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Luxuries, Necessities, and the Allocation of Time*

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Abstract

We develop and estimate a novel framework for thinking about the allocation of time by revisiting Becker's notion that the opportunity cost of time is determined by activities other than market work. These activities are produced by combining time and goods. We document that households engage in two types of activities: luxuries and necessities. An increasing share of time and goods is allocated to luxuries as wages rise. The opposite is true for necessities. To rationalize these facts, we estimate a model with non-homothetic preferences in time use. We use the model to study the effect of wage changes and price changes on hours worked, the allocation of time and goods to activities, and welfare. Our results show that households compensate rises in activity prices or reductions in wages by shifting from luxuries to necessities. Since activities are highly substitutable and the activity production inputs time and goods can be substituted to a lesser extent, households are able to absorb some of the reduction in income by shifting to time-intensive necessities. As a result, household welfare declines less than income. We argue that these findings have novel implications for thinking about cross-sectional differences in hours worked and the relation between income and welfare inequality.

JEL Codes: J22, E21, D11
Keywords: Time Allocation, Consumption Expenditures, Elasticity of Substitution, Labor Supply, Non-homothetic Preferences

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1. Introduction

Becker (1965) recognized early on that individuals spent most of their time on activities other than market work and that the allocation of non-working time may be more important for welfare than that of hours worked. His seminal work has inspired an important literature on the allocation of time (for example, Aguiar and Hurst (2007) and Aguiar et al. (2020)), home production (i.e. Greenwood et al. (2005) or Boerma and Karabarbounis (2020)), and the production of leisure (i.e., Bridgman (2016) or Boppart and Ngai (2019)). Yet, the literature often ignores that prices of goods and services that are necessary to enjoy certain activities are in fact quite heterogeneous (see Figure 1). These prices do not only vary across activities, but also follow very different time trends. For example, while we have seen a large decline in the price for video games and related computer accessories, other leisure activity inputs, such as the price for tennis lessons or magazines, have steadily increased. What are the implications of varying input prices for the allocation of time and goods to different activities? How do households respond to price changes of activity inputs and what are the consequences for household welfare?

This paper is, to our knowledge, the first attempt to develop and estimate a comprehensive framework that allows us to understand how the variation in activity input prices affects the allocation of time to different leisure and non-market work activities, the cross-sectional variation in hours worked, and the relation between income and welfare inequality. To do so, we require a model that explicitly allows households to engage in a variety of activities, each of which requires a different share of time and goods inputs in order to be enjoyed. In such a framework, price changes translate into changing time and goods allocations to different activities. In addition, price effects will differ across households if wages, and therefore the opportunity cost of time, vary.

We begin our analysis by documenting two facts in the micro data. First, the correlation between wages and time as well as wages and goods varies across different activities. We use data from the American Time Use Survey and the Consumer Expenditure Survey between 2003 and 2018 to establish that the share of time and goods allocated to a leisure or non-market work activity is either simultaneously increasing or decreasing as wages rise. This finding is robust to a variety of sample splits. We thus define two types of activities:

luxuries and necessities. A luxury is an activity for which demand rises proportionally more than income as wages increase. The income effect then implies that households allocate a larger share of their time and a higher share of their expenditures to luxuries. The opposite is true for necessities. Second, using detailed subseries of the Consumer Price Index, we show that prices for market goods and services that serve as activity production inputs are quite heterogeneous and follow different trends over time.

To rationalize these observations, we develop a framework in which consumption is an aggregate of luxuries and necessities. Time and goods are required inputs in the production of these activities. The key innovation of our model is that it entails a non-homothetic time component in the production function of activities and encompasses heterogeneous non-market work and leisure activities. To estimate the model, we construct a novel data set that combines time use shares and expenditure shares for luxuries and necessities. We develop a consistent mapping between time and expenditures from the American Time Use Survey and the Consumer Expenditure Survey. Activity inputs are expressed as shares of total time and shares of total expenditures. These activity-specific shares vary by households of different education types and over time. We supplement the resulting pseudo-panel with education-specific wages and activity-specific prices. Education-specific wages come from the Current Population Survey Outgoing Rotation Group. Activity-specific prices are derived from the subindices underlying the aggregate Consumer Price Index published by the Bureau of Labor Statistics.

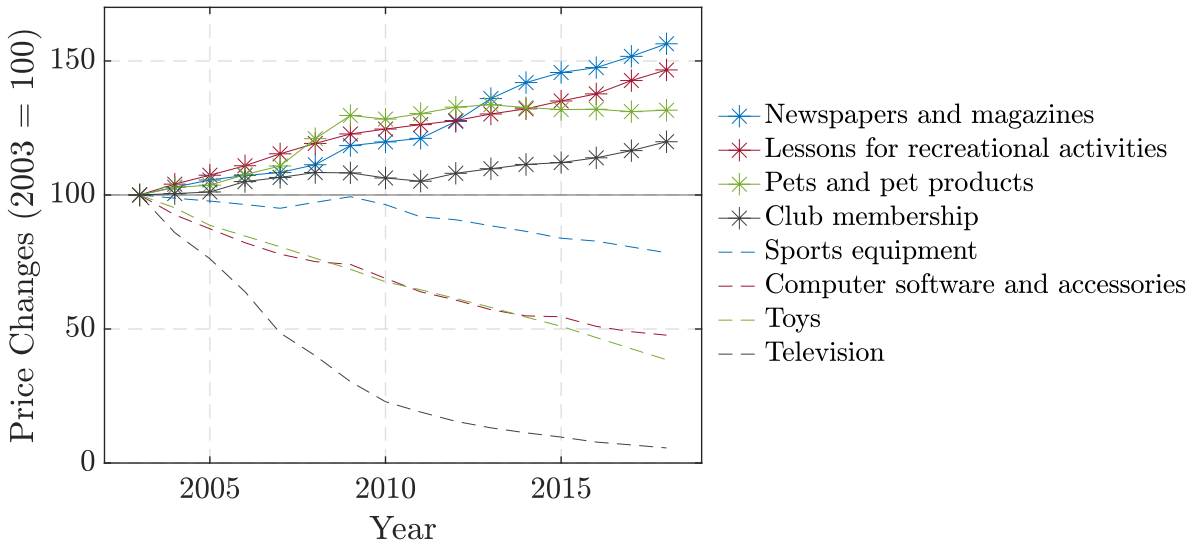
The estimation results reflect that activities are quite heterogeneous in the way they are produced, suggesting that thinking of leisure and non-market work as an aggregate consumption item matches the data poorly and misses important margins of adjustments that are available to households in response to income changes. First, non-homotheticities in time use are an important feature of the data and particularly strong for leisure luxuries and leisure necessities. These non-homotheticities imply that more time and goods are allocated to luxuries in the model as wages rise, while the opposite is true for necessities. This is consistent with our first data fact. Second, while luxuries are expenditure-intensive, necessities have a higher share of time in the activity production function. This is true for both non-market work and leisure activities. As a result, an increase in wages, which raises the opportunity cost of time, will lead to a shift from time-intensive (necessities) to

expenditure-intensive (luxuries) activities. The reallocation is driven by our third result: activities are highly substitutable and the elasticity of substitution between activities is much higher than in framework that assume that all leisure or non-market work activities are produced by teh same production function.

We use the model to study the response to activity price changes. An activity-specific price increase leads to a reduction of time and goods allocated to that particular activity, independent of whether it is a luxury or a necessity. At the same time, the production inputs for all other activities increase proportionally more. Yet, the responses of households to luxury versus a necessity price changes differ. A rise in the price of an expenditure-intensive luxury leads to a reallocation of time and goods to time-intensive necessities. The reallocation is strongest among highly educated households as they consume the highest amount of luxury leisure and are hence most affected by the price increase. A price increase of a time-intensive necessity, on the other hand, leads to large reallocation of time to other necessities, while the increase in the share of time and goods allocated to luxuries is relatively weak.

Finally, we use the model to study how wage and price changes between 2003 and 2018 have affected income and welfare in the cross-section of households. We find that income inequality between 2008 and 2013 is roughly increases by twice as much as welfare inequality. After 2013, trends reverse and both income and welfare inequality decline. The model implies that decline in income inequality is about 50% larger than the decline in welfare inequality. These opposing trends result from the combined effect of activity-specific price growth differences and cross-sectional differences in the evolution of wages. We also show that welfare inequality would be twice in a model with three activities in which low educated households were not able to consume time-intensive leisure necessities. Similarly, if leisure luxuries were absent in the model, welfare inequality would be reduced in half. This suggests that the consumption of leisure luxuries and necessities are crucial for explaining welfare inequality in the cross-section.

(a) Leisure Activities



(b) Non-Market Work Activities

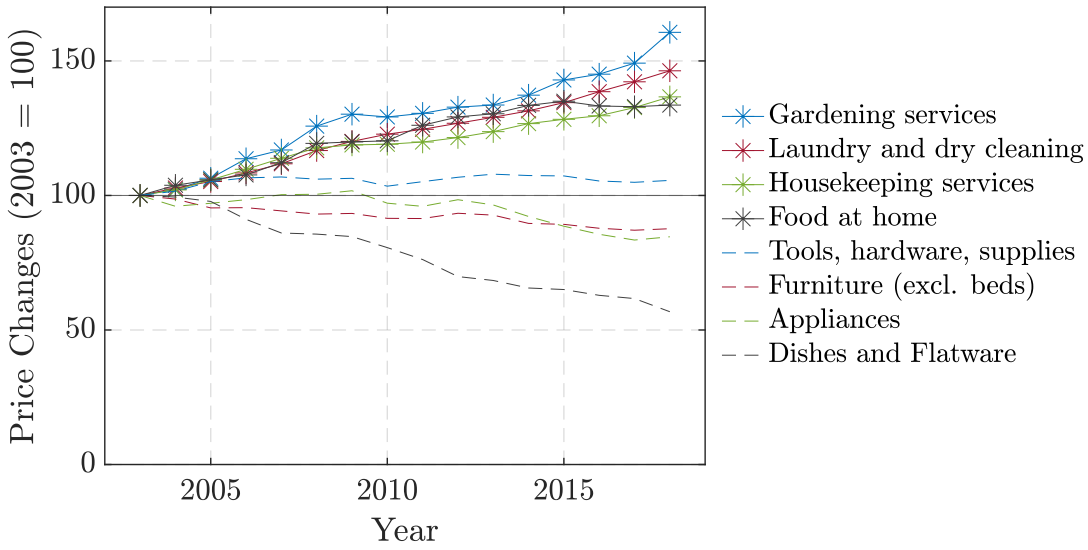


Figure 1: Price of goods & services for individual activities

Notes: Data comes from the CPI database provided by the Bureau of Labor Statistics. Monthly data is averaged to obtain annual values. For leisure activities, we plot subindices SERG01, SERF03, SERB01, SERF01, SERC02, SEEE02, SERE01, and SERA01. For non-market work activities, we plot subindices SEHP02, SEGD03, SEHP01, SAF11, SEHM01, SEHJ02, SEHK, and SEHL03.

Related Literature The paper contributes to a large and growing literature on home production and the production of leisure.[1] However, this paper is to our knowledge the first one to fully embed the idea that households enjoy activities that are produced with heterogeneous production functions in a quantitative framework. The crucial innovation of this paper is the distinction between luxuries and necessities in non-market work and leisure. Our proposed framework featuring non-homotheticities in time use generates correlations between wages and activity inputs that are consistent with the data and absent in models with homothetic preferences. These correlations together with the fact that activities are highly substitutable imply that income inequality translates into less welfare inequality compared to frameworks that abstract from luxuries and necessities.

The literature on time allocation going back to Aguiar and Hurst (2007) and Aguiar et al. (2013) inspired our work. A more recent paper, Aguiar et al. (2020), finds that innovations in recreational computing technology can account for a large fraction of the decline in young men's labor supply since 2004. We contribute and extend this literature by documenting cross-sectional heterogeneity in the types of activities that households enjoy and by studying bundles of time and goods across a wide set of activities. Boerma and Karabarbounis (2021) study the implications of heterogeneity in home productivity for welfare inequality. They infer difference in home productivity since home production hours do not covary with consumption and wages in the cross-section. However, like other papers, the authors do not consider that households can reallocate between luxuries and necessities in home production and leisure in response to income shocks. Instead, households can only substitute time and market goods that have a single price. Our estimation shows that the elasticity of substitution between time and goods within an activity is lower than the elasticity of substitution between activities. As a result, our setup implies a lesser decline in welfare due to a negative income shock.

Few papers have studied the impact of activity prices on hours worked and the allocation of time and goods to various activities. A notable exception is Kopytov et al. (2020) consider the fall in real prices of recreation goods and services over the last century and

[1] See, for example, Benhabib et al. (1991), Greenwood and Hercowitz (1991), McGrattan et al. (1997), Vandenbroucke (2009), Kopecky (2011), Ngai and Pissarides (2011), Bridgman (2016), Fang and Zhu (2017), and Ngai and Petrongolo (2017).

link it to the decline in hours worked across OECD countries. In their setup, households directly derive utility from leisure goods and services. A price decline makes it possible to consume more leisure goods and services and hence household utility increases. While data constraints do not allow us to take a long-run perspective on the evolution of market hours and time allocated to luxuries and necessities, we believe that classifying activities into luxuries and necessities provides novel insights for thinking about the evolution of welfare and welfare inequality. In our setup, a price decline in leisure luxuries would increase utility for high income households relatively more than for low income households, thereby increasing welfare inequality. Yet, a price increase on leisure necessities has little effect on welfare and welfare inequality as these activities are time-intensive.

Finally, this paper is more broadly related to a growing macroeconomic literature that considers the importance of non-homothetic preferences for matching trends in consumption in the cross-section, over time, and across countries. Foellmi and Zweimüller (2006) introduce non-homothetic preferences into an economic growth model to study the impact of wealth inequality on growth. Straub (2019) documents that consumption is not linearly increasing in permanent income. He proposes a model with non-homothetic preferences across periods to capture the fact that high income households save relatively more compared to poorer households. Similarly, Hubmer (2020) documents that richer U.S. households spent more on labor-intensive goods and services, which he interprets through the lens of a model with non-homothetic preferences. We interpret such expenditures as luxuries and show that time allocated to these activities is also increasing as households become richer. The fact that we model luxuries not only as an expenditure on market goods and services, but a combination of time and goods has novel implications for the household responses to income changes and the implied changes in welfare.

The rest of the paper is organized as follows. Section 2 presents data facts on the allocation of time and goods to luxuries and necessities and explains how we construct the data for estimation. Section 3 summarizes the theoretical framework. Section 4 explains the estimation strategy, summarizes the results, and discusses the model fit. We simulate the model in Section 5 to highlight its key mechanisms. We analyze cross-sectional trends in wages and prices and their implications for income and welfare inequality through the lens of our model in Section 6. Section 7 concludes.

2. Time and Goods in the Cross Section

To develop and estimate a quantitative model that encompasses the production of various activities, we first turn to the data. Our ideal data set would capture the allocation of time and goods to detailed activities for various households. However, such a data set does not exist. Hence, we first develop a mapping that classifies time use and expenditures for a consistent set of activities across data sets. We use time use data from the American Time Use Survey (ATUS) and expenditure data on market goods and services from the Consumer Expenditure Survey (CEX). Using the constructed data, we estimate the correlations between wages and time and wages and expenditures for each activity. Based on the results, we assign activities to four activity types that households engage in when they do not formally work in the market: leisure luxuries, leisure necessities, non-market work luxuries and non-market work necessities.

2.1 Assigning Time and Goods to Activities

We first turn to the data on time use. The ATUS records an individual's time allocation on more than 100 activities over a 24-hour period. We follow Aguiar et al. (2013) to classify the activities into 14 distinct categories. The CEX collects data on more than 600 different types of expenditures on market goods and services. We map these expenditures to the 14 activities identified in the time use data. The matching involves two steps. First, we create a baseline match for the 14 activities between both surveys using the aggregated consumption expenditure categories provided by the Bureau of Labor Statistics. We then check the underlying expenditure series at the most detailed level using Universal Classification Codes (UCCs). If necessary, we reassign UCCs to different activity in order to maintain a consistent mapping between time and expenditures. The details of the data construction process and assignments of UCCs to activities are described in Appendix A.

Given the novelty of the data set and the quantitative framework we develop, we choose to study allocations of time and goods to activities in a static setup. For this reason, we abstract from any activity that can be considered an investment decision. In terms of time use, such activities mainly constitute time spent on education and own medical care. We

view time and goods allocated to these activities as human capital investments. Similarly, child care is an activity which is strongly tied to the life cycle. Finally, we time spent sleeping. In the expenditure data, the most significant investment good is the purchase of a house.[2] Thus we abstract from it as well. Studying activities that have dynamic implications over the life cycle are important extensions of the analysis presented in this paper. Another important caveat in the CEX data is that expenditures on transportation, such as gas, maintenance of a vehicle, or public transportation cannot be separated into expenditures associated with distinct activities (for example: driving to work versus driving to enjoy a holiday weekend). We therefore create the expenditure categories Transportation Usage and Transportation Ownership. We provide summary statistics for these expenditure categories in the appendix in table A.3, however, given that they cannot be assigned to a specific activity, we disregard them in our analysis. Despite these shortcomings, we are able to assign close to 60% of total consumption expenditures to one of the nine activity categories that we consider in this study. We refer these expenditures as 'core expenditures.'

