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Bundling Time and Goods: Implications for the Dispersion in Hours Worked

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Abstract

We document that the dispersion in hours worked is large in the cross-section. We study the quantitative effect of wage dispersion on hours dispersion using a model in which households combine their time and market goods to produce consumption activities. We estimate several models with different numbers of activities on the paired expenditures and time use data by consumption activity. The estimated model can account for 25%-87% of the dispersion in hours worked over 2003-2018 with the model incorporating more activities generating more dispersion. The substitutability between goods and time within an activity and across activities is key to the result.

JEL Codes: J22, E21, D11
Keywords: Time Allocation, Consumption Expenditures, Hours Dispersion, Elasticity of Substitution

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1. Introduction

The dispersion of market hours across workers is large. The literature often relies on the unobserved tastes for leisure to generate the hours dispersion that we observe in the data.[1] Studying hours dispersion instead as a result of observables improves our understanding of the earnings distribution, which is an essential ingredient in analyzing questions in macroeconomics, labor economics, and public finance.

This paper proposes a model that generates large dispersion in market hours with the observed heterogeneity in wages and is also consistent with the rich cross-sectional patterns of time use and expenditures. In the model, households combine time and market goods to enjoy non-market activities.[2] Non-market activities are consumption activities that are related to home production and leisure. One example is a restaurant meal, which requires the purchase of market goods and services, combined with households' time to enjoy utility from it. This idea goes back to Becker (1965) and it forms the basis of the home production and leisure production literatures. We generalize the idea by considering a large number of activities.

In our model, non-market time is divided into many time segments and each segment is paired with a specific market goods and services to produce a consumption activity through a constant elasticity of substitution (CES) production function. The activities are then aggregated through another CES function to generate a composite consumption good that households enjoy. In addition, the elasticity of substitution between time and goods in the production function differs across activities. In the model, the response of hours worked to wage changes depends on the substitutability between goods and time within an activity and across activities. Hence, to what extent wage dispersion translates into hours dispersion crucially depends on the magnitude of these two types of elasticities of substitution and, ultimately, remains a quantitative question.

Following Fang et al. (2021), we construct data on the allocations of time and expenditures by education over 2003-2018 across market work and eight non-market activities:

[1] See, for example, Kaplan (2012) or Heathcote et al. (2014).

[2] For simplicity, we refer to market goods and services as market goods.

core home production, other care, obtaining goods and services, home ownership, watching TV, socializing, eating & personal care, and hobbies & entertainment. Using the constructed allocations, we document substantial heterogeneity in the time and expenditure share allocated to different activities by education. Market work requires hardly any expenditures and varies mostly along the time dimension with more educated households spending significantly more time in the market. Among all non-market activities, core home production is the activity with the largest fraction in households' expenditures and watching TV is the activity with the largest share of households' time. Expenditure shares and time spent on core home production both decline in education, with high-school dropouts spent 15 percentage points more of their expenditure and 3 hours more per week on it. Watching TV is associated with low expenditures and time spent on it decreases with education, with high-school dropouts spending 10 more hours on it per week than college graduates. Expenditure shares and time spent on eating & personal care and hobbies & entertainment are both rising with education. College graduates allocate 6 percentage points more of their core expenditures on each of these two categories than high school dropouts, and they also allocate 6 more hours per week for hobbies & entertainment and eating & personal care combined.

The variation of time and expenditure share by education helps us to identify the model parameters. Because the number of activities to consider is somewhat arbitrary, we explore the effects of wage dispersion on hours dispersion in models with different numbers of non-market activities. In particular, we investigate the implications in models with one activity, two activities, four activities, and eight activities. The estimation generates large elasticity of substitution among activities and also between time and goods for each activity.

Using the entire wage distribution from the Current Population Survey over 2013-2018, we simulate the model and find that wage dispersion accounts for 25-87% of the dispersion in market hours over the sample period, depending on the number of activities included in the model. Moreover, models with more activities explain a larger share of the hours dispersion. Two model innovations are important for the results: (1) the division of

non-market time into activity-specific segments and (2) the inclusion of more than one non-market activities that households derive utility from. The two innovations enable household to substitute between goods and time within an activity and over a large set of activities. With the estimated high degree of substitutability along these two margins, households can reallocate time and goods within and across activities easily, and this generates large responses of market hours to changes in wages. Moreover, as the number of activities rises, households are able to substitute expenditures and time across a larger set of activities. Thus the response of hours to wage changes becomes larger and the dispersion in hours worked rises.

This paper relates to a literature that relies on ex ante heterogeneity in preferences for leisure to generate dispersion in hours worked (e.g. Heathcote et al. (2014), Kaplan (2012), Bils et al. (2012), and Mustre del Rio (2015)). The model presented in this paper, in contrast, does not rely on preference heterogeneity. It generates dispersion in hours only through heterogeneity in wages, which is observable and relatively well measured.

This paper also relates to the empirical literature on time allocation. Aguiar et al. (2012) discuss the available time use data and review the recent literature in analyzing the long-run trends in time use. Freeman and Schettkat (2005) and Fang and McDaniel (2017) document differences in time allocation between the United States and European countries. Bridgman et al. (2018) study the patterns of household production time in 43 countries and provide evidence for marketization of home hours while GDP per capita increases. Burda et al. (2008) show that the total of market hours and home hours are roughly similar for men and women. Aguiar et al. (2013) find that during the Great Recession roughly 30% of the forgone market hours are absorbed by home production and 50% are absorbed by leisure. All these papers only study patterns in time allocation. We contribute to this literature by documenting not only patterns of time use but also patterns of expenditure shares for the same activity across a wide set of activities by education groups.

Lastly, this paper contributes to a large and growing literature on home production and leisure production inspired by the pioneer work by Becker (1965). Aguiar et al. (2012) summarize the literature on the importance of home production in accounting for business-

cycle fluctuations. Greenwood et al. (2005), Rogerson (2008), McDaniel (2011), Ngai and Pissarides (2011), Ngai and Petrongolo (2017), and Duernecker and Herrendorf (2018) demonstrate that home production is important in accounting for the variation in market labor supply either over time or across countries.[3] Vandenbroucke (2009) and Kopecky (2011) find that modeling leisure production helps to account for the decline in employment over the last century. Boppart and Ngai (2021) show the rise in average leisure time and the increase in leisure inequality over time can be generated simultaneously in a model with leisure production. Bridgman (2020) measures the value of leisure and find that the value of leisure is large and the productivity growth of leisure time has slowed in the digital era. Boerma and Karabarbounis (2019a) and Boerma and Karabarbounis (2019b) use a model in the spirit of Becker (1965) and find that changes in home and leisure productivity are important for changes in welfare inequality. Fang et al. (2021) use a model similar to ours but they divide activities into luxuries and necessities and study the effects of wage and price changes on welfare inequality. We contribute to this literature by analyzing the effects of wage dispersion on hours dispersion in a model with activity production and showing that incorporating more activities increases the dispersion in market hours.

The rest of the paper is organized as follows. Section 2 presents data facts on the dispersion in market hours and the allocations of time and expenditure across different activities by education group. Section 3 presents the model. Section 4 discusses the estimation strategy and estimation results. Section 5 uses the estimated models to understand the effects of wage dispersion on hours dispersion. Section 6 concludes.

2. Data

This section documents the large dispersion in hours worked by education group. This dispersion is related to the heterogeneity in households' choices outside the market. Using time-use and expenditure data, we provide evidence that bundles of expenditure and time used in the production of non-market activities vary greatly across households.

[3] See, for more examples, Olovsson (2009), Ragan (2013), and Fang and Zhu (2017).

2.1 Dispersion of Hours Worked

We measure dispersion in hours worked as the standard deviation of log usual hours worked in the Current Population Survey Outgoing Rotation Group (CPS-ORG) between 2003 and 2018. We restrict the sample to individuals between the ages of 21 and 65. We group households into four education categories: (1) less than high school, (2) high school, (3) some college, and (4) college and above.

Table 1 summarizes the results across all years and for two subperiods: 2003-2007 and 2008-2018. Dispersion in hours worked is slightly higher for individuals with at least some college education and increased somewhat during and after the Great Recession. However, the variation across education groups and across time periods is relatively small. Hence, we use the average dispersion over the entire sample period in our analysis.

Table 1: Dispersion in Hours Worked

	2003-2018	2003-2007	2008-2018
Less than HS	0.307	0.284	0.320
High School	0.302	0.293	0.307
Some College	0.345	0.335	0.350
College	0.319	0.327	0.316
Total	0.323	0.317	0.326

Data Source: IPUMS-CPS Outgoing Rotation Group 2003-2018. The sample is restricted to workers aged 21-65. We drop observations with top-coded weekly earnings and top-coded usual hours worked. The sample is restricted to hourly wages above USD 5 and below USD 100. Dispersion of hours worked is measured as the standard deviation of log usual hours worked per week.

2.2 Time and Expenditure Allocations

An ideal data set for our study would include the allocation of time and expenditures to detailed consumption activities since the production of activities requires both inputs. However, to our knowledge, such a data set does not exist. To overcome this challenge, we follow Fang et al. (2021) to classify time use and expenditures for a consistent set of

activities between the American Time Use Survey (ATUS) and the Consumer Expenditure Survey (CEX). Specifically, we start from the time use classification of Aguiar et al. (2012) and assign expenditure in the CEX to these time use categories. The result is a unique data set that combines time and expenditures for the same consumption activity. We restrict observations from both data sets to reference persons between the ages of 21 and 65. We remove students and retirees, since we do not model education or retirement decisions. Because our main focus is the dispersion of market hours, we also restrict the sample to households with working individuals. The sample period is 2003-2018.

