Marketization in a Heterogeneous Skill Economy*

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Abstract

The surge in marketization – the purchase of services from the market that would otherwise be produced at home – in the US has been attributed to decreases in the marginal cost of personal services through increased productivity. In this paper, I show that low-skilled labor is the largest input to the production of these personal services, and thus low-skilled wage movements contribute to marginal cost declines. To illustrate the role that the rising skill premium has played in marketization, I build a model to study the economic forces that shape households' resource allocation in a heterogeneous skill economy. In contrast to the findings in the representative household models, my quantitative exercise shows that changes to the wage structure, rather than a larger growth of productivity of the personal service sector relative to the home sector, are the predominant drivers of marketization. Thus, the combination of Skill-Biased Technological Change along with increase in relative supply of skill can account for more than 60% in marketization. This new mechanism suggests that policies and labor market institutions that are responsible for the trajectory of the skill premium can also affect the extent of marketization.

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1 Introduction

Economists have long recognized the critical role of reallocation between the home sector and the market sector in shaping economic fluctuations and long-term growth.[1] The process whereby households purchase services from the market that would otherwise be produced at home is defined as *marketization* by Freeman and Schettkat (2005). This reallocation is relevant to economic outcomes because of the large substitutability between the output of home production and personal services. Previous research on marketization typically focuses on representative households and, as a result, concludes that marketization is completely driven by the increase in productivity of the personal services sector relative to the home sector.[2]

In this paper, I examine the role of Skill-Biased Technological Change (SBTC) in explaining the marketization of the home production sector. The key observation that workers providing personal services have low educational attainments suggests that the price of personal services could be affected by a wage change for low-skilled workers. Given the real wage decline of low-skilled workers from 1980 to 2019 in the US, it is worth examining how recent changes in the supply and demand of skill interacts with marketization.

The analysis in this paper proceeds as follows. First, using data from the Census and the American Community Surveys, I show that the personal services sector has the highest share of low-skilled worker hours compared to other sectors. Using time diaries, I document that both high- and low-skilled households have spent less time on home production from 1980 to 2019. Using expenditure diaries, I find that both the high- and low-skilled households experience an increase in the expenditure share for home production substitutes. Second, I build a quantitative heterogeneous agent model with high- and low-skilled households to study how different productivity changes affect marketization trends through relative prices. Third, I use a calibrated model to match the aggregate change in skill premium, home production time, and

[1] See Benhabib, Rogerson and Wright (1991), Greenwood and Hercowitz (1991), McGrattan, Rogerson and Wright (1997) as starting points for business cycles; Becker (1965), Greenwood, Seshadri and Yorukoglu (2005), Greenwood, Guner and Marto (2021) for long-term growth

[2] One exception is Ngai and Petrongolo (2017), who study marketization by genders.

expenditure share on personal services from 1980 to 2019. The quantitative exercise suggests that the opposite trajectories of market opportunities for the high- and low-skilled household, along with the relative supply increase of the high-skilled, can account for at least 60% of aggregate trends. Instead, a relative increase of productivity in the market sector over the home sector is *not* necessary to match the aggregate trends in a heterogeneous skill economy. This project links the change of skill premium to the level of marketization, which is particularly relevant in "re-thinking" the service sector size difference between the US and Europe (as Europe has not experienced as large a change in the skill premium as the US in the past four decades).

Empirical facts that low-skilled households display similar qualitative patterns on marketization as high-skilled households contradicts the standard intuition suggested by a representative household economy. In a representative household economy, marketization is explained through a decline in the cost of market service relative to the opportunity cost of home production. However, given the wage stagnation of low-skilled households from 1980 to 2019, the intuition drawn from a representative household economy suggests that low-skilled household would show less (or no) marketization pattern than the high-skilled household, which is not the case empirically. A heterogeneous skill economy is a promising framework within which to examine this tension, as it allows changes to the wage structure to be introduced. The framework is also helpful in evaluating the general-equilibrium implication of low-skilled wages if the productivity of personal services grows faster than the productivity of the home sector.

The modeling exercise suggests that the underlying forces that shape wage structure by skills also affect the relative prices among market goods, market services, and home production. On the one hand, a decrease in market opportunities for low-skilled workers reduces the price of personal services and, as a result, the service bundle becomes cheaper relative for goods, prompting both types to spend less time on home production and to work more. On the other hand, an increase in market opportunities for high-skilled workers due to higher marginal productivity makes market services relatively more expensive. Hence, both types can

spend more of their income on market services. Therefore, it is essential to leverage on the change of skill premium in order to quantify how the underlying technological changes relate to marketization in a heterogeneous skill economy.

In Section 2, I use data from Census, the American Time Use Surveys and the Consumer Expenditure Survey to establish three stylized facts on marketization. First, I find that more than 80% of the personal service sector's labor input is from the low-skilled labor force. This fraction is the largest when compared with the manufacturing and other service sectors. Second, for the aggregate, from 1980 – 2019, the ratio per hour between home and market work has declined, while the expenditure share on home production substitutes has increased. Third, I look at the same measures but separate workers by skill (high- or low-skilled). I find that the aggregate trend holds for both skill groups with a slight increase in the change of hours for the high-skilled, compared to the low-skilled.

Motivated by these findings, Section 3 builds a model to study marketization with households from two skill groups. I then discuss how relative price movements could give rise to different trends in home production time and the expenditure share, noting that one *does not* imply the other. In particular, a higher wage is associated with a larger share of market personal service expenditure while holding the price of goods and market services constant. A lower price of market-produced services corresponds to less time on home production, holding wages and the price of goods constant. These results suggest that changes in wages and prices have distinct implications on marketization outcomes. To generate a realistic prediction, the changes in both wages and price need to be matched.

Section 4 consists of two parts. I first show the results of a selection of numerical comparative statics to illustrate how technical change affects marketization through relative price movements. This step yields two results: first, I confirm that a relative productivity increase of market services, relative to home production, will give rise to marketization in this heterogeneous skill economy. Second, I discover that a joint change in the skill level will also give rise to marketization in this economy. Further, I exploit the model prediction through a change

in the supply of skill in the economy and find that the results conflict with the data. This suggests that one cannot abstract away from the change in supply in order to explain marketization trends, and a representative economy fails to capture that. I then use this model to account for aggregate changes from 1980 – 2019 to assess which technical change matters more quantitatively. Conditional on matching the aggregate, my finding is in contrast with the results from a representative household economy, whereby more than 60% of the marketization is captured through significant changes in wage structure, whereas the relative productivity change between home and market is quantitatively small.

Related Literature

This paper contributes to three strands of literature that study the cause of marketization. I extend previous models by adding a role for skills; hence, both wage and productivity affect the price of market services. My paper is particularly relevant to the theory presented in Rogerson (2008) and Ngai and Pissarides (2008). I make two main contributions. First, I confirm that an increase in market productivity relative to home production gives rise to marketization by reducing the relative price in a heterogeneous economy. Second, I provide a new mechanism for marketization in a heterogeneous skill economy, suggesting that a change in wage structure also explains marketization.

My work also relates to the literature that studies the rise of the skill premium compared to the size of the service sector (Buera and Kaboski (2012), Buera et al. (2022)). Early literature discussing the increase in the skill premium includes Katz and Murphy (1992), Bound and Johnson (1992), Manning (2004). I argue that both the increase in market opportunities for the high-skilled and the decrease in market opportunities for the low-skilled, while giving rise to skill premium, have potential to account for marketization (Mazzolari and Ragusa (2013), Cerina, Moro and Rendall (2021)).

Furthermore, I examine an extensive literature on time use in macroeconomics. I extend the empirical analysis to 2019 using the existing method. The utilization of time surveys has

become more prevalent in the literature thanks to the earlier work of Aguiar and Hurst (2007*b*), Ramey and Francis (2009). A similar model appears in Fang and Zhu (2017), who jointly estimate home productivity and the elasticity between market goods and home hours.

The rest of the paper is structured as follows. Section 2 uses time use and expenditure surveys to highlight that the time spent on home production has been declining, and that the expenditure share on market service has been increasing for both high- and low-skilled workers from 1980 to 2019. Section 3 develops a parsimonious model that incorporates the two skilled groups and allows households to outsource their home production to the market. Section 4 presents the calibrated result and discusses the main exercise. Section 5 concludes.

2 Empirical Facts

In this section, I document three sets of facts. I start by reviewing the wage evolution between the high-skilled and the low-skilled from 1980 to 2019, and reporting the sectoral labor supply composition by skills. I find that more than 80% of the personal service sector's labor input is from low-skilled workers, a fraction higher than the manufacturing and other services sectors. This suggests that the real wage decline of the low-skilled workers should transmit to the marginal cost of the personal services, resulting, in a lower price. I then reporting the aggregate decline in home production and increase in expenditure share on personal services. I conclude this section by showing that both trends have been observed for households with different educational attainments. The magnitudes of both level change and percentage change are comparable across skills, which suggests that the adoption of market substitutes instead of home production is not simply limited to households that experience a growing opportunity costs of time.

2.1 Data Descriptions

I briefly describe the three datasets used in this paper. Time-use facts are based on the four major time-use surveys. Expenditure facts are from the diary portion of the Consumer Expenditure Surveys. Facts related to the skill premium and sectoral labor composition are drawn from Census and the American Community Surveys.

2.1.1 American Time Use Survey

To document facts on the evolution of time allocation, I use the four major time-use surveys extensively studied in Aguiar, Hurst and Karabarbounis (2012) and other literature: the 1975 - 1976 Time Use in Economics and Social Accounts; the Americans' Use of Time in 1985; the National Human Activity Pattern Survey from 1992 - 1994; and the American Time Use Survey (ATUS) from 2003 onwards. The ATUS has been sponsored by the Bureau of Labor Statistics and conducted by the US Census Bureau starting from Jan 2003. Each respondent is asked to recall their activities starting at 4 a.m. the previous day and ending at 4 a.m. on the interview day. The respondents' educational attainments are inferred from their CPS response. I refer readers to Aguiar and Hurst (2007*b*) for a comprehensive overview of the earlier datasets.

One challenge specific to this paper is to have a consistent estimate of childcare and adult care hours from the data from 1975 to 2019. First, the surveys before 2003 do not contain information on whether care time is spent with someone within or outside the family. Second, the later surveys use slightly different rules for categorizing activities relative to the earlier surveys. For example, the activity "feed the children" involves meal preparation and childcare. The 1975 survey would code half of the time to "meal preparation" and half to "baby care"(childcare) if the child is four years old or less. The activity would be coded entirely to "meal preparation" if the child is older than four years old. However, this will be coded entirely to "Caring for and Helping Household Children/Physical care" using rules listed in ATUS coding rules after 2003.

To address this issue, I first calculate the ratio of care time (children and adults) spent with household members and the total care time $\left(\frac{\text{household childcare + household adult care}}{\text{total childcare and adult care}}\right)$ for each

demographic cell post-2003. I then use a linear trend to approximate this ratio for surveys prior to 2003 for each cell and take the average. Since I can observe the total care time in the early surveys, the extrapolated ratios allow me to estimate care time spent with household members for the earlier surveys. I choose ratios to extrapolate in order to avoid potential multiplicative measurement errors.

2.1.2 Consumption Expenditure Survey

To document facts on the spending patterns on personal services, I use the weekly diary portion of the Consumer Expenditure Surveys (CEX) from 1990 to 2019 since it covers small and frequent purchases of personal services that are highly substitutable to home production. Due to data availability, I focus my analysis on the period from 1990 to 2019. Unlike the interview portion, the diary portion relies less on the respondent's recall since the data collection period is much shorter. At the beginning of the two-week collection period, the reference person would report the demographic features of their household and receive the daily expenditure record for the unit to record their expenditures for the week. At the end of each week, the interviewer collects the diary and reviews the entries. On average, less than 5% of the surveyed households report only one week of expenditure. I limit the sample to households with reference persons aged 25 through 55 and who are neither students nor retirees. I use the reference person's educational level to denote the consumer unit's educational attainment. The harmonization process is identical to the process described in Section 2.1.1.

One caveat to address before combining results from time-use and expenditure surveys is the difference in survey units. Responses from the time-use surveys are on individual levels, whereas responses from the expenditure surveys are on household levels. Although I cannot speak to the change in division of labor within married households, I can interpret the weighted moments from the time-use surveys as the averages across households. Under an additional assumption of perfectly assortative matching, time moments by skills can be interpreted as the average across households of different skills.

