Back to Becker: Producing Consumption with Time and Goods

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Abstract

Households combine market goods and their time to produce different types of consumption activities, from which they derive utility. This paper documents that households with more education allocate more time and a higher share of expenditure to expenditure-intensive leisure activities, such as entertainment; while households with less education allocate more time on time-intensive leisure activities, such as watching TV. Employing the difference in the allocation of time and expenditures, this paper estimates a utility function with different substitutability between time and expenditure across consumption activities. Compared with a standard utility function in which time generates utility only through the form of leisure, the proposed utility function exhibits a larger response in labor supply and a smaller response in welfare inequality to wage and price changes.

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1 Introduction

A majority of economic models, certainly most dynamic equilibrium models, view households' utility as being defined over an aggregate of consumption and an aggregate of non-working time (leisure). The alternative view, elaborated in Becker (1965) and called Beckerian utility henceforward, defines utility over different combinations of consumption and time use. Becker (1965) emphasizes that as there are many types of consumption goods, there are many types of time use, and that households combine different types of time use and goods to produce consumption activities, such as meals, child care, and entertainment, from which they derive utility. The closest application to this view is the utility adopted by the literature on home production, in which households combine market goods and time to produce home goods. However, all activities enjoyed by households, require an input of time and an input of market goods or services. For example, enjoying a theater play or watching TV requires combining a certain amount of time and a certain amount of market goods.

A key way in which Beckerian utility differs from standard utility is the presence of additional substitution margins. With a standard utility function, households can only substitute consumption with aggregate leisure time. With a Beckerian utility function, goods and time use are divided according to their use in the production of consumption activities. Depending on the importance of a consumption activity in households' utility and households' willingness and incentives to substitute between goods and time use for each activity and across activities, the Beckerian utility can have very different implications from the standard utility for macroeconomic variables. For example, using an estimated Beckerian utility function, this paper shows that the Beckerian utility leads to larger response of labor supply to changes in wages and smaller response in welfare inequality between 2003 – 2014.

Despite the appeal of the Beckerian approach, the literature adopted the Beckerian utility is quite limited. The challenge is the shortage of data on expenditure and time use for the same set of consumption activities. This paper, to our knowledge, is the first attempt to construct such data and estimate a form of the Beckerian utility. Using the estimated utility, we demonstrate the importance of Beckerian approach in studying welfare inequality and labor supply.

We combine data from the American Time Use Survey (ATUS) and from the Consumer Expenditure Survey (CEX) to construct a pseudo-panel of households grouped according to education, income, and age, that spans for 11 years. For each household-type, we obtain data of expenditures and time uses for a common set of consumption activities. Our point of departure is the set of time-use activities

proposed by Aguiar, Hurst, and Karabarbounis (2013), who classify time allocation to market work, non-market work, and leisure (and sub-categories therein). We take those categories as given and map each expenditure group in the CEX to one of the time-use categories. By doing so, we create consistent categories of activities which have associated with a level of time use and an expenditure amount.

The constructed data allow us to examine the cross-sectional variations in the allocation of time and expenditures by activity across demographic groups. We view this as another contribution of the paper.[1] We find that although households with less education enjoy more leisure time, their expenditure shares of leisure activities are rather smaller. Among those households, leisure time is concentrated in time-intensive leisure activities, such as sleeping and watching TV. Households with more education devote more time and a higher share of expenditure to expenditure-intensive leisure activities, such as concert and vacation.

The data patterns contain information about preference parameters, and thus can help us identify the Beckerian utility. The intuition is as follows. The allocation of time and expenditures across education groups is closely related to wage rates and relative prices of the market goods used in producing different activities. The size of the elasticities of substitution between goods and time use for each activity and across activities determines how much of the differences in wages and prices are translated into the differences in the allocation of time and expenditures in the cross section and over time. Exploiting the rich heterogeneity in the allocation of time and expenditures, we estimate CES forms of Beckerian and standard utility.

Using the estimated utility functions, we first study the response of labor supply to wage changes and find that the Beckerian utility gives rise to larger response of market hours. We then study the change in welfare inequality between 2003 – 2014 from the two utility. The literature on inequality mostly focused on income and consumption inequality.[2] However, as pointed out by Attanasio and Pistaferri (2016), leisure is a nonnegligible component in the welfare calculation. Following this insight, this paper uses a measure of welfare incorporating both consumption and leisure.