As in Fang et al. (2021), we exclude several activities from the analysis. First, because we use a static framework for the analysis, we exclude investment activities and activities with strong life-cycle patterns, such as purchase of a house or car, education, medical care, and child care. Second, we disregard transportation expenditures since in the CEX expenditures on transportation cannot be separated into expenditures associated with distinct activities (e.g. driving to work versus driving to enjoy a holiday weekend). We refer to the expenditures left as "core expenditures" which constitute roughly 60% of total consumption expenditures reported in the CEX over the sample period.

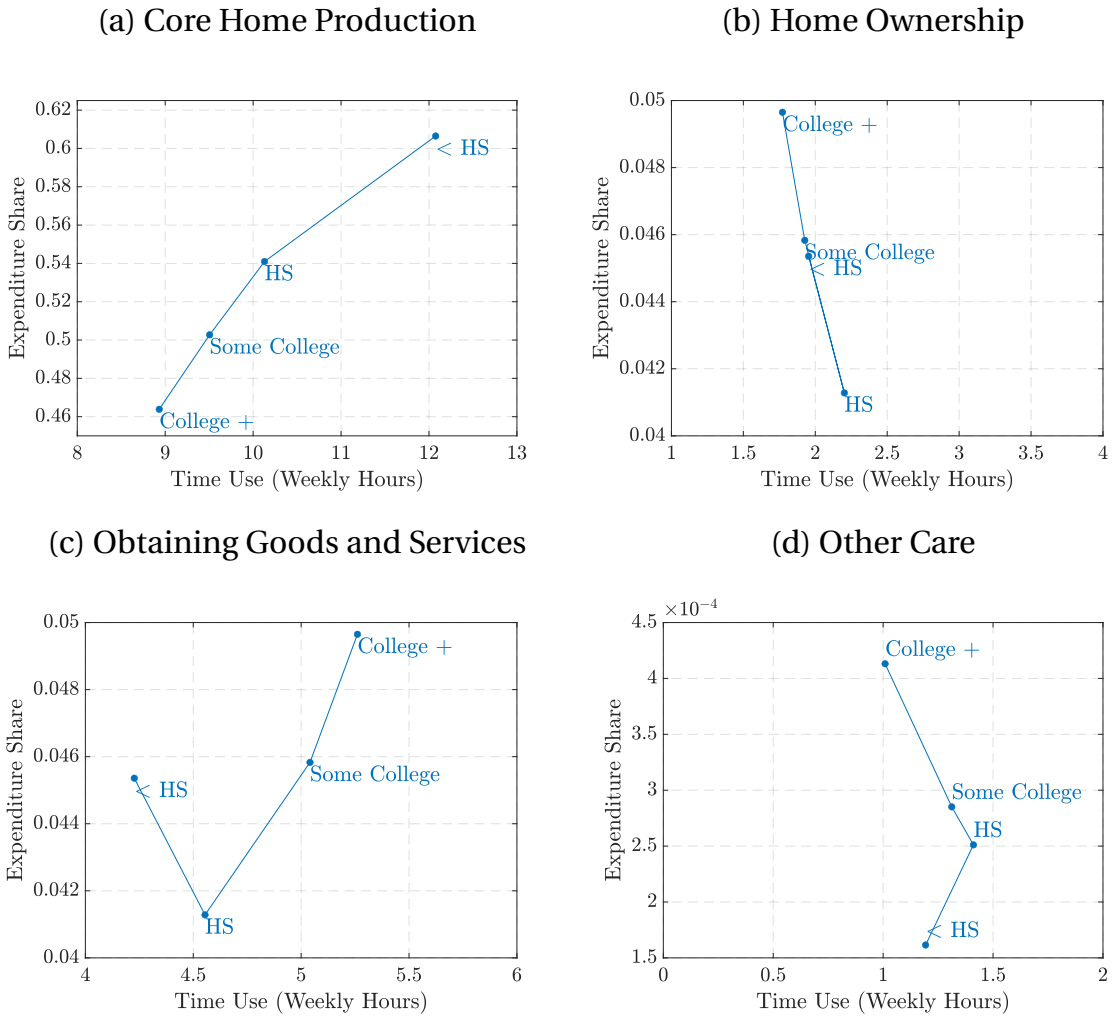
This data construction process leads to eight activities besides market work. Among those activities, four of them are home production activities: core home production, home ownership, obtaining goods and services, and other care, and the others are leisure activities: watching TV, socializing, eating & personal care, and hobbies & entertainment. Please refer to Tables A.2 and A.1 for a detailed description of these categories.

2.2.1 Stylized Facts

This section studies the allocations of time and expenditures by activity and by education attainment. We find that market work requires hardly any expenditures and market hours increase with education as in Aguiar and Hurst (2007b). College graduates spend roughly 13 more hours per week working in the market than high school dropouts. Such big difference in market hours implies that allocations to non-market activities also vary tremendously across households. Figures 1 and 2 document the heterogeneity in time and

expenditures allocated to non-market activities by education group. Time spent on each activity, plotted on the x-axis, is reported as weekly hours. Expenditures for market goods allocated to the same activity are shown on the y-axis and reported as a fraction of core expenditures. We report average allocations over the entire sample period as time and expenditure shares vary little over time.

Figure 1: Time and Expenditure Allocations to Home Activities by Education



Data Source: American Time Use Survey and Consumer Expenditure Survey. Consumption expenditures are expressed as a fraction of core expenditures. Time use is reported as weekly hours. "HS" refers to high school and "<HS" refers to less than high school. Values reported are the averages between 2003-2018.

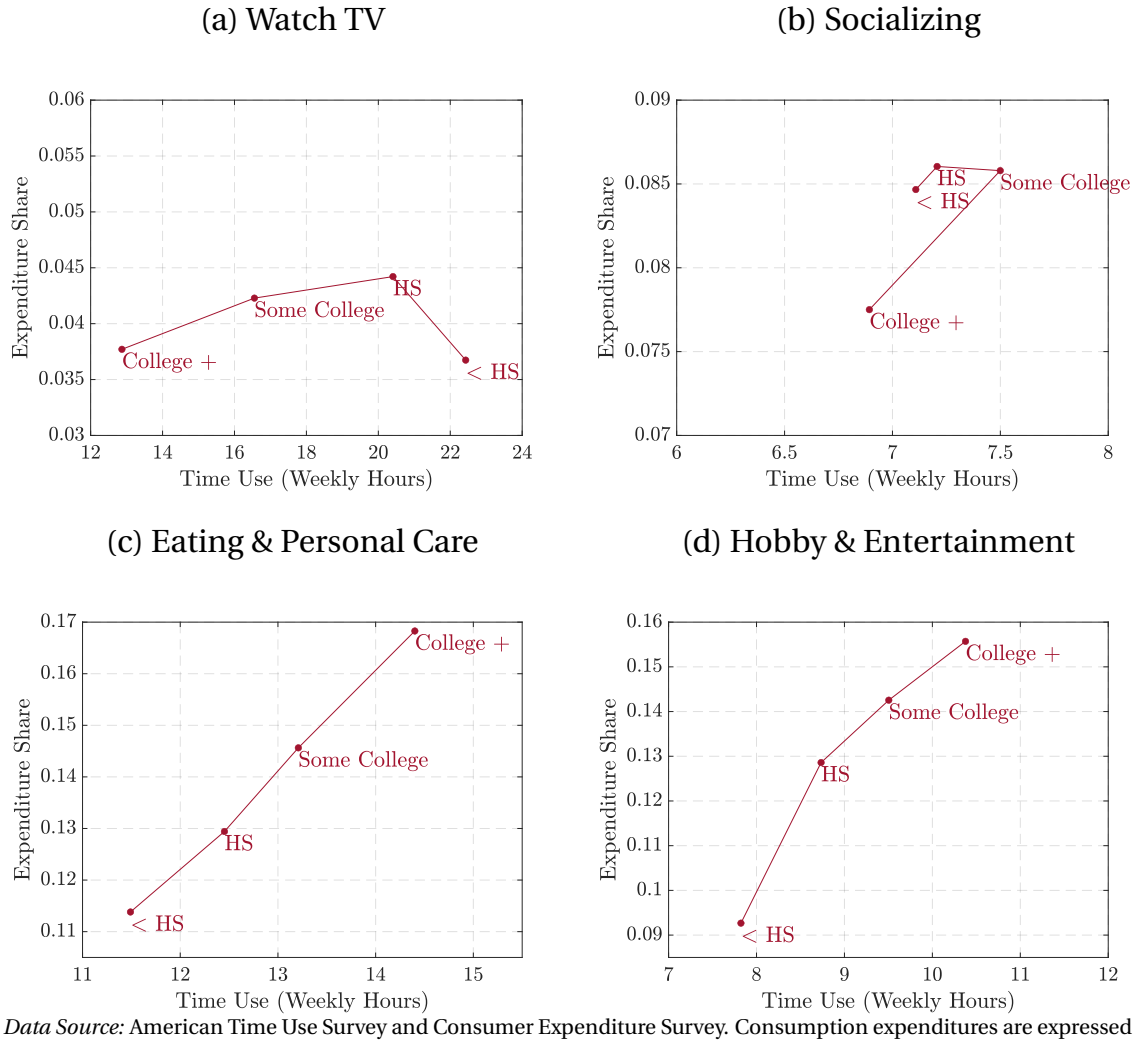
Figure 1 plots the time and expenditure shares allocated to the four home activities. Among all home and leisure activities, core home production is the activity that households spend most of their expenditures on. The expenditure in this category is 46%-61%

of core expenditures. Expenditure share on core home production declines in education, with high school dropouts allocating 15 percentage points more of their core expenditures to core home production activities than college graduates. Core home production hours also decline in education, with high school dropouts spending 3 more hours per week than college graduates. Expenditure shares on home ownership and obtaining goods and services are both around 4%-5% and the variations are less dramatic across education groups. Time spent on obtaining goods and services is 4 to 5 hours per week and increases with education. Other care is an activity that consists only a small amount of time and expenditures because most households do not perform this activity.