2.1.3 Census and the American Community Survey (ACS)

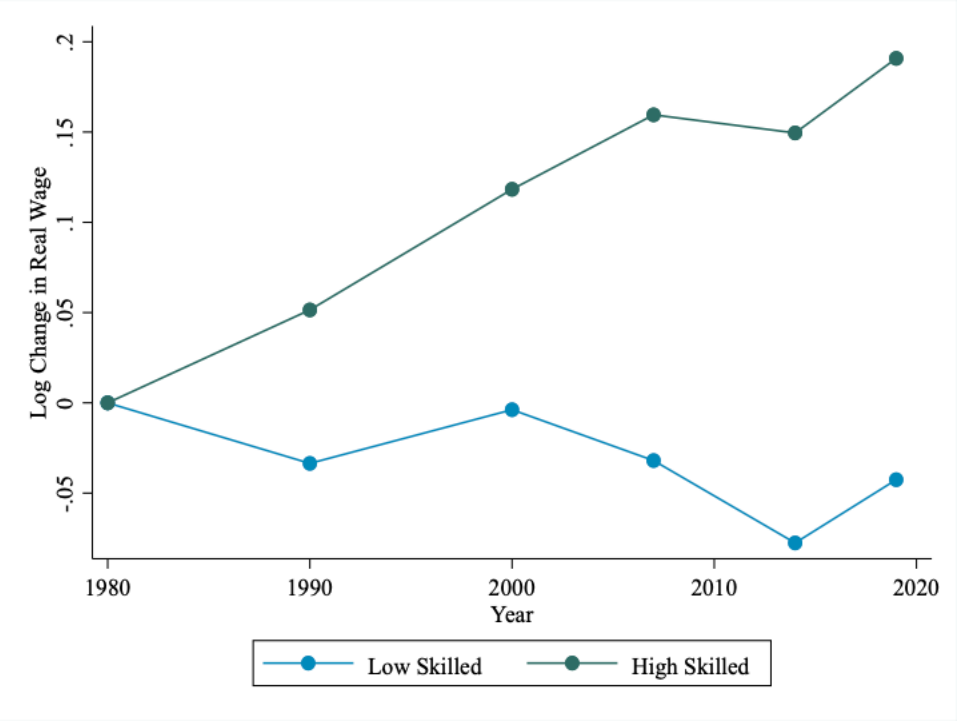
To document the evolution of wage structure and sectoral labor composition, I use the 5% decennial Census for 1980, 1990, and 2000 and the American Community Survey (ACS) for 2007 and 2019, both provided by Ruggles et al. (2022). I limit the sample to individuals aged 25 to 55 in the labor force who worked in non-farming sectors in the previous year for more than 30 hours per week. I identify the high-skilled workers as those with at least four years of college, while low-skilled workers are those with less than four years of college. I remove self-employed workers and unpaid family workers from my earning sample. Top-coded incomes are imputed to 150% of the top code. Wages are computed by dividing incomes by the product of weekly hours of work times weeks of work[3]. For those missing hours or weeks, wages are imputed using occupations and education information. I focus on real wages in my analysis which is deflated by the personal consumption expenditure price index published by the Bureau of Economics Analysis. I use the original population weights *perwt* to construct the labor supply weight *lswt*. It is calculated as the product of *perwt*, hours of work, and weeks of work, each normalized by 35 hours per week and 50 weeks of work. I use the information on occupations and education levels to impute labor supply weights for those who miss working hours or weeks.

2.2 Skill Premium and Sectoral Skill Composition

I review the evolution of the skill premium from 1980 - 2019 and then document the skill composition of the personal service sector. Figure 1 plots mean log real wage changes by skills from 1980 to 2019. Consistent with works such as Autor (2019), this graph suggests that the real wage for low-skilled workers remains stagnant for the recent three decades. The widening of the skill premium is entirely driven by the increase in real wages of the high-skilled workers.

The low-skilled workers are the majority in the personal services sector. I focus on three

[3]The Census from 1980 to 2000, ACS 2007 and 2019 asked the exact number of weeks that respondents worked for, but responses on weeks worked are only available in intervals for the 2015 ACS. Therefore, I took the mean of each interval as an approximation.



Note: Figure plots the time series of the mean log wage from 1980 to 2019, using data on individuals aged 25 to 55 in the labor force working in nonfarm sectors for more than 30 hours per week. The data are sorted into demographic-education-experience groups of two sexes, whether white or no, whether foreign-born or not, two education categories (≥ 16 years of education, and below), and four potential experience categories (0–9, 10–19, 20–29, and 30–39 years). Log weekly wages of full-time, full-year workers are regressed in each year separately on dummy variables for sex, two education categories, a quartic in experience, white or other race, and foreign-born dummies. The mean log wage in a given year is the predicted log wage from these regressions evaluated for native-born white males at the yearly-mean experience level.

Figure 1: Wage Evolution from 1980 to 2019

sectors: personal service, manufacturing, and other services. To identify industries in the personal service sector, which range from urban transportation to residential care facilities, I rely on the industry code *ind1990* in both the CENSUS and ACS. Table A2 lists all industries under the personal service sector in detail. To demonstrate that it is mainly the low-skilled labor that provides personal services, I compute the share of hours of the low-skilled workers within a given sector across years. Figure 2 shows the result, and suggests that the personal service sector has taken the largest share of hours from the low-skilled compared to manufacturing and other services. This finding is consistent across all years and Figure A1 shows the results for each year.

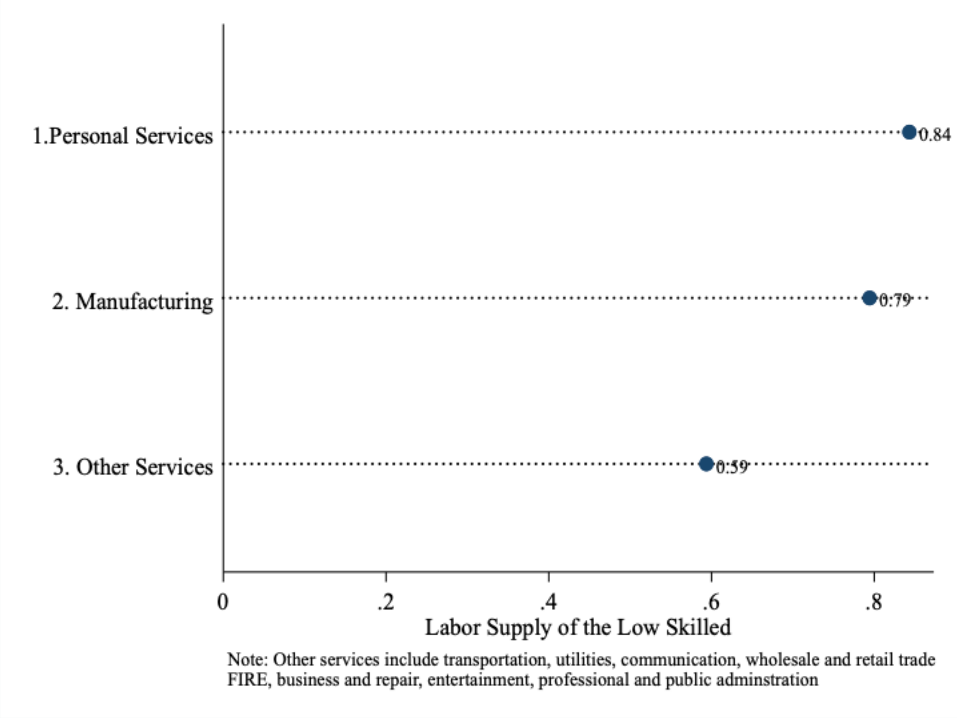


Figure 2: Skill Compositions by Sectors

2.3 Aggregate Marketization Facts

I now present evidence that households have increasingly substituted home production for their market substitutes in the last few decades. The evidence presented here is two-fold. First, I show that the time spent on nonmarket work has declined at a faster rate compared to market work from 1975 to 2019. Second, I show that the expenditure share of personal services has increased steadily from 1990 to 2019. This evidence has been discussed in previous work, but I include them here for completeness.

2.3.1 Change in Time Use Trend

I start by defining activities relevant to these three categories in Table 1. I consider two main measures related to home production. The first is the "Narrow nonmarket work", which includes meal preparation, housework, home maintenance, outdoor cleaning, vehicle repair, gardening, pet care, and obtaining good and services.[4] The second measure, "Broad Nonmarket

[4]The "Narrow nonmarket work" corresponds to the "Total Nonmarket Work" in Table 1 of Aguiar and Hurst (2007*b*). To show the comparison between my result and those in Aguiar and Hurst (2007*b*), table A3 reports the

Activity Summary	Activities
Narrow Nonmarket Work	
Meal Preparation	Preparation, presentation and clean-up
Housework	Interior cleaning, laundry, sewing and storing
Home Maintenance	Interior and exterior maintenance; vehicle care and maintenance and travel related
Garden and pet	Lawn, garden, pet care and travel related
Obtaining items	Grocery shopping, hiring service workers
Broad Nonmarket Work = Narrow Nonmarket Work + Below	
Personal Care	Grooming, putting on nail polish, etc
Basic Childcare	Physical care; organization and planning; Attending children's event; activities related to children's health and travel related.
Childcare with Education purpose	Reading and talking with children; attending activities related to children's education and travel related.
Play with Child	Playing, arts and crafts
Adult Care	Caring and helping adults.
Market Work	
Work travel	Travel related to work
Work core	Work at main job and other income-generating activities
Work related	Attending events with coworkers and clients
Leisure	
Socializing, Relaxing, and Telephone Calls	Hanging out with family and friends; TV time; Attending shows
Exercise, sports	Participating and attending sport events
Mail	Responding to household mail and email

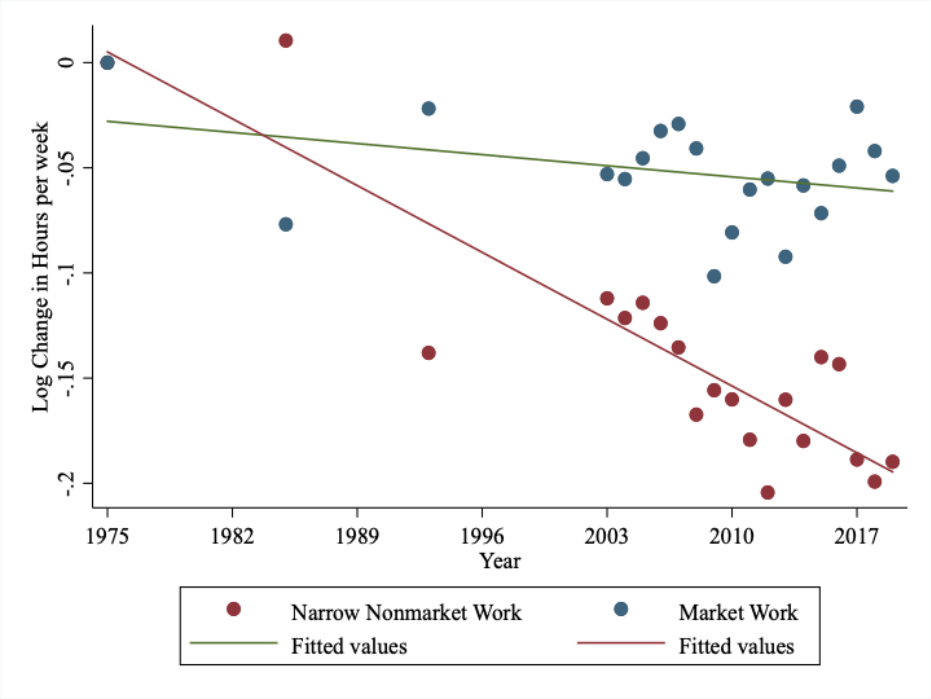
Note: The definition of Market work is identical to the "Total market work" definition in Aguiar and Hurst (2007*b*) which includes travel related to work and attending events with coworker and clients. My leisure measure only include a subset of the "leisure measure 1" in Aguiar and Hurst (2007*b*): Beside socializing and exercise, they also include time spent on gardening, animal, and pet care.

Table 1: Time-Spent Activities Description

Work", includes the first measure, plus time spent on personal care, childcare and adult care. For the data before 2003, I extrapolate the time spent on childcare and adult care using the procedure described in Section 2.1.1.

The nonmarket work time has declined faster than market work time. In Figure 3, I show the log point difference for narrow nonmarket work and market work from 1975 to 2019. The time spent on "narrow nonmarket work" sees a decline of 20 log points, much larger than the decline of market work of 5 log points. In Table 2, I report the time ratio between nonmarket work and market work. This ratio is of particular interest since marketization primarily influences the time allocation between these two discretionary time uses. The ratio between the narrow

raw estimates.



Note: Figure reports the log point change in time spent on nonmarket work and market work from 1975 onward. Narrow nonmarket work includes home production and obtaining good and services. The numbers reported are weighted average by relevant (composition-adjusted) cell means. I limit my sample to respondents aged 25 through 55 who are neither students nor retiree and whose response time add up to 1440 minutes. The data are sorted into 16 demographic cells of two sexes, four age bins (25-30, 31-40, 41-50, 51-55) and kid status (yes or no). The time-consistent weights are constructed in a same procedure as Katz and Murphy (1992) and Aguiar and Hurst (2007*b*). For each survey, weights are adjusted to address the issue of uneven days of sampling.

