, I lower the technology parameter z to 0.55 to reflect that GDP per worker in Brazil was 25% of that in the US that year. The remaining parameters are kept fixed at their 1990 levels.

The bottom row of Table 10 shows the female LFP and adoption levels predicted by the model and their data counterparts in 2005. The model performs well in matching the observed female LFP level in this year (70% versus 66% in the data). As in the steady state computed for 1990, the model is not as successful in predicting the adoption levels, but the same caveats apply here since I am comparing the model predictions with the adoption of only washing machines. However, qualitatively it performs well in predicting an increase in the number of households that use the new technologies embedded in the durable goods as observed in the data for washing machines.[6]

Another important dimension to evaluate the theory is to compare the predicted (between the two computed steady states) and the observed change in female LFP for each country. Table 11 shows this for Brazil. According to the data, female

[5] As in Hall and Jones (1999), I assume that the measure of human capital per worker in each country is given by $h = \exp(\Phi(s))$, where Φ is a function of years of schooling (s), determined by rates of return that vary with the average years of schooling consistent with empirical estimates. Specifically, I set $\Phi(s) = 0.134s$ for $s \in [0, 4]$, $\Phi(s) = 0.134 \times 4 + 0.101(s-4)$ for $s \in (0, 8]$, and $\Phi(s) = 0.134 \times 4 + 0.101 \times 4 + 0.068(s-8)$ for $s > 8$. I use the average years of schooling in each country as reported by Barro and Lee (2013).

[6] As another approximation for the adoption of new technologies, we can also examine available data on the percentage of households with refrigerators. According to these data, from c. 1990 to 2005 the percentage of households with refrigerators in Brazil increased by 23%.

Table 12
Model predictions for Mexico.

Year	Female LFP (%)		Adoption (%)	
	Data	Model	Data	Model
1990	37	55	36	21
2005	48	63	64	49

LFP rose by 69% between these two periods and the model predicts an increase of 71%; thus, the model accounts for almost all the observed change in female LFP. The model succeeds in this dimension, which I interpret as the most important finding of the experiment. The results suggest that the economic forces incorporated in the proposed theory are quantitatively important in accounting for observed changes in female LFP observed in this country.

6.2. Model predictions for Mexico

I follow the same procedure for the Mexican data. I first compute a steady-state for 1990. As before, I use data from the 1985 benchmark of the PWT (version 6.2) to determine the ratio of relative price of washing machines between Mexico and US (in international prices). Therefore, I choose q_{1990}^{MEX} such that $q_{1990}^{MEX}/q_{1990}^{US}=0.94$, which gives $q_{1990}^{MEX}=0.22$.

Again, there is a set of parameters specific to Mexico. I set $\sigma_h=0.84$ to resemble a Gini coefficient of Mexico in 1990 of 0.50 (it is 0.49 in the data). In addition, I set $\mu_h=-0.57$ so that the average human capital level of Mexico is 58% of the one computed for the US in 1990.

When computing the steady state, for access to infrastructure in Mexico I assign to each household a value of $\gamma=1$ or $\gamma=0$ such that, in equilibrium, 48% of Mexican households in the first income quintile have access to electricity *and* running water (45% in the data); 63% in the second income quintile (64% in the data); 83% in the third quintile (80% in the data); 83% in the fourth quintile (86% in the data), and 95% in the fifth quintile (92% in the data).

I also choose $\phi=0.88$ so the model in equilibrium reproduces the female earnings as a percentage of male earnings that closely resembles the observed in the Mexican data-that is, 0.72 (0.73 in the data). Finally, according to PWT data the output per worker in international dollars in Mexico was 50% of that in the US, so I lower the technology parameter z to 0.88 to reproduce that gap.

In addition, I compute another steady state for Mexico but now for 2005. As before, I set the relative price of durable goods, q_{2005}^{MEX}, to be consistent with the decline of 26% in this price observed in the data between 1990 and 2005 (see Section 2.4). Specifically, I set $q_{2005}^{MEX}=0.16$. Additionally, according to the data, in 2005 the relative earnings of females with respect to males are slightly higher, 0.76, so I set $\phi=0.83$. I also raise $\mu_h=-0.32$ to reflect a narrower gap in human capital levels between Mexico and the US: the human capital level of Mexico in 2005 is 70% of that calculated for the US in the same year. Furthermore, I set $\sigma=0.83$ to generate a Gini coefficient for income in 2005 of 0.50 (0.49 in the data).