The classification leaves us with four non-market work activities and four leisure activities and formal market work. For all these activities, we are able to classify time and goods consistently. Non-market work activities include core home production, home ownership, obtaining goods and services, and other care. Leisure activities include watching TV, socializing, eating & personal care, and hobbies & entertainment. Table A.1 summarizes the activity codes included in each of these activities in the ATUS and Table A.2 and A.3 summarize the expenditures included in each of these activities in the CEX.

2.2 Activities and the Relation to Wages

After classifying time use and expenditures consistently in the ATUS and CEX, we study the relation between wages and time and wages and goods for every activity. We use the data from 2003-2018 and impose a minimal set of sample restrictions in both data sets. We require the reference person to be between the ages of 21 and 65 and remove students and retirees. In the CEX, we also drop households in which neither the head or the spouse of

[2]Note that we include time and goods for maintaining a house in our activity category home ownership activities.

the household are working.

We express time use as a share of activity-related time to total time and express expenditures as a share of activity-related expenditures to core expenditures. Defining variables this way alleviates the problem that the ATUS is surveyed at the individual level and the CEX is surveyed at the household level. To further address this inconsistency in the two surveys, we provide evidence in Appendix B.3 and B.4 that the relationship between wages and activity inputs is unaffected if we restrict the sample to include only men or women, single individuals or married couples or to households with or without children.

Using our common classification scheme, we now turn to study the relationship between time and wages as well as goods and wages for the same activity. For simplicity and to be consistent with Becker (1965)'s terminology, we simply refer to expenditures on market inputs as 'goods'.

2.2.1 Relation Between Time and Wages

The ATUS records time use in the form of a time diary over 24 hours. The diaries are either recorded on weekdays or weekends. Not surprisingly, individuals on average spend a lot more time on non-market work and leisure activities on weekends rather than weekdays. As a result, time allocation to non-market and leisure activities is relatively low for individuals who was surveyed during weekdays. We address this issue by approximating the average time spent on each activity throughout the week for each individual. To do so, we compute time use averages of each activity on weekdays and weekends for different demographic cells. Demographic cells consist of four education groups, five age groups, gender and whether the household has a child younger than 18.[3] This gives us a total of 72 demographic cells. The individual time use for an activity is defined as the weighted average of time use during weekdays and weekends with weekdays having a weight of $5/7$ and weekends having a weight of $2/7$. For individuals who were surveyed on weekdays, the weekend time allocation is approximated by the average weekend time use of their demographic cell. Similarly, we use the weekday averages of the corresponding demographic cells to approximate time allocations for individuals who were surveyed on weekends.

[3]For ages 60 and above, we do not distinguish between households with and without children.

Table 1: Time Use Regressions

	A. Non-market Work			
	(1)	(2)	(3)	(4)
	Core Hm	Oth Care	Obt Gds Svs	Hm Own
Ln Wage	-4.12***	0.00	0.22***	0.76***
	(0.07)	(0.00)	(0.02)	(0.03)
N	97,525	97,525	97,525	97,525
	B. Leisure			
	(5)	(6)	(7)	(8)
	Watch TV	Social	Eat & Pcare	Hobby & Ent
Ln Wage	-1.13***	-0.30***	0.38***	0.23***
	(0.06)	(0.04)	(0.03)	(0.05)
N	64,074	64,074	64,074	64,074

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Notes: Linear regression model. Data comes from the American Time Use Survey between 2003–2018. The dependent variable is a weighted average of hours per weekday and weekend spent on each activity as a fraction of the total time from the following categories: Market work, four non-market work activities: (1) core home production, (2) other care, (3) obtaining goods and services, (4) home ownership activities, and four leisure activities: (5) watching TV, (6) socializing, (7) eating & personal care, (8) hobby & entertainment. Control variables include years of education, age, age squared, dummy variables for gender, marital status, race, the number of children, and the year of the survey. Appendix B.6 and B.7 provide the full regression results.

We use a linear regression model to study the relation between time use and wages at the individual level. The dependent variable is the share of activity-related time to total time, where total time is defined as the sum of market work and the time spent on the nine activity categories included in our analysis. Wages are constructed from the ATUS by dividing income over market hours. Table B.6 and Table B.7 summarize the regression results between wages and each of the nine activities, respectively. All regressions control for years of education as well as age and age squared to capture non-linear age effects. The regression also includes a set of indicator variables that take the value of one if the individual is male, married, or black. Finally, the regression controls for the number of children younger than 18 in the household and include a linear time trend.

Tables 1 demonstrates that the relation between wages and time differs across non-market work and leisure activities. For example, while time spent on home ownership activities such as gardening, and obtaining goods and services increases as wage rise, the opposite is true for core home production activities such as cooking and cleaning, as well as time spent on caring for others. Similarly, the relation between time use and wages in the four leisure subcategories is far from homogeneous. Time spent watching TV and socializing is negatively correlated with wages, while higher wages imply that a larger fraction of time is spent on activities related to eating & personal care and hobby & entertainment.

Appendix B.5 repeats the analysis without time imputations and performs the analysis separately for time diaries conducted on weekdays and weekends. The estimated correlations between time use and wages for all the activities are very similar to analysis using imputed values for weekdays and weekends. The two exceptions are the activities core home production and socializing. Both activities are negatively correlated with wages during the week and positively on weekends (see Table B.14 and B.15). This finding is not surprising since higher wages are associated with working longer hours in the market during weekdays. Thus, the majority of time spent on core home production and socializing occurs during the weekend. However, the negative correlation between wages and time on weekdays is much larger. As a result, the correlation between time and wages using averages across weekdays and weekends is overall negative for both activities.

2.2.2 Relation Between Goods and Wages

Using the expenditure and wage data from the CEX,[4], we repeat the analysis for the relationship between goods and wages for the same set of activities. The dependent variable is the share of expenditures on each activity relative to core expenditures.

Table 2 summarizes the results for the activities related to non-market work and leisure. Again, the relationship between wages and goods is heterogeneous within non-market work and leisure activities. While the share of expenditures allocated to core home production and other care declines as wages increase, expenditures on goods for home ownership and obtaining goods and services are increasing in wages.[5] The shared of expenditures allocated to watching TV, eating & personal care, as well as hobby & entertainment are increasing in wages, while expenditure shares for socializing activities decline as wages rise.

2.3 Luxuries and Necessities

In sum, the correlations between time and wages as well as goods and wages vary across activities. Table 3 summarizes the signs of the estimated regression coefficients from Table 1 and 2. Based on the results, we identify two distinct types of activities: luxuries and necessities. We refer an activities as luxury if the allocated time and expenditure share are both positively correlated with wages, while we refer to all other activities as necessities. In other words, time and expenditure shares for luxuries simultaneously increase as wage rise.

Both non-market and leisure activities consist of luxuries and necessities. This give rise to four types of activities: (1) Non-market luxuries including home ownership activities, and obtaining goods and services; (2) Non-market necessities including core home production and other care; (3) Leisure luxuries including eating & personal care and hobby & entertainment; and (4) Leisure necessities such as watching TV and socializing.

[4]Household wage is the total income of the household divided by the total working hours of all members. We only include household members with a positive amount of hours and income.

[5]The effect of wages on expenditures for other care is statistically insignificant. Note that we were only able to map three UCC codes from the CEX to the activity other care. Hence, we observe few positive expenditures for this category and it is not surprising that the coefficient of interest is not precisely estimated.

Table 2: Expenditure Regressions

	A. Non-market Work			
	(1)	(2)	(3)	(4)
	Core Hm	Oth Care	Obt Gds Svs	Hm Own
Ln Wage	-4.12***	0.00	0.22***	0.76***
	(0.07)	(0.00)	(0.02)	(0.03)
N	130,360	130,360	130,360	130,360
	B. Leisure			
	(5)	(6)	(7)	(8)
	Watch TV	Social	Eat & Pcare	Hobby & Ent
Ln Wage	0.17***	-0.20***	1.76***	0.75***
	(0.02)	(0.03)	(0.04)	(0.05)
N	130,360	130,360	130,360	130,360

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Notes: Linear regression model. Data comes from the Consumer Expenditure Survey between 2003–2018. The dependent variable is the fraction of activity-related to total expenditures from the following categories: market work, four non-market work activities: (1) core home production, (2) other care, (3) obtaining goods and services, (4) home ownership activities, and four leisure activities (5) watching TV, (6) socializing, (7) eating & personal care, (8) hobby & entertainment. Control variables include years of education, age, age squared, dummy variables for gender, marital status, race, the number of children, and the year of the survey. Appendix B.8 and B.9 provide the full regression results.

The coefficient of log wages for the non-market work activity other care is not precisely estimated in the expenditure regressions. This is not surprising since there are only three expenditure classification codes in the CEX that we can assign to the activity other care. As a result, the fraction of expenditures allocated to this activity is zero for at least 90% of the sample and the mean expenditure on other care in the sample is 0.04% (see Table B.5 in Appendix B). Given that the coefficient for the time use regressions is negative for this activity, we categorize other care as a non-market work necessity.

A second category that may not be as clear to categorize is watching TV. The coefficient of wages for time spent watching TV is negative, while the coefficient of wages on the ex-

Table 3: Wages and the Relation to Time and Expenditure

	A. Non-market Work				B. Leisure			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Cr Hm	Oth C	Obt GS	Hm Own	TV	Soc	Eat	Hobby
Time	−	−	+	+	−	−	+	+
Expenditure	−	o	+	+	+	−	+	+

Notes: This table summarizes the sign of the estimated coefficient on Ln Wages from the linear probability models presented in Table B.6, B.7, B.8 and B.9. Non-Market Work activities include (1) core home production, (2) home ownership, (3) Obtaining goods and services, and (4) other care. Leisure activities include (5) watching TV, (6) socializing, (7) eating & personal care, and (8) hobby & entertainment. '+' stands for a positive estimated coefficient and '-' stands for a positive estimated coefficient on log wages at the 1%-significance level. 'o' stands for a coefficient that is statistically not different from zero.

penditure share is positive. However, watching TV is a time-intensive activity (on average 14% of weekly hours, see Table B.4), while less than 4% of expenditures are allocated to this activity (see Table B.5). We thus include watching TV as a leisure necessity.

3. Model

Becker (1965) emphasizes that different types of time use and different types of market inputs 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 production function. Households combine time l_i and market inputs x_i in a CES production function to produce consumption of activity i, denoted by c_i. Household utility is defined over the combination of all

activities and aggregated using CES preferences:

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

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

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 the price of market input x_i associated with activity i. The budget constraint is

$$\sum_i p_i x_i = w(1 - \sum_i \ell_i).$$

Five sets of parameters govern the utility function. First, α_i determines the relative weights of every activity in the overall set of activities. Second, ρ captures the elasticity of substitution between these consumption activities. Third, for a given activity i, κ_i determines the weight of market inputs in the production of every activity. Fourth, the elasticity of substitution between market inputs and time is given by ξ_i. This parameter can vary across activities, implying that the extent to which households substitute between market inputs and their own time may differ across activities.

There are two model components that generate non-homothetic preferences, which helps us to match the correlation between time and wages and expenditures and wages in the data. The first component is the elasticity of substitution between time and goods, ξ_i, which is activity-specific. The second component is the non-homothetic term $\bar{\ell}_i$ that enters time use in the activity production function. The non-homotheticity parameters are necessary to capture the rising share of both time and goods allocated to luxuries as wages increase. We observe the opposite pattern for the necessities and the heterogeneity in the estimated values for $\bar{\ell}_i$ in the estimation reflects that. Without a non-homothetic term in time use, the model would predict that the correlation between wages and time is negative for all activities. Similarly, if we restrict the elasticity of substitution between

time and goods, ξ_i, to be the same across all activities, the model no longer matches the correlation between wages and time that we see in the data. In sum, both components are important to quantitatively match input levels and generate the correlations between inputs and wages that we see in the data.

3.1 Substitution Between Time and Goods

A key innovation of our model 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 a specific activity. This departs from the standard assumption that all leisure hours are perfect substitutes. If leisure hours are imperfect substitutes, households care about the allocation of time to activities instead of the total time spent on leisure. Changes in wages therefore have different effects on the allocation of time and goods across activities since the substitutability between both inputs is activity-specific. To see this, consider the optimal ratio of time and goods for an activity and let λ be the Lagrangian Multiplier. The ratio between time and goods for activity i can be derived from the F.O.Cs:

$$\frac{\partial U}{\partial c_{ij}}\frac{\partial c_{ij}}{\partial x_{ij}} = \lambda p_i \tag{1}$$

$$\frac{\partial U}{\partial c_{ij}}\frac{\partial c_{ij}}{\partial \ell_{ij}} = \lambda w_j \tag{2}$$

Taking the ratio between these two equations gives:

$$\frac{\ell_{ij}+\bar{\ell}_i}{x_{ij}} = \left(\frac{p_i}{w_j}\right)^{\xi_i}\left(\frac{1-\kappa_i}{\kappa_i}\right)^{\xi_i}. \tag{3}$$

Given that $\xi_i \geq 0\ \forall i$, an increase in wages leads to a decline in the input ratio $\frac{\ell_{ij}+\bar{\ell}_i}{x_{ij}}$. The intuition is simple: Wage increases induce more market work and thus a reduction in non-market time ℓ_{ij} spent on producing activity i. At the same time, the increase in income enables households to purchase additional market inputs x_{ij}. As a result, households substitute market inputs for time. The magnitude of the substitution is governed by ξ_i. Since ξ_i is activity-specific, so is the response of allocations to wage increases. A higher elasticity, ξ_i, implies that time and market inputs are more substitutable, resulting in larger decreases

in the non-market time segment ℓ_{ij} and therefore a larger increase in market hours.

3.2 Substitution Between Activities

The model not only departs from the common assumption in the home production and leisure production literature that all non-market time uses are perfectly substitutable (aggregated into leisure, for example). The same assumption is made for market inputs. For instance, these models assume that cable services are a perfect substitute for restaurant services and that time spent on watching TV can be perfectly substituted for time spent dining out. In contrast, the model inspired by Becker (1965) interprets watching TV and eating in a restaurant as two distinct activities that follow separate production processes with different weights on time and goods as production inputs and a varying degree of substitutability between them. A large weight on goods in the production process makes an activity expenditure-intensiveIf the price of goods inputs for such an activity increase, households switch to more time-intensive activities. The effect of a change in the relative price between activity i and activity k can be derived from equation (1):

$$\frac{\frac{\partial U}{\partial c_{kj}}\frac{\partial c_{kj}}{\partial x_{kj}}}{\frac{\partial U}{\partial c_{ij}}\frac{\partial c_{ij}}{\partial x_{ij}}} = \frac{p_k}{p_i}. \tag{4}$$

Plugging in the partial derivatives gives:

$$\frac{\alpha_k \kappa_k}{\alpha_i \kappa_i}\frac{c_{kj}^{1-\frac{\xi_k}{\rho}}}{c_{ij}^{1-\frac{\xi_i}{\rho}}}\frac{x_{kj}^{\frac{1}{\xi_k}}}{x_{ij}^{\frac{1}{\xi_i}}} = \frac{p_k}{p_i}. \tag{5}$$

The response of allocations to price changes is not only affected by the elasticity of substitution between market inputs and time ξ_i, but also by the elasticity of substitution between activities ρ. A higher ρ implies that activities are more substitutable, resulting in a larger reallocation of time and goods in response to price changes.

4. Estimation

Before discussing the results of the estimation, we sketch the estimation strategy and explain how we construct wage and activity-specific prices to estimate the model inspired by (Becker, 1965). We also show that the model replicates the correlations between activity inputs and wages that we document in section 2. We emphasize that the non-homothetic model components are key for the model to match the data quantitatively.

4.1 Estimation Strategy

We estimate the model proposed in section 3 using data between 2003 and 2018. Since there is no single data set that contains detailed information on time and goods allocations for the same household, we use the variation in activity inputs across education and over time to identify the model parameters. To this end, we construct a pseudo-panel of time and goods allocations for each education group. We consider four education groups: less than high school, high school, associate degree, and college and above. The averages of time use and expenditures on goods are then assigned as inputs to the production of an activity.

In the estimation, we take wages and prices of market inputs for each activity from the data and use an estimator that minimizes the distance of time and goods allocations between the data and the model. There are 12 parameters to estimate: $\{\xi_i\}$ (4), $\{\kappa_i\}$ (4), $\{\alpha_i\}$ (3), and ρ (1). Given prices and wages, the estimation targets allocations of time and goods between 2003 and 2018 for each activity by education group. In the cross-section and over time, households face different wages and prices and choose different allocations as a result. The response of time and goods allocations to a change in wages or prices reflects the substitutability between time and market inputs within activities and across activities. Thus, the variation in household allocations by education and over time helps identify the parameters.