Figure 3: Time Spent on Nonmarket and Market Work: 1975 - 2019

measure of homework and market work has declined by 5 percentage points, and the ratio between the broad measure and market work has declined by 3 percentage points.

2.3.2 Change in Expenditure Share Trend

In this subsection, I examine the change in the expenditure share on personal services from 1990 to 2019. I identify personal service expenditures by constructing a crosswalk, summarized in Table 3, between home production activities and expenditure categories. I then consider two main categories: benchmark expenditure and total personal care. The first one corresponds to the narrow measure of home work, and the latter corresponds to the broad measure of nonmarket work which includes childcare and adult care.

From 1990 to 2019, there has been a 3 percentage points increase in the expenditure share on personal service. Table 4 suggests that, on average, households spend 13.2% of their weekly budget on acquiring the benchmark personal services in 1990, 14.8% for the total personal

	1975-85	2017-19	Change
$\frac{\text{Narrow Nonmarket Work}}{\text{Total Work (excl. care)}}$	0.37	0.32	-0.05
$\frac{\text{Leisure}}{\text{Total Work (excl. care)}}$	0.59	0.58	-0.01
$\frac{\text{Broad Nonmarket Work}}{\text{Total Work (incl. care)}}$	0.48	0.44	-0.03
$\frac{\text{Leisure}}{\text{Total Work (incl. care)}}$	0.49	0.48	-0.01

Note: Table reports ratios of time spent on different categories. The numbers reported are weighted average by relevant (composition-adjusted) cell means. I limit my sample to respondents aged 25 through 55 who are neither students nor retiree and whose response time add up to 1440 minutes. The data are sorted into 16 demographic cells of two sexes, four age bins (25-30, 31-40, 41-50, 51-55) and kid status (yes or no). The time-consistent weights are constructed in a same procedure as Katz and Murphy (1992) and Aguiar and Hurst (2007*b*). Data are pooled for the 1975-1985 and 2017–2019 periods

Table 2: Time Allocation Among Nonmarket Work, Market Work and Leisure: Ratios

service including care. This number goes up by 3.1 percentage points from 1990 to 2019, and 3.3 percentage points once including care. Interestingly, there is little change in weekly expenditure share on childcare and adult care unlike the results from the time use survey. This is partially because costs such as daycare occur monthly or every three months, less than the weekly/bi-weekly frequency. Hence they are not recorded in the diary portion of the survey.

2.4 Marketization Facts by Skills

I investigate the degree of marketization by skills. The decline of home production time is observed for both the high- and low-skilled workers. The increase of the expenditure share on personal services is also observed for both. Both results suggest that acquiring home production substitutes from the market is common for households facing different opportunity costs of time.

2.4.1 Change in Time Use Trend

From 1975 to 2019, time spent on home production decline for both skill groups, yet the trade-off between nonmarket time and market work time is more pronounced for the high-skilled household. Figure 4 suggests that the high-skilled household shows a larger decline in the

Expenditure Categories	Time Use Activities
Food and Drinks Away from Home	Meal Preparations
Pet Services	Pet care
Shoe Repair and Alteration of Apparel	Housework
Housekeeping Services	
Apparel Laundry	
Maintenance of Property	Garden care and home maintenance
Reupholstering, Furniture Repair Services	
Care in Convalescent or Nursing Home	Adult Care
Babysitting and Childcare	Childcare

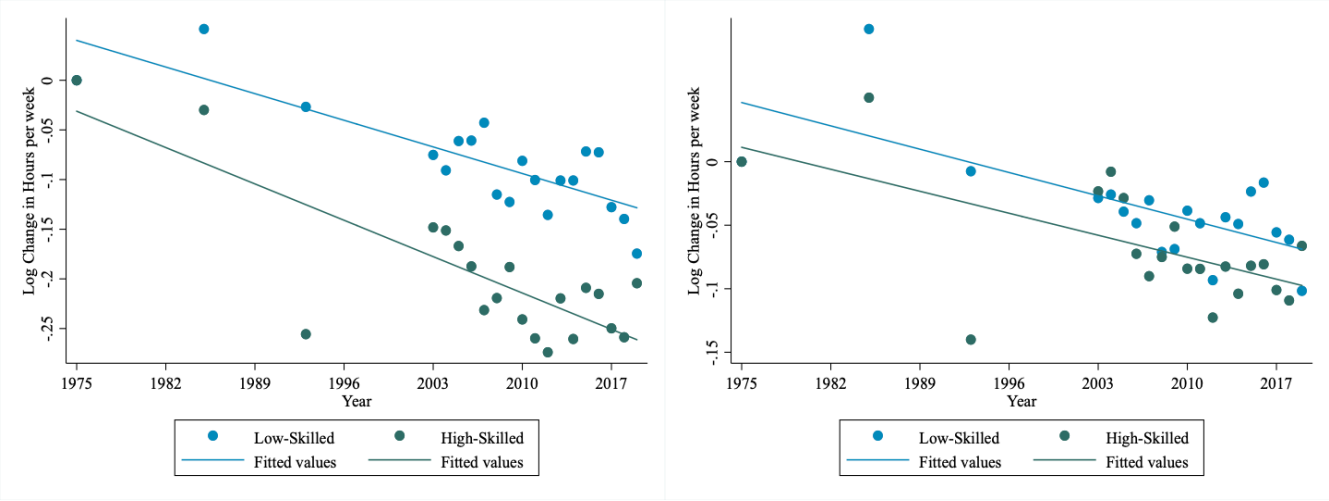
Table 3: Home Production Activities and their Corresponding Personal Service Expenditure Categories

Weekly Expenditure Share	1990	2019	Difference 2019 - 1990
Benchmark Expenditure	0.132	0.164	0.031
Total Personal Service	0.148	0.180	0.033

Note: Table reports the aggregate expenditure share on personal service over time. The numbers reported are weighted average by relevant (composition-adjusted) cell means. I limit my sample to respondents aged 25 through 55 who are neither students nor retiree and whose response time add up to 1440 minutes. The data are sorted into 16 demographic cells of two sexes, four age bins (25-30, 31-40, 41-50, 51-55) and kid status (yes or no). The time-consistent weights are constructed in a same procedure as Katz and Murphy (1992) and Aguiar and Hurst (2007*b*). Data are pooled for the 1990-1992 and 2017–2019 periods.

Table 4: Expenditure Share on Home Production Substitute: 1990 - 2019

narrow measure of homework in log points, but a similar decline in the broad measure as the high-skilled household sees a larger increase in time spent on childcare and adult care compared to the low-skilled household. Table A4 in the appendix reports the patterns in details. I then report the trend for the ratio of nonmarket time to total work time by skill in Table 5 which suggests that, similar to the aggregate trend, nonmarket work declines at a faster rate than market work. The ratio suggests that the tradeoff between nonmarket and market time is twice as large for the high-skilled individuals, partly because they did not experience much decline in market work time.



(a) Narrow Nonmarket Work (b) Broad Nonmarket Work

Note: Figure reports the log point change in time spent on nonmarket work by skills from 1975 onward. Narrow nonmarket work includes home production and obtaining good and services. The numbers reported are weighted average by relevant (composition-adjusted) cell means. I limit my sample to respondents aged 25 through 55 who are neither students nor retiree and whose response time add up to 1440 minutes. The data are sorted into 16 demographic cells of two sexes, four age bins (25-30, 31-40, 41-50, 51-55) and kid status (yes or no). The time-consistent weights are constructed in a same procedure as Katz and Murphy (1992) and Aguiar and Hurst (2007*b*). For each survey, weights are adjusted to address the issue of uneven days of sampling.

Figure 4: Time Spent on Nonmarket and Market Work: 1975 - 2019

I detail steps on how to transform these moments to targets for the quantitative exercise in the later section. Although there are some sizable fluctuations in leisure time from 1975 to 2019, I abstract from these in order to isolate the economics intuition of marketization. I focus on the time allocation within the total work time that consists of market and nonmarket work. To adjust the targets, I calculate the average aggregate leisure fraction $\left(\frac{\text{leisure}}{\text{leisure + work + homework}}\right)$ from 1975 to 2019 and use it as the leisure target for all households in my model. I then use the ratio $\left(\frac{\text{time spent on homework}}{\text{time spent on market work}}\right)$ presented in Table 2 and 5 to generate ratios for the aggregates and the two different skill groups. The results for the different homework measures are reported in Table 6 and 7 respectively. This exercise essentially attempts to normalize the targets in order to focus on the tradeoff between market time and nonmarket time for households with heterogeneous education attainment while having a reasonable leisure target.

2.4.2 Change in Expenditure Trend by Skill

From 1990 to 2019, the increase in expenditure share of personal service is common for households with different educational attainments. The low-skilled household shows a 3.2 percent-

		1975-85	2017-19	Change
$\frac{\text{Narrow Nonmarket Work}}{\text{Total Work (excl. care)}}$	Low-Skilled	0.37	0.34	-0.03
	High-Skilled	0.36	0.30	-0.06
$\frac{\text{Leisure}}{\text{Total Work (excl. care)}}$	Low-Skilled	0.60	0.63	0.04
	High-Skilled	0.55	0.51	-0.04
$\frac{\text{Broad Nonmarket Work}}{\text{Total Work (incl. care)}}$	Low-Skilled	0.47	0.45	-0.02
	High-Skilled	0.47	0.43	-0.04
$\frac{\text{Leisure}}{\text{Total Work (incl. care)}}$	Low-Skilled	0.50	0.52	0.03
	High-Skilled	0.45	0.42	-0.04

Note: Table reports ratios of time spent on different categories. Data are pooled for the 1975-1985 and 2017–2019 periods

Table 5: Time Allocation Among Nonmarket Work, Market Work and Leisure by Skills: Ratios

age point increase on the benchmark expenditure, slightly larger than the 2.3 percentage point increase for the high-skilled. Once including spending on childcare and adult care, however, the difference in the expenditure on home production substitutes between the low- and high-skilled further reduces. The high-skilled experiences an increase of 2.5 percentage point in expenditure share on the total personal service whereas the low-skilled experience a 3 percentage point increase.

To summarize, in this section I have established that the decline in home production time and the increase in expenditure share on personal services has gone hand-in-hand since 1980. Both trends are observed for households with different educational attainments. Evidence presented here suggests that marketization is common across households of different levels of skills.

		1980	2019	Level Change 2019 - 1980	Percentage Change 2019 - 1980
$\frac{\text{Work}}{\text{Leisure + Total Work}}$	Aggregate	0.394	0.423	0.028	0.072
	Skilled	0.398	0.434	0.036	0.091
	Unskilled	0.395	0.413	0.019	0.047
$\frac{\text{Nonmarket}}{\text{Leisure + Total Work}}$	Aggregate	0.229	0.200	-0.028	-0.124
	Skilled	0.225	0.189	-0.036	-0.161
	Unskilled	0.228	0.209	-0.019	-0.082

Table 6: Adjusted Time Fraction using Narrow Homework Measure

		1980	2019	Level Change 2019 - 1980	Percentage Change 2019 - 1980
$\frac{\text{Work}}{\text{Leisure + Total Work}}$	Aggregate	0.349	0.372	0.023	0.065
	Skilled	0.353	0.379	0.026	0.074
	Unskilled	0.350	0.366	0.015	0.044
$\frac{\text{Nonmarket}}{\text{Leisure + Total Work}}$	Aggregate	0.317	0.294	-0.023	-0.072
	Skilled	0.313	0.287	-0.026	-0.084
	Unskilled	0.316	0.300	-0.015	-0.049

Table 7: Adjusted Time Fraction using Broad Homework Measure

Weekly Expenditure Share	1990-92	2017-19	Difference
Low-Skilled			
Benchmark Expenditure	0.125	0.157	0.032
Total Personal Service	0.139	0.170	0.030
High-Skilled			
Benchmark Expenditure	0.149	0.172	0.023
Total Personal Service	0.170	0.195	0.025

Note: Table reports the aggregate expenditure share on personal service over time. The numbers reported are weighted average by relevant (composition-adjusted) cell means. I limit my sample to respondents aged 25 through 55 who are neither students nor retiree and whose response time add up to 1440 minutes. The data are sorted into 16 demographic cells of two sexes, four age bins (25-30, 31-40, 41-50, 51-55) and kid status (yes or no). The time-consistent weights are constructed in a same procedure as Katz and Murphy (1992) and Aguiar and Hurst (2007*b*). Data are pooled for the 1990-1992 and 2017–2019 periods.

Table 8: Expenditure Share on Home Production Substitute by Skill Level: 1990 - 2019

3 The Model

The evidence presented in the previous section highlights two empirical facts: first, the past few decades have observed a decline in home production time and an increase in the expenditure share on personal services; and second, both trends are common for the high- and low-skilled. Any models with heterogeneous agents facing different wages should have a mechanism to account for the disaggregate, in addition to matching the aggregate trends.