To reflect the substantial improvements in access to infrastructure observed in the data, I now assign to each household a value of $\gamma=1$ or $\gamma=0$ such that in the steady-state equilibrium 75% of Mexican households in the first income quintile have access to electricity *and* running water (the access level is 74% in 2005), 88% in the second income quintile (87% in 2005), 93% in the third quintile (93% in 2005), 95% in the fourth quintile (95% in 1990), and 100% in the fifth quintile (97% in 2005). Finally, I lower the technology parameter z to 0.70 providing that GDP per worker Mexico was 35% of the US GDP per worker in that year (as did Brazil, Mexican economy got poorer relative to the US economy between 1990 and 2005).

Table 12 shows the adoption levels in Mexico in the model (column 5) versus their data counterparts (column 4). The model accounts for 60% and 77% of the adoption levels observed in the data in 1990 and 2005, respectively. However, the same caveats apply for the Mexican case: even though the model performs much better than for Brazil, the adoption levels in the data refer only to the adoption of washing machines. Yet, as the data show, the model qualitatively succeeds in three important dimensions: it predicts (i) a lower adoption rate compared with the US, (ii) an adoption rate that is higher than the one observed in Brazil, and (iii) an increase in the adoption rate between 1990 and 2005.

Table 12 also depicts the levels of Mexican female LFP and adoption predicted by the model (column 3) and their data counterparts (column 2). Contrary to the Brazilian case, the model overpredicts the levels of female LFP in both 1990 and 2005 (55% versus 37% in the data for 1990 and 63% versus 48% in the data for 2005). Apparently, for Mexico there are variables that were not incorporated into this model that prevent it from reproducing the observed levels of female LFP. Compared with the US, even though the model predicts a narrower gap in female LFP between Mexico and the US compared

Table 13
Change in female LFP 1990 (=100) versus 2005 for Mexico.

Year	Data	Model
1990	100	100
2005	130	115

Table 14
Female LFP (1990 = 100) in the counterfactual experiment.

Country	Data	Model prediction	Counterfactual	Contribution (%)
Brazil	174	171	105	7
Mexico	130	115	100	0

with the data (this is a direct consequence of overpredicting the levels for Mexico), qualitatively it still performs well since it predicts a lower female LFP for Mexico, as observed in the data. More importantly, Table 13 shows that the exogenous variables incorporated into the model account for 50% of the observed changes in female LFP in this country. Although it misses the levels, the model does well in predicting the change between 1990 and 2005. This suggests that the proposed theory is also quantitatively important in accounting for observed changes in female LFP in this country.

6.3. *The importance of access to infrastructure and distortions*

Conducting a counterfactual experiment is one way to assess the impact of the observed increase in infrastructure access and the decrease in the price of household appliances in generating the observed increase in female LFP. The counterfactual can be viewed as a "policy" exercise providing the documented evidence on the observed changes of the trade policy and access to infrastructure underlying the changes in the price of appliances and access to running water and electricity. The experiment consists of shutting down the observed increase in the access to infrastructure and the change in the price of appliances between 1990 and 2005 in both Brazil and Mexico. Here, "shutting down" means keeping them at their 1990 levels. Since these two variables are potentially linked and this correlation is not modeled here, I consider these two factors together. Specifically, I solve the model for both Brazil and Mexico in 2005 but set the access to infrastructure and the relative price of household appliances of their 1990 levels.

Table 14 shows the results. According to the model, with this counterfactual where (i) households maintain their 1990 levels of access to electricity and running water and (ii) the price of appliances is kept at their 1990 level, the model accounts for only 7% and 0% of the observed increase in female LFP in Brazil and Mexico, respectively. According to these results, access to infrastructure and the reduction in the price of household appliances are the main forces behind the observed increase in female LFP in these countries.