4.2 Wages and Prices

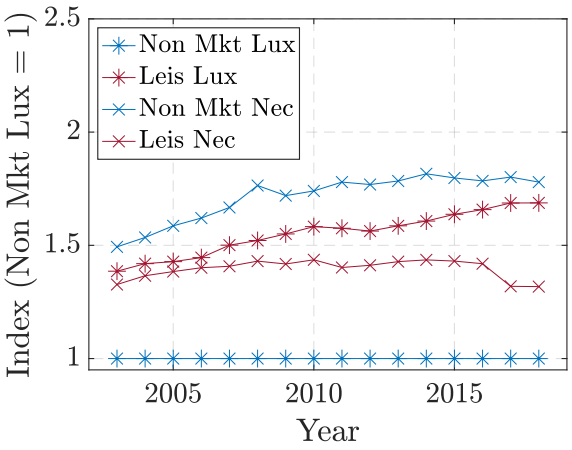
Each activity is produced by combining time and market inputs (goods and services). To obtain the market price for each market input, we turn to the disaggregated price indices of the Consumer Price Index (CPI) provided by the Bureau of Labor Statistics. We follow Casey (2010) to map the disaggregated price indices consistently to the activity-specific expenditures on market inputs constructed in the CEX. To derive an aggregated price index for the four activities in every year between 2003 and 2018, we proceed in three steps. First, we compute expenditure shares at the household level using the most detailed level of expenditures available in the CEX. Second, we use these shares as weights to aggregate the corresponding CPI indices to a weighted price index at the household level for each of the four activities. Finally, we average across all households using CEX sample weights to find the aggregate price index for leisure luxuries and necessities and non-market work activities in a given year.[6]

Figure 2 plots the price indices for each activity both in levels and normalized to one at the beginning of the sample period. We observe a significant increase in prices over the sample period which are most pronounced for non-market work necessities. It is also the activity with the highest price level. Similarly, leisure luxuries experienced a price growth of close to 50% over the 16 years of the sample. Price increases are present, but less pronounced for the non-market work luxury activities. Leisure necessities even show a small decline in prices after 2015. Notably, prices at the end of the sample in 2018 are significantly more dispersed than at the beginning of the sample.

We rely on the CPS Outgoing Rotation Group (CPS-ORG) to construct wages by education group since hourly wages can be measured more precisely in this data set. For hourly workers, hourly wages are directly observed. For salary workers, wages are defined as the ratio between usual weekly earnings and usual weekly hours worked. We restrict the sample to individuals ages 21 to 65 and drop workers with more than one job. We top code hourly wages at USD 100 and drop hourly wages less than USD 5 as they are below the federal minimum wage in 2003. In addition, we remove allocated values. We average the remaining hourly wages by education group and year using the earnings weights provided

[6] In the baseline specification of our model, we assume all households face the same input prices. We explore the effects of heterogeneous prices by education group in Appendix D.1.

(a) Normalized Prices



(b) Price Growth

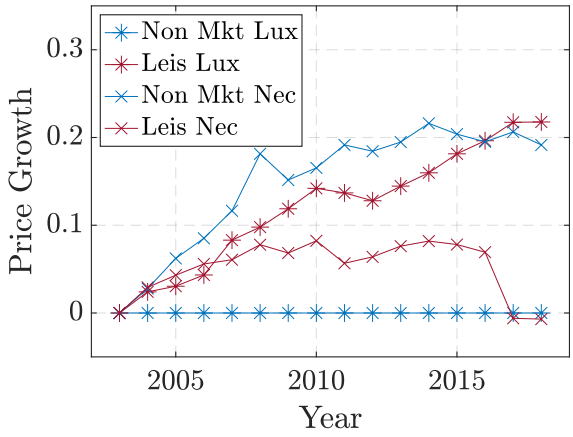


Figure 2: Normalized Activity Prices

Notes: Data comes from the detailed Consumer Price Indices provided by the Bureau of Labor Statistics between 2003 and 2018. 'Non Mkt Lux' is the price index for non-market work luxuries, 'Leis Lux' is is the price index for leisure luxuries, 'Non Mkt Nec' is the price index for non-market work necessities, and 'Leis Nec' is the price index for leisure necessities.

by the CPS-ORG. Finally, as with activity prices, we normalize wages by the price of non-market luxury activities in every year. Figure 3 plots the normalized wages over time and the growth of normalized wages by education group. Note that activity prices and wages have roughly followed the same trend until 2008. After 2008, wage growth has significantly slowed down until 2013, while prices continued to rise. During the last 5 years of the sample, price growth has slowed for all activities, while wage growth has picked up again. We return to this point in section 6.2 when we analyze the impact of wages and prices on income and welfare inequality between 2003 and 2018 through the lens of our model.

4.3 Estimation Results

Table 4 summarizes the estimated parameters with standard errors in parentheses. We obtain standard errors by bootstrapping the individual-level data of the ATUS and CEX. The standard errors are small, implying that the parameters are precisely identified. Formal proof of identification is difficult, as the model is highly nonlinear. Instead, we examine the curvature of the minimized objective function in the neighborhood of the estimated

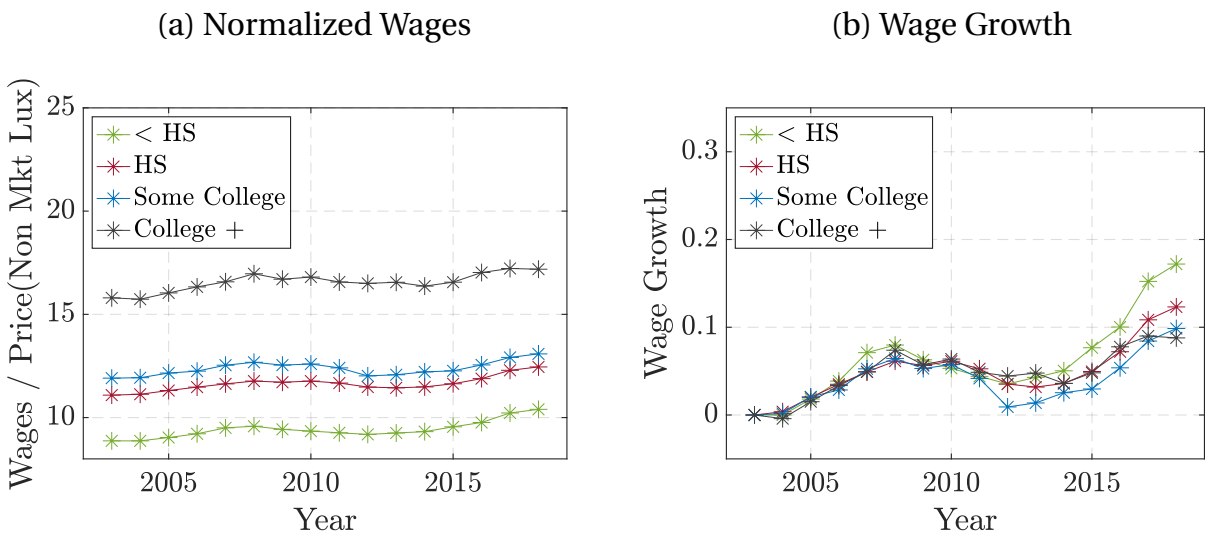


Figure 3: Normalized Wages

Notes: Data comes from the Current Population Survey - Outgoing Rotation Group (CPS-ORG) between 2003 and 2018. Wages are normalized by the price of non-market luxury goods in every year (see Figure 2).

parameter values. Changing one parameter at a time, Figure D.1 in the Appendix shows that the objective function indeed reaches its minimum at the estimated parameter values.

Consistent with Becker (1965)'s notion, our estimation confirms that there are two types of activities that households can engage in: time-intensive activities and expenditure-intensive activities. To see this, note that the estimated shares of market inputs (κ_i) varies across activities and is higher for luxuries than for necessities. For leisure luxuries, the market input share is even close to one. For necessities the share of market inputs is smaller than 0.07, making both activities time-intensive. Becker suggested that the opportunity cost of time is low for households that earn low wages. As a result, he hypothesized that such households will engage in activities that require higher time inputs and lower market inputs. The estimated standard errors for all parameters are small. This implies that the share of market inputs for every activity is significantly different from zero. This provides confidence in Becker's notion that households require a combination of market inputs and time to enjoy consumption of non-market activities.

There is another estimation result suggesting that the activities households engage in

Table 4: Parameter Estimates

	(1) Non Mkt Luxury	(2) Leis Luxury	(3) Non Mkt Necessity	(4) Leis Necessity
Elast. Time & Goods	$\hat{\xi}_{NML}$	$\hat{\xi}_{LL}$	$\hat{\xi}_{NMI}$	$\hat{\xi}_{LI}$
	1.683	0.347	1.112	1.431
	(0.032)	(0.005)	(0.012)	(0.013)
Expenditure Shares	$\hat{\kappa}_{NML}$	$\hat{\kappa}_{LL}$	$\hat{\kappa}_{NMI}$	$\hat{\kappa}_{LI}$
	0.161	0.999	0.068	0.035
	(0.007)	(0.000)	(0.001)	(0.000)
Non-Homotheticity	$\hat{\bar{\ell}}_{NML}$	$\hat{\bar{\ell}}_{LL}$	$\hat{\bar{\ell}}_{NMI}$	$\hat{\bar{\ell}}_{LI}$
	-0.020	-0.207	2.127	1.269
	(0.003)	(0.002)	(0.027)	(0.013)
Utility Weights	$\hat{\alpha}_{NML}$	$\hat{\alpha}_{LL}$	$\hat{\alpha}_{NMI}$	$\hat{\alpha}_{LI}$
	0.110	0.046	0.461	0.384
	(0.002)	(0.002)	(0.001)	(0.002)
Elast. b/w Activities	$\hat{\rho}$			
	2.628			
	(0.028)			

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).

are widely different from each other: the elasticity of substitution between market inputs and time (ξ_i). For most activities, the elasticity is much larger than one which means that households can substitute time for market inputs in the production of activities if the opportunity cost of time changes. An elasticity larger than one also implies that the optimal ratio of time to goods for these activities, as illustrated in equation (3), changes by more than the change in wages and prices. The reallocation is much larger than what a Cobb-Douglas specification would imply, where changes in wages and prices would translate one-to-one into changes in the ratio of time to market inputs. The elasticity of substitu-

tion for leisure luxury, on the other hand, is less than one, implying a small reallocation of time and market inputs as wage and price change. Yet, the high share of market inputs in the activity production, κ_{LL}, is extremely high. Hence, the amount of luxury leisure that can be consumed is highly sensitive to income changes.

Consider a reduction in income as a result of a decline in wages. Becker (1965) suggests that households will replace expenditure-intensive activities, such as luxury leisure, with time-intensive activities to compensate the decline in income. The estimation results confirm this intuition. The elasticity of substitution across activities, ρ, has an estimated value of 2.6 and is therefore even larger than any of the elasticities of substitution between time and market inputs for a given activity. Hence, households can easily re-optimize their activity production in response to wage and prices changes. The high degree of substitutability of activities implies that households can re-optimize their activity production in response to change in wages or prices. Hence, the model implies that income changes may translate into much smaller changes in welfare than implied by models that do not distinguish the production of luxuries and necessities.

The non-homothetic terms ($\bar{\ell}_i$) are negative for luxuries and imply an income elasticity larger than one. Therefore time and market inputs for these activities increase as income rises. For necessities, the non-homothetic term is positive, which suggests an income elasticity smaller than one. Hence, time and market inputs for these activities decline when income goes up. The non-homothetic terms are necessary to match the varying shares of time and market inputs allocated to different activities. For example, the market input share for non-market work necessities is 0.61 for less than high school educated households, while the market input share of non-market luxuries is 0.06. In the absence of non-homothetic $\bar{\ell}_i$-terms, the model has a hard time to match these varying shares in the data.

Finally, the weight of each activity (α_i) in the overall utility of households also varies. The two necessities have weights that are around 0.4, while luxury activities have a much smaller weight. The weights suggest that leisure-related activities constitute an important component of household utility as both leisure activity weights sum to 0.43. Hence, it is not surprising that formalizing Becker's idea beyond home production significantly alters how households reallocate time and market inputs in response to wage and price changes.

4.4 Model Fit and Validation

We check the fit of our model by confronting it with cross-sectional data on expenditures for market inputs and time spent on activities. Table 5 reports average allocations of time and market inputs by education group. The model does a good job of matching the allocation of activity-specific time and expenditure in the cross-section.

Table 5: Model Fit – Time and Goods Allocation

	Time							
	Model				Data			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Education	NML	LL	NMN	LN	NML	LL	NMN	LN
$<$ HS	0.116	0.209	0.115	0.311	0.120	0.207	0.128	0.315
HS	0.118	0.222	0.111	0.274	0.113	0.217	0.103	0.283
Some College	0.119	0.226	0.109	0.262	0.117	0.238	0.098	0.251
College +	0.123	0.254	0.088	0.202	0.125	0.249	0.090	0.199
	Goods							
	Model				Data			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Education	NML	LL	NMN	LN	NML	LL	NMN	LN
$<$ HS	0.067	0.208	0.597	0.128	0.064	0.201	0.610	0.120
HS	0.078	0.249	0.547	0.126	0.070	0.250	0.544	0.130
Some College	0.081	0.261	0.532	0.125	0.084	0.277	0.505	0.127
College +	0.101	0.316	0.463	0.121	0.103	0.308	0.467	0.114

Notes: The top panel reports the share of time use in the model and in the data (average from 2003-2018). The bottom panel reports expenditure shares on market goods by education from the model and the CEX between 2003-2018. 'NML' is non-market luxury, 'LL' is leisure luxury, 'NMN' is non-market necessity, and 'LN' is leisure necessity.

We further validate the estimation results by testing whether the model replicates the activity-specific correlations between wages and time and wages and expenditure that are

presented in Section 2. To generate the correlations implied by the model, we simulate the model using the entire distribution of wages from the CPS-ORG between 2003 and 2018. We then regress the share of time and the share of expenditures allocated to an activity on wages. Table 6 reports the results. The model replicates the correlations between wages and time and wages and expenditure for all luxuries and necessities in the data. Note that the model-implied correlations are slightly stronger than the correlations in the data. This is due to the fact that we estimate a simple static model without heterogeneity in household composition or income uncertainty.

The two non-homothetic model components, ξ_i and $\bar{\ell}_i$, are important for the model to generate the correlations with wages that we see in the data. To illustrate this point, we estimate a model with homothetic preferences. The model is the same as the one presented in 3, except that the non-homothetic terms $\bar{\ell}_i$ are set to zero for all activities and the elasticity of substitution between market inputs and time, ξ, is no longer activity specific. We report the parameter estimates of the model with homothetic preferences in Appendix D.17. he estimation reveals three key differences compared to the model with non-homothetic preferences. First, the implied elasticity between time and goods for leisure activities, $\hat{\xi}_{LL}$ and $\hat{\xi}_{LI}$, is much larger in the model with homothetic preferences. Second, the estimation implies much larger expenditure shares $\hat{\kappa}_{NMI}$ and $\hat{\kappa}_{LI}$ for necessities. Finally, the elasticity between activities ρ is close to one. This implies that activities are far less substitutable in a model with homothetic preferences.

All three findings lead to the fact that the correlations between wages and time and wages and goods no longer match the data. Table 7 reports the correlation between wages and time and wages and expenditure implied by the model with homothetic preferences. The correlations between wages and time are always negative, while the correlations between wages and expenditure are always positive, except for leisure necessities. This implies that the model with homothetic preferences can not generate the correlations between activity inputs and wages that we observe in the data.

Table 6: Correlation With Ln Wages: Data vs. Model

	Time			
	(1)	(2)	(3)	(4)
	Non Mkt Lux	Leisure Lux	Non Mkt Nec	Leisure Nec
Data	0.51***	1.10***	-0.57***	-1.59***
	(0.04)	(0.05)	(0.04)	(0.06)
N	97,525	97,525	97,525	97,525
Model	1.23***	9.70***	-7.95***	-14.21***
	(0.00)	(0.00)	(0.01)	(0.00)
N	1,031,132	1,031,132	1,031,132	1,031,132
	Goods			
	(1)	(2)	(3)	(4)
	Non Mkt Lux	Leisure Lux	Non Mkt Nec	Leisure Nec
Data	1.76***	4.61***	-6.06***	-0.37***
	(0.06)	(0.09)	(0.10)	(0.05)
N	113,139	113,139	113,139	113,139
Model	7.92***	5.87***	-12.60***	-1.19***
	(0.00)	(0.00)	(0.00)	(0.00)
N	1,031,132	1,031,132	1,031,132	1,031,132

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Notes: Data regressions for the correlation between time allocated to an activity and Ln Wages in the top panel are based on data from the ATUS 2003-2018. Data Regressions for the correlation between good expenditures allocated to an activity and Ln Wages in the top panel are based on data from the CES 2003-2018. All data regressions include the control variables Grade, Age, Age^2, Male, Married, Black, Nb. Child and a linear time trend.

Table 7: A Model with Homothetic Preferences

	Time			
	(1)	(2)	(3)	(4)
	Non Mkt Lux	Leisure Lux	Non Mkt Nec	Leisure Nec
Data	0.51***	1.10***	-0.57***	-1.59***
	(0.04)	(0.05)	(0.04)	(0.06)
N	97,525	97,525	97,525	97,525
Model	-0.18***	-0.17***	-0.02***	-0.58***
	(0.00)	(0.00)	(0.00)	(0.00)
N	1,448,697	1,448,697	1,448,697	1,448,697
	Goods			
	(1)	(2)	(3)	(4)
	Non Mkt Lux	Leisure Lux	Non Mkt Nec	Leisure Nec
Data	1.76***	4.61***	-6.06***	-0.37***
	(0.06)	(0.09)	(0.10)	(0.05)
N	113,139	113,139	113,139	113,139
Model	-0.00***	-0.15***	-0.14***	0.30***
	(0.00)	(0.00)	(0.00)	(0.00)
N	1,448,697	1,448,697	1,448,697	1,448,697

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Notes: Data regressions for the correlation between time allocated to an activity and Ln Wages in the top panel are based on data from the ATUS 2003-2018. Data Regressions for the correlation between good expenditures allocated to an activity and Ln Wages in the top panel are based on data from the CES 2003-2018. All data regressions include the control variables Grade, Age, Age^2, Male, Married, Black, Nb. Child and a linear time trend.