The model presented in this section is essentially a heterogeneous agent version of the representative agent economy studied in Rogerson (2008). There are two types of households: the high skilled (H) and the low skilled (L). There are two types of commodities in the consumption bundle: a general good (g) and personal services (s). Households can acquire personal services through either home production or the market, while the general good is only available through the market. The model is static, since no capital is involved in the production, and time subscripts are omitted.

3.1 Households

There is a unit mass of households of two types: low skilled (L) and high skilled (H). The fraction of the low skilled is f_L, and the fraction of the high skilled is f_H with $f_L + f_H = 1$. Each household i has utility over composite consumption c_i and leisure $(1 - h_i)$ given by:

$$U(c_i, h_i) = \log c_i + \varphi \log(1 - h_i) \tag{1}$$

where h_i is the sum of time spent in market work plus home work ($h_i = h_{iw} + h_{id}$), $i \in \{L, H\}$.

The composite consumption is a nested CES:

$$c_i = \left[\alpha s_i^{\frac{\epsilon-1}{\epsilon}} + (1-\alpha) g_i^{\frac{\epsilon-1}{\epsilon}} \right]^{\frac{\epsilon}{\epsilon-1}} \tag{2}$$

where g_i is the consumption of a general consumption good and s_i is the consumption of per-

sonal services. The parameter ϵ represents the elasticity of substitution between the general goods and the composite of personal service. In the quantitative analysis, ϵ will be less than 1, implying that the two consumptions are complements. Personal services s_i is a CES aggregator over market purchased personal services (s_{im}) and home produced personal services (s_{id}).

$$s_i = \left[\psi s_{id}^{\frac{\sigma-1}{\sigma}} + (1-\psi) s_{im}^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} \tag{3}$$

The parameter σ represents the elasticity of substitution between home and market produced personal services. σ will be greater than 1 in the quantitative exercise, implying that they are substitutes.

Home production s_{id} is produced by

$$s_{id} = A_{S_d} h_{id} \tag{4}$$

where A_{S_d} is the productivity of home production. Prices for g and s_m are given by p_g and p_s.

Given market wages (w_H, w_L) and market price (p_g, p_s), each household chooses consumption $\{s_i, g_i\}$ and time allocation $\{h_{id}, h_{iw}\}$ to maximize the utility function (1) subject to (2) - (3) and the budget constraint (5):

$$p_g g_i + p_s s_{im} \leq y_i \tag{5}$$

where

$$y_i = \begin{cases} w_L h_{iw} & \text{Low-skilled} \\ w_H h_{iw} & \text{High-skilled} \end{cases} \tag{6}$$

3.2 Production

Production of the general good uses high-skilled and low-skilled labor. For simplicity, I assume that the personal services market production function uses only the low-skilled labor. The two

production functions are:

$$S_m = A_{S_m} N_{SL} \tag{7}$$

$$G = \left[\eta (A_{GH} N_{GH})^{\frac{\xi-1}{\xi}} + (1-\eta)(A_{GL} N_{GL})^{\frac{\xi-1}{\xi}} \right]^{\frac{\xi}{\xi-1}} \tag{8}$$

where N_{SL} is the total hours of low skilled labor in sector S_m. N_{GL} is the total hours of low-skilled labor in sector G, and N_{GH} is total hours of high-skilled labor in sector G.

Given that the production function exhibits constant returns to scale, I will assume that a representative firm operates in each sector.

3.3 Competitive Equilibrium

A competitive equilibrium is defined by unit wages (w_L, w_H), prices (p_g, p_s), consumption $\{g_i, s_i\}_{i\in\{S,U\}}$, and time allocation $\{h_{iw}, h_{id}\}_{i\in\{S,U\}}$ such that:

(i) the representative firms maximize profits, subject to production functions (7), (8); and households maximize utility (1), subject to (5);

(ii) given the optimal choices of firms and households, unit wages and prices clear the market in each sector and the labor market for each occupation:
Market Produced Personal Service:

$$S = (1-f_H)s_m^L + f_H s_m^S$$

Good:

$$G = (1-f_H)g^L + f_H g^S$$

Labor Market:

$$N_{GL} + N_{SL} = (1 - f_H)h_w^L$$

$$N_{GH} = f_H h_w^H$$

As is always the case, one price can be normalized to be 1. In what follows, I normalize the price of the good p_g to be 1. However, I still include it in some expressions when useful to the exposition to remind the reader that prices are relative.

3.4 Time Allocation and Expenditure Share

I focus on providing intuitions on how time allocation and expenditure share, two key empirical outcomes of marketization, are affected by two relative price movements by discussing the household decision rules. Unlike the expenditure share on market services, time allocation on home production directly determines the *quantity* of home production. Therefore, a decrease in home production time does not automatically implies an increase in expenditure share on home production substitutes since they measure different objects. I then propose two propositions to further characterize how wage and price of market services affect the two key outcomes. Ultimately, the price of market services is proportional to the wage of the low-skilled once embedded in a general equilibrium setting.

The nested CES structure in household's preference gives rise to the price index $\tilde{p}_s$ of the personal service bundle:

$$\tilde{p}_s = \left[\psi^\sigma p_{ih}^{1-\sigma} + (1-\psi)^\sigma p_s^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \tag{9}$$

where p_{ih} denotes the opportunity cost of time of doing home production:

$$p_{ih} = \frac{w_i}{A_{S_d}}$$

In the following discussion, I set $A_{S_d} = 1$ so that I can use wage and the opportunity cost of

home production interchangeably. One can solve for the home production time h_{id} and the expenditure share of the market personal service Ω_i:

$$h_{id} = \frac{1}{1+\varphi}\left[\frac{\alpha^{\epsilon}\left(\frac{\tilde{p}_s}{p_g}\right)^{1-\epsilon}}{\alpha^{\epsilon}\left(\frac{\tilde{p}_s}{p_g}\right)^{1-\epsilon}+(1-\alpha)^{\epsilon}}\right]\left[\frac{\psi^{\sigma}}{(1-\psi)^{\sigma}\left(\frac{p_s}{w_i}\right)^{1-\sigma}+\psi^{\sigma}}\right] \tag{10}$$

$$\Omega_i = 1 - \frac{(1-\alpha)^{\epsilon}}{\alpha^{\epsilon}\left(\frac{\tilde{p}_s}{p_g}\right)^{1-\epsilon}\frac{(1-\psi)^{\sigma}\left(\frac{p_s}{w_i}\right)^{1-\sigma}}{(1-\psi)^{\sigma}\left(\frac{p_s}{w_i}\right)^{1-\sigma}+\psi^{\sigma}}+(1-\alpha)^{\epsilon}} \tag{11}$$

$$= \frac{\alpha^{\epsilon}\left(\frac{\tilde{p}_s}{p_g}\right)^{1-\epsilon}}{\alpha^{\epsilon}\left(\frac{\tilde{p}_s}{p_g}\right)^{1-\epsilon}+(1-\alpha)^{\epsilon}} - \frac{h_{id}}{h_{iw}}\frac{(1-\alpha)^{\epsilon}}{\alpha^{\epsilon}\left(\frac{\tilde{p}_s}{p_g}\right)^{1-\epsilon}+(1-\alpha)^{\epsilon}} \tag{12}$$

Equation 10 illustrates that the amount of time individuals spend on home production is determined through two relative price movements, $\frac{\tilde{p}_s}{p_g}$ and $\frac{p_s}{w_i}$, with two elasticities ϵ and σ determining the directions on how the relative prices affect h_{id}. The second bracket illustrates how home production time is determined through the relative price $\frac{p_s}{w_i}$ *within the service bundle*. In particular, this fraction pins down the value-added share of home production in the services bundle, describing the magnitude of adjustment along the intensive margin. The close substitutability ($\sigma > 1$) suggests that a lower price of market services relative to wage will decrease home production time while holding $\frac{\tilde{p}_s}{p_g}$ fixed. The first bracket shows how home production time is affected through the price ratio of the service bundle relative to good $\frac{\tilde{p}_s}{p_g}$ *across the service bundle and good*. The weak substitutability ($\epsilon < 1$) suggests that a decrease in relative prices of the service bundle relative to the good $\frac{\tilde{p}_s}{p_g}$ will also decrease home production time while holding the $\frac{p_s}{w_i}$ fixed, providing an extensive margin on how time on home production responds to the price of the service bundle relative to the good. If the service bundle becomes cheaper relative to goods, less resource will be spent on services relative to goods. Even if the value-added share of home production in service is constant, the quantity of home production still reduces.

Similarly, equation 12 also suggests that the same two relative prices are critical when considering the dynamics of the expenditure share Ω_i. In particular, holding $\frac{\tilde{p}_s}{p_g}$ constant, a lower price of market services relative to wage will increase the expenditure share: holding $\frac{p_s}{w_i}$ constant, a decrease of the service bundle relative to good will lead to a decrease in expenditure share on home production substitute. The intuition is similar to the case for h_{id}: a cheaper service bundle relative to good will encourage household to shift more resource to good expenditure relative to the service bundle due to the complementarity, hence reducing the expenditure share of the market service.

Therefore, it is mistaken to think that a decrease in h_{id} automatically implies an increase in Ω_i. In the simplified case where $\frac{p_s}{w_i}$ is held constant, an increase in $\frac{\tilde{p}_s}{p_g}$ leads to an increase in both home production time and expenditure share on home production substitutes. In a general equilibrium setting, price movements are endogenous. Like all nested CES setup, the price index $\tilde{p}_s$ is determined by p_s and w_i jointly. As a result, not only the price ratio $\frac{p_s}{w_i}$ between market and home matters, the *level* (relative to p_G) also matters. In the following propositions, I characterize how changes in prices will affect these decision rules.

Proposition 1. *Let the good price p_g and wage w_i be constant. If $\sigma > 1 > \epsilon$, then $\frac{\partial h_{id}}{\partial p_s} > 0$. That is, a lower price of market produced personal service corresponds to a lower home production time.*

Proof. Take the partial derivative of the two factors of h_{id} separately. See A.3 in the Appendix for details. □

Proposition 1 is intuitive by analyzing each part in equation 10. Holding w_i constant, a lower price of market produced personal service p_s reduces the price ratio $\frac{p_s}{w_i}$ and moves hours away from home to market because $\sigma > 1$. At the same time, it also lowers the price of the personal service bundle $\tilde{p}_s = w_i \left[\psi^\sigma + (1-\psi)^\sigma \left(\frac{p_s}{w_i} \right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}$. Therefore, hours move away from personal services since $\epsilon < 1$.

In general, it is not possible to characterize the relationship between home production hours and wage $\left(\frac{\partial h_{id}}{\partial w_i} \right)$ as clearly as seen in proposition 1. A higher wage would encourage a household to move hours away from home by reducing $\frac{p_s}{w_i}$ ($\sigma > 1$). However, the personal service

price index $\tilde{p}_s = p_s\left[\psi^\sigma\left(\frac{w_i}{p_s}\right)^{1-\sigma} + (1-\psi)^\sigma\right]^{\frac{1}{1-\sigma}}$ increases and encourages them to move hours to home ($\epsilon < 1$). This illustrates the point that even though one may know the change of relative price between home and market for personal services, it is not sufficient to understand the change of home production hours.[5] This mechanism confirms the insights provided in Ngai and Pissarides (2008), where, in their setup the marketization force moves hours from home to market, and the structural change force moves hours to the sector where the output has become relatively more expensive.

Similarly, the expenditure share for the market produced personal services is determined by the cost of doing home production p_{ih} and the cost of market produced personal service p_s.

Proposition 2. *Let p_g be p_s constant. If $\sigma > 1 > \epsilon$, then $\frac{\partial \Omega_i}{\partial w_i} > 0$. That is, a higher wage is associated with a larger share of market personal service expenditure.*

Proof. Take the partial derivative and use the chain rule. See A.3 in the Appendix for details. □

The result in proposition 2 highlights two layers of reallocations associated with higher wages, each governed by the elasticities ϵ and σ. First, a larger relative price $\tilde{p}_s$ would encourage households to shift their expenditure share towards the service bundle. This is because $\epsilon < 1$ is in household's preference: since personal services and good are complements to each other, the relative demand $\frac{s_i}{g_i}$ decrease is dominated by the increase in relative price $\frac{\tilde{p}_s}{p_G}$. The second layer occurs within the personal services bundle. The opportunity cost of time of doing home production p_{ih} is higher for the higher wage households. Since $\sigma > 1$: market home service and home production are substitutes. Hence the shift in expenditure share goes toward market personal services which get relative cheaper.

Proposition 3. *Holding the good price and wage to be constant, there exists a ratio $\lambda^\star$ such that when $\lambda = \frac{p_s}{p_{ih}} < \lambda^\star$, $\frac{\partial \Omega_i}{\partial p_s} > 0$ and when $\lambda > \lambda^\star$, $\frac{\partial \Omega_i}{\partial p_s} < 0$. In particular, $\lambda^\star \to 0$ when $\epsilon \to 1$ or $\psi \to 1$*

[5] In a special case where wage w_i and market price p_s grow by the same proportion, the change of home hours can be determined by whether or not wage w_i goes up. In my model, workers in the bottom occupation fall into this special case.

or $\sigma \to \infty$.