7. Conclusions

I document that differences in the access to basic infrastructure and the relative price of household appliances are quantitatively important in accounting for differences in female LFP between a set of LA countries and the US. In addition, because TFP and human capital levels are lower in developing countries, households purchase fewer time-saving household durable goods, which prevents females from participating in the labor market. I support the theory by uncovering new disaggregated data based on household surveys for a set of LA countries with a model of home production with endogenous female LFP. One important implication of this study is that distortive policies that affect household production – such as trade restrictions (applied in these countries until the early 1990s) – may have very undesirable effects in the labor supply. Moreover, by analyzing the interplay between the access to basic infrastructure and LFP, this study provides new insights regarding the returns to infrastructure investments, which will be the object of future research.

Acknowledgment

I thank Stefania Albanesi, Raquel Fernandez, Martin Lopez-Daneri, B. Ravikumar, Diego Restuccia, Pedro Silos, Michelle Tertilt, Guillaume Vandenbroucke and Gustavo Ventura for their useful comments as well as seminar participants at the Federal Reserve Bank of Atlanta, Central Bank of Uruguay, CINVE, SITE-Stanford University, Growth and Development Conference LAEF-UC Santa Barbara, and LACEA-LAMES.

Data appendix

Labor force participation

The data on labor force participation are from the Key Indicators of the Labour Market, International Labor Organization, KILM (2008). The LFP rate is calculated by expressing the number of employed and unemployed persons in the labor force as a percentage of the population between the ages of 25 and 64. Both formal and informal sector participants are taken into account.

Gender earnings gap

The gender earnings gap is calculated as the average income of employed women as a percentage of the average income of employed men in urban areas. The data are provided by the Economic Commission for Latin America and the Caribbean (ECLAC) and were prepared based on household surveys of each country (http://estadisticas.cepal.org/cepalstat/WEB_CEPALSTAT/estadisticasIndicadores.asp?idioma=e).

Relative price of household appliances

For the pre-reform period (1990), I use the 1985 benchmark data of the PWT, which presents cross-country data on the price of washing machines and aggregate consumption in international dollars. For each country I compute the relative price of washing machines and then divide that ratio by the relative price computed for the US (http://pwt.econ.upenn.edu/Downloads/benchmark\\/benchmark.html).

The time series for the relative price of household appliances for each country is calculated by dividing the price index of household appliances over the general price index. The data for the U.S. are obtained from the Bureau of Labor Statistics (BLS). The specific category used to represent the price of household appliances is Major Appliances (series ID: WPU 1241), a subcategory of the group Furniture and Household Durables. The general price index is obtained from the same source (series ID: WPU 00000000).

For Brazil and Mexico, I use the general price index and the price index of Furniture, Appliances, and Household Accessories. The source for Mexico is the Bank of Mexico (http://dgcnesyp.inegi.org.mx/cgi-win/bdieintsi.exe/NIVL1000100020001\\00020$#ARBOL).

For Brazil, the data on wholesale price indexes are from the Fundaçao Getúlio Vargas (http://portalibre.fgv.br/main.jsp?lumChannelId=402880811D8E34B\\9011D92B6F9D30FAE).

Households with washing machines, electricity, running water, and household income Gini coefficients

For Latin American countries, the data are from the Socio-Economic Database for Latin America and the Caribbean (SEDLAC, 2013). This database includes statistics on social and economic variables of Latin American and Caribbean countries. All statistics are computed from microdata of the main household surveys in these countries (http://www.depeco.econo.unlp.edu.ar/sedlac/eng/index.php).

The US data on household appliances and access to infrastructure are from the American Housing Survey for the United States in 1991 and 2005 from the U.S. Census Bureau.

Tariff rates

The data on average tariff rates are obtained from the World Development Indicators database (World Bank, WDI, 2013). The data refer to the simple mean of effectively applied rates for all products subject to tariffs calculated for all traded goods and for manufactured traded goods.

GDP per capita

Data on GDP per worker used in my calculations are from the Penn World Table (version 6.2) (http://pwt.econ.upenn.edu/php_site/pwt62/pwt62_form.php).

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