5. Model Mechanisms

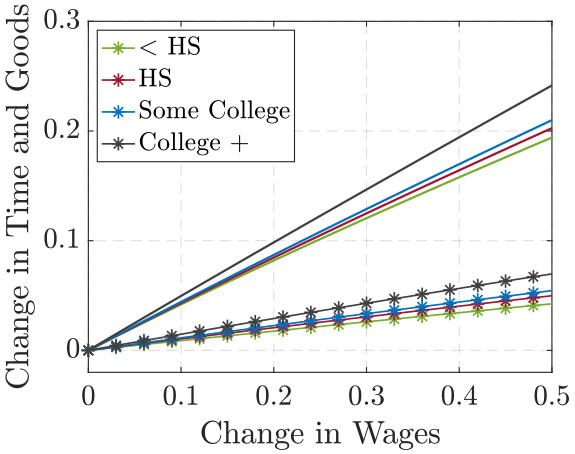
Section 4 has demonstrated that the proposed model is able to generate the correlations of time and expenditure with wages as in the data. To understand the underlying mechanisms, this section explores the effects of changes in wages and prices on the allocations of time and expenditure across activities and hours worked. To do so, we simulate changes in time and expenditure allocations for each education group in response to wage and price changes.

5.1 Response to Wage Changes

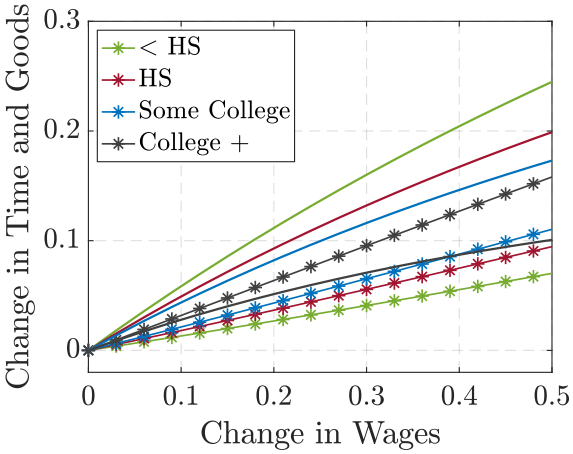
Increasing wages raise the opportunity cost of time, which makes time as an input in the production of activities more expensive. Households thus increase hours worked and reduce time spent on activities. However, time is not reduced equally across activities. Additional market hours are entirely taken out of the production of necessities. The additional income, generated by a combination of higher wages and higher market hours, is shifted towards the production of luxury activities since activities are highly substitutable in the model (ρ is large). The non-homothetic terms $\bar{\ell}_{NML}$ and $\bar{\ell}_{LL}$ imply that the additional income allocated to the production of luxury activities (increasing expenditure shares) is matched by increasing time inputs. As a result, rising wages lead to both higher market hours and more time spent on the production of luxury activities. The income effect and implied shift of resources from necessities to luxuries is more pronounced for higher educated households as they earn higher market wages.

Figure 4 summarizes these results. Although time and expenditure shares co-move in response to wage changes for any given activity, the magnitude of the response differs between both inputs. Time changes are more pronounced for necessities relative to expenditure share changes. The result is driven by the fact that necessities are time intensive and the weight of time inputs, $(1-\kappa_i)$, in the production of necessities is higher than for luxuries. The increase in the opportunity cost of time make it more expensive to produce such time-intensive activities. At the same time, the high degree of substitutability between time and expenditures ($\xi_i > 1$) implies that households can easily free up the expensive

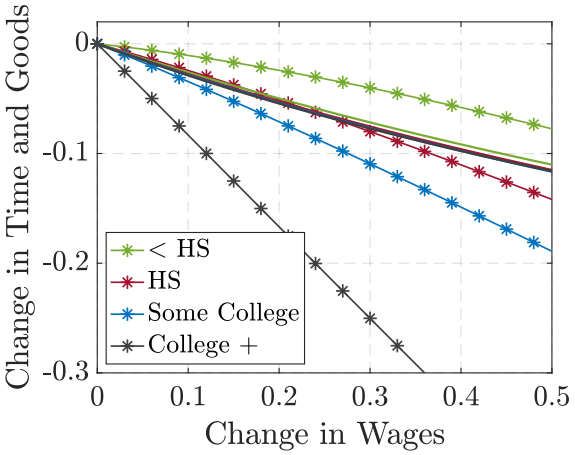
(a) Non-Market Luxuries



(b) Leisure Luxuries



(c) Non-Market Necessities



(d) Leisure Necessities

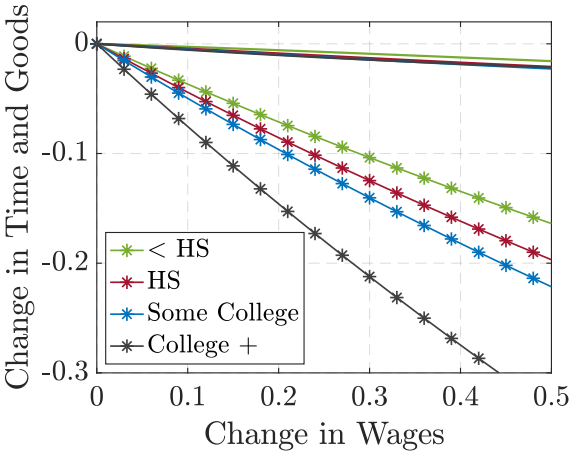


Figure 4: Responses of Time and Expenditure Share to Changes in Wages

Notes: Solid lines indicate the percentage change in share of expenditures for activity-specific goods in response to a percentage change in wages. Crossed lines indicate the percentage change in the fraction of time allocated to an activity in response to a percentage change in wages.

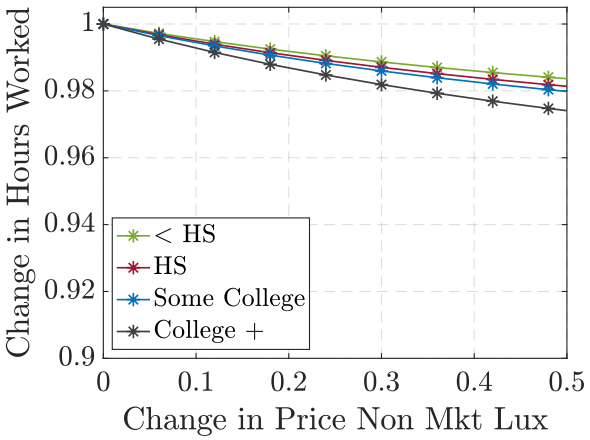
input time and reduce expenditure shares only mildly (see Figure 4.c and 4.d). The additional income due to the combination of rising wages and higher market hours is shifted towards luxury activities. For non-market luxuries, $\xi_i > 1$, which implies that this luxury activity can be produced by investing relatively more income rather than time to increase the production of this activity (see Figure 4.a). In the case of leisure luxuries, the share of expenditures in the production, κ_{LL}, is very high, which means a lot of the additional income is shifted towards luxury leisure. At the same time, the degree of substitutability between time and expenditures, ξ_{LL}, is fairly low. Thus, increasing expenditure shares have to be met with additional time inputs (see Figure 4.b).

5.2 Response to Price Changes

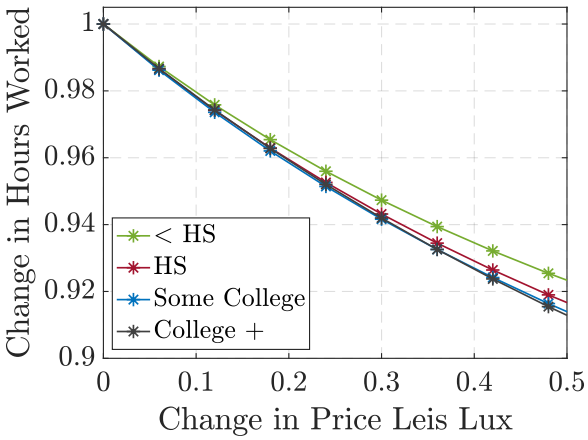
Price increases make time as an input for activity production relatively cheaper. Hence, any activity price increase reduces hours worked (see Figure 5), thereby increasing total time spent on activity production. The reduction in hours worked is larger if an activity is expenditure-intensive (κ_i is high). Since leisure luxuries are the most expenditure-intensive activity in our sample, an increase in the luxury leisure price reduces hours worked more than any other activity price increase. Note that response of hours worked differs by education and activity type. Since highly educated households have more time and expenditures allocated to luxury activities, they reduce hours worked more in response to luxury activity price increases compared to low educated households (see Figure 5.a and 5.b). Necessities are time-intensive and hence an increase in necessity prices reduces hours worked less than luxury activity price increases. From Figure 5.c and 5.d we can see that low educated households react more strongly to necessity price changes. They earn lower wages and hence a larger share of their time and expenditure budgets are allocated to the production of necessities.

How do households reallocate time and expenditures across activities if one activity price changes? The increase of an activity price makes it more costly to purchase market goods and services as inputs to produce an activity. Hence, households reduce time and expenditures allocated to the activity, while shifting more inputs to the production of all other activities. The high elasticity of substitution between activities (ρ) is key for the

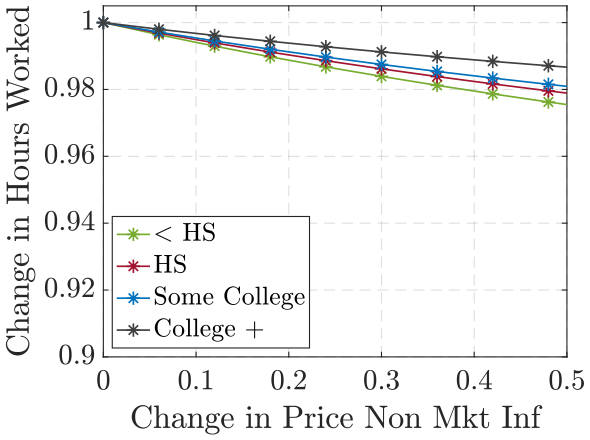
(a) Price for Non-Market Luxuries



(b) Price for Leisure Luxuries



(c) Price for Non-Market Necessities



(d) Price for Leisure Necessities

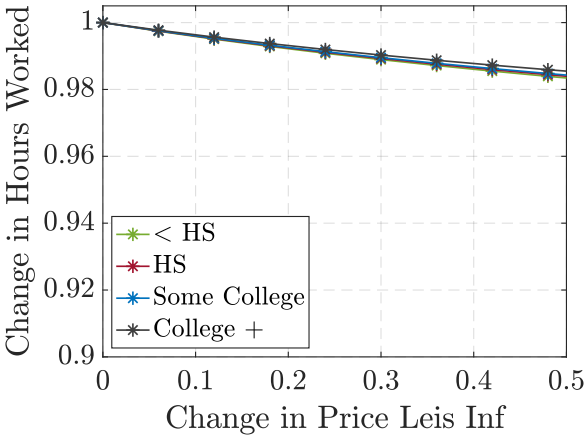


Figure 5: Responses of Hours Worked to Price Changes

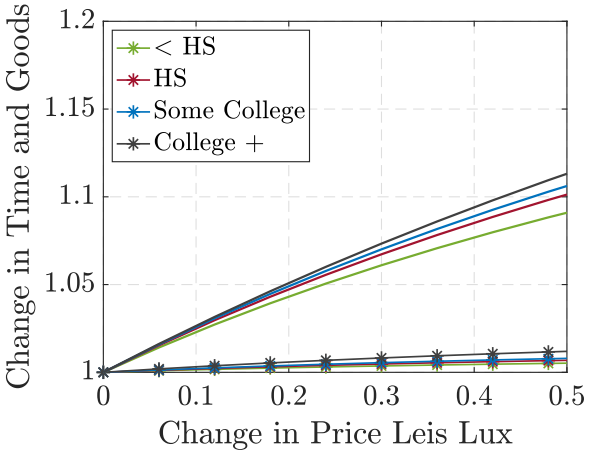
Notes: Solid lines indicate the percentage change in share of expenditures for activity-specific goods in response to a percentage change in wages. Crossed lines indicate the percentage change in the fraction of time allocated to an activity in response to a percentage change in wages.

households to be able to re-optimize their activity production.

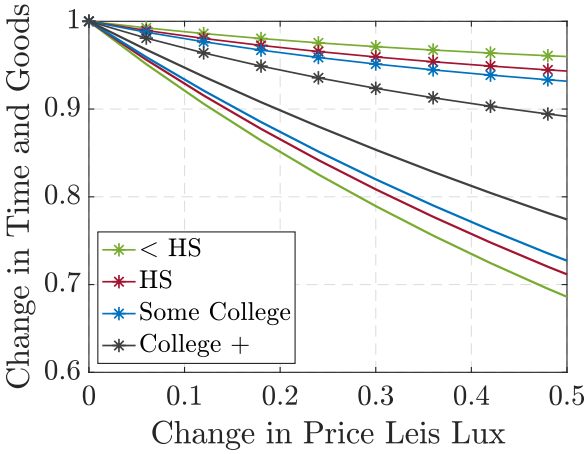
Let us first consider an increase in the price of luxury leisure. Households can no longer afford the same amount of luxury leisure and reduce their luxury leisure production. One example of such a reallocation is the cancellation of tennis lessons in favor of watching more TV or following YouTube exercise videos at home. Since luxury activities are expenditure-intensive, the decline in expenditure shares is more pronounced than the decline in time inputs (see Figure 6.b). Households optimally respond to the tightening of their budget constraint by increasing the production of time-intensive activities that require fewer expenditure inputs. This way, they achieve a higher level of utility than if they kept the shares of luxuries and necessities in the overall activity production constant. The reallocation is most pronounced for highly educated households who are most affected by the luxury leisure price increase. The additional income stemming from the reduction of leisure luxury expenditures is equally distributed across the three other activities. The activity model therefore implies that households are able to buffer the tightening of their budget constraint by shifting to more time- and less expenditure-intensive activities.

The opposite logic holds if households are confronted with a price increase for necessities. These activities are time-intensive. Consider an increase in the price of non-market necessity. Since few expenditures are needed to produce these activities, the decline in expenditures is modest and only a small share of expenditures are now available to be allocated to the production of other activities (see Figure 7.c). This implies that we hardly observe any input being shifted towards expenditure-intensive luxury activities. Instead, the reduction in the production of non-market necessities mainly frees up time that can now be allocated towards leisure necessities, another time-intensive activity. This suggests that households absorb the impact of price changes on their optimal activity bundle very differently in the case of a luxury versus a necessity price increases. Highly educated households earn more and thus are less constrained by the non-market necessity price increase. They can shift a larger fraction of time away from the production of non-market work activities and towards the production of luxury activities, even though the differences across education groups is extremely small.