Proof. Take the partial derivative and use the chain rule. See A.3 in the Appendix for details. □

4 Quantitative Analysis

4.1 Calibrations

The model has eight parameters to be determined, including one demographic share, three elasticities and four relative weights. The demographic parameter is the mass of the low-skilled f_L. The three elasticities ϵ, σ, ξ describe the substitutability among good, services and home production and substitutability between high-skilled and low-skilled labor. The four parameters on relative weights $\alpha, \psi, \varphi, \eta$ appear in the preference function and the production function. Table 9 lists all the parameter values and I will describe them below.

Three parameters are taken from the literature. I consider individuals with educational attainment over 16 years to be the high-skilled workers following the definition in Katz and Murphy (1992). I consider the rest to be the low skilled, and pin down the mass of low skilled f_L using the 1980 Census 5% as the benchmark. I set ξ to be 1.4 following Katz and Murphy (1992). [6] I set ϵ to be 0.6, slightly higher than the typical range (0,0.3] given by Ngai and Pissarides (2008). This is because the service sector in my model is a subset of the broad service sector in Ngai and Pissarides (2008), and the "good" sector in my model includes service industry such as financial services. The substitutability between the home production and personal service is specified to be $\sigma = 2.5$, a conservative value of the literature's estimate. [7]

The remaining parameters are calibrated using moments drawn from the Census, ATUS and the CEX either directly or indirectly. The skill premium is the regression coefficient on education while regressing log wages on observables such as experience, gender, foreign born

[6] The sensitivity analysis on ξ is available in appendix A.4.3

[7] Rogerson (2007) provides a value of 5. Aguiar and Hurst (2007*a*) estimates a value of 1.8.

	A. Aggregate		
f_L	Mass of low skilled	0.773	1980 Census
	B. Elasticity		
ϵ	Generic and Domestic Service	0.6	Ngai and Pissarides (2008)
σ	Home and Market	2.5	Aguiar and Hurst (2007*a*)
ξ	High skilled and low skilled	1.4	Katz and Murphy (1992)
	C. Relative weights		
α	Weight on personal service bundle	0.606	Internally calibrated
ψ	Weight on home produced personal service	0.699	Internally calibrated
φ	Weight on leisure	0.502	Internally calibrated
η	Weight on H-type labor	0.414	Internally calibrated

Table 9: Model Parameters

status and race. The expenditure share at the 1980 economy period is obtained through an extrapolation procedure that I infer using the yearly growth rate implied by the 1990 - 2019 data on the broad expenditure share measure presented in Table 8. The time measures are obtained through Table 7. I present calibration results using the broad homework measure for the time and expenditure share targets below. The results using the narrow homework measure are available in Appendix A.4.2.

I report the matching between the model and data in Table 10. Overall, the model is able to match the targets well. Moreover, the model does a relatively good job in matching the untargeted moments. In particular, it is able to match disaggregate moments on time, despite four out of five targets reflecting the aggregate values. Even though the model overshoots the expenditure share ratio by skill groups, it is able to reflect the qualitative feature (Ω^S/Ω^U) in the data.

Moments	Model	Targets	Sources
$\log \frac{w_H}{w_L}$: Skill premium in 1980	0.362	0.362	1980 Census 5%
Ω: Aggregate expenditure share	0.128	0.128	CEX extrapolated
f_L: Mass of the low-skilled	0.773	0.773	1980 Census 5%
$\mathcal{H}_l$: Aggregate leisure fraction	0.334	0.334	ATUS extrapolated
$\mathcal{H}_w$: Aggregate market work fraction	0.349	0.349	ATUS extrapolated
Untargeted Moments			
Ω^H/Ω^L: Expenditure share ratio by skill	1.659	1.235	CEX extrapolated
h_w^H/h_d^H: Total work allocation of the high-skilled	1.134	1.126	ATUS extrapolated
h_w^L/h_d^L: Total work allocation of the low-skilled	1.093	1.110	ATUS extrapolated
h_w^H/h_w^L: Market work ratio by skills	1.018	1.006	ATUS extrapolated

Table 10: Moments Matching

4.2 Numerical Comparative Static Exercise

In this section, I conduct numerical comparative statics exercises where I change the sectoral productivity levels one at a time to study how they yield different implications on marketization through the change of relative prices. Since the economy is homothetic, a level change of productivity across all sectors would lead to the same allocation as a proportional change with one productivity normalized to 1. Therefore, there are essentially three productivities of interests: the productivity of the low skill workers in the good sector A_{GL}, the productivity of the high-skilled workers in the good sector A_{GH}, and the productivity of low-skilled workers in the market produced service A_{S_m} with the home sector productivity normalized to 1 ($A_{S_d} = 1$). In this section, I perturb each parameter by 10% of their calibrated benchmark values while keeping the rest at their benchmark values reported in Table 9. In addition, I also show the results when I change the fraction of the high-skilled population f_H to its 2019 level since one cannot abstract away from the change of relative skill supply. Table 11 summarizes the parameter values that I am changing.

Three findings are established in this exercise. First, I confirm that in this heterogeneous

	Benchmark	10% perturbation
A. Change A_{S_m}		
A_{S_m}	1	1.1000
B. Change A_{GL}		
A_{GL}	1	0.9000
C. Change f_S		
f_S	0.2271	0.4128
D. Change A_{GH}		
A_{GH}	1	1.1000

Table 11: Individual Parameter to Change

skill economy, an increase in the productivity of market services relative to home services ($A_{S_m} \uparrow$) can generate the marketization trend. Second, I argue that a *simultaneous* change in productivity can also generate the aggregate marketization trend. Neither a decrease in market opportunities for the low skilled $A_{GL} \downarrow$ nor an increase in market opportunities for the high skilled $A_{GH} \uparrow$ alone provides the full marketization trend. However, combining both forces can account for the full set of changes. Third, I show that a pure increase in the relative supply of skills has a distinct impact on the marketization outcomes. The fact that these results are opposite to the data suggests that one cannot abstract away from the change in skill supply in order to explain marketization trends.

In the following discussion, I provide intuition on how different productivity changes affect the time allocation and expenditure share decision by skill through changes in relative prices. Table 12 reports the log change of prices, wages, and level change of the time allocation $\frac{h_d}{h_w}$ and expenditure share Ω. Recall that $\tilde{p}$ denotes the personal service bundle price by skills and the price of the good is the numeraire. Therefore, all prices reported in this table are relative to the price of good in the economy.

Panel A reports the result where I increase the market produced personal service productivity A_{S_m}. This is the driving force of marketization in a representative agent economy, and

Δw_L	Δw_H	Δp_s	$\Delta \tilde{p}_L$	$\Delta \tilde{p}_H$	$\Delta \frac{h_d^H}{h_w^H}$	$\Delta \frac{h_d^L}{h_w^L}$	$\Delta \Omega^H$	$\Delta \Omega^L$
A. Increase A_{S_m} by 10%								
0.007	-0.014	-0.093	-0.004	-0.028	-0.042	-0.031	0.013	0.014
B. Decrease A_{GL} by 10%								
-0.075	-0.047	-0.075	-0.075	-0.052	-0.026	-0.024	0.002	-0.003
C. Increase A_{GH} by 10%								
0.028	0.049	0.028	0.028	0.045	0.004	0.009	0.007	0.001
D. Decrease A_{GL} and increase A_{GH} both by 10%								
-0.050	-0.001	-0.050	-0.050	-0.009	-0.024	-0.016	0.009	-0.002
E. Increase f_H to 2019 level								
0.223	-0.372	0.223	0.223	-0.300	0.097	0.075	-0.101	0.009
Data								
					-0.126	-0.079	0.047	0.050

Table 12: Numerical Comparative Statics

Panel A in Table 12 suggests that it remains true in a heterogeneous skill economy. As the market becomes more productive at producing personal services, it has two direct effects in this heterogeneous skill economy: first, the relative price of market produced personal services p_s goes down by 9.3%; second, the unit wage of the low skilled w_L goes up by 0.7%, and together, they make up to the 10% increase in A_{S_m}. In a representative household economy, the entire increase in A_{S_m} is fully translated to a decrease in p_s.

The high skilled and the low skilled face different price changes on service bundle $\tilde{p}_s$. $\tilde{p}_s$ depends on both p_s and $\left(\frac{w_i}{p_s}\right)$. For the low skilled, the increase in $\frac{w_i}{p_s}$ is 10%, dominating the decrease of p_s of 9.3%. Therefore $\Delta \tilde{p}^L > 0$. For the high skilled, both $\left(\frac{w_i}{p_s}\right)$ and p_s decline. Therefore $\Delta \tilde{p}^H < 0$. In a representative economy, $\tilde{p}$ monotonically decreases with respect to A_{S_m}, holding everything else fixed.

Hours are pinned down by two different forces due to the nested preference, namely the home-market force and the service-good force. The home-market force is pinned down by $\frac{w}{p_s}$.

An increase in price ratio between wage and market personal service move hours away from home since home and market personal service are substitutes. The service-good force is pinned down by $\tilde{p}$. A smaller price ratio between the personal service bundle and good moves hours away from home since they are complements. For the high skilled, both forces shift hours away from home. For the low skilled, the first force shifts hours away from home but the second force counteracts this. Therefore, $\frac{h_d}{h_w}$ declines more for the high skilled than the low skilled.

The expenditures shares are also determined by the exact two forces that pin down the home production hours. An increase in the price ratio between wage and market personal service moves up the expenditure share on market personal services, and an increase in the price ratio between the personal service bundle and good also increases the expenditure share on market personal services. For the low skilled, both forces increase the expenditure share. For the high skilled, the first force increases the expenditure share yet the second force counteracts it. Therefore, Ω increases more for the low skilled than the high skilled, despite of a larger decrease in the home-market work ratio for the high skilled.

Panel B shows the result where the low skilled experiences worse market opportunities due to a decrease of A_{GL} of 10%. The result shows that a decrease in market opportunity for the low skilled generates the right shape of time allocation. The direct effect of a decrease in A_{GL} is a drop in the wage of the low skilled w_L of 7.5%. This makes the market produced personal services cheaper by lowering its price through an equilibrium condition where marginal revenue equals the marginal cost $p_s A_{S_m} = w_L$. Therefore, the low skilled only faces the relative price decrease of the personal services bundle $\tilde{p}^L$ and no change in the home-market allocation within personal services. This results in a decrease in both home-market time ratio $\frac{h_d}{h_w}$ and expenditure share Ω.

For the high skilled in Panel B, their wage w_H also declines by 4.7% as well since their marginal productivity decreases. However, it does not decline as much as p_s so the price ratio between home and market service actually increases slightly by 2.8%. Therefore, the home-market force moves hours away from home, and increases the expenditure share. Given that

the market price goes down by 7.5%, the price of the service bundle for the high skilled $\tilde{p}^H$ decreases by 5.2% which suggests that the service bundle is becoming relatively cheaper compared to good. The good-service force also moves hours away from home, while reducing the expenditure share. This results in a decrease in home-market time ratio, and a net increase in expenditure share.

Panel C shows the result following an increase of market opportunities of the high skilled modeled by an increase of A_{GH} of 10%. The result in Panel C suggests that an increase of A_{GH} can generate the right shape of expenditure share. The direct effect of an increase in A_{GH} is an increase of the wage of the high skilled w_H of 4.9%. At the same time, it also increases the marginal productivity of the low skilled, hence w_L increases by 2.8%. This results in a more expensive market service $p_s \uparrow$. The price index for the services bundle for the low-skilled $\tilde{p}^L$ increases by the same magnitude as (p_s), yet the index for the high-skilled $\tilde{p}^H$ increases more since their wage increases more than the market service.

For the low skilled in Panel C, they only face the relative price increase of the personal services bundle $\tilde{p}^L$. Therefore both the home-market time ratio $\frac{h_d}{h_w}$ and expenditure share Ω increase. For the high skilled in panel C, home production becomes relatively more expensive than market services. The home-market force moves hours away from home, and increases the expenditure share for services. However, since $\tilde{p}^H$ increases, the good-service force moves hours to home, and increases the expenditure share. Therefore, it results in smaller net increase in home production and a larger increase in expenditure share, compared to the low skilled.

In Panel D, I report the results associated with a simultaneous change of a decrease in A_{GL} and an increase in A_{GH} of 10%. Results in Panel D are essentially a summation of Panel B and Panel C. The results are able to generate the aggregate marketization trend, with a correct pattern on the time allocation by skills and the change of expenditure share of the high skilled. It suggests that both a decrease in A_{GH} and an increase in A_{GH} are critical in generating the correct marketization trend.