Figure 2 plots time use and expenditure shares for the four leisure activities. Watching TV is associated with little expenditures but is the activity with the largest share of time. This activity drives the difference in total leisure hours by education. High school dropouts spend 10 more hours per week watching TV than college graduates. The variations in time and expenditure share for socializing are relatively small across education groups. Hobbies & entertainment and eating & personal care, are the two leisure activities that dominate household expenditures. Households spend 10%-17% of their core expenditures on each of these two activities. Expenditure shares and time spent on these activities are both rising with education. College graduates spend 6 percentage points more of their core expenditures on each of these two categories than high school dropouts, and they also allocate 6 more hours per week for hobbies & entertainment and eating & personal care combined. Taken together, these patterns imply that more educated households spend less time but a larger fraction of their core expenditures on leisure activities overall.

We perform several checks to demonstrate the robustness of these stylized facts. First, we split the sample into two subperiods: 2003-2007 and 2008-2018. Tables B.3 and B.4 show that the cross-sectional time and expenditure allocations are similar for the two subsamples. Second, instead of grouping households by education, we split them by income quartiles. Figures B.1 and B.2 in the appendix show the results. Although the patterns of the allocations by income are largely consistent with those by education, we lose a nontrivial number of observations due to the fact that the household income variable in the

Figure 2: Time and Expenditure Allocations to Leisure Activities by Education



Data Source: American Time Use Survey and Consumer Expenditure Survey. Consumption expenditures are expressed as a fraction of core expenditures. Time use is reported as weekly hours. "HS" refers to high school and "<HS" refers to less than high school. Values reported are the averages between 2003-2018.

ATUS contains a lot of missing observations. Hence, we choose to continue the analysis with the education groups. The documented patterns of allocations by education will be used to identify parameters in the activity production model proposed in the next section.

3. Structural Framework

Becker (1965) emphasizes that different types of time use and different types of market goods can be combined in various ways to provide utility. Hence, his notion of utility is far more general than the standard assumption in the macroeconomics literature, in which

total non-market time is often combined into a general notion of leisure time. We formalize Becker's (1965) notion in a nested CES household production function, the structure of which is the same as that in Fang et al. (2021). Household j combines time l_{ij} and goods x_{ij} in a CES production function to produce the consumption of activity i, denoted by c_{ij}. Household $j's$ utility is defined over the combination of all activities c_{ij} $(i = 1, ...n)$ and aggregated using CES preferences:

$$u(c_{1j}, ...c_{nj}) = \log\left\{\left(\sum_{i}^{n} \alpha_i c_{ij}^{\frac{\rho-1}{\rho}}\right)^{\frac{\rho}{\rho-1}}\right\}, \quad c_{ij} = \left(\kappa_i x_{ij}^{\frac{\xi_i-1}{\xi_i}} + (1-\kappa_i)(\ell_{ij} + \bar{\ell}_i)^{\frac{\xi_i-1}{\xi_i}}\right)^{\frac{\xi_i}{\xi_i-1}},$$

with $0 \leq \alpha \leq 1$, $0 \leq \kappa \leq 1$, $\rho \geq 0$, and $\xi_i \geq 0$.

α_i is the relative utility weight of activity i in the overall set of activities. ρ captures the elasticity of substitution among the consumption activities. κ_i determines the weight of goods in the production of activity i. ξ_i governs the elasticity of substitution between goods and time for activity i and can vary across activities. $\bar{\ell}_i$ is a fixed term measured in units of time and can be either positive or negative. As Fang et al. (2021) show, the existence of $\bar{\ell}_i$ makes the household production function nonhomothetic and is important for the model to generate the correlations between time and expenditure shares with wages shown in the data.

In the data, consumption expenditures related to market work are virtually zero. Hence, we assume that market work only involves time but not expenditures. Each household has one unit of time that can be allocated to the production of non-market activities or market work. Let w be the wage rate and p_i be the price of market goods x_i. The budget constraint is given by:

$$\sum_i p_i x_{ij} = w_j(1 - \sum_i \ell_{ij}). \tag{1}$$

Two model innovations distinguish our framework from more commonly used macroeconomic models and thus warrant further discussion. The first innovation is that non-market time—the standard notion of leisure—is divided into several time segments and each segment is linked to the production of one activity. Hence, we depart from the standard assumption that all leisure hours are perfect substitutes. The effect of this innovation

is reflected by the optimal ratio of time to goods for activity i:

$$\frac{\ell_{ij}+\bar{\ell}_i}{x_{ij}} = \left(\frac{p_i}{w_j}\right)^{\xi_i}\left(\frac{1-\kappa_i}{\kappa_i}\right)^{\xi_i}. \tag{2}$$

This ratio is derived from the household's optimization problem. The details of the derivation are in the appendix C.1. Because $\xi_i \geq 0, \forall i$ equation (2) implies that a decline in the relative price $\frac{p_i}{w}$ leads to a decline in the input ratio $\frac{\ell_{ij}+\bar{\ell}_i}{x_{ij}}$. The intuition is simple: An increase in wage w or a decrease in goods prices p_i induces households to substitute time with goods in the production of activity i. The magnitude of the substitution is determined by the elasticity of substitution between time and goods ξ_i. A higher elasticity ξ_i implies that time and goods are more substitutable and generates a larger decrease in the input ratio $\frac{\ell_{ij}+\bar{\ell}_i}{x_{ij}}$ in response to a decline in $\frac{p_i}{w}$. Hence the division of non-market time into several segments combined with the activity-specific elasticity of substitution between time and goods generates activity-specific response of time to wage and price changes. This implies that in our model households not only care about the total time spent on leisure, but also care about the allocation of time to each activity.

The second model innovation is the introduction of more than one non-market activities. This allows households to substitute among activities. The substitution between activity i and activity k is reflected in the following equation derived from the households' maximization problem:

$$\frac{\alpha_k\kappa_k}{\alpha_i\kappa_i}\frac{c_{kj}^{\frac{1}{\xi_k}-\frac{1}{\rho}}}{c_{ij}^{\frac{1}{\xi_i}-\frac{1}{\rho}}}\frac{x_{kj}^{-\frac{1}{\xi_k}}}{x_{ij}^{-\frac{1}{\xi_i}}} = \frac{p_k}{p_i}. \tag{3}$$

The quantitative effect of the substitution among activities on the allocations of time and goods is governed by the elasticity of substitution parameter ρ.

4. Estimation

In this section, we first discuss the estimation procedures and the number of activities incorporated in the estimation. We then discuss the estimated parameter values and show that the estimated model matches the data well.

4.1 Estimation Procedure

Our estimation uses the variations in time and expenditure shares across activities by education group and over time in the data. Because the choice in the number of activities to consider is arbitrary, we explore the effects of wage dispersion on hours dispersion in models with different numbers of activities. In particular, we investigate the implications in models with one activity, two activities, four activities, and eight activities. The eight-activity model consists of all the eight non-market activities studied in section 2: core home production, other care, obtaining goods and services, home ownership, watching TV, socializing, eating & personal care, and hobbies & entertainment. The four-activity model follows Fang et al. (2021) to divide the eight activities into home necessities (core home production and other care), home luxuries (obtaining goods and services and home ownership), leisure necessities (watching TV and socializing), and leisure luxuries (eating & personal care and hobbies & entertainment). The two-activity model further aggregates home necessities and home luxuries into home activities and aggregates leisure necessities and leisure luxuries into leisure activities. Lastly, the one-activity model combines all eight activities.

The parameters to be estimated are ρ, $\{\xi_i\}_{i=1}^n$, $\{\kappa_i\}_{i=1}^n$, $\{\alpha_i\}_{i=1}^n$, and $\{\bar{\ell}_i\}_{i=1}^n$, where n is the number of activities included in the model. We use a minimum-distance estimator to estimate the parameters. Taking education-group-specific wages and the prices of goods inputs for each activity from the data, the estimation minimizes the distance of allocations between model and data. The targeted moments are the allocations of time and expenditure shares between 2003 and 2018 for each activity and each education group constructed in section 2. From equations (2) and (3), given wages, prices, and the allocations of time and expenditure shares by activity, we can infer the mode parameters, including the degree of substitutability between time and goods within an activity and the substitutability among activities. As a result, taking wages and prices as given from the data, variations in allocations in the cross-section and over time identify the model parameters.