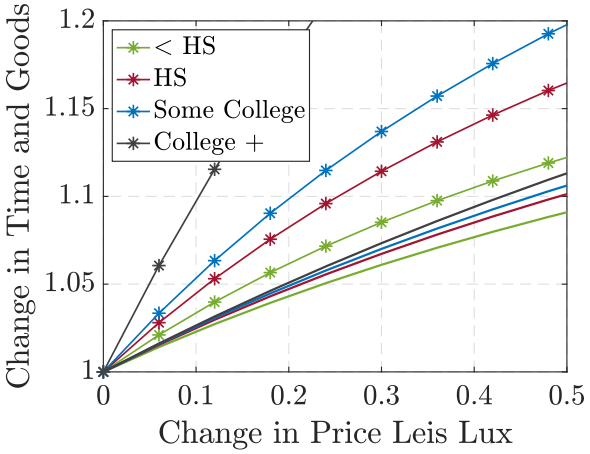
(a) Non-Market Luxuries



(b) Leisure Luxuries (P↑)



(c) Non-Market Necessities



(d) Leisure Necessities

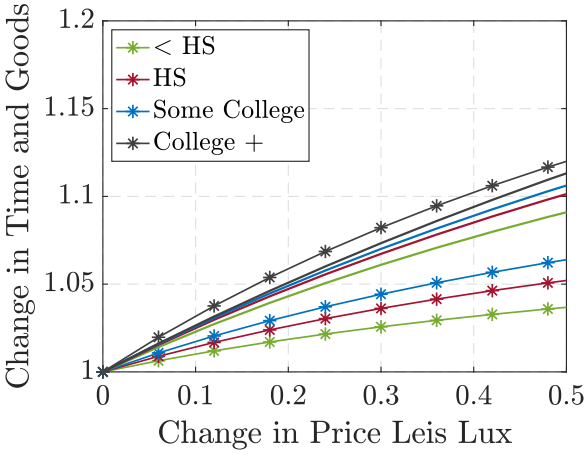
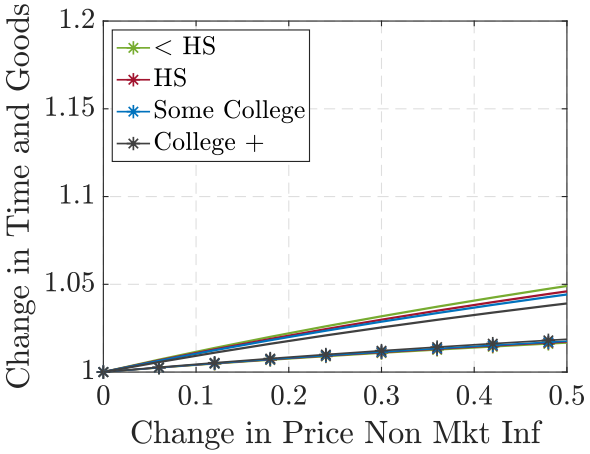


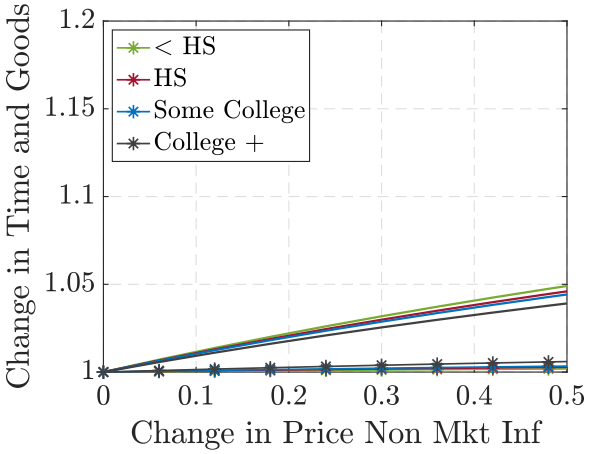
Figure 6: Responses of Time and Expenditure Share to Price Change in Luxury Leisure

Notes: Solid lines indicate the percentage change in share of expenditures for activity-specific goods in response to a percentage change in wages. Crossed lines indicate the percentage change in the fraction of time allocated to an activity in response to a percentage a change in the price of leisure luxuries.

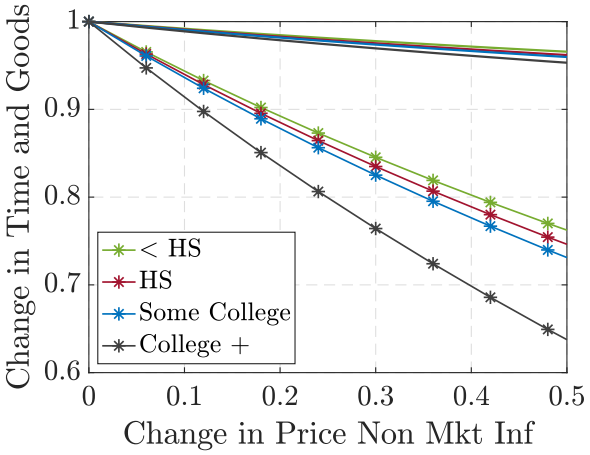
(a) Non-Market Luxuries



(b) Leisure Luxuries



(c) Non-Market Necessities (P↑)



(d) Leisure Necessities

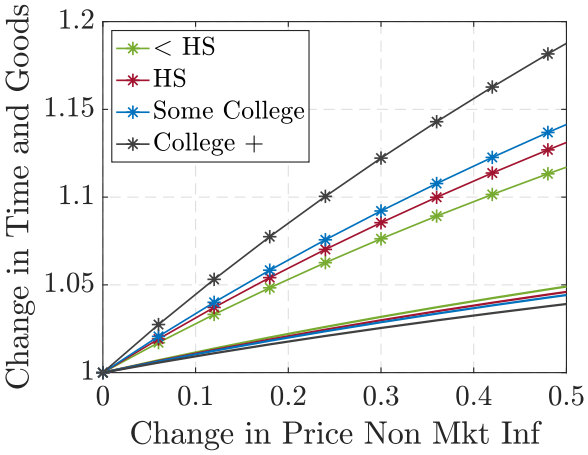


Figure 7: Responses of Time and Expenditure Share to Price Change in Non-Market Necessities

Notes: Solid lines indicate percentage changes in share of expenditures for activity-specific goods in response to a percentage change in wages. Crossed lines indicate percentage changes in the fraction of time allocated to an activity in response to a percentage change in the price of non-market necessities.

6. Welfare Analysis

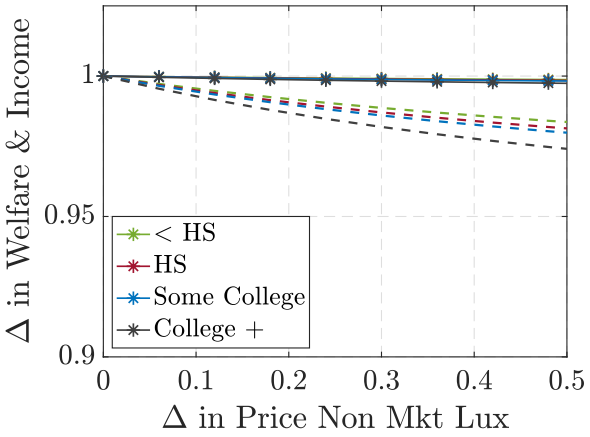
So far, we have explored the effects of wage and input price changes on allocations of time and expenditures. These effects necessarily lead to changes in income and welfare. While rising wages increase income and welfare, we showed in section 5.2 that input price increases lead to a decline in market hours and hence a decline in income. In addition, the effect of wage and price changes on welfare differs across education groups, which generates important implications for income and welfare inequality.

6.1 Implications for Income and Welfare

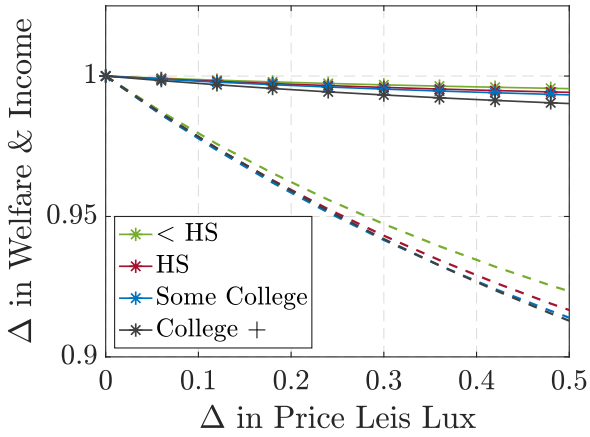
Figure 8 plots the effect of wage and activity price increases on income and welfare. When considering the effect of an activity price increase in Panel (a) to (d), we see that welfare changes in the model with activity production are much smaller than the associated changes in income. This is because households can buffer a decline in income by shifting their time and expenditures towards activities that are less expenditure-intensive. The substitution away from luxuries towards necessities results in a moderate welfare decline that would have been much starker if households were unable to adjust their activity portfolios. Note that activity price increases cause a larger dispersion in income across education groups than in welfare. Thus, the model predicts that rising income inequality is associated with a much smaller increase in welfare inequality. The notable exception are increases in the price of luxury leisure activities. The implied dispersion in welfare is much larger than for other activity price changes and almost as large as the dispersion in income (even though the welfare level declines by much less than income).

Panel (e) of Figure 8 repeats the exercise for an increase in wages. Not surprisingly, income and welfare increase as a result of rising wages. Again, the increase in welfare is much smaller than the associated increase in income. However, the same percentage changes in wages increase welfare relatively more for highly educated households, leading to a larger dispersion of welfare across education groups. In sum, activity price increases cause a decline in welfare that is much smaller than the associated income change and the effects do not vary in the cross-section. The same percent change in wages, on the other

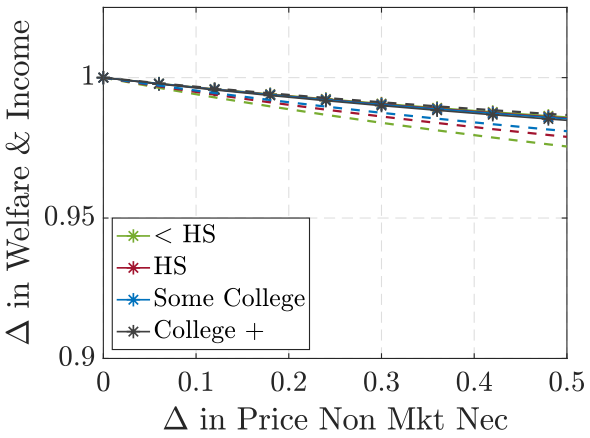
(a) Non-Market Luxury Price ↑



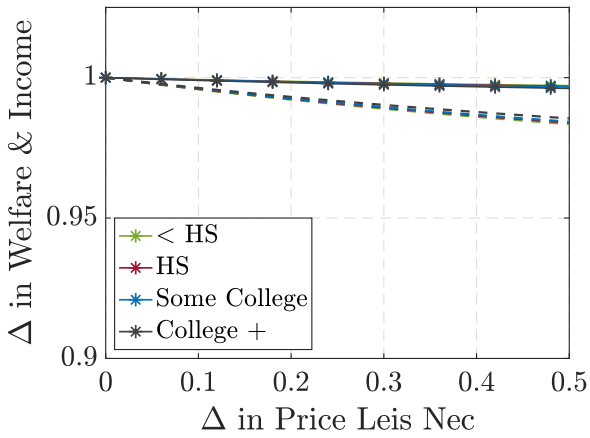
(b) Leisure Luxury Price ↑



(c) Non-Market Necessity Price ↑



(d) Leisure Necessity Price ↑



(e) Wage ↑

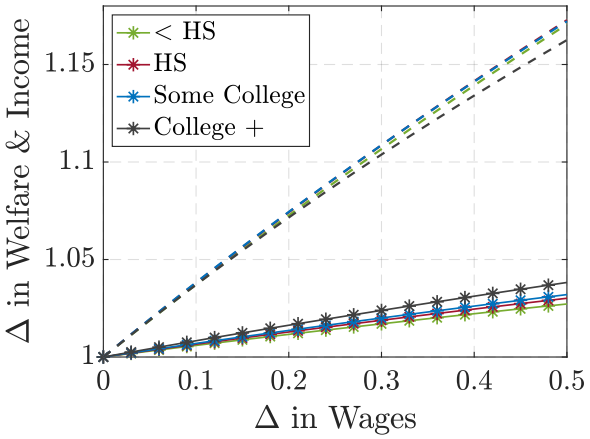


Figure 8: Welfare and Income Changes due to Wage and Price Changes

Notes: Starred lines indicate the changes in welfare in response to a percentage change in activity prices or wages. Solid lines indicate the changes in income in response to a percentage change in activity prices or wages.

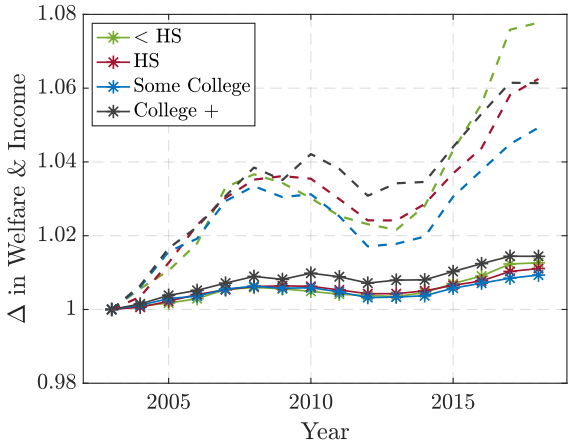
hand, causes significant cross-sectional dispersion in welfare.

6.2 Income and Welfare Inequality over the Sample Period

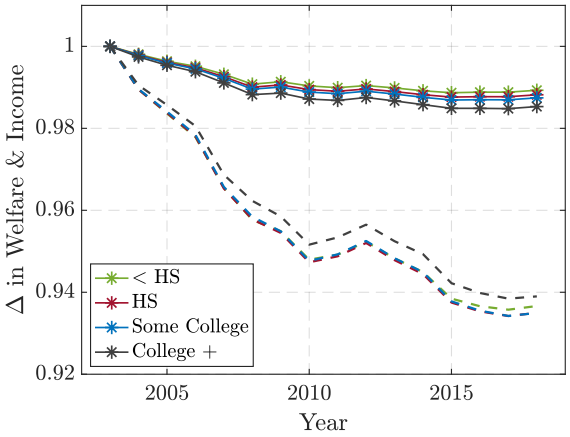
This section explores the evolution of income and welfare inequality in the cross-section over the sample period. We analyze how luxuries and necessities affect welfare in the cross-section. Taking changes in wages and inputs prices between 2003 and 2018 as given, Figure 9 summarizes the changes in total income and welfare for each education group. Panel (a) and (b) show that rising wages and price increases had opposite effects on income as well as welfare for all education groups. Before 2008, rising wages compensated the negative effect of activity price increases and welfare remained roughly constant over these years. After 2008, wage growth declined and remained at low levels until 2013 while activity prices continued to rise. During this period, the negative effect of price increases and declining wages lead to large declines in income and a substantial reduction in household welfare. Moreover, the differential evolution of wages combined with higher price increases for less than college educated groups lead to a relatively larger decline in welfare for these households. After 2013, prices continued to rise for leisure luxuries, but were stable or even somewhat declining for all other activities. In addition, wage growth accelerated and was more pronounced for the lowest education group.

Figure 10 summarizes the implied changes for cross-sectional income and welfare inequality across education groups. Income inequality is defined as the variance of the natural log of income, while welfare inequality is the natural log of welfare as implied by the four activity model. Income and welfare inequality have remained relatively stable until 2008. With the onset of the great recession both income and welfare inequality rose and remained at a higher level than pre-crisis until about 2013. As shown in Figure 9.a, this decline is largely driven by a slowdown in wage growth that is more pronounced for lower educated households. As a result, their income and welfare drops more relative to college educated households. Table 8 shows that the increase in income inequality during this period was almost twice as large as the resulting increase in welfare inequality. After 2013, both income and welfare inequality decline continuously and are at lower levels in 2018 than they were at the beginning of the sample. The decline in inequality is driven by a new

(a) Wage Effects



(b) Price Effects



(c) Total Income and Welfare Changes

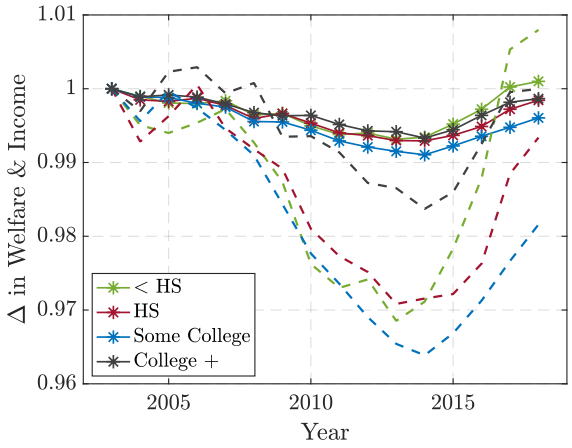


Figure 9: Evolution of Income and Welfare over the Sample Period

Notes: We simulate the model between 2003 and 2018, taking education-specific wages and activity-specific prices between as given. Dashed lines indicate the effect of wages and prices on income. Crossed lines indicate welfare. All series are normalized to one in 2003.

onset in wage growth that is particularly strong for the lowest education group and a slowdown in price growth or all activities but luxury leisure. For leisure necessities, prices have even slightly declined in the last few sample years. Low educated households benefit most from the activity price decline as they consume relatively fewer leisure luxuries. Taken together, these effects imply that welfare for low educated households has increased more during this period and hence welfare inequality declined between 2013 and 2018.

(a) Income Inequality (b) Welfare Inequality

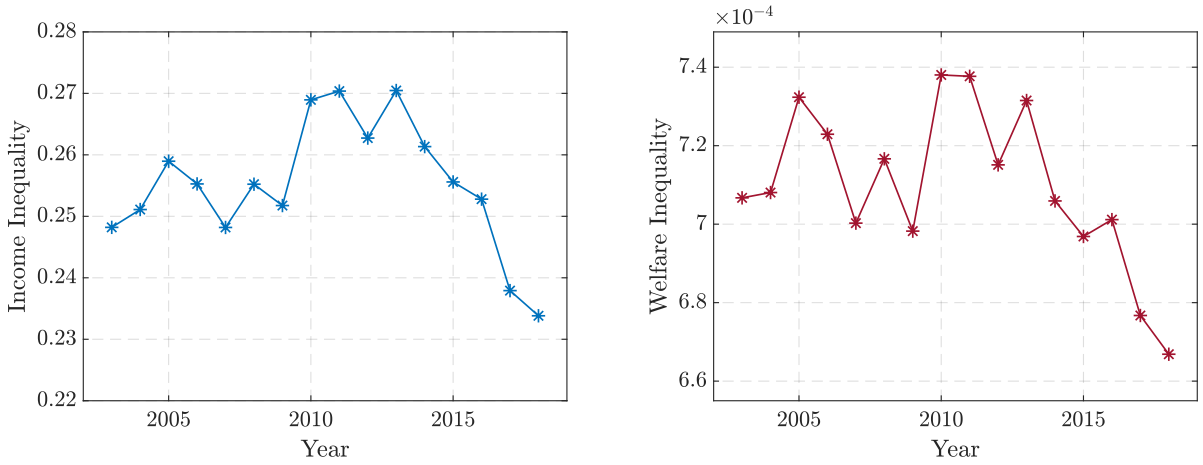


Figure 10: Income and Welfare Inequality between 2003 and 2018

Notes: We plot income and welfare inequality across education groups in a given year. Income inequality is defined as the variance of the natural log of income for each education group. Similarly, welfare inequality is the variance of the natural log of welfare by education group.