We find that the Beckerian utility leads to a much smaller decrease in the welfare inequality than the standard utility over this period of time. The reason is twofold. First, Beckerian utility provides households with more margins to substitute between goods and time. Consequently, when the wage ratio between college and less than high school households decreases by 9.5% over this period, as they

[1] In the main text, we only analyzed the the cross-sectional variations by education. In the online Appendix, we also analyzed the the cross-sectional variations by age and income groups as well as the time-series trend changes in the allocation of time and expenditures by activity since 1965.

[2] See Attanasio and Pistaferri (2016) for a literature review.

do in the data, the ratio of measured welfare between the two groups has decreased by 1.7% in the case of the Beckerian utility, in contrast to a decrease of 2.3% in the case of the standard utility. Second, relative prices of the market goods used in producing different activities play important roles in the case of Beckerian utility while have no effect in the case of the standard utility. The evolution of relative prices over this period leads to an increase of 1.3% in the ratio of measured welfare between college and less than high school households. As a result, the overall decrease in the welfare ratio is only 0.5% in the case of the Beckerian utility.

The idea of consumption production is related to the literature on home production and leisure production in which households combine market goods and their time to produce either home goods or leisure goods.[3] This paper combines these two literatures and generalizes the idea of home and leisure production to all activities that can generate utility.

This paper is also related to the literature that study time allocation in the cross section and in the time series. The most prominent example is Aguiar and Hurst (2007), who document trends in time allocated to market work, non-market work, and leisure. A more recent paper, Aguiar, Bils, Charles, and Hurst (2017), finds that innovations to recreational computing technology can account for a large fraction of the decline in younger men's labor supply since 2004. Relative to these papers analyzing time allocation only, our paper is the first one to empirically map time use categories to expenditure categories. This mapping allows us to study how the bundle of time and expenditure differs across a wide set of consumption activities for different types of households.

The rest of the paper is organized as follows. Section 2 describes the data construction procedure and discusses the data facts. Section 3 estimates CES forms of Beckerian and standard utility. Section 4 studies the quantitative differences in labor supply and welfare inequality implied by the two utility. Section 5 concludes.

2 Data

2.1 American Time Use Survey

Detailed measures of time use are available for the U.S. roughly every ten years since 1965. From 2003 onwards, the American Time Use Survey (ATUS), which surveys a sub-sample of households in the Current Population Survey (CPS), has been conducted annually by the Bureau of Labor Statistics (BLS). This paper uses

[3]For home production, see for examples: Benhabib, Rogerson, and Wright (1991), Greenwood and Hercowitz (1991), McGrattan, Rogerson, and Wright (1997) and Ngai and Pissarides (2011). For leisure production, see for examples: Vandenbroucke (2009), Kopecky (2011) and Bridgman (2016).

all the available time use surveys for the U.S. from 1965, 1975, 1985, 1993, and 2003 - 2014. The time use surveys record data across more than 100 activities assigning every minute of a day to a particular activity. Both weekdays and weekends are included, and we weight those accordingly so that each day of the week is evenly represented.

We follow Aguiar, Hurst, and Karabarbounis (2013) when grouping time-use categories and as a result we assign activities to each of the five major groups: Market Work, Non-Market Work, Leisure, Child Care, and Other. Market Work only includes time spent working and commuting. Non-Market work comprises of time spent on core home production, obtaining goods and services, and caring for adults. The major category of Leisure is divided into Watching TV, Socializing, Eating and Personal Care, and Hobby and Entertainment. We group the rest of time into the category "Other" which mainly includes time spent on own education and own medical care. Please refer to the Appendix for a detailed description of activities included in each category.

2.2 Consumer Expenditure Survey

For the years corresponding to the time use surveys, we get data on consumption expenditures from the Consumer Expenditure Survey (CEX).[4] The CEX records quarterly households' expenditures for a large number of categories. Some of the expenditure categories, mainly those related to housing and transportation, cannot be easily assigned to a time-use category. We label the set of expenditures to which we can assign a time use category as core expenditures, which excludes expenditures related to the purchase of a personal vehicle and the rent or mortgage of a residence.[5] Table 1 shows the evolution across decades of core expenditures, housing, and transportation as a share of total expenditures. The share of core expenditures has dropped 9 percentage points over the past half century; to a large extent, that drop has been used to finance more housing. However the share is stable over the 2000's, which is the period we will rely on for our estimation.