We use the CPS-ORG to construct wages by education group. Wages are defined as the ratio between weekly earnings and weekly working hours. We then average wages by

education group and year to match them with the pseudo-panel of time use and expenditure. In the baseline specification of our model, we assume all households face the same goods prices.[4] The prices are obtained from the disaggregated indices of the Consumer Price Index (CPI) published by the Bureau of Labor Statistics. We follow the method of Casey (2010) to consistently map these disaggregated indices to activity-specific expenditures. The price for an activity is derived as follows. We first compute expenditure shares for each of the most detailed expenditure category available in the CEX at the household level. We then use these shares as weights to aggregate the corresponding CPI indices to a weighted price index at the household level for each activity we consider. Finally, we derive the price for an activity by averaging across all households using CEX sample weights for every year between 2003 and 2018.

4.2 Estimation Results

Tables 2 - 4 summarize the estimated parameters for the one-activity, two-activity, four-activity, and eight-activity models. The standard errors, reported in parentheses, are obtained by bootstrapping the household-level data sets. Standard errors are all small, implying that the parameters are precisely identified.

The tables show that the activity-specific elasticities of substitution between goods and time (ξ_i) are larger than one for almost all activities in all four models considered. This result implies that time and goods are quite substitutable and thus households react strongly to wage changes by reallocating time and expenditures within activities.

The estimated share for goods in the activity production, κ_i, varies largely across activities. Most of the estimates are less than 0.3. The standard errors associated with the estimates are all small, implying that the share of time inputs, $1-\kappa_i$, for every activity is significantly different from zero. This provides confidence in Becker's notion that households require a combination of goods and time to enjoy consumption of non-market activities.

The weights of activities in the utility of households, α_i, also vary significantly. Overall the combination of all home production activities has a weight larger than the combina-

[4] We explore the effects of heterogeneous prices by education group in Section 5.2.

tion of all leisure activities in the models with more than one activity. However, leisure activities also play an important role in households' utility. They have a combined utility weight between 0.15 to 0.5 depending on the number of activities in the model. This suggests that leisure-related activities constitute an important component of household utility. Hence it is not surprising that formalizing Becker's idea beyond home production significantly alters how households reallocate time between market work and non-market activities and across different types of non-market activities in response to wage changes.

Table 2: Parameter Estimates for One- and Two-Activity Models

	1-activity model	2-activity model	
		(1)	(2)
		Home Activities	Leisure Activities
Elast. Time & Goods	$\hat{\xi}$	$\hat{\xi}_H$	$\hat{\xi}_L$
	3.393	1.284	3.740
	(0.269)	(0.014)	(0.053)
Share of Goods	$\hat{\kappa}$	$\hat{\kappa}_H$	$\hat{\kappa}_L$
	0.255	0.130	0.190
	(0.009)	(0.001)	(0.002)
Nonhomotheticity	$\hat{\bar{\ell}}$	$\hat{\bar{\ell}}_H$	$\hat{\bar{\ell}}_L$
	-0.628	0.884	-0.452
	(0.008)	(0.007)	(0.002)
Utility Weights		$\hat{\alpha}_H$	$\hat{\alpha}_L$
		0.880	0.120
		(0.003)	(0.003)
Elast. b/w Activities		$\hat{\rho}$	
		0.992	
		(0.022)	

Notes: The table reports the means of the bootstrapped distributions for the preference parameters of the model described in section 3 (bootstrapped standard errors are in parentheses).

Table 3: Parameter Estimates for Four-Activity Model

	(1) Home Luxuries	(2) Leis Luxuries	(3) Home Necessities	(4) Leis Necessities
Elast. Time & Goods	$\hat{\xi}_{HL}$	$\hat{\xi}_{LL}$	$\hat{\xi}_{HN}$	$\hat{\xi}_{LN}$
	1.527	0.273	1.071	1.379
	(0.245)	(0.006)	(0.017)	(0.022)
Share of Goods	$\hat{\kappa}_{HL}$	$\hat{\kappa}_{LL}$	$\hat{\kappa}_{HN}$	$\hat{\kappa}_{LN}$
	0.255	0.999	0.067	0.041
	(0.138)	(0.000)	(0.010)	(0.005)
Nonhomotheticity	$\hat{\bar{\ell}}_{HL}$	$\hat{\bar{\ell}}_{LL}$	$\hat{\bar{\ell}}_{HN}$	$\hat{\bar{\ell}}_{LN}$
	-0.009	-0.205	2.312	1.359
	(0.032)	(0.002)	(0.316)	(0.217)
Utility Weights	$\hat{\alpha}_{HL}$	$\hat{\alpha}_{LL}$	$\hat{\alpha}_{HN}$	$\hat{\alpha}_{LN}$
	0.116	0.072	0.448	0.365
	(0.022)	(0.004)	(0.012)	(0.010)
Elast. b/w Activities	$\hat{\rho}$			
	2.657			
	(0.047)			

Notes: The table reports the means of the bootstrapped distributions for the preference parameters of the model described in section 3 (bootstrapped standard errors are in parentheses).

The estimated parameter values for the nonhomothetic term $\bar{\ell}_i$ can be positive or negative. As discussed in Fang et al. (2021), the combination of $\bar{\ell}_i$, ξ_i, and κ_i governs the correlations of time and expenditure shares with wages for activity i. The elasticity of substitution across activities, ρ, has an estimated value between 0.9 and 2.6. This suggests that consumption activities themselves are quite substitutable. Hence households strongly adjust the portfolio of activities they enjoy in response to wage changes.

We check the fit of our model by confronting it with the cross-sectional data on expenditure shares and time use for each activity. Tables 5-7 report average allocations by education group over the sample years for each of the four models. The model replicates

Table 4: Parameter Estimates for Eight-Activity Model

	(1) Core Home	(2) Home Own	(3) Obt Gds Svs	(4) Oth Care	(5) Watch TV	(6) Social	(7) Eat & Pcare	(8) Hobby & Ent
Elast. Time & Goods	$\hat{\xi}_{CH}$	$\hat{\xi}_{HO}$	$\hat{\xi}_{GS}$	$\hat{\xi}_{OC}$	$\hat{\xi}_{TV}$	$\hat{\xi}_{SC}$	$\hat{\xi}_{EP}$	$\hat{\xi}_{HE}$
	1.266	8.935	12.281	2.879	1.719	0.698	3.951	10.347
	(0.011)	(0.447)	(5.126)	(9.083)	(0.020)	(0.030)	(0.521)	(0.456)
Share of Goods	$\hat{\kappa}_{CH}$	$\hat{\kappa}_{HO}$	$\hat{\kappa}_{GS}$	$\hat{\kappa}_{OC}$	$\hat{\kappa}_{TV}$	$\hat{\kappa}_{SC}$	$\hat{\kappa}_{EP}$	$\hat{\kappa}_{HE}$
	0.114	0.116	0.343	0.162	0.034	0.879	0.383	0.151
	(0.003)	(0.002)	(0.043)	(0.038)	(0.001)	(0.024)	(0.052)	(0.002)
Nonhomotheticity	$\hat{\ell}_{CH}$	$\hat{\ell}_{HO}$	$\hat{\ell}_{GS}$	$\hat{\ell}_{OC}$	$\hat{\ell}_{TV}$	$\hat{\ell}_{SC}$	$\hat{\ell}_{EP}$	$\hat{\ell}_{HE}$
	1.047	−0.018	−0.051	−0.009	0.953	−0.060	−0.141	−0.093
	(0.055)	(0.000)	(0.000)	(0.001)	(0.065)	(0.001)	(0.001)	(0.001)
Utility Weights	$\hat{\alpha}_{CH}$	$\hat{\alpha}_{HO}$	$\hat{\alpha}_{GS}$	$\hat{\alpha}_{OC}$	$\hat{\alpha}_{TV}$	$\hat{\alpha}_{SC}$	$\hat{\alpha}_{EP}$	$\hat{\alpha}_{HE}$
	0.418	0.030	0.017	0.023	0.384	0.028	0.044	0.056
	(0.003)	(0.001)	(0.001)	(0.005)	(0.005)	(0.002)	(0.003)	(0.001)
Elast. b/w Activities	$\hat{\rho}$							
	1.951							
	(0.020)							

Notes: The table reports the means of the bootstrapped distributions for the preference parameters of the model described in section 3 (bootstrapped standard errors are in parentheses).

the expenditure shares and time use data fairly well.

5. Results

5.1 Hours Dispersion

Using the estimated model, we study the quantitative effect of wage dispersion on hours dispersion. In our model, dispersion in wages is the only source of heterogeneity across households. To account for the effect of this heterogeneity on hours dispersion, we simulate the expenditure and time allocations for each activity using the entire distribution of wages from the CPS-ORG and the prices of goods constructed in section 4 over 2013-2018. Table 8 reports the predicted dispersion in log hours in levels and as a percentage of the dispersion in the data. The model explains 25-87% of the average hours dispersion over the sample period, depending on the the number of activities included in the model.