Finally, we assess to what impact of luxuries versus necessities on the cross-sectional distribution of welfare. To do so, we reduce the model to a three activity model and shut down the consumption of a particular activity, c_{ij}, one at a time. What matters in this experiment is whether the absence of a certain activity amplifies or decreases welfare inequality relative to the baseline. Figure 11.a plots welfare inequality between 2003 to 2018 if either non-market work or leisure luxuries are absent. The absence of non-market work luxuries, but especially leisure luxuries compresses welfare inequality in the cross-section. Figure 11.b shows that the opposite is true for necessities. The absence of time-intensive necessities dramatically increases welfare inequality. This effect is again strongest for the absence of leisure necessities, like watching TV or playing video games. Low educated households consume a larger share of leisure necessities, while highly educated house-

Table 8: Changes in Income and Welfare Inequality

	Changes in	
Sample Period	Income Inequality	Welfare Inequality
2003 – 2007	-0.01 %	-0.91 %
2007 – 2013	8.24 %	4.27 %
2013 – 2018	-13.55 %	-8.84 %

Notes: The table reports income and welfare inequality measured as the variance of log income and log welfare across education groups given wages and prices in each year.

holds can afford a larger share of leisure luxuries. In the absence of leisure necessities, the welfare differences between low and highly educated households increase, thereby amplifying welfare inequality.

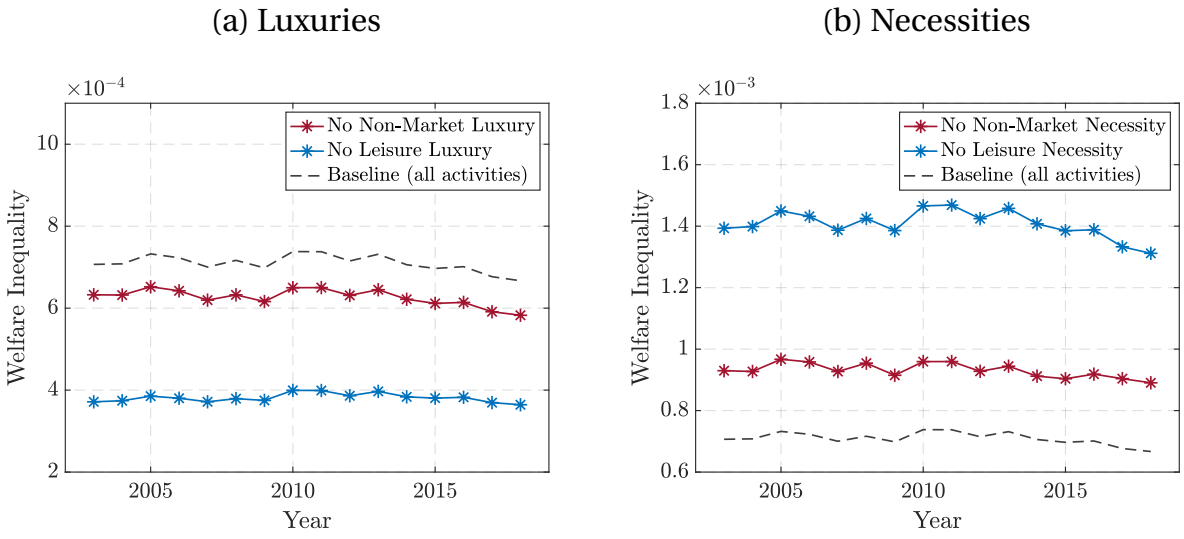


Figure 11: The Impact of Luxuries and Necessities on Welfare Inequality

Notes: We plot welfare inequality in the baseline model and in four counterfactual scenarios. Each time, we reduce the model to a three activity model and shut down the consumption of a particular activity c_{ij}. We re-compute welfare inequality between education groups for each counterfactual in a given year.

7. Conclusion

We develop and estimate a model that conceptualizes the notion of Becker (1965) in which households derive utility from different activities other than market work by combining time and goods to enjoy utility. This is, to our knowledge, the first paper that attempts to quantify the implications of Becker's framework on income and welfare inequality. To estimate the model, we detailed activity-level data on time use and consumption expenditures in an economically meaningful way by estimating the correlation between activity inputs and wages. Based on the results, we find that households engage in two types of activities: necessities and luxuries. Our estimation results suggest that households absorb income declines by switching from expenditure- to time-intensive activities. Key to this result is the high substitutability between activities implied by the model.

We apply the model to assess the impact of changes in wages and activity prices on income and welfare inequality over the sample period 2003–2018. We find that the absence of necessities increase welfare inequality in the cross-section, while the absence of luxuries reduces inequality. These results have wide implications for a wide range of economic issues, including the effect of progressive taxation on consumption and welfare or the cyclical movement of the "labor wedge," which measures empirical deviations in the marginal rate of substitution between consumption and leisure and the wage rate.

While we present the most parsimonious model that formalizes Becker (1965)'s notion to study the impact on consumption and welfare across households, there are many important extensions of our framework that we can think of. First, we did not explicitly model changes in time and market input allocations over the lifecycle. The rich structure of our framework can be useful in analyzing the substantial activity allocation changes that occur before and after retirement. Similarly, one can study allocation differences between households with and without children in the cross-section. The presence of children may require a substantial increase in the amount of non-market work activities that households have to produce. Our framework suggests that households differ considerably in the way how these activities are produced and how wage and price changes affect allocations. We leave all these questions for future research.

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Online Appendix (Not for Publication)

A Data for Estimation

A.1 American Time Use Survey 2003-2018

Following Aguiar et al. (2013), we divide the total time for every individual in the American Time Use Survey (ATUS) into 9 categories. These categories can be aggregated into three main time use categories: "market work", "non-market work", and "leisure". "Non-market work" includes core home production, home ownership activities, obtaining goods and services as well as care for others. "Leisure" summarizes time spent on watching TV, socializing, eating and personal care, and hobbies and entertainment.

Table A.1 summarizes the underlying ATUS activity codes for these categories. ATUS indicates whether a time diary was recorded on a weekday or a weekend (or holiday). To obtain a representative estimate of the weekly hours allocated to one activity, we weight weekday records by $\frac{5}{7}$ and weekend or holiday records by $\frac{2}{7}$.

A.2 Consumer Expenditure Survey 2003-2018

The Consumer Expenditure Survey (CEX) consists of two components with separate questionnaires and independent samples. We use the Interview panel survey in which Consumer Units (CU) are interviewed once every three months over five consecutive quarters. The survey therefore records consumption expenditures for every CU over the period of one year. The data for the Interview panel is released in eight major data files for each wave separately. For this study, we make use of the FMLI and MTBI files.

To select households into our sample, we use the FMLI files which contain CU characteristics, CU income as well as earnings of the reference person and the spouse. Income data are collected on an annual basis during the second and the fifth interviews only. We therefore use information from the fifth interview to approximate labor income as well as the labor force status of the CU. We define a CU to be "in the labor force" if the reference person or the spouse report in their fifth interview that they worked at least one week during the last 12 months. If the information from the fifth interview is missing, we use the information from the second interview.

Table A.1: ATUS 2003-18 Categorization: Activity Codes

Activity	ATUS Activity Code
1. Market Work	05-01, 05-02, 05-99, 18-05-01, 18-05-02, 18-05-99
2. Non-market Work	
2.1 Core Home Production	02-01, 02-02, 02-03 (excl. 02-03-01), 02-07, 02-08, 02-09 (excl. 02-09-03), 02-09-04, 02-99, 18-02-01, 18-02-02, 18-02-03, 18-02-07, 18-02-08, 18-02-09, 18-02-99
2.2 Home Ownership Activities	02-03-01, 02-04, 02-05, 18-02-04, 18-02-05
2.3 Obtaining Goods and Services	07, 08 (excl. 08-04), 09,10, 18-07, 18-08 (excl. 18-08-04), 18-09, 18-10
2.4 Others Care	03-04, 03-05, 03-99, 04-04, 04-05, 04-99, 18-03-04, 18-03-05, 18-03-99, 18-04-04, 18-04-05, 18-04-99
3. Leisure	
3.1 Watching TV	12-03-03, 12-03-04
3.2 Socializing	12-01, 12-02, 12-03-07, 12-05-01, 12-05-02, 16, 18-12-01, 18-12-02, 18-16
3.3 Eating and Personal Care	01-02, 01-04, 01-05, 01-99, 11, 18-01, 18-11
3.4 Hobbies and Entertainment	02-06, 02-09-03, 02-09-04, 12-03 (excl. 12-03-03 and 12-03-04), 12-03-07, 12-04, 12-05 (excl. 12-05-01 and 12-05-02), 12-99, 13, 18-02-06, 18-12 (excl. 18-12-01 and 18-12-02), 18-13

A.3 Combining ATUS and CEX

Sample Selection We limit the sample in both the ATUS and CEX to reference persons between age 21 and 65, excluding students and retirees. We also restrict the sample to households with at least one spouse reported being "in the labor force". In the ATUS, this includes individuals being employed, absent from work, or unemployed either on layoff or looking for a job. This leaves us with 114,936 observations across all survey years in the ATUS.

The CEX only reports the number of weeks the reference person or the spouse have worked within the last 12 months. If either the reference person or the spouse reports to have worked at least one week, we include them in our sample. We impose additional restrictions on household income before calculating expenditure shares. First, we drop all households with zero or negative household income. Next, we drop households with

income in the bottom and top 5% of the sample in every survey year. We lose 17,135 observations due to this restriction. The final CEX sample contains 148,152 observations.

Linking ATUS and CEX To create consistent expenditure shares and time use associated with each activity, we start with the time-use activity categories discussed in section **??** and map the associated consumption expenditure categories to the time use categories as closely as possible. The CEX releases detailed expenditure information in its MTBI files. Consumption and investment expenditures are organized by Universal Classification Codes (UCCs). The files contain approximately 600 different UCCs, with one record for every purchase of the CU in a given month. The Bureau of Labor Statistics (BLS) provides summary level variables that aggregate a certain set of UCCs. These summary variables serve as a guideline for the classification of expenditure categories. For every summary variable, we check the underlying UCCs and, if necessary, refine the categorization. Table A.2 provides a description of the expenditures associated with each category, while table A.3 documents the corresponding UCCs.

In additional to consumption expenditures, the CEX also collects information on the purchases and sales of assets. We classify the purchase and investment of housing and vehicles as separate categories, as they involve investment decisions and cannot be linked to a particular activity. Note that the investment categories only contain outlays related to the acquisition of new assets. Expenditures associated with the maintenance or repair of housing or vehicles, that the CU already owns, are matched with a corresponding time use category.

We exclude investment expenditures in the analysis for two reasons. First, they can not be linked to a specific time-use category. Second, the static model employed in this paper can not be used to analyze the investment decisions. Similarly, we exclude education and medical care time and expenditures from our main analysis as we view them as human capital investments. We exclude time spent on civic and unclassified activities because they can not be linked to any expenditure categories. Expenditures spent on transportation usage cannot be separated into direct transportation costs associated with actual activities. We therefore exclude it from our analysis as well. We refer to the expenditures included in our analysis as “core expenditures.” Over the sample period, our measure

of core expenditures accounts for slightly over one-half of all consumption expenditures reported in the CEX.

The ATUS and the CEX cannot be linked at the household level. We therefore link them either by education or income every year. We partition the observations into four education groups: less than high school, high school, some college, college and above. In both the ATUS and the CEX, the highest level of educational attainment of the reference person determines which education bin the household is assigned to.

To partition data by household income, we first use the continuous information on family income before taxes from the CEX to construct weighted income quartiles in each survey year using survey weights. We drop negative incomes as well as the bottom and top 5% of the income distribution. We find that the 25th percentile is $26,600, the 50th percentile is $50,000, the 75th percentile is $83,900. In the ATUS, combined income of all family members during the last 12 month is only reported in bins and not as a continuous variable. We thus chose the bins that most closely approximate the quartiles derived from the CEX. While we can match the 50th percentile exactly, we have to move the cut off points for the 25th and 75th percentile, so we can define income groups consistently across both data sets. The bin that encompasses the 75th percentile in the CEX ranges from $75,000 to $99,999 in the CEX. Thus, we chose $99,999 in both data sets as the cut off point for the highest income group (group 4). Similarly, we move the cut off for the 25th percentile to $25,000 and define the lowest income group (group 1) as any family with income below this threshold.

Table A.2: 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. Non-market Work	

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; non-permanent carpet squares; blinds; clocks; lamps; decorative items; kitchen utensils; household services; rental of furniture; rental of household and office equipment for non-business 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 non-business use)
2.2 Home Ownership	Maintenance, repairs and other expenses (excl. homeowner's insurance, parking and management fees); floor coverings (excl. non-permanent carpet squares); installed and non-installed wall-to-wall carpeting; building an attic, a pool or finishing the 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 camper, boat or aircraft; reading (excl. encyclopedia); miscellaneous entertainment outlays; pets, toys and playground equipment; musical instruments; photographic equipment; event fees and admission; computers and software for non-business use; tobacco and smoking supplies

Table A.3: CEX 2003-18 UCC codes

Activity	Universal Classification Codes (UCCs)
1. Market Work	320901 360110 360901 380510 380902 690115 800700 900002
2. Non-market Work	
2.1 Core Home Production	230117 230118 250111 250112 250113 250114 250211 250212 250213 250214 250221 250222 250223 250224 250901 250902 250903 250904 250911 250912 250913 250914 260111 260112 260113 260114 260211 260212 260213 260214 270211 270212 270213 270214 270411 270412 270413 270414 270901 270902 270903 270904 280110 280130 280210 280220 280230 280900 290120 290210 290310 290320 290410 290420 290430 290440 300111 300112 300211 300212 300221 300222 300311 300312 300321 300322 300331 300332 300411 300412 320110 320111 320120 320210 320220 320231 320233 320310 320320 320330 320340 320350 320360 320370 320420 320511 320512 320521 320522 320902 320903 320904 340310 340420 340510 340520 340530 340620 340630 340901 340903 340904 340907 340908 340911 340912 340914 340915 420110 420120 440110 440120 440130 440150 440210 440900 690220 690241 690242 690243 690244 690245 790210 790230 990900
2.2 Home Ownership	230112 230113 230114 230115 230121 230122 230123 230131 230132 230133 230134 230141 230142 230150 230151 230152 230901 230902 240111 240112 240113 240121 240122 240123 240211 240212 240213 240214 240221 240222 240223 240311 240312 240313 240321 240322 240323 320161 320162 320163 320410 320611 320612 320613 320621 320622 320623 320631 320632 320633 330511 340410 790690 990920 990930 990940 990950
2.3 Obtaining Goods and Services	360210 360311 360312 360330 360340 360410 360511 360512 360513 370110 370120 370130 370211 370213 370220 370311 370312 370313 370314 370903 380110 380210 380311 380312 380313 380320 380331 380332 380333 380420 380430 380901 390110 390120 390210 390221 390222 390223 390321 390322 390901 400110 400210 400220 400310 410110 410120 410130 410901 440140

2.4 Other Care	340906 340910 570220
3. Leisure	
3.1 Watching TV	270310 310110 310120 310130 310140 310240 310334 340610 340902 690320 690330
3.2 Socializing	190902 270101 270102 270103 270104 270105 320232 430110 430120 680310 680320 680904 690210
3.3 Eating and Personal Care	640130 640420 650110 650210 650310 650900 190903 190904 200900 790310 790320 790330 790410 790420
3.4 Hobbies and Entertainment	210210 270311 310210 310220 310230 310311 310312 310313 310314 310320 310330 310333 310340 310341 310342 310350 320150 340905 360120 360350 360902 370902 370904 380340 380903 390230 390902 430130 520901 520902 520903 520904 520905 520906 520907 590111 590112 590211 590212 590220 590230 590310 590410 600110 600121 600122 600127 600128 600132 600138 600141 600142 600143 600144 600210 600310 600410 600420 600430 600901 600902 610110 610120 610130 610140 610210 610230 610320 610900 620111 620115 620121 620122 620211 620212 620221 620222 620310 620320 620330 620410 620420 620903 620904 620905 620906 620908 620909 620912 620916 620919 620921 620922 620926 620930 630110 630210 680905 690111 690112 690113 690114 690116 690310 690340 690350 690230

Notes: UCCs change across survey waves. In every quarter, UCCs might be discontinued while new ones are potentially added to the survey. In addition, new UCCs may not be represented in all quarters. This table reports the UCCs for all survey waves combined.