Panel E reports results following an increase in f_H. This is to reflect the increase in relative

supply of skill from 1980 to 2019. The prediction for the high skilled is some distance from the data, suggesting that the change of the relative supply has a nontrivial effect on the understanding of marketization, and hence cannot be neglected. A relative increase of f_H brings down the wage of the high skilled by 33%, and causes the good to be relatively more abundant in the economy. Therefore, personal services become relatively scarce and p_s increases by 22.3%. The decline of $\frac{w_H}{p_s}$ of 59.5% dominates the change of p_s of 22.3%, hence the service bundle price $\tilde{p}^H$ for the high skilled decline. The home-market force moves hours to home and reduces the expenditure share on services. The good-service force moves hour away from home, and also reduces the expenditure share. Hence there is a significant decrease of expenditure of -10%, and a net increase in home-market work ratio due to the strong home-market force.

4.3 Accounting for Changes from 1980 - 2019

After establishing that there are two mechanisms that can explain marketization in this heterogeneous skill economy while holding the relative supply of skilled to be constant, I use the model to account for changes in marketization observed from 1980 - 2019. The goal is to assess the quantitative importance of these two mechanisms in explaining the data, while I treat the change of the supply of skill to be exogenous. My finding suggests that the change of supply and demand of skill does not only account for the change of skill premium, it also generates more than 60% of the marketization trends. I then compare my results with results in a representative economy where the marketization facts are accounted for entirely by a relative productivity increase of market service sector to home. The comparison suggests that in an economy with skill heterogeneity, a positive growth in the productivity of the personal service sector relative to the home sector is not the only force to match the marketization facts. The key result from this exercise is that the change of wage structure can generate sizable marketization.

The full exercise in this section aims to match the change of relative supply of skill, the change in skill premium, the aggregate decrease of home-market ratio, and the aggregate increase of expenditure share by changing the composition of the high skilled f_H, the market

Parameter Values		Annual Growth Rate
New Productivities		
A_{GL}^{new}	0.114	-5.28%
A_{GH}^{new}	6.885	4.94%
$A_{S_m}^{new}$	1.156	0.36%
Demographics		
f_H^{new}	0.413	1.51%

Table 13: Accounting for Changes from 1980 - 2019: Parameters Values

service productivity A_{S_m}, and the factor-specific productivity in the good sector A_{GL}, A_{GH}. Table 13 lists the calibrated productivities. These changes of productivities are able to match the targets well. Table 14 reports the matching of the percentage change of the skill premium, the percentage point change of the aggregate home-market hour ratio and the aggregate expenditure share. In order to interpret the scale of these numbers, I transform them to annual growth rates: the A_{GL}^{new} of 0.114 implies a decline rate of 5.28% annually from 1980 to 2019; the A_{GH}^{new} of 6.885 implies an annual growth rate of 4.94%; and the $A_{S_m}^{new}$ of 1.156 implies a growth rate of 0.36% yearly. At the same time, there is a steady increase in the supply of the high skilled by 1.5% annually.

It is important to provide an interpretation of these numbers, particularly given their signs and magnitudes. I interpret the decline of the low-skilled workers in the goods sector as the reduced-form displacement effect shown in Acemoglu and Restrepo (2019). As low-skilled workers are replaced by robots, they face a decrease in market opportunities. Therefore, they take on jobs in marketized sectors at a much lower wage, reducing the price of market service. Given the recent debate on the substitutability of the high-skilled and low-skilled, I perform a similar analysis using a larger ξ value suggested, as suggested in Bils, Kaymak and Wu (2022). Table A18 shows the result. The magnitudes for ΔA_{GL} and ΔA_{GH} are much smaller, yet the

Moments	Targets	(1) Full Model	(2) Only A_{GH}	(3) SBTC & $f_S \uparrow$	(4) Only A_{S_m}
$\Delta\pi$: Change of skill premium	0.212	0.211	0.331	0.261	-0.030
$\Delta\frac{\mathcal{H}_d}{\mathcal{H}_w}$: Change of aggregate home-market hour ratio	-0.118	-0.117	0.201	-0.072	-0.050
$\Delta\Omega$: Change of aggregate expenditure share	0.053	0.053	0.055	0.034	0.020

Table 14: Accounting for Changes from 1980 - 2019: Aggregate Matching

change of A_{S_m} remains the same.

Results in Table 13 suggest that a large change in the wage structure, due to increasing market opportunities for the high skilled and decreasing market opportunities for the low skilled, along with the change in relative supply of skills and an increase in productivity of personal service sector jointly match the skill premium and the aggregate marketization pattern. I further decompose the results in Table 14. Column (3) suggests that the Skill-Biased Technological Change and the increase in supply of skill can account for more than 60% of the aggregate trends in marketization, while matching the change of the skill premium. Column (4) suggests that an increase in productivity of the personal service sector, on the other hand, accounts for the rest of the marketization trends. It is important to note that the Skill-Biased Technological Change leads to the outcomes through a collective movement where A_{GH} increases and A_{GL} decreases. In other words, a simple increase in the skill premium alone does *not* explain marketization. In column (2), I increase the labor-augmenting productivity for the high skilled A_{GH} to the calibrated productivity only. Despite generating a large increase in skill premium, the model fails to capture the reduction in home production time.

These results are in contrast to the representative household economy, where marketization is solely driven by an increase in productivity at the personal service sector. To illustrate the difference, I first calibrate a representative household economy in Section A.4.1 using aggregate targets from Table 10. I then report results on implied productivity and matching from a similar exercise in Table A8 and Table A7 where I target the aggregate decrease of home-market ratio and the aggregate increase of expenditure share. In the representative household economy, marketization is generated by a larger growth of the market service sector relative to

Δw_L	Δw_H	Δp_s	$\Delta \tilde{p}_L$	$\Delta \tilde{p}_H$	$\Delta \frac{h_d^H}{h_w^H}$	$\Delta \frac{h_d^L}{h_w^L}$	$\Delta \Omega^H$	$\Delta \Omega^L$
A. Only A_{GH}								
0.676	1.007	0.676	0.676	0.936	0.070	0.244	0.143	0.030
B. A_{GH} and A_{GL}								
-0.128	0.133	-0.128	-0.128	0.080	-0.100	-0.041	0.057	-0.005
C. Only A_{S_m}								
0.011	-0.020	-0.134	-0.007	-0.041	-0.062	-0.046	0.019	0.020
D. Full Model								
-0.092	0.119	-0.237	-0.109	0.042	-0.156	-0.076	0.075	0.015
Data								
					-0.126	-0.079	0.047	0.050

Table 15: Accounting for Changes from 1980 - 2019: Disaggregate Matching

home.[8]

I exploit the matching of the model by looking at the predictions on the disaggregate measure, and it does relatively well on these dimensions. I report these results in Table 15. My model provides a reasonable match for three out of the four measures, except for the expenditure for the high skilled. It does overshoot the actions of the high skilled, however. This is likely because the model doesn't include the possibility where home production sometimes overlap with leisure, and high-skilled workers might value that.

[8]My result in Table A8 suggests that A_G grows slower than A_{S_m} over time comparing to the numbers in Rogerson (2008). There are two caveats behind this difference. First of all, a faster A_G growth over A_{S_m} is not a necessary condition to match the qualitative feature of the reallocation out of the good sector. I report the decrease of labor supply ratio between good and service in Table A7 which suggests that labor are shifting away from the good sector even when A_G grows slower than A_{S_m}. This is because the relative price increase between service bundle and good is the key to match the labor reallocation, conditional on growth of A_{S_m} relative to home which is pinned down through a shrinking time on home sector. As long as good is getting relatively more expensive than the service price bundle, it can deliver the correct labor reallocation results pattern. Second, we have different calibration strategy. In particular, they take the productivity from the data and use it to calibrate the preference parameter, whereas my process is the opposite.

5 Conclusions

In this paper, I present a new theory and evidence of the mechanism of marketization. In particular, I link the change in wage structure to marketization and examine how the change in supply and demand of skills affects the understanding of marketization. My finding shows that this change alone can account for more than 60% aggregate marketization change in the US from 1980 to 2019. Furthermore, it suggests that the change in wage structure relates to the formation of marketization.

This paper also re-opens a discussion on why Europe has seen a smaller service sector than the US, despite a rapid rise towards the technology frontier. Earlier work, such as that of Rogerson (2006), Rogerson (2008), Ohanian, Raffo and Rogerson (2008), McDaniel (2011), focuses on the tax scheme difference between the US and Europe. However, this paper suggests that the skill premium difference can also help rationalize the size difference in the service sector. Recent work by Doepke and Gaetani (2020) suggests that institutions such as an employment protection program could account for the gap in skill premium between Germany and the U.S. Future work could investigate how the different trajectories of skill premium can quantitatively explain the distinct marketization trend between these two countries.

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A Appendices

A.1 Data Appendix

A.1.1 ATUS & CEX Crosswalk

Household Activities (ATUS)	Household Expenditures (CEX)
Interior/Exterior Cleaning	Maintenance of property
Laundry	Apparel laundry and dry cleaning
Food preparation, presentation and clean up	Meals and drinks away from home
Lawn, garden, and houseplant care	Gardening, lawn care and pet service
Interior arrangement, decoration	Housekeeping services
Exterior repair, improvement & decoration	Garbage, trash collection
Sewing, repairing & maintaining textiles	Alteration, tailoring of apparel, and shoe repairing
Caring for & helping household children	Babysitting and child care
Caring for & helping household adults	Care in convalescent or nursing home

Table A1: Crosswalk between Activities in Time-Use Survey and Expenditure Items in CEX

A.1.2 Industries Included under the Personal Service Sector

ind1990	Industry Descriptions
401	Bus service and urban transit
402	Taxicab service
641	Eating and drinking places
761	Private households
771	Laundry, cleaning, and garment services
772	Beauty shops
780	Barber shops
782	Shoe repair shops
790	Dressmaking shops
862	Child day care services
863	Family child care homes
870	Residential care facilities, without nursing

Table A2: Personal Service Industries

A.2 Empirical Facts Appendix

A.2.1 Additional Facts on Sectoral Skill Composition

In Figure A1, I examine the sectoral share of hours from the low-skilled for 1980, 2000 and 2019. The personal service sector has been consistently the one with the highest share of hours from the low-skilled workers.

A.2.2 Additional Facts on Time Use

From 1980 - 2019, the total nonmarket time measured by the narrow measure has declined by 18% and 11% for the broad measure. In Table A3, I report weekly hours, level change, and percentage change. During the period I focus on, time spent on homework has declined

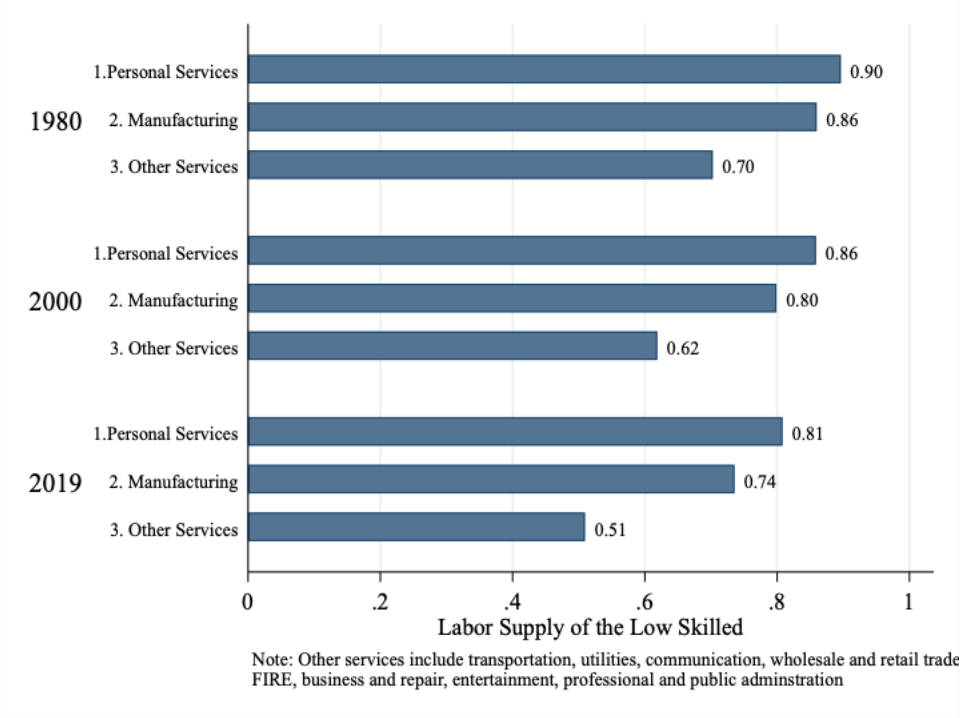

Figure A1: Skill Compositions by Industries: by Years

except for childcare and adult care. The magnitudes reported on nonmarket homework and market work time from 1975 to 2003 are consistent with results in Aguiar and Hurst (2007*b*). However, I observe a decreasing trend in leisure, unlike their results. This is due to both sample selection and leisure definition. They focus on individuals aged 21 - 65 and include time spent on gardening and pet care in their leisure time. I report the point estimates on leisure where I focus on the same definition and population as Aguiar and Hurst (2007*b*) in the last column of Table A3. The results are in line with their findings.