Table 5: Data vs. Model: One- and Two-Activity Models

	One-Activity Model		Two-Activity Model							
	Time Use		Time Use				Expenditure Shares			
	Model	Data	Model		Data		Model		Data	
			Home	Leisure	Home	Leisure	Home	Leisure	Home	Leisure
< HS	0.762	0.765	0.214	0.547	0.221	0.545	0.670	0.330	0.669	0.325
HS	0.715	0.711	0.204	0.517	0.196	0.516	0.611	0.389	0.608	0.386
Some College	0.693	0.697	0.198	0.501	0.193	0.504	0.586	0.414	0.580	0.413
College +	0.653	0.653	0.177	0.470	0.183	0.469	0.559	0.441	0.555	0.436

Data Source: American Time Use Survey and Consumer Expenditure Survey. Consumption expenditures are expressed as a fraction of core expenditures. Time use is reported as weekly hours. "HS" refers to high school and "<HS" refers to less than high school. Values reported are the averages between 2003-2018.

Table 6: Data vs. Model: Four-Activity Model

	Time Use							
	Model				Data			
	Home Lux	Leis Lux	Home Nec	Leis Nec	Home Lux	Leis Lux	Home Nec	Leis Nec
< HS	0.058	0.223	0.128	0.327	0.069	0.221	0.143	0.331
HS	0.061	0.232	0.123	0.294	0.072	0.229	0.113	0.296
Some College	0.063	0.239	0.118	0.274	0.075	0.251	0.107	0.263
College +	0.071	0.272	0.091	0.207	0.076	0.265	0.100	0.211
	Expenditure Shares							
	Model				Data			
	Home Lux	Leis Lux	Home Nec	Leis Nec	Home Lux	Leis Lux	Home Nec	Leis Nec
< HS	0.076	0.212	0.586	0.126	0.060	0.204	0.610	0.121
HS	0.084	0.248	0.543	0.124	0.064	0.256	0.543	0.130
Some College	0.090	0.268	0.519	0.123	0.074	0.285	0.505	0.128
College +	0.111	0.320	0.450	0.119	0.089	0.321	0.467	0.115

Data Source: American Time Use Survey and Consumer Expenditure Survey. Consumption expenditures are expressed as a fraction of core expenditures. Time use is reported as weekly hours. "HS" refers to high school and "<HS" refers to less than high school. Values reported are the averages between 2003-2018.

Table 7: Data vs. Model: Eight-Activity Model

	Core Home	Home Own	Obt Gds Svs	Oth Care	Watch TV	Social	Eat&Pcare	Hobby&Ent
Time Use - Model								
$<$ HS	0.124	0.023	0.051	0.013	0.239	0.072	0.142	0.100
HS	0.119	0.020	0.051	0.013	0.212	0.074	0.141	0.094
Some College	0.115	0.019	0.051	0.013	0.194	0.076	0.141	0.094
College +	0.096	0.018	0.051	0.012	0.134	0.081	0.141	0.093
Time Use - Data								
$<$ HS	0.141	0.020	0.047	0.012	0.250	0.078	0.132	0.086
HS	0.111	0.022	0.048	0.014	0.217	0.075	0.135	0.090
Some College	0.105	0.020	0.054	0.014	0.179	0.079	0.146	0.100
College +	0.099	0.018	0.056	0.010	0.136	0.072	0.154	0.108
Expenditure Shares - Model								
$<$ HS	0.597	0.011	0.042	0.001	0.040	0.088	0.123	0.096
HS	0.543	0.026	0.045	0.001	0.040	0.083	0.133	0.128
Some College	0.520	0.032	0.047	0.002	0.041	0.081	0.140	0.137
College +	0.461	0.039	0.055	0.003	0.043	0.075	0.164	0.160
Expenditure Shares - Data								
$<$ HS	0.609	0.015	0.045	0.000	0.037	0.084	0.112	0.093
HS	0.543	0.023	0.042	0.000	0.044	0.086	0.128	0.128
Some College	0.505	0.028	0.046	0.000	0.042	0.086	0.143	0.142
College +	0.466	0.039	0.050	0.000	0.038	0.078	0.165	0.156

Data Source: American Time Use Survey and Consumer Expenditure Survey. Consumption expenditures are expressed as a fraction of core expenditures. Time use is reported as weekly hours. "HS" refers to high school and "<HS" refers to less than high school. Values reported are the averages between 2003-2018.

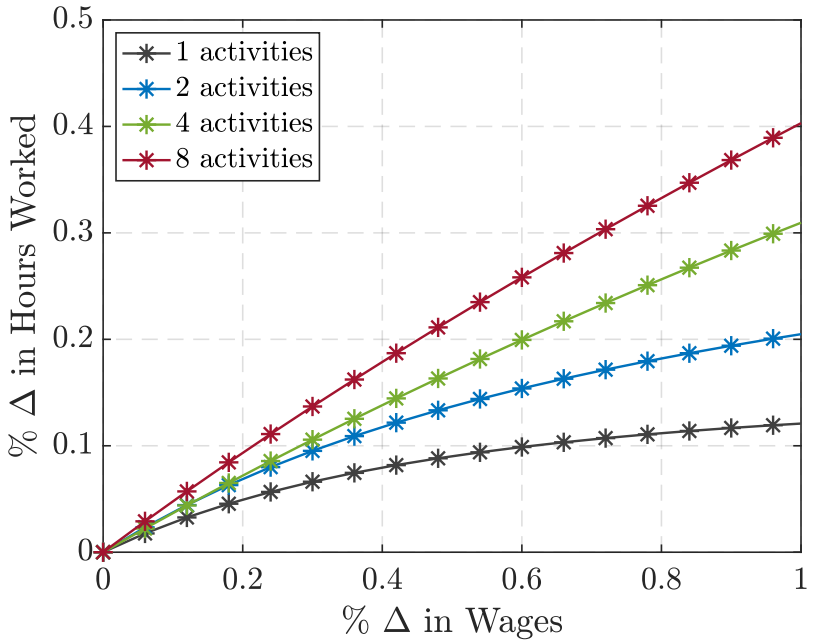
Table 8: Dispersion in Hours Worked - Data vs. Models

	Dispersion	Dispersion (as % of data)
Data	0.323	1.000
1-Activity Model	0.082	0.254
2-Activity Model	0.150	0.463
4-Activity Model	0.210	0.651
8-Activity Model	0.282	0.873
Estimation with education-specific prices		
4-Activity Model	0.170	0.525

Table 8 shows that models with more activities explain a larger share of the hours dispersion. This is because wage changes result in more pronounced changes in hours worked in the models with more activities. To show it, we simulate the model for a successive wage increase up to 100% from the mean wage in the sample, with prices held constant at the average values over the sample period. Figure 3 plots the implied changes in hours worked. It shows that hours worked increase more in models with more activities for the same percentage changes in wages.

Our models with more than one activity have two major differences from the one-activity model or other standard macroeconomic models that combine all non-market time to leisure: (1) including more than one non-market activities that households derive utility from and (2) dividing non-market time into activity-specific time segments and combining each segment with activity-specific market goods to produce an consumption activity. Both model innovations are key for the quantitative results. They give households additional substitution margins, i.e., the substitution between goods and time within an activity and over a large set of activities. Because the estimated elasticities of substitution (ξ_i and ρ) for these margins are large, households are willing and able to substitute across these extra margins and thus can allocate expenditures and time much more flexibly. As

Figure 3: Response of Hours Worked to a Percentage Change in Wage



a result, in models with more than one activity, variation in wages leads to a much larger dispersion in hours worked than in the one-activity model that lacks these features. Moreover, as the number of activities rises, households are able to substitute expenditures and time across a larger set of activities. Thus the response of hours worked to wage changes becomes larger and the dispersion rises.

The comparison between model results with different numbers of activities implies that a number of activities more than eight might have the potential to account for more dispersion in hours worked and bring the model prediction even closer the data. While we agree with this statement, two constraints prevent us from modeling a finer breakdown of activities in a meaningful way. First, as the number of activities increases, the measurement error from inconsistent classification between expenditure and time categories becomes more severe. Second, as the breakdown of activities becomes finer, it is more likely to have an activity that most of the population are not engaging on a weekly basis. This will leads to imprecise estimates of parameters.

5.2 Education-Specific Prices

In the analysis above, we have assumed that all households face the same goods price for a given activity. However, households may face different prices because they use different types of goods or services to produce the same activity. For instance, rich households may hire a maid to clean their houses while poor households buy cleaning supplies to do the work themselves. It follows that the goods price of home production for rich households is more sensitive to maid services, while the price for poor households is more sensitive to cleaning supplies. To address this issues, we construct the goods price for each activity by education group. The procedure is the same as described in section 4 except that in the last step we average prices by education. We reestimate the models and repeat the analyses on hours dispersion using education-specific prices. Table D.5 in the Appendix reports the estimated parameter values. The implied dispersion in hours worked is close to the model with uniform prices. As an example, the last row of Table 8 shows that the four-activity model with education-specific price accounts for 53% of the hours dispersion, compared to a value of 65% in the model with the same number of activity but with uniform prices.

There are other reasons that households may face different prices. One example is that they consume the same type of goods but of different qualities. For instance, rich households are more likely to eat at a fine dining restaurant while poor households are more likely to eat at a fast food restaurant. Recent studies using scanner data have found substantial price dispersion for similar goods. This dispersion is observable both across stores and within a store over short periods of time, through the use of sales and discounts (Aguiar and Hurst (2007a) and Kaplan and Menzio (2015)). Capturing such price differences requires price and household-level expenditure data for the same product consumed at different qualities. To the best of our knowledge, such data are not available, except for a small subset of goods while our study requires data over all households expenditure categories.