B Data Analysis

B.1 Dependent Variables

B.2 Extended Regression Results

B.3 Robustness - Time Use Regressions

B.4 Robustness - Expenditure Regressions

B.5 Time Use by Weekday and Weekends

Table B.4: Time Use Regressions - Summary Statistics

	Non-Market Work Activities			
	(1)	(2)	(3)	(4)
	Core Hm	Hm Own	Obt Gds Svs	Oth Care
Mean	8.29	1.70	4.66	0.96
Std Dev	6.31	3.36	4.23	2.30
p10	2.67	0.28	1.69	0 .23
p25	3.80	0.48	2.11	0.31
p50	6.63	0.77	3.12	0.46
p75	10.78	1.44	5.75	0.71
p90	15.85	3.20	9.49	1.37
Min	0.25	0.00	0.00	0.00
Max	80.30	71.85	71.37	75.88
N	97,525	97,525	97,525	97,525
	Leisure Activities			
	(1)	(2)	(3)	(4)
	Watch TV	Social	Eat & Pcare	Hobby & Ent
Mean	13.81	6.03	12.90	8.13
Std Dev	8.04	5.59	4.28	6.18
p10	5.58	2.29	8.66	2.95
p25	8.27	2.76	10.37	4.16
p50	12.20	3.82	12.28	6.32
p75	17.31	7.17	14.66	10.07
p90	23.57	12.71	17.60	15.47
Min	0.00	0.00	1.85	0.00
Max	79.67	74.98	76.67	79.97
N	97,525	97,525	97,525	97,525

Notes: Summary statistics for the dependent variable used in time use regressions. Time use is expressed as a fraction of total time spent on all activities.

Table B.5: Expenditure Regressions - Summary Statistics

	Non-Market Work Activities			
	(1)	(2)	(3)	(4)
	Core Hm	Hm Own	Obt Gds Svs	Oth Care
Mean	49.33	2.86	4.51	0.04
Std Dev	16.80	8.30	5.14	1.09
p10	27.82	0.00	0.00	0.00
p25	37.32	0.00	0.18	0.00
p50	48.83	0.00	3.13	0.00
p75	60.81	1.76	6.70	0.00
p90	71.70	7.51	11.04	0.00
Min	0.00	0.00	0.00	0.00
Max	99.96	96.06	73.75	85.11
N	176,481	176,481	176,481	176,481
	Leisure Activities			
	(1)	(2)	(3)	(4)
	Watch TV	Social	Eat & Pcare	Hobby & Ent
Mean	3.94	8.05	14.28	13.61
Std Dev	4.38	6.18	10.81	11.55
p10	0.00	1.85	2.12	1.48
p25	0.45	4.00	6.66	4.95
p50	3.15	6.92	12.32	11.02
p75	5.55	10.72	19.59	19.47
p90	8.65	15.26	28.20	28.85
Min	0.00	0.00	0.00	0.00
Max	87.60	92.17	98.37	98.96
N	176,481	176,481	176,481	176,481

Notes: Summary statistics for the dependent variable used in expenditure regressions. Expenditures are expressed as a fraction of total expenditures for all activities.

Table B.6: Time Use Regressions - Non-Market Work

	(1)	(2)	(3)	(4)
	Core Hm	Hm Own	Obt Gds Svs	Oth Care
Ln Wage	-0.56***	0.20***	0.26***	-0.10***
	(0.04)	(0.02)	(0.03)	(0.02)
Grade	-0.12***	-0.06***	0.04***	-0.03***
	(0.01)	(0.00)	(0.01)	(0.00)
Age	0.27***	0.08***	0.02*	-0.02***
	(0.01)	(0.01)	(0.01)	(0.01)
Age^2	-0.00***	-0.00***	-0.00	0.00***
	(0.00)	(0.00)	(0.00)	(0.00)
Male	-5.34***	1.22***	-1.60***	0.04***
	(0.04)	(0.02)	(0.03)	(0.02)
Married	0.26***	0.34***	0.05	0.01
	(0.04)	(0.02)	(0.03)	(0.02)
Black	-0.73***	-0.37***	0.07*	0.03
	(0.05)	(0.03)	(0.04)	(0.02)
Nb. Child	0.67***	0.03**	-0.01	-0.12***
	(0.02)	(0.01)	(0.01)	(0.01)
Year	0.02***	-0.02***	-0.03***	-0.01***
	(0.00)	(0.00)	(0.00)	(0.00)
N	97,525	97,525	97,525	97,525
adj. R^2	0.214	0.068	0.037	0.009

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Notes: Linear probability model. Data comes from the American Time Use Survey between 2003–2018. The dependent variable is a weighted average of hours per weekday and weekend spent on each activity as a fraction of the total time from the following categories: Market work, four non-market work activities: (1) core home production, (2) home ownership activities, (3) obtaining goods and services, (4) other care, and four leisure activities watching TV, socializing, eating & personal care, hobby & entertainment.

Table B.7: Time Use Regressions - Leisure

	(1)	(2)	(3)	(4)
	Watch TV	Social	Eat & Pcare	Hobby & Ent
Ln Wage	-1.13***	-0.30***	0.38***	0.23***
	(0.06)	(0.04)	(0.03)	(0.05)
Grade	-0.57***	0.06***	0.11***	0.34***
	(0.01)	(0.01)	(0.01)	(0.01)
Age	-0.04**	-0.32***	-0.19***	-0.14***
	(0.02)	(0.01)	(0.01)	(0.02)
Age^2	0.00***	0.00***	0.00***	0.00***
	(0.00)	(0.00)	(0.00)	(0.00)
Male	3.41***	-0.30***	-1.42***	1.13***
	(0.07)	(0.06)	(0.04)	(0.06)
Married	-0.56***	-0.22***	0.26***	-0.58***
	(0.07)	(0.05)	(0.04)	(0.05)
Black	1.67***	0.11*	-0.05	-0.70***
	(0.09)	(0.06)	(0.05)	(0.07)
Nb. Child	-1.00***	-0.49***	-0.45***	-0.72***
	(0.03)	(0.02)	(0.02)	(0.02)
Year	0.04***	-0.02***	-0.01*	-0.02***
	(0.01)	(0.00)	(0.00)	(0.01)
N	64074	64074	64074	64074
adj. R^2	0.146	0.034	0.046	0.063

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Notes: Linear regression model. Data comes from the American Time Use Survey between 2003–2018. The dependent variable is a weighted average of hours per weekday and weekend spent on each activity as a fraction of the total time from the following categories: Market Work, four non-market work activities: core home production, home ownership activities, obtaining goods and services, other care, and four leisure activities (1) watching TV, (2) socializing, (3) eating & personal care, (4) hobby & entertainment.

Table B.8: Expenditure Regressions - Non-Market Work

	(1)	(2)	(3)	(4)
	Core Hm	Hm Own	Obt Gds Svs	Oth Care
Ln Wage	-4.12***	0.76***	0.22***	0.00
	(0.07)	(0.03)	(0.02)	(0.00)
Grade	-1.21***	0.24***	0.08***	0.00***
	(0.02)	(0.01)	(0.01)	(0.00)
Age	0.47***	-0.03**	-0.19***	-0.00
	(0.03)	(0.02)	(0.01)	(0.00)
Age^2	-0.00***	0.00***	0.00***	0.00**
	(0.00)	(0.00)	(0.00)	(0.00)
Male	-0.50***	-0.41***	-0.82***	-0.01**
	(0.09)	(0.05)	(0.03)	(0.01)
Married	0.88***	0.44***	0.01	0.03***
	(0.10)	(0.05)	(0.03)	(0.01)
Black	3.29***	-0.61***	0.60***	-0.02*
	(0.14)	(0.07)	(0.05)	(0.01)
Nb. Child	1.90***	-0.14***	0.51***	-0.01*
	(0.04)	(0.02)	(0.01)	(0.00)
Year	-0.07***	-0.03***	-0.05***	-0.00***
	(0.01)	(0.00)	(0.00)	(0.00)
N	130,360	130,360	130,360	130,360
adj. R^2	0.114	0.030	0.038	0.001

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Notes: Linear regression model. Data comes from the Consumer Expenditure Survey between 2003–2018. The dependent variable is the fraction of activity-related to total expenditures from the following categories: Market Work, five Non-Market Work activities: (1) Childcare, (2) Core Home Production, (3) Home Ownership Activities, (4) Obtaining Goods and Services, (5) Other Care, and four Leisure activities Watching TV, Socializing, Eating & Personal Care, Hobby & Entertainment.

Table B.9: Expenditure Regressions - Leisure

	(1)	(2)	(3)	(4)
	Watch TV	Social	Eat & Pcare	Hobby & Ent
Ln Wage	0.17***	-0.20***	1.76***	0.75***
	(0.02)	(0.03)	(0.04)	(0.05)
Grade	-0.09***	-0.16***	0.32***	0.56***
	(0.01)	(0.01)	(0.01)	(0.01)
Age	0.04***	0.13***	-0.37***	0.11***
	(0.01)	(0.01)	(0.02)	(0.02)
Age^2	-0.00**	-0.00***	0.00***	-0.00***
	(0.00)	(0.00)	(0.00)	(0.00)
Male	-0.11***	-0.50***	2.41***	0.47***
	(0.02)	(0.03)	(0.06)	(0.06)
Married	-0.31***	0.47***	-2.36***	0.15**
	(0.03)	(0.04)	(0.06)	(0.07)
Black	0.88***	1.82***	-1.23***	-4.96***
	(0.04)	(0.06)	(0.09)	(0.10)
Nb. Child	-0.33***	-0.47***	-2.07***	-0.75***
	(0.01)	(0.02)	(0.03)	(0.03)
Year	0.01***	0.02***	0.24***	-0.07***
	(0.00)	(0.00)	(0.01)	(0.01)
N	130,360	130,360	130,360	130,360
adj. R^2	0.020	0.019	0.133	0.046

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Notes: Linear regression model. Data comes from the Consumer Expenditure Survey between 2003–2018. The dependent variable is a weighted average of hours per weekday and weekend used on each time use category as a fraction of the total time from the following categories: Market Work, five Non-Market Work activities: Childcare, Core Home Production, Home Ownership Activities, Obtaining Goods and Services, Other Care, and four Leisure activities (1) Watching TV, (2) Socializing, (3) Eating & Personal Care, (4) Hobby & Entertainment.

Table B.10: Time Use Regressions - Non-Market Work

	(1) Core Hm	(2) Hm Own	(3) Obt Gds Svs	(4) Oth Care
		A. Married Couples		
Ln Wage	-0.62***	0.18***	0.13***	-0.11***
	(0.05)	(0.03)	(0.04)	(0.02)
N	55,462	55,462	55,462	55,462
		B. Singles		
Ln Wage	-0.30***	0.19***	0.44***	-0.07***
	(0.06)	(0.03)	(0.04)	(0.02)
N	42,063	42,063	42,063	42,063
		C. Men		
Ln Wage	0.02	0.40***	0.26***	-0.05**
	(0.04)	(0.04)	(0.04)	(0.02)
N	46,712	46,712	46,712	46,712
		D. Women		
Ln Wage	-0.80***	-0.05**	0.25***	-0.14***
	(0.06)	(0.02)	(0.04)	(0.02)
N	50,813	50,813	50,813	50,813
		E. Households with children		
Ln Wage	-0.72***	0.16***	0.14***	-0.11***
	(0.05)	(0.03)	(0.04)	(0.02)
N	51,892	51,892	51,892	51,892
		F. Households without children		
Ln Wage	-0.31***	0.24***	0.39***	-0.08***
	(0.05)	(0.03)	(0.04)	(0.02)
N	45,633	45,633	45,633	45,633

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Notes: Linear regression model. Data comes from the American Time Use Survey between 2003–2018. The dependent variable is a weighted average of hours per weekday and weekend spent on each activity as a fraction of the total time from the following non-market work categories: (1) core home production, (2) home ownership activities, (3) obtaining goods and services, (4) other care. Control variables include age, age^2, number of children, dummies for black, and year. Panel A. and B. also control for gender, while panel C., D., E. and F. additionally control for marital status.

Table B.11: Time Use Regressions - Leisure

	(1) Watch TV	(2) Social	(3) Eat & Pcare	(4) Hobby & Ent
			A. Married Couples	
Ln Wage	-1.20***	-0.29***	0.50***	0.38***
	(0.06)	(0.04)	(0.03)	(0.05)
N	55,462	55,462	55,462	55,462
			B. Singles	
Ln Wage	-1.48***	-0.18***	0.64***	0.43***
	(0.08)	(0.06)	(0.04)	(0.06)
N	42,063	42,063	42,063	42,063
			C. Men	
Ln Wage	-1.48***	-0.13**	0.67***	0.58***
	(0.07)	(0.05)	(0.04)	(0.06)
N	46,712	46,712	46,712	46,712
			D. Women	
Ln Wage	-1.20***	-0.33***	0.42***	0.24***
	(0.06)	(0.05)	(0.04)	(0.05)
N	50,813	50,813	50,813	50,813
			E. Households with children	
Ln Wage	-1.27***	-0.25***	0.50***	0.37***
	(0.06)	(0.05)	(0.04)	(0.05)
N	51,892	51,892	51,892	51,892
			F. Households without children	
Ln Wage	-1.29***	-0.26***	0.61***	0.44***
	(0.08)	(0.05)	(0.04)	(0.06)
N	45,633	45,633	45,633	45,633

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Notes: Linear regression model. Data comes from the American Time Use Survey between 2003–2018. The dependent variable is a weighted average of hours per weekday and weekend spent on each activity as a fraction of the total time from the following leisure categories: (1) watching TV, (2) socializing, (3) eating & personal care, (4) hobby & entertainment. Control variables include age, age^2, number of children, dummies for black, and year. Panel A. and B. also control for gender, while panel C., D., E. and F. additionally control for marital status.

Table B.12: Expenditure Regressions - Non-Market Work

	(1)	(2)	(3)	(4)
	Core Hm	Hm Own	Obt Gds Svs	Oth Care
		A. Married Couples		
Ln Wage	-4.03***	0.73***	0.19***	0.00
	(0.09)	(0.05)	(0.03)	(0.01)
N	80,316	80,316	80,316	80,316
		B. Singles		
Ln Wage	-4.19***	0.79***	0.30***	-0.00
	(0.11)	(0.05)	(0.04)	(0.00)
N	50,044	50,044	50,044	50,044
		C. Men		
Ln Wage	-3.83***	0.70***	0.15***	-0.01
	(0.10)	(0.05)	(0.03)	(0.01)
N	69,182	69,182	69,182	69,182
		D. Women		
Ln Wage	-4.37***	0.82***	0.31***	0.01
	(0.09)	(0.05)	(0.03)	(0.01)
N	61,178	61,178	61,178	61,178
		E. Households with children		
Ln Wage	-4.58***	0.63***	0.00	0.00
	(0.10)	(0.05)	(0.03)	(0.01)
N	57,056	57,056	57,056	57,056
		F. Households without children		
Ln Wage	-3.86***	0.87***	0.36***	-0.00
	(0.09)	(0.05)	(0.03)	(0.01)
N	73,304	73,304	73,304	73,304

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Notes: Linear regression model. Data comes from the American Time Use Survey between 2003–2018. The dependent variable is a weighted average of hours per weekday and weekend spent on each activity as a fraction of the total time from the following non-market work categories: (1) core home production, (2) home ownership activities, (3) obtaining goods and services, (4) other care. Control variables include age, age^2, number of children, dummies for black, and year. Panel A. and B. also control for gender, while panel C., D., E. and F. additionally control for marital status.

Table B.13: Expenditure Regressions - Leisure

	(1)	(2)	(3)	(4)
	Watch TV	Social	Eat & Pcare	Hobby & Ent
			A. Married Couples	
Ln Wage	0.08***	-0.28***	1.57***	0.84***
	(0.02)	(0.03)	(0.05)	(0.06)
N	80,316	80,316	80,316	80,316
			B. Singles	
Ln Wage	0.28***	-0.11***	1.92***	0.58***
	(0.03)	(0.04)	(0.08)	(0.08)
N	50,044	50,044	50,044	50,044
			C. Men	
Ln Wage	0.19***	-0.27***	1.72***	0.76***
	(0.03)	(0.04)	(0.07)	(0.07)
N	69,182	69,182	69,182	69,182
			D. Women	
Ln Wage	0.15***	-0.13***	1.72***	0.71***
	(0.03)	(0.04)	(0.06)	(0.07)
N	61,178	61,178	61,178	61,178
			E. Households with children	
Ln Wage	0.13***	-0.18***	1.67***	0.97***
	(0.03)	(0.04)	(0.05)	(0.07)
N	57,056	57,056	57,056	57,056
			F. Households without children	
Ln Wage	0.22***	-0.18***	1.88***	0.59***
	(0.03)	(0.04)	(0.07)	(0.07)
N	73,304	73,304	73,304	73,304

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Notes: Linear regression model. Data comes from the American Time Use Survey between 2003–2018. The dependent variable is a weighted average of hours per weekday and weekend spent on each activity as a fraction of the total time from the following leisure categories: (1) watching TV, (2) socializing, (3) eating & personal care, (4) hobby & entertainment. Control variables include age, age^2, number of children, dummies for black, and year. Panel A. and B. also control for gender, while panel C., D., E. and F. additionally control for marital status.