Table A4 shows the time spending pattern in more details. Under the narrow measure, the high-skilled household has seen a 18 log points of decline and the low-skilled has seen a 16 log points decline. Under the broad measure, the high-skilled has seen a 6 log points decline and the low-skilled has seen a 10 log points decline. In terms of market work, the high-skilled sees almost no change in market work but the low-skilled experience a slight decline. I also report leisure measured in definition and population from Aguiar and Hurst (2007*b*) and find that the low-skilled experience less change in leisure time compared to the high-skilled.

(Hours per week)	1975	2003	2019	Level Change 2019 - 1975	Percentage Change 2019 - 1975
Home Production Categories					
(1) Benchmark Activities	14.83	12.92	12.02	-2.81	-0.19
(2) Obtaining Items	5.10	5.28	4.59	-0.51	-0.10
(3) Personal Care	7.25	4.82	5.01	-2.24	-0.31
(4) Childcare + Adult care	3.14	5.80	6.16	3.02	0.96
Narrow Nonmarket Work ((1)+(2))	19.93	18.20	16.61	-3.31	-0.17
Broad Nonmarket Work ((1)+(2)+(3)+(4))	30.31	28.83	27.78	-2.53	-0.08
Market Work	34.95	34.25	35.26	0.31	0.01
Leisure	32.39	31.73	30.33	-2.06	-0.06
Leisure (Aguiar & Hurst)	34.27	34.95	33.90	-0.38	-0.01

Note: "Benchmark Activities" include meal preparation, housework, home maintenance, outdoor cleaning, vehicle repair, gardening and pet care

Table A3: Time Allocation Among Nonmarket Work, Market Work and Leisure: Levels

A.2.3 Additional Facts on Consumer Expenditure Share

A.3 Model Appendix

Proof of proposition 1

Proof. Equation 10 shows the analytic form of the home hours. It consists of two parts Λ_1, Λ_2 that are relevant for the analysis. Namely:

$$\Lambda_1 = \frac{\alpha^\epsilon (\tilde{p}_s)^{1-\epsilon}}{\alpha^\epsilon (\tilde{p}_s)^{1-\epsilon} + (1-\alpha)^\epsilon (p_G)^{1-\epsilon}} = 1 - \frac{(1-\alpha)^\epsilon (p_G)^{1-\epsilon}}{\alpha^\epsilon (\tilde{p}_s)^{1-\epsilon} + (1-\alpha)^\epsilon (p_G)^{1-\epsilon}}$$

$$\Lambda_2 = \frac{\psi^\sigma p_{ih}^{1-\sigma}}{(1-\psi)^\sigma p_s^{1-\sigma} + \psi^\sigma p_{ih}^{1-\sigma}}$$

Since $\Lambda_1, \Lambda_2 > 0$, it is equivalent to show that

$$\frac{\partial \Lambda_1}{\partial p_s} > 0 \qquad \frac{\partial \Lambda_2}{\partial p_s} > 0$$

(Hours per week)	1975	2003	2019	Level Change 2019 - 1975	Percentage Change 2019 - 1975
Low-Skilled					
(1) Benchmark Activities	14.71	13.36	12.40	-2.31	-0.16
(2) Obtaining Items	4.97	4.90	4.13	-0.84	-0.17
(3) Personal Care	7.17	4.79	4.94	-2.23	-0.31
(4) Childcare + Adult care	3.08	5.22	5.44	2.36	0.77
Narrow Nonmarket Work ((1)+(2))	19.68	18.26	16.53	-3.15	-0.16
Broad Nonmarket Work ((1)+(2)+(3)+(4))	29.93	28.27	26.91	-3.02	-0.10
Market Work	34.97	32.83	34.00	-0.97	-0.03
Leisure	32.82	33.32	31.95	-0.87	-0.03
Leisure (Aguiar & Hurst)	34.55	36.35	35.44	0.89	0.03
High-Skilled					
(1) Benchmark Activities	15.16	11.93	11.72	-3.44	-0.23
(2) Obtaining Items	5.70	6.05	5.29	-0.41	-0.07
(3) Personal Care	7.39	4.91	5.08	-2.31	-0.31
(4) Childcare + Adult care	3.18	7.06	7.39	4.21	1.32
Narrow Nonmarket Work ((1)+(2))	20.86	17.99	17.00	-3.86	-0.18
Broad Nonmarket Work ((1)+(2)+(3)+(4))	31.43	29.96	29.47	-1.95	-0.06
Market Work	36.45	37.50	36.27	-0.18	-0.00
Leisure	29.55	28.12	27.98	-1.57	-0.05
Leisure (Aguiar & Hurst)	32.86	31.26	31.25	-1.61	-0.05

Note: Table reports the change in time spent on home production by skills from 1975 to 2019. "Benchmark Activities" include meal preparation, housework, home maintenance, outdoor cleaning, vehicle repair, gardening and pet care. The numbers reported are weighted average by relevant (composition-adjusted) cell means. I use the individual education attainment and categorize the high-skilled as those whose education attainment exceeds 16 years, and the remaining individuals are low-skilled. I limit my sample to respondents aged 25 through 55 who are neither students nor retiree and whose response time add up to 1440 minutes. The data are sorted into 16 demographic cells of two sexes, four age bins (25-30, 31-40, 41-50, 51-55) and kid status (yes or no). The time-consistent weights are constructed in a same procedure as Katz and Murphy (1992) and Aguiar and Hurst (2007*b*). For each survey, weights are adjusted to address the issue of uneven days of sampling.

Table A4: Time Allocation Among Nonmarket Work, Market Work and Leisure by Skills: Levels

Note that $\frac{\partial \Lambda_2}{\partial p_s} > 0$ since $\sigma > 1$. Moreover, $\frac{\partial \Lambda_1}{\partial \tilde{p}_s} > 0$ since $\epsilon < 1$.

$$\frac{\partial \tilde{p}_s}{\partial p_s} = (\tilde{p}_s)^{\sigma}(1-\psi)^{\sigma} p_s^{-\sigma} > 0$$

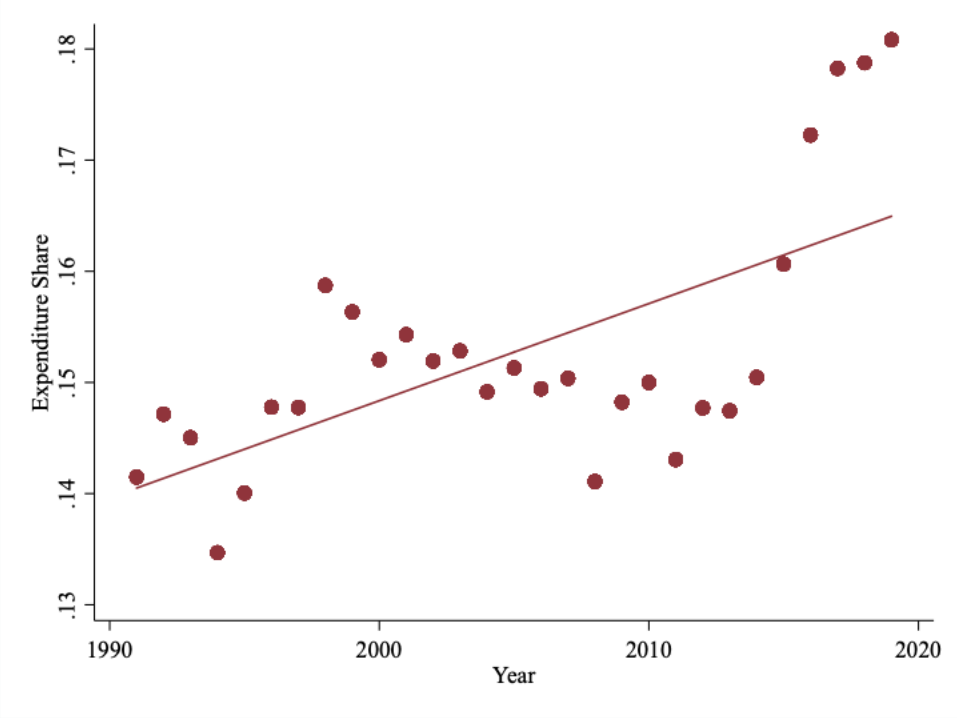

Figure A2: Expenditure Share on Home Production Substitute (Including Care): 1990 - 2019

By chain rule, we have $\frac{\partial \Lambda_1}{\partial p_s} = \frac{\partial \Lambda_1}{\partial \tilde{p}_s}\frac{\partial \tilde{p}_s}{\partial p_s} > 0$ □

Proof of proposition 2

Proof. Equation 12 shows the analytic form of the expenditure share on market produced personal service. For composition purpose, I denote the expenditure share as Ω_i below. To show proposition 2, it is equivalent to show

$$\frac{\partial \Omega_i}{\partial w_i} > 0$$

Apply the chain rule, we have:

$$\frac{\partial \Omega_i}{\partial w_i} = \frac{\partial \Omega_i}{\partial \tilde{p}_s}\frac{\partial \tilde{p}_s}{\partial w_i} = \frac{\partial \Omega_i}{\partial \tilde{p}_s}\frac{\partial \tilde{p}_s}{\partial p_{ih}}\frac{\partial p_{ih}}{\partial w_i}$$

Take the partial derivative, we have

$$\frac{\partial \Omega_i}{\partial \tilde{p}_s} = \frac{(1-\alpha)^{\epsilon} p_G^{1-\epsilon}}{\left[\alpha^{\epsilon}(\tilde{p}_s)^{\sigma-\epsilon}(1-\psi)^{\sigma} p_s^{1-\sigma} + (1-\alpha)^{\epsilon} p_G^{1-\epsilon}\right]^2} \alpha^{\epsilon}(1-\psi)^{\sigma} p_s^{1-\sigma}(\sigma-\epsilon)(\tilde{p}_s)^{\sigma-\epsilon-1} > 0$$

since $\epsilon < 1 < \sigma$, $0 < \alpha, \psi < 1$

$$\frac{\partial \tilde{p}_s}{\partial p_{ih}} = (\tilde{p}_s)^{\sigma} \psi^{\sigma} p_{ih}^{-\sigma} > 0$$

$$\frac{\partial p_{ih}}{\partial w_i} = \frac{1}{A_h} > 0$$

□

Proof of proposition 3

Proof. Notice that it is equivalent to determine the sign of $\frac{\partial \tilde{\Omega}}{\partial p_s}$ where

$$\tilde{\Omega} = \alpha^{\epsilon} (\tilde{p}_s)^{1-\epsilon} \left[1 - \frac{\psi^{\sigma} p_{ih}^{1-\sigma}}{\psi^{\sigma} p_{ih}^{1-\sigma} + (1-\psi)^{\sigma} p_s^{1-\sigma}} \right]$$

$$\frac{\partial \tilde{\Omega}}{\partial p_s} = \alpha^{\epsilon} \left[(1-\epsilon) \frac{\partial \tilde{p}_s}{\partial p_s} (\tilde{p}_s)^{-\epsilon} - \psi^{\sigma} p_{ih}^{1-\sigma} (\sigma - \epsilon) \frac{\partial \tilde{p}_s}{\partial p_s} (\tilde{p}_s)^{\sigma-\epsilon-1} \right] \tag{13}$$

$$= \underbrace{\alpha^{\epsilon} (\tilde{p}_s)^{-\epsilon} \frac{\partial \tilde{p}_s}{\partial p_s}}_{>0} \left[(1-\epsilon) - (\sigma - \epsilon) \frac{\psi^{\sigma} p_{ih}^{1-\sigma}}{\psi^{\sigma} p_{ih}^{1-\sigma} + (1-\psi)^{\sigma} p_s^{1-\sigma}} \right] \tag{14}$$

Equation (14) < 0 if and only if

$$(1-\epsilon) < (\sigma - \epsilon) \frac{\psi^{\sigma} p_{ih}^{1-\sigma}}{\psi^{\sigma} p_{ih}^{1-\sigma} + (1-\psi)^{\sigma} p_s^{1-\sigma}}$$

Denote $\lambda \equiv \frac{p_s}{p_{ih}}$ and solve the inequality above, one can get:

$$\lambda > \left(\frac{1-\psi}{\psi} \right)^{-\frac{\sigma}{1-\sigma}} \left(\frac{\sigma - 1}{1-\epsilon} \right)^{\frac{1}{1-\sigma}}$$

Denote $\lambda^{\star} = \left(\frac{1-\psi}{\psi} \right)^{\frac{\sigma}{\sigma-1}} \left(\frac{1-\epsilon}{\sigma-1} \right)^{\frac{1}{\sigma-1}}$. $\lambda^{\star} \to 0$ if one of the following conditions met: 1) $\psi \to 1$; 2) $\epsilon \to 1$; 3) $\sigma \to \infty$

Therefore $\frac{\partial \Omega}{\partial p_s} > 0$ when $\lambda < \lambda^{\star}$; $\frac{\partial \Omega}{\partial p_s} < 0$ when $\lambda > \lambda^{\star}$ □

A.4 Quantitative Exercise Appendix

A.4.1 A representative economy

In this section, I outline the model in a representative economy setting (identical to Rogerson (2008)) with calibration to 1980 benchmark and accounting for the change from 1980 to 2019. The household decision is identical to those in Section 3. The production in much simpler as outlined in the following.

$$S_m = A_{S_m} N_S \tag{15}$$

$$G = A_G N_G \tag{16}$$

The market clearing condition requires:

$$N_S + N_G = h_w \tag{17}$$

$$g = G \tag{18}$$

$$s = S_m \tag{19}$$

The model only has five parameters to be calibrated, including two elasticities ϵ, σ and three preference parameters α, ψ, φ. Similar to section 4.1, I set ϵ to be 0.3 and σ to be 4 following Ngai and Pissarides (2007) and Aguiar and Hurst (2007*b*) respectively.