6. Conclusion

We use a model in which households derive utility from combining time and market goods, to study the implications of wage changes for hours worked. In the model, households divide their time outside the market into different time segments. Each segment is combined with a specific market good to produce an activity that households enjoy. In this framework, households respond more flexibly to wage changes because they can substitute between market goods and their time, both within and across a given set of activities. We construct the paired allocations on time and expenditures for the same activity and use the constructed data to estimate the proposed model. We find that the estimated model can account for 25-87% of the dispersion in hours worked with the model incorporating more activities generating more dispersion.

It is not surprising that wage dispersion can not fully account for hours dispersion. Other factors, such as, heterogeneity in preferences on leisure and home production as well as indivisibility of market hours, may also contribute to the dispersion in hours worked. We leave these topics for future research.

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Appendix

A Data Classification

Table A.1: CEX 2003-18 Categorization

Activity	Description of Expenditures
1. Market Work	Office furniture for home use; suits and uniforms for men and women; personal digital assistants; meals received as pay; occupational expenses
2. Home Activities	
2.1 Core Home Production	Utilities, fuels, and public services (excl. telephone services); household textiles (excl. bedroom linens); furniture (excl. mattresses and new springs); major appliances; small appliances; nonpermanent carpet squares; blinds; clocks; lamps; decorative items; kitchen utensils; household services; rental of furniture; rental of household and office equipment for nonbusiness use; management fees; other apparel products and services (excl. watches and jewelry, clothing rental); food at home (excl. food or board at school); other household expenses (excl. computers and software for nonbusiness use)
2.2 Homeownership	Maintenance, repairs, and other expenses (excl. homeowner's insurance, parking, and management fees); floor coverings (excl. nonpermanent carpet squares); installed and noninstalled wall-to-wall carpeting; building an attic, installing a pool, or finishing a basement
2.3 Obtaining Goods and Services	Clothing for men and women (excl. suits and uniforms, nightwear, sports coats, active sportswear, other sportswear, and costumes); clothing for boys and girls (excl. nightwear, active sportswear, and costumes); clothing for children (excl. sleeping garments); footwear; clothing rental
2.4 Other Care	Care for invalids or elderly persons; adult-care centers; care in nursing home (net outlay)
3. Leisure	
3.1 Watching TV	Cable services; TVs; video streaming; satellite dishes; repair, rental, and installation of TV and satellite equipment
3.2 Socializing	Catered affairs; live entertainment; party supplies; telephone services and devices; watches; jewelry; dating services
3.3 Eating and Personal Care	Personal-care appliances and services; rental and repair of personal-care appliances; food and beverages during out-of-town trips; alcoholic beverages; dining out at restaurants

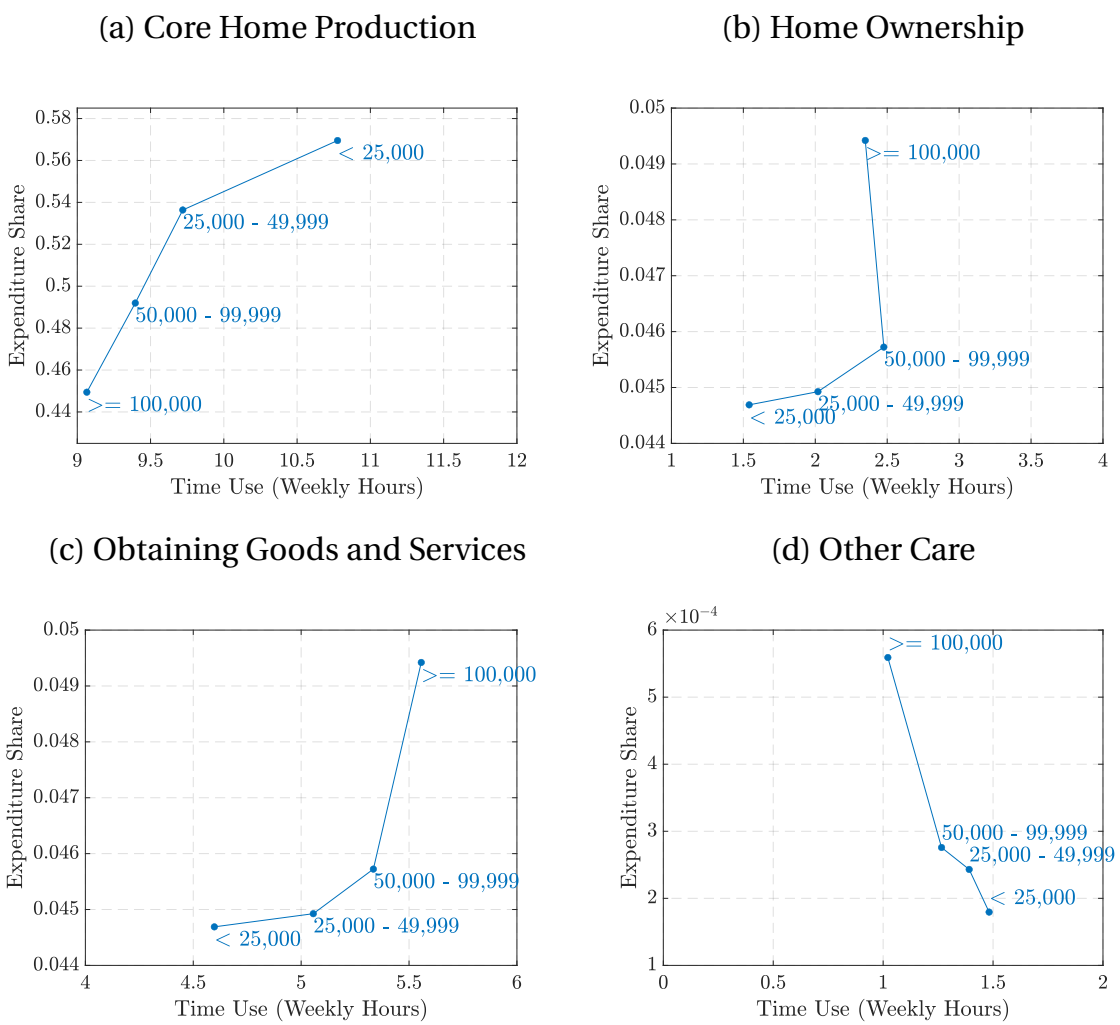
3.4 Hobbies and Entertainment	Trip expenditures on lodging; satellite-radio services; video, radio, and sound equipment; records, CDs, videos, and audio tapes; streaming audio files; outdoor equipment; sport coats, sportswear, and costumes; travel items; rental or purchase of trailer-type campers, boats, or aircraft; reading (excl. encyclopedias); miscellaneous entertainment outlays; pets, toys, and playground equipment; musical instruments; photographic equipment; event fees and admission; computers and software for nonbusiness use; tobacco and smoking supplies

Table A.2: ATUS 2003-18 Categorization

Activity	Description of Activities
1. Market Work	Working, Work-Related Activities, Work and Work-Related Activities n.e.c., Travel Related to Working, Travel Related to Work-Related Activities, Travel Related to Work n.e.c.
2. Home Activities	
2.1 Core Home Production	Housework, Food & Drink Prep., Presentation & Clean-up, Interior Maintenance, Repair & Decoration, Vehicles, Appliances, Tools, Toys, Household Management, Travel Related to Household Activities
2.2 Homeownership Activities	Interior Maintenance; Repair & Decoration, Exterior Maintenance; Repair & Decoration; Lawn, Garden & Houseplants; Travel Related to Exterior Maintenance; Repair & Decoration; Travel Related to Lawn, Garden & Houseplant Care
2.3 Obtaining Goods & Services	Consumer Purchases, Professional & Personal-Care Services, Household Services, Government Services & Civic Obligations, Travel Related to Consumer Purchases, Travel Related to Using Professional and Personal-Care Services, Travel Related to Using Household Services, Travel Related to Using Govt Services & Civic Obligations
2.4 Others Care	Caring for Household (HH) Adults, Helping Household Adults, Caring for & Helping HH Members, n.e.c., Caring for Non-HH Adults, Helping Non-HH Adults, Caring for & Helping Non-HH Members, n.e.c., Travel Related to Caring for HH Adults, Travel Related to Helping HH Adults, Travel Related to Caring for & Helping HH Members, Travel Related to Caring for Non-HH Adults, Travel Related to Helping Non-HH Adults, Travel Related to Caring for & Helping Non-HH Members, n.e.c.
3. Leisure Activities	
3.1 Watching TV	Television and Movies (not Religious), Television (Religious)
3.2 Socializing	Socializing and Communicating, Attending or Hosting Social Events, Playing Games, Waiting Assoc. with Socializing & Communicating, Waiting Assoc. with Attending/Hosting Social Events, Telephone Calls, Travel Related to Socializing and Communicating, Travel Related to Attending or Hosting Social Events, Travel Related to Telephone Calls
3.3 Eating and Personal Care	Grooming, Personal Activities, Personal-Care Emergencies, Personal Care, n.e.c., Eating and Drinking, Travel Related to Personal Care, Travel Related to Eating and Drinking
3.4 Hobbies and Entertainment	Animals and Pets; HH & Personal Mail & Messages (except E-mail); HH & Personal E-mail and Messages; Relaxing and Leisure; Arts and Entertainment (Other than Sports); Waiting Associated with Socializing, Relaxing, and Leisure; Socializing, Relaxing, and Leisure, n.e.c.; Sports, Exercise, and Recreation; Travel Related to Care for Animals and Pets (not Vet Care); Travel Related to Relaxing and Leisure; Travel Related to Sports, Exercise, & Recreation