Table B.14: Time Use Regressions By Weekdays - Non-market Work

	Core Hm		Hm Own		Obt Gds Svs		Oth Care	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Ln Wage	-1.14^{***}	0.45^{***}	0.03	0.58^{***}	0.02	1.05^{***}	-0.14^{***}	-0.01
	(0.09)	(0.12)	(0.05)	(0.08)	(0.07)	(0.09)	(0.04)	(0.05)
Grade	-0.15^{***}	-0.04^{*}	-0.06^{***}	-0.05^{***}	0.03^{**}	0.05^{**}	-0.03^{***}	-0.02
	(0.02)	(0.03)	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)
Age	0.18^{***}	0.55^{***}	0.02	0.19^{***}	-0.01	0.07^{**}	-0.03^{**}	-0.01
	(0.03)	(0.04)	(0.02)	(0.03)	(0.02)	(0.03)	(0.01)	(0.02)
Age^2	-0.00^{***}	-0.01^{***}	0.00	-0.00^{***}	0.00	-0.00^{**}	0.00^{***}	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Male	-4.78^{***}	-6.79^{***}	0.81^{***}	2.06^{***}	-1.42^{***}	-2.01^{***}	-0.05	0.23^{***}
	(0.09)	(0.12)	(0.05)	(0.08)	(0.07)	(0.09)	(0.04)	(0.05)
Married	0.71^{***}	0.10	0.43^{***}	0.91^{***}	-0.02	0.52^{***}	0.09^{**}	0.01
	(0.10)	(0.13)	(0.05)	(0.09)	(0.07)	(0.10)	(0.04)	(0.06)
Black	-1.16^{***}	-2.38^{***}	-0.48^{***}	-1.54^{***}	0.28^{***}	-0.33^{**}	0.03	-0.06
	(0.13)	(0.18)	(0.07)	(0.12)	(0.10)	(0.14)	(0.05)	(0.08)
Nb. Child	0.67^{***}	0.88^{***}	-0.03	0.01	0.04	-0.12^{**}	-0.10^{***}	-0.22^{***}
	(0.04)	(0.06)	(0.02)	(0.04)	(0.03)	(0.05)	(0.02)	(0.03)
Year	0.02^{**}	0.01	-0.03^{***}	-0.08^{***}	-0.05^{***}	-0.09^{***}	-0.02^{***}	-0.02^{***}
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)
N	48,386	49,133	48,387	49,134	48,387	49,134	48,386	49,134

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Notes: Linear regression model. Data comes from the American Time Use Survey between 2003–2018. The dependent variable is hours per weekday or weekend spent on four non-market work activities: core home production, home ownership activities, obtaining goods and services, other care. (1) includes time diaries for weekdays only, while (2) contains all time diaries recorded on weekends.

Table B.15: Time Use Regressions By Weekdays - Leisure

	Watch TV		Social		Eat Pcare		Hobby	
	(1)	(2)	(1)	(2)	(1)	(2)		
Ln Wage	-1.42^{***}	-1.01^{***}	-0.43^{***}	0.29^{**}	0.39^{***}	1.00^{***}	-0.04	1.64^{***}
	(0.12)	(0.16)	(0.08)	(0.13)	(0.07)	(0.08)	(0.09)	(0.13)
Grade	-0.55^{***}	-0.70^{***}	0.05^{***}	0.06^{**}	0.11^{***}	0.22^{***}	0.26^{***}	0.44^{***}
	(0.03)	(0.04)	(0.02)	(0.03)	(0.01)	(0.02)	(0.02)	(0.03)
Age	-0.09^{**}	0.15^{***}	-0.29^{***}	-0.50^{***}	-0.20^{***}	-0.21^{***}	-0.13^{***}	-0.17^{***}
	(0.04)	(0.06)	(0.03)	(0.05)	(0.02)	(0.03)	(0.03)	(0.05)
Age^2	0.00^{***}	-0.00	0.00^{***}	0.00^{***}	0.00^{***}	0.00^{***}	0.00^{***}	0.00^{***}
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Male	2.01^{***}	5.10^{***}	-0.36^{***}	-0.85^{***}	-1.08^{***}	-1.62^{***}	0.69^{***}	1.17^{***}
	(0.12)	(0.16)	(0.09)	(0.14)	(0.07)	(0.08)	(0.10)	(0.13)
Married	-0.68^{***}	-1.37^{***}	-0.61^{***}	0.14	0.27^{***}	0.98^{***}	-0.91^{***}	-0.98^{***}
	(0.13)	(0.17)	(0.09)	(0.15)	(0.07)	(0.09)	(0.10)	(0.15)
Black	2.56^{***}	3.29^{***}	0.34^{***}	-0.00	-0.29^{***}	-0.70^{***}	-0.77^{***}	-2.43^{***}
	(0.18)	(0.24)	(0.13)	(0.20)	(0.10)	(0.13)	(0.14)	(0.20)
Nb. Child	-1.01^{***}	-1.37^{***}	-0.25^{***}	-0.58^{***}	-0.51^{***}	-0.35^{***}	-0.61^{***}	-0.83^{***}
	(0.06)	(0.08)	(0.04)	(0.07)	(0.03)	(0.04)	(0.05)	(0.07)
Year	0.05^{***}	0.11^{***}	-0.01	-0.06^{***}	-0.03^{***}	-0.02^{***}	-0.05^{***}	-0.08^{***}
	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
N	48,383	49,103	48386	49,133	48,385	49129	48,382	49,122

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Notes: Linear regression model. Data comes from the American Time Use Survey between 2003–2018. The dependent variable is hours per weekday or weekend spent on each activity as a fraction of the total time spent on four leisure activities: watching TV, socializing, eating & personal care, hobby & entertainment. (1) includes time diaries for weekdays only, while (2) contains all time diaries recorded on weekends.

C Model Solution

Let i be the index for an activity and j be the index for education. The utility function for education j is then given by:

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

The budget constraint is:

$$\sum_i p_{ij} x_{ij} = w_j (1 - \sum_i \ell_{ij}). \tag{6}$$

Each education group maximizes utility subject to the budget constraint. Let λ_j be the Lagrangian Multiplier. The F.O.Cs are as follows:

$$\frac{\partial U}{\partial c_{ij}} \frac{\partial c_{ij}}{\partial x_{ij}} = \lambda_j p_{ij} \tag{7}$$

$$\frac{\partial U}{\partial c_{ij}} \frac{\partial c_{ij}}{\partial \ell_{ij}} = \lambda_j w_j \tag{8}$$

Taking the ratio between these two equations gives:

$$\frac{\ell_{ij} + \bar{\ell}_i}{x_{ij}} = \left(\frac{p_{ij}}{w_j} \right)^{\xi_i} \left(\frac{1-\kappa_i}{\kappa_i} \right)^{\xi_i}. \tag{9}$$

Simple manipulations of the definition of c_{ij} gives:

$$c_{ij} = x_{ij} \kappa_i^{\frac{\xi_i}{\xi_i-1}} \left[1 + \frac{1-\kappa_i}{\kappa_i} \left(\frac{\ell_{ij}+\bar{\ell}_i}{x_{ij}} \right)^{\frac{\xi_i-1}{\xi_i}} \right]^{\frac{\xi_i}{\xi_i-1}}. \tag{10}$$

Plugging equation (9) into the above equation gives:

$$c_{ij} = x_{ij} \kappa_i^{\frac{\xi_i}{\xi_i-1}} \left[1 + \left(\frac{1-\kappa_i}{\kappa_i} \right)^{\xi_i} \left(\frac{p_{ij}}{w_j} \right)^{\xi_i - 1} \right]^{\frac{\xi_i}{\xi_i-1}} \tag{11}$$

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

From equation (7), we can derive the following equation between activity i and activity

1:

$$\frac{\frac{\partial U}{\partial c_{1j}}\frac{\partial c_{1j}}{\partial x_{1j}}}{\frac{\partial U}{\partial c_{ij}}\frac{\partial c_{ij}}{\partial x_{ij}}} = \frac{p_{1j}}{p_{ij}}. \tag{12}$$

Plugging in the partial derivatives gives:

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

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

$$x_{ij} = \left(\frac{p_{1j}}{p_{ij}}\right)^{\rho}\left(\frac{\alpha_i\kappa_i}{\alpha_1\kappa_1}\right)^{\rho}\frac{M_{ij}^{\frac{\rho}{\xi_i}}}{M_{1j}^{\frac{\rho}{\xi_1}}}\left(\frac{M_{1j}}{M_{ij}}x_{1j}\right) \tag{14}$$

Equation (14) can be simplified as:

$$\frac{x_{ij}}{x_{1j}} = \left(\frac{p_{1j}}{p_{ij}}\right)^{\rho}\left(\frac{\alpha_i\kappa_i}{\alpha_1\kappa_1}\right)^{\rho}\frac{M_{ij}^{\frac{\rho-\xi_i}{\xi_i}}}{M_{1j}^{\frac{\rho-\xi_1}{\xi_1}}}. \tag{15}$$

Define $N_{i1j} = \left(\frac{p_{1j}}{p_{ij}}\right)^{\rho}\left(\frac{\alpha_i\kappa_i}{\alpha_1\kappa_1}\right)^{\rho}\frac{M_{ij}^{\frac{\rho-\xi_i}{\xi_i}}}{M_{1j}^{\frac{\rho-\xi_1}{\xi_1}}}$. Then, $x_{ij} = N_{i1j}x_{1j}$. This and equations (9) give ℓ_{ij} as a function of x_{1j}:

$$\ell_{ij} + \bar{\ell}_i = \left(\frac{p_{ij}}{w_j}\right)^{\xi_i}\left(\frac{1-\kappa_i}{\kappa_i}\right)^{\xi_i}N_{i1j}x_{1j}. \tag{16}$$

The budget constraint can be rewritten as follows:

$$x_{1j}\sum_i p_{ij}\frac{x_{ij}}{x_{1j}} = w_j\left(1 - \sum_i(\ell_{ij} + \bar{\ell}_i)\right) + w_j\sum_i\bar{\ell}_i. \tag{17}$$

$$x_{1j}\sum_i p_{ij}N_{i1j} = w_j\left[1 - \sum_i\left(\frac{p_{ij}}{w_j}\right)^{\xi_i}\left(\frac{1-\kappa_i}{\kappa_i}\right)^{\xi_i}N_{i1j}x_{1j}\right] + w_j\sum_i\bar{\ell}_i. \tag{18}$$

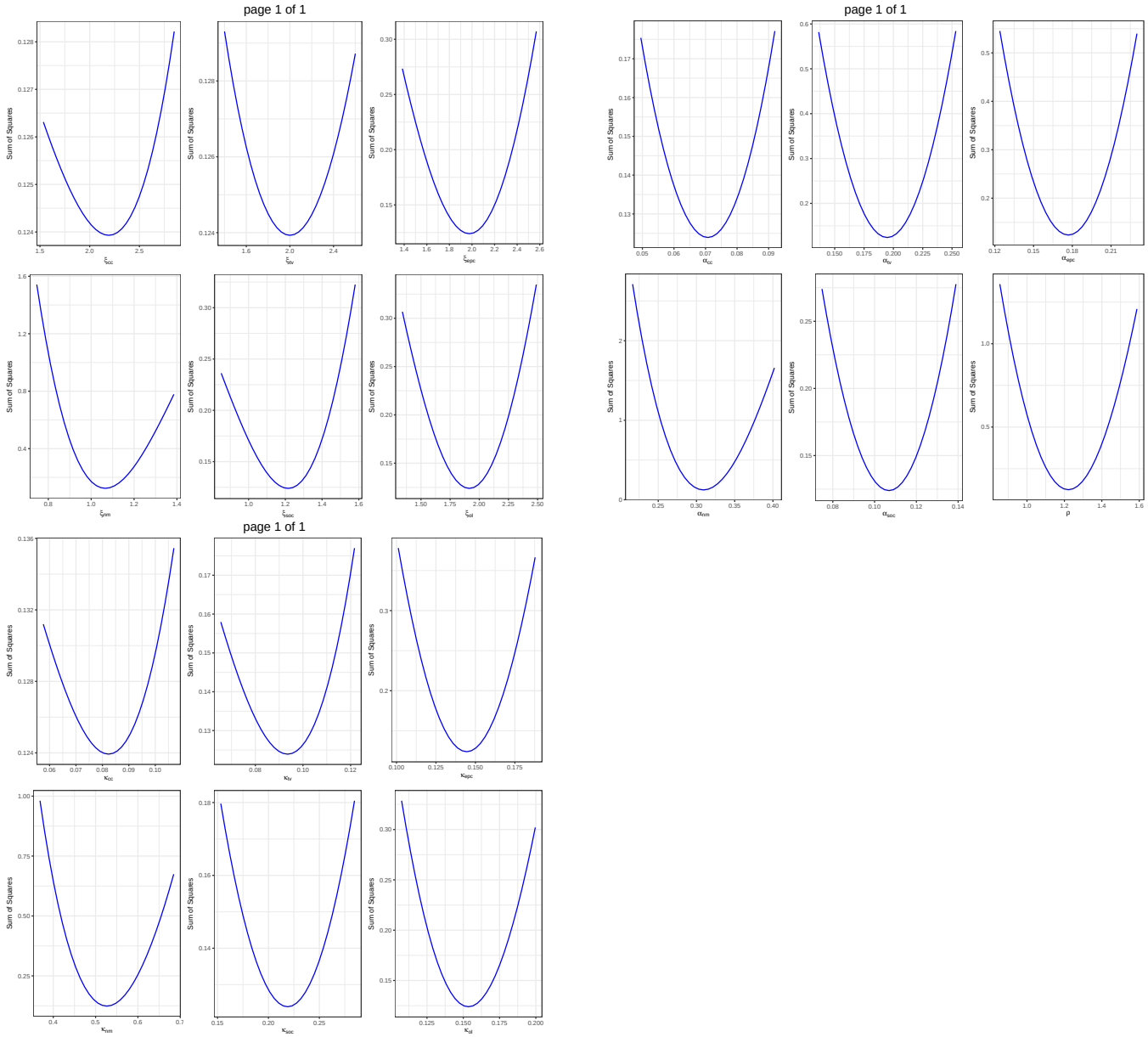
Solve x_{1j} from the above equation gives:

$$x_{1j} = \frac{w_j + w_j\sum_i\bar{\ell}_i}{\sum_i p_{ij}N_{i1j} + w_j\sum_i\left(\frac{p_{ij}}{w_j}\right)^{\xi_i}\left(\frac{1-\kappa_i}{\kappa_i}\right)^{\xi_i}N_{i1j}} \tag{19}$$

x_{ij} can then be solved from equation (15) and ℓ_{ij} can be solved from equation (9).

D Estimation

Figure D.1: Identification of Parameters



Notes: Each sub-plot depicts the value of the objective function when a given parameter value changes in a neighborhood of its estimated value.

D.1 Robustness: Estimation with Education-Specific Prices

Table D.16: Parameter Estimates with Education-specific Prices

	(1) Non Mkt Luxury	(2) Leis Luxury	(3) Non Mkt Necessity	(4) Leis Necessity
Elast. Time & Goods	$\hat{\xi}_{NML}$	$\hat{\xi}_{LL}$	$\hat{\xi}_{NMI}$	$\hat{\xi}_{LI}$
	1.656	0.512	1.057	1.357
	(0.026)	(0.034)	(0.023)	(0.021)
Expenditure Shares	$\hat{\kappa}_{NML}$	$\hat{\kappa}_{LL}$	$\hat{\kappa}_{NMI}$	$\hat{\kappa}_{LI}$
	0.086	0.971	0.054	0.032
	(0.003)	(0.010)	(0.001)	(0.001)
Non-Homotheticity	$\hat{\bar{\ell}}_{NML}$	$\hat{\bar{\ell}}_{LL}$	$\hat{\bar{\ell}}_{NMI}$	$\hat{\bar{\ell}}_{LI}$
	0.091	-0.189	2.667	1.462
	(0.009)	(0.003)	(0.059)	(0.051)
Utility Weights	$\hat{\alpha}_{NML}$	$\hat{\alpha}_{LL}$	$\hat{\alpha}_{NMI}$	$\hat{\alpha}_{LI}$
	0.161	0.043	0.435	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). Prices are education-specific.

D.2 Robustness: Estimation with Homothetic Preferences

Table D.17: Parameter Estimates of a Model with Homothetic Preferences

	(1) Non Mkt Luxury	(2) Leis Luxury	(3) Non Mkt Necessity	(4) Leis Necessity
Elast. Time & Goods	$\hat{\xi}$			
	2.205			
	(0.056)			
Expenditure Shares	$\hat{\kappa}_{NML}$	$\hat{\kappa}_{LL}$	$\hat{\kappa}_{NMI}$	$\hat{\kappa}_{LI}$
	0.097	0.147	0.271	0.100
	(0.001)	(0.002)	(0.006)	(0.001)
Utility Weights	$\hat{\alpha}_{NML}$	$\hat{\alpha}_{LL}$	$\hat{\alpha}_{NMI}$	$\hat{\alpha}_{LI}$
	0.026	0.339	0.357	0.277
	(0.020)	(0.006)	(0.051)	(0.030)
Elast. b/w Activities	$\hat{\rho}$			
	0.277			
	(0.101)			

Notes: The table reports the means of the bootstrapped distributions for the preference parameters of a model with homothetic preferences. It corresponds to the model described in Section 3, except that the non-homothetic term $\bar{\ell}_i$ is set to zero for all activities and the elasticity between time and goods ρ is no longer activity-specific. Bootstrapped standard errors are in parentheses.