	A. Elasticity		
ϵ	Generic and Domestic Service	0.6	Ngai and Pissarides (2008)
σ	Home and Market	2.5	Aguiar and Hurst (2007*a*)
	B. Relative weights		
α	Weight on personal service bundle	0.482	Internally calibrated
ψ	Weight on home produced personal service	0.686	Internally calibrated
φ	Weight on leisure	0.502	Internally calibrated

Table A5: Model Parameters

Moments	Model	Targets	Sources
Ω: Aggregate expenditure share	0.128	0.128	CEX extrapolated
$\mathcal{H}_l$: Aggregate leisure fraction	0.334	0.334	ATUS extrapolated
$\mathcal{H}_w$: Aggregate market work fraction	0.349	0.349	ATUS extrapolated

Table A6: Moments Matching

Table A8 and Table A7 report the productivity changes needed to match the change of aggregate home-market ratio and aggregate expenditure share and the matching.

Moments	Targets	Full Model
$\Delta\frac{\mathcal{H}_d}{\mathcal{H}_w}$: Change of aggregate home-market hour ratio	-0.118	-0.116
$\Delta\Omega$: Change of aggregate expenditure share	0.053	0.054
$\Delta\frac{N_G}{N_S}$: Change of Sectoral Labor Allocation (untarget)		-2.304

Table A7: Accounting for Changes from 1980 - 2019: Aggregate Match

Productivities	Values	Annual Growth Rate
A_G^{new}	1.054	0.13%
$A_{S_m}^{new}$	1.383	0.81%

Table A8: Accounting for Changes from 1980 - 2019: Parameters Values

A.4.2 Calibration and full exercise with targets not including care

All targets (time and expenditure share) reported in this section do not include child care and adult care.

	A. Aggregate		
f_L	Mass of low skilled	0.773	1980 Census
	B. Elasticity		
ϵ	Generic and Domestic Service	0.6	Ngai and Pissarides (2008)
σ	Home and Market	2.5	Aguiar and Hurst (2007*a*)
ξ	High skilled and low skilled	1.4	Katz and Murphy (1992)
	C. Relative weights		
α	Weight on personal service bundle	0.606	Internally calibrated
ψ	Weight on home produced personal service	0.699	Internally calibrated
φ	Weight on leisure	0.502	Internally calibrated
η	Weight on H-type labor	0.414	Internally calibrated

Table A9: Model Parameters

Moments	Model	Targets	Sources
$\log \frac{w_H}{w_L}$: Skill premium in 1980	0.362	0.362	1980 Census 5%
Ω: Aggregate expenditure share	0.115	0.115	CEX extrapolated
f_L: Mass of the low-skilled	0.773	0.773	1980 Census 5%
$\mathcal{H}_l$: Aggregate leisure fraction	0.377	0.377	ATUS extrapolated
$\mathcal{H}_w$: Aggregate market work fraction	0.394	0.394	ATUS extrapolated
Untargeted Moments			
Ω^H/Ω^L: Expenditure share ratio by skill	1.629	1.215	CEX extrapolated
h_w^H/h_d^H: Total work allocation of the high-skilled	1.803	1.766	ATUS extrapolated
h_w^L/h_d^L: Total work allocation of the low-skilled	1.706	1.731	ATUS extrapolated
h_w^H/h_m^L: Market work ratio by skill	1.020	1.007	ATUS extrapolated

Table A10: Moments Matching

Δw_L	Δw_H	Δp_s	$\Delta \tilde{p}_L$	$\Delta \tilde{p}_H$	$\Delta \frac{h_d^H}{h_w^H}$	$\Delta \frac{h_d^L}{h_w^L}$	$\Delta \Omega^H$	$\Delta \Omega^L$
A. Increase A_{S_m} by 10%								
0.006	-0.011	-0.094	-0.010	-0.031	-0.030	-0.023	0.012	0.012
B. Decrease A_{GL} by 10%								
-0.075	-0.048	-0.075	-0.075	-0.054	-0.018	-0.016	0.001	-0.003
C. Increase A_{GH} by 10%								
0.027	0.049	0.027	0.027	0.044	0.002	0.006	0.006	0.001
D. Decrease A_{GL} and increase A_{GH} both by 10%								
-0.051	-0.001	-0.051	-0.051	-0.013	-0.017	-0.011	0.007	-0.002
E. Increase f_H to 2019 level								
0.219	-0.374	0.219	0.219	-0.278	0.078	0.048	-0.087	0.008
Data								
					-0.126	-0.079	0.042	0.051

Table A11: Numerical Comparative Statics

Table A13 shows the targets I chose to discipline the parameters in Table A12. I chose the change of average expenditure share on the marketized personal service as one indicator on how the that particular sector changes over time. The overall takeaway is consistent with the one in the main section.

Parameter Values		Annual Growth Rate
New Productivities		
A_{GL}^{new}	0.125	-5.06 %
A_{GH}^{new}	6.471	4.78 %
$A_{S_m}^{new}$	1.222	0.50 %
Demographics		
f_H^{new}	0.413	1.51 %

Table A12: Comparative Static:
Parameters Values

Moments	Targets	(1) Full Model	(2) Only A_{GH}	(3) SBTC & $f_S \uparrow$	(4) Only A_{S_m}
$\Delta\pi$: Change of skill premium	0.212	0.212	0.346	0.268	-0.035
$\Delta\frac{\mathcal{H}_d}{\mathcal{H}_w}$: Change of aggregate home-market hour ratio	-0.124	-0.106	0.117	-0.059	-0.051
$\Delta\Omega$: Change of aggregate expenditure share	0.050	0.050	0.048	0.027	0.024

Table A13: Comparative Static: Targets

Δw_L	Δw_H	Δp_s	$\Delta \tilde{p}_L$	$\Delta \tilde{p}_H$	$\Delta \frac{h_d^H}{h_w^H}$	$\Delta \frac{h_d^L}{h_w^L}$	$\Delta \Omega^H$	$\Delta \Omega^L$
A. Only A_{GH}								
0.629	0.976	0.629	0.629	0.880	0.026	0.147	0.125	0.025
B. A_{GH} and A_{GL}								
-0.168	0.100	-0.168	-0.168	0.028	-0.078	-0.035	0.046	-0.006
C. Only A_{S_m}								
0.012	-0.023	-0.189	-0.022	-0.065	-0.061	-0.048	0.023	0.024
D. Full Model								
-0.129	0.083	-0.330	-0.163	-0.036	-0.134	-0.074	0.067	0.018
Data								
					-0.126	-0.079	0.042	0.051

Table A14: Comparative Static: Decision Rule

A.4.3 Calibration and full exercise with $\xi = 4$

In this section, I present results on calibration, the numerical comparative statics and the final exercise with $\xi = 4$ suggested by Bils, Kaymak and Wu (2022). All targets (time and expenditure share) reported in this section includes child care and adult care.

The key message from the exercise remains unchanged as suggested in A18. Although the magnitude of A_{GL} and A_{GH} changes, the change of A_{S_m} is virtually identical as Table 13.

	A. Aggregate		
f_L	Mass of the low-skilled	0.773	1980 Census
	B. Elasticity		
ϵ	Generic and Domestic Service	0.6	Ngai and Pissarides (2008)
σ	Home and Market	2.5	Aguiar and Hurst (2007*a*)
ξ	Skilled and Unskilled	4.0	Bils, Kaymak and Wu (2022)
	C. Relative weights		
α	Weight on personal service bundle	0.615	Internally calibrated
ψ	Weight on home produced personal service	0.699	Internally calibrated
φ	Weight on leisure	0.502	Internally calibrated
η	Weight on H-type labor	0.528	Internally calibrated

Table A15: Model Parameters

Moments	Model	Targets	Sources
$\log \frac{w_H}{w_L}$: Skill premium in 1980	0.362	0.362	1980 Census 5%
Ω: Aggregate expenditure share	0.128	0.128	CEX extrapolated
f_L: Mass of the low-skilled	0.773	0.773	1980 Census 5%
$\mathcal{H}_l$: Aggregate leisure fraction	0.334	0.334	ATUS extrapolated
$\mathcal{H}_w$: Aggregate market work fraction	0.349	0.349	ATUS extrapolated
Untargeted Moments			
Ω^H/Ω^L: Expenditure share ratio by skill	1.659	1.235	CEX extrapolated
h_w^H/h_d^H: Total work allocation of the high-skilled	1.134	1.126	ATUS extrapolated
h_w^L/h_d^L: Total work allocation of the low-skilled	1.093	1.110	ATUS extrapolated
h_w^H/h_w^L: Market work ratio by skills	1.018	1.006	ATUS extrapolated

Table A16: Moments Matching

Δw_L	Δw_H	Δp_s	$\Delta \tilde{p}_H$	$\Delta \tilde{p}_L$	$\Delta \frac{h_d^H}{h_w^H}$	$\Delta \frac{h_d^L}{h_w^L}$	$\Delta \Omega^H$	$\Delta \Omega^L$
A. Increase A_{S_m} by 10%								
0.003	-0.005	-0.097	-0.009	-0.022	-0.046	-0.033	0.016	0.013
B. Decrease A_{GL} by 10%								
-0.090	-0.019	-0.090	-0.090	-0.032	-0.040	-0.029	0.011	-0.004
C. Increase A_{GH} by 10%								
0.011	0.080	0.011	0.011	0.067	-0.011	0.004	0.017	0.000
D. Decrease A_{GL} and increase A_{GH} both by 10%								
-0.082	0.060	-0.082	-0.082	0.033	-0.055	-0.026	0.030	-0.003
E. Increase f_H to 2019 level								
0.097	-0.130	0.097	0.097	-0.095	0.060	0.032	-0.044	0.004
Data								
					-0.126	-0.079	0.047	0.050

Table A17: Numerical Comparative Statics

Parameter Values		Annual Growth Rate
New Productivities		
A_{GL}^{new}	0.691	-0.92 %
A_{GH}^{new}	1.436	0.91 %
$A_{S_m}^{new}$	1.154	0.36 %
Demographics		
f_H^{new}	0.413	1.51 %

Table A18: Accounting for Changes from 1980 - 2019: Parameters Values

Moments	Targets	(1) Full Model	(2) Only A_{GH}	(3) SBTC & $f_S \uparrow$	(4) Only A_{S_m}
$\Delta\pi$: Change of skill premium	0.212	0.212	0.242	0.237	-0.012
$\Delta\frac{\mathcal{H}_d}{\mathcal{H}_w}$: Change of aggregate home-market hour ratio	-0.118	-0.117	-0.001	-0.064	-0.052
$\Delta\Omega$: Change of aggregate expenditure share	0.053	0.053	0.016	0.033	0.020

Table A19: Accounting for Changes from 1980 - 2019: $\xi = 4$

Δw_L	Δw_H	Δp_s	$\Delta\tilde{p}_L$	$\Delta\tilde{p}_H$	$\Delta\frac{h_d^H}{h_w^H}$	$\Delta\frac{h_d^L}{h_w^L}$	$\Delta\Omega^H$	$\Delta\Omega^L$
A. Only A_{GH}								
0.047	0.288	0.047	0.047	0.240	-0.052	0.015	0.065	0.002
B. A_{GH} and A_{GL}								
-0.110	0.127	-0.110	-0.110	0.080	-0.089	-0.035	0.052	-0.004
C. Only A_{S_m}								
0.004	-0.008	-0.139	-0.013	-0.033	-0.067	-0.047	0.023	0.020
D. Full Model								
-0.092	0.120	-0.235	-0.109	0.043	-0.155	-0.076	0.075	0.015
Data								
					-0.126	-0.079	0.047	0.050

Table A20: Accounting for Changes from 1980 - 2019: Disaggregate Matching