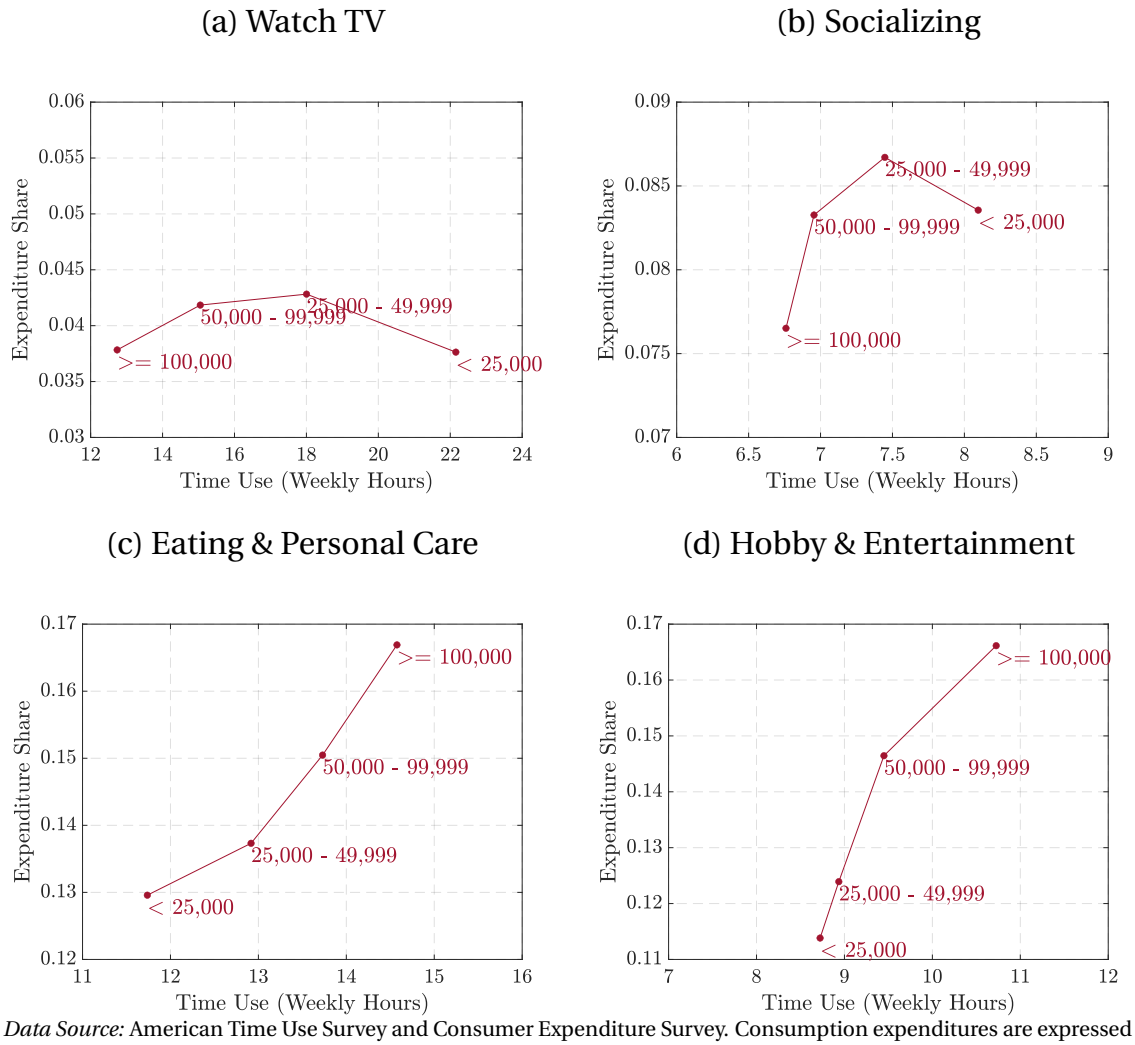
B Robustness: Data Facts

Figure B.1: Time and Expenditure Allocations to Home Activities by Income



Data Source: American Time Use Survey and Consumer Expenditure Survey. Consumption expenditures are expressed as a fraction of core expenditures. Time use is reported as weekly hours. The numbers in the figure indicate the income brackets. Values reported are the averages between 2003-2018.

Figure B.2: Time and Expenditure Allocations to Leisure Activities by Income



Data Source: American Time Use Survey and Consumer Expenditure Survey. Consumption expenditures are expressed as a fraction of core expenditures. Time use is reported as weekly hours. The numbers in the figure indicate the income brackets. Values reported are the averages between 2003-2018.

Table B.3: Sample Split – Average Time Use (Weekly Hours) by Education

		Time Use								
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Edu		Core Home	Home Own	Obt Gds Svs	Oth Care	Watch TV	Social	Eat & Pcare	Hobby & Ent	Mkt Wk
$<$ HS	2003-2007	12.05	2.13	4.57	1.31	21.72	7.41	11.57	7.73	26.60
	2008-2018	12.09	1.87	4.05	1.14	22.78	6.96	11.45	7.87	23.89
	2003-2018	12.08	1.95	4.23	1.19	22.43	7.11	11.49	7.82	24.80
HS	2003-2007	10.23	2.39	4.98	1.60	19.29	7.45	12.62	8.79	31.96
	2008-2018	10.08	2.11	4.36	1.32	20.93	7.10	12.38	8.71	30.68
	2003-2018	10.13	2.20	4.55	1.41	20.41	7.21	12.45	8.73	31.08
Some Col	2003-2007	9.47	2.29	5.53	1.44	15.65	7.63	13.45	9.65	33.24
	2008-2018	9.52	1.77	4.83	1.26	16.95	7.44	13.10	9.44	31.94
	2003-2018	9.51	1.93	5.04	1.31	16.55	7.50	13.21	9.50	32.34
Col $+$	2003-2007	8.89	2.19	5.66	1.17	12.18	6.82	14.44	10.70	37.61
	2008-2018	8.95	1.62	5.12	0.95	13.13	6.92	14.39	10.26	36.90
	2003-2018	8.93	1.77	5.26	1.01	12.87	6.89	14.40	10.38	37.09

Data Source: American Time Use Survey and Consumer Expenditure Survey. Consumption expenditures are expressed as a fraction of core expenditures. Time use is reported as weekly hours. "HS" refers to high school, "$<$HS" refers to less than high school, "Some Col" refers to some college, and "Col $+$" refers to college $+$. "Mkt Wk" (column (9)) refers to market hours. Values reported are the averages between 2003-2018.

Table B.4: Sample Split – Average Expenditure Shares by Education

		Expenditure Shares							
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Edu		Core Home	Home Own	Obt Gds Svs	Oth Care	Watch TV	Social	Eat & Pcare	Hobby & Ent
$<$ HS	2003-2007	0.62	0.02	0.05	0.00	0.04	0.08	0.10	0.10
	2008-2018	0.60	0.01	0.04	0.00	0.04	0.09	0.12	0.09
	2003-2018	0.61	0.01	0.05	0.00	0.04	0.08	0.11	0.09
HS	2003-2007	0.55	0.02	0.05	0.00	0.04	0.08	0.12	0.13
	2008-2018	0.54	0.02	0.04	0.00	0.04	0.09	0.13	0.13
	2003-2018	0.54	0.02	0.04	0.00	0.04	0.09	0.13	0.13
Some Col	2003-2007	0.51	0.03	0.05	0.00	0.04	0.08	0.14	0.15
	2008-2018	0.50	0.03	0.04	0.00	0.04	0.09	0.15	0.14
	2003-2018	0.50	0.03	0.05	0.00	0.04	0.09	0.15	0.14
Col $+$	2003-2007	0.47	0.04	0.05	0.00	0.04	0.08	0.15	0.16
	2008-2018	0.46	0.04	0.05	0.00	0.04	0.08	0.17	0.15
	2003-2018	0.46	0.04	0.05	0.00	0.04	0.08	0.17	0.16

Data Source: American Time Use Survey and Consumer Expenditure Survey. Consumption expenditures are expressed as a fraction of core expenditures. Time use is reported as weekly hours. "HS" refers to high school, "$<$HS" refers to less than high school, "Some Col" refers to some college, and "Col $+$" refers to college $+$. Values reported are the averages between 2003-2018.

C Model Solution

C.1 Models with More Than One Activity

The utility function for household j is given by

$$\begin{aligned} U(c_{1j},...c_{nj}) &= log\left(\sum_i \alpha_i c_{ij}^{\frac{\rho-1}{\rho}}\right)^{\frac{\rho}{\rho-1}} \\ c_{ij} &= \left(\kappa_i x_{ij}^{\frac{\xi_i-1}{\xi_i}} + (1-\kappa_i)(\ell_{ij}+\bar{\ell}_i)^{\frac{\xi_i-1}{\xi_i}}\right)^{\frac{\xi_i}{\xi_i-1}}. \end{aligned}$$

The budget constraint is

$$\sum_i p_i x_{ij} = w_j(1-\sum_i \ell_{ij}). \tag{4}$$

Each household maximizes utility subject to the budget constraint. Let λ_j be the Lagrangian multiplier. The FOCs are as follows:

$$\frac{\partial U}{\partial c_{ij}}\frac{\partial c_{ij}}{\partial x_{ij}} = \lambda_j p_i \tag{5}$$

$$\frac{\partial U}{\partial c_{ij}}\frac{\partial c_{ij}}{\partial \ell_{ij}} = \lambda_j w_j. \tag{6}$$

Taking the ratio between these two equations gives

$$\frac{\ell_{ij}+\bar{\ell}_i}{x_{ij}} = \left(\frac{p_i}{w_j}\right)^{\xi_i}\left(\frac{1-\kappa_i}{\kappa_i}\right)^{\xi_i}. \tag{7}$$

Simple manipulation of the definition of c_{ij} gives

$$c_{ij} = x_{ij}\kappa_i^{\frac{\xi_i}{\xi_i-1}}\left[1+\frac{1-\kappa_i}{\kappa_i}\left(\frac{\ell_{ij}+\bar{\ell}_i}{x_{ij}}\right)^{\frac{\xi_i-1}{\xi_i}}\right]^{\frac{\xi_i}{\xi_i-1}}. \tag{8}$$

Plugging equation (7) into the above equation gives

$$c_{ij} = x_{ij}\kappa_i^{\frac{\xi_i}{\xi_i-1}}\left[1+\left(\frac{1-\kappa_i}{\kappa_i}\right)^{\xi_i}\left(\frac{p_i}{w_j}\right)^{\xi_i-1}\right]^{\frac{\xi_i}{\xi_i-1}}. \tag{9}$$

Define $M_{ij} \equiv \kappa_i^{\frac{\xi_i}{\xi_i-1}}\left[1+\left(\frac{1-\kappa_i}{\kappa_i}\right)^{\xi_i}\left(\frac{p_i}{w_j}\right)^{\xi_i-1}\right]^{\frac{\xi_i}{\xi_i-1}}$. Therefore $c_{ij} = M_{ij}x_{ij}$.

From equation (5), we can derive the following equation between activity i and activity

1:

$$\frac{\frac{\partial U}{\partial c_{1j}}\frac{\partial c_{1j}}{\partial x_{1j}}}{\frac{\partial U}{\partial c_{ij}}\frac{\partial c_{ij}}{\partial x_{ij}}} = \frac{p_1}{p_i}. \tag{10}$$

Plugging in the partial derivatives gives

$$\frac{\alpha_1\kappa_1 c_{1j}^{\frac{-1}{\rho}}\left(\frac{c_{1j}}{x_{1j}}\right)^{\frac{1}{\xi_1}}}{\alpha_i\kappa_i c_{ij}^{\frac{-1}{\rho}}\left(\frac{c_{ij}}{x_{ij}}\right)^{\frac{1}{\xi_i}}} = \frac{p_1}{p_i}. \tag{11}$$

Plugging $c_{ij} = M_{ij}x_{ij}$ into the above equation gives x_{ij} as a function of x_{1j}:

$$x_{ij} = \left(\frac{p_1}{p_i}\right)^{\rho}\left(\frac{\alpha_i\kappa_i}{\alpha_1\kappa_1}\right)^{\rho}\frac{M_{ij}^{\frac{\rho}{\xi_i}}}{M_{1j}^{\frac{\rho}{\xi_1}}}\left(\frac{M_{1j}}{M_{ij}}x_{1j}\right). \tag{12}$$

Equation (12) can be simplified as

$$\frac{x_{ij}}{x_{1j}} = \left(\frac{p_1}{p_i}\right)^{\rho}\left(\frac{\alpha_i\kappa_i}{\alpha_1\kappa_1}\right)^{\rho}\frac{M_{ij}^{\frac{\rho-\xi_i}{\xi_i}}}{M_{1j}^{\frac{\rho-\xi_1}{\xi_1}}}. \tag{13}$$

Define $N_{i1j} \equiv \left(\frac{p_1}{p_i}\right)^{\rho}\left(\frac{\alpha_i\kappa_i}{\alpha_1\kappa_1}\right)^{\rho}\frac{M_{ij}^{\frac{\rho-\xi_i}{\xi_i}}}{M_{1j}^{\frac{\rho-\xi_1}{\xi_1}}}$. Then, $x_{ij} = N_{i1j}x_{1j}$. This and equation (7) give ℓ_{ij} as a function of x_{1j}:

$$\ell_{ij} + \bar{\ell}_i = \left(\frac{p_i}{w_j}\right)^{\xi_i}\left(\frac{1-\kappa_i}{\kappa_i}\right)^{\xi_i}N_{i1j}x_{1j}. \tag{14}$$

The budget constraint can be rewritten as follows:

$$x_{1j}\sum_i p_i\frac{x_{ij}}{x_{1j}} = w_j\left(1 - \sum_i(\ell_{ij} + \bar{\ell}_i)\right) + w_j\sum_i\bar{\ell}_i. \tag{15}$$

$$x_{1j}\sum_i p_i N_{i1j} = w_j\left[1 - \sum_i\left(\frac{p_i}{w_j}\right)^{\xi_i}\left(\frac{1-\kappa_i}{\kappa_i}\right)^{\xi_i}N_{i1j}x_{1j}\right] + w_j\sum_i\bar{\ell}_i. \tag{16}$$

Solving for x_{1j} from the above equation gives

$$x_{1j} = \frac{w_j + w_j\sum_i\bar{\ell}_i}{\sum_i p_i N_{i1j} + w_j\sum_i\left(\frac{p_i}{w_j}\right)^{\xi_i}\left(\frac{1-\kappa_i}{\kappa_i}\right)^{\xi_i}N_{i1j}}. \tag{17}$$

x_{ij} can then be solved from equation (13), and ℓ_{ij} can be solved from equation (7).

C.2 One-Activity Model

The utility function for household j is given by:

$$U(C_j^s) = log(C_j^s), \quad C_j^s = \left(\phi^s (x_j^s)^{\frac{\sigma^s-1}{\sigma^s}} + (1-\phi^s)(\ell_j^s + \bar{\ell}^s)^{\frac{\sigma^s-1}{\sigma^s}}\right)^{\frac{\sigma^s}{\sigma^s-1}}.$$

Normalize the price of x_j^s to one. The budget constraint is

$$x_j^s = w_j(1-\ell_j^s). \tag{18}$$

Let λ_j^s be the lagrange multiplier. The first order conditions are:

$$(C_j^s)^{\frac{1}{\sigma^s}} \phi^s (x_j^s)^{-\frac{1}{\sigma^s}} = \lambda_j^s \tag{19}$$

$$(C_j^s)^{\frac{1}{\sigma^s}} (1-\phi^s)(\ell_j^s + \bar{\ell}^s)^{-\frac{1}{\sigma^s}} = \lambda_j^s w_j. \tag{20}$$

The ratio between these two equations gives:

$$\frac{\ell_j^s + \bar{\ell}^s}{x_j^s} = \left(\frac{1}{w_j}\right)^{\sigma^s} \left(\frac{1-\phi^s}{\phi^s}\right)^{\sigma^s}. \tag{21}$$

Plug equation (21) into the budget constraint gives:

$$x_j^s = \frac{w_j(1+\bar{\ell}^s)}{1 + (w_j)^{1-\sigma^s}\left(\frac{1-\phi^s}{\phi^s}\right)^{\sigma^s}}. \tag{22}$$

D Robustness: Estimation with Education-Specific Prices

Table D.5: Parameter Estimates for Four-Activity Model with Education-Specific Prices

	(1) Home Luxuries	(2) Leis Luxuries	(3) Home Necessities	(4) Leis Necessities
Elast. Time & Goods	$\hat{\xi}_{HL}$	$\hat{\xi}_{LL}$	$\hat{\xi}_{HN}$	$\hat{\xi}_{LN}$
	1.656	0.512	1.057	1.357
	(0.026)	(0.034)	(0.023)	(0.021)
Share of Goods	$\hat{\kappa}_{HL}$	$\hat{\kappa}_{LL}$	$\hat{\kappa}_{HN}$	$\hat{\kappa}_{LN}$
	0.086	0.971	0.054	0.032
	(0.003)	(0.010)	(0.001)	(0.001)
Nonhomotheticity	$\hat{\bar{\ell}}_{HL}$	$\hat{\bar{\ell}}_{LL}$	$\hat{\bar{\ell}}_{HN}$	$\hat{\bar{\ell}}_{LN}$
	0.091	-0.189	2.667	1.462
	(0.009)	(0.003)	(0.059)	(0.051)
Utility Weights	$\hat{\alpha}_{HL}$	$\hat{\alpha}_{LL}$	$\hat{\alpha}_{HN}$	$\hat{\alpha}_{LN}$
	0.162	0.043	0.35	0.360
	(0.001)	(0.001)	(0.001)	(0.001)
Elast. b/w Activities	$\hat{\rho}$			
	2.891			
	(0.035)			

Notes: The table reports the means of the bootstrapped distributions for the preference parameters of the model described in section 3 (bootstrapped standard errors are in parentheses).