2.3 Linking the Two Surveys

The mapping between the hundreds of expenditure categories in the CEX to the constructed time-use groups is described in detail in the Appendix. We summa-

[4]Prior to 1980, only two waves of CEX are available, conducted during 1960-1961 and 1972-1973. We use these two waves to construct expenditures corresponding to the 1965 and 1975 time use surveys.

[5]Our definition of core expenditures differs from the definition of Consumption of Non Durables and Services provided by the Bureau of Economic Analysis in that we include expenditures in smaller durables (e.g. household appliances) and we do not include a category for housing services imputed from a household's residential capital stock.

rize here the two main steps involved. We first begin with the major categories of consumption expenditures used to construct the Consumer Price Index (CPI), provided by the Bureau of Labor Statistics (BLS). Each of these major expenditure groups is assigned to a time-use category. We then check, for each major expenditure group, the underlying sub-categories, reassigning whenever necessary subcategories to a different time-use group.

Our sample is comprised of households in which the reference person is between 21 and 65 years old, and in the labor force. The restriction on labor force is to have a meaningful wage when estimating the preferences. We focus on the shares of expenditures rather than levels for two reasons. First, to avoid having to deflate using relative prices of different consumption categories over time. Second, to partially account for the different sampling unit in the CEX (household) and the ATUS (individual).

In order to describe the cross-sectional and time-series patterns of expenditures and time use bundles, we construct a synthetic cohort of households by year. We group households across characteristics we deem relevant from an economic standpoint: education and income. The grouping is based on the characteristics of the reference person. We consider income quartiles and four education groups: less than high school, high school graduate, some college, college degree and above.

3 Data Facts

3.1 Cross-Sectional Data Facts

For the cross-sectional analysis we rely on the ATUS and CEX between 2003 and 2014. The time-use values and expenditure shares are averaged across time. To display results by education or income, we take averages across all households belonging to each group.[6]

3.1.1 Analysis By Education

Figure 1 plots average hours per week and expenditures as shares of core consumption expenditures for the major categories.[7] Numbers 1 - 4 in the figure represent education group in the order of less than high school, high school graduate, some college, and college graduate or above.

Households with a higher level of education spend more time working, more time on own education and medical care, less time performing non-market work,

[6]Expenditure shares are computed by first at the household level and subsequently averaging at the group level.

[7]To facilitate the comparison across groups, the figure also includes in a box the actual values plotted.

and substantially less time enjoying leisure. The difference of hours devoted to Market Work is 12.1 hours per week between the highest and lowest education group. This gap is mirrored almost exactly by the difference in Leisure time of 11.3 hours. The differences of hours devoted to Non-Market Work and Other are 1 - 2 hours. Time use in Child Care is U-shaped: households with some but neither much nor little education spend fewer hours providing child care, but the difference is small across education groups.

We also observe sizable differences in the allocation of expenditure shares across education groups. In addition to spending less time, highly-educated households spend a smaller share of resources on Non-Market Work. The 61% share of expenditure observed for high-school dropouts drops to 46% for households with at least a bachelors degree. When it comes to Leisure, expenditure shares and time use move to opposite directions with education. Expenditure share for households with the highest education is 7 percentage points higher than those for households with the lowest education. While more educated households do indeed spend a larger share on Child Care but the differences are small across education groups. The expenditure share of Market Work is virtually zero.

Figure 2 plots the expenditure shares and weekly hours of the subcomponents in the Leisure category. There are five subcategories: Watching TV, Sleeping, Socializing, Eating and Personal Care, and Hobby and Entertainment. There are large differences in both monetary resources and time allocated to each of these categories by education group. The least educated households spend about 76.7% of their total leisure time on Watching TV and Sleeping, which are activities that require large time inputs and small expenditures and thus can be considered as time-intensive. In contrast, the most educated households spend only 68.8% of their Leisure time on these activities, even though they enjoy 11-hour less of total leisure. Consequently, these two categories are chiefly responsible in accounting for the drop of Leisure time as education level increases. The difference of 10 and 7 hours per week, for Watching TV and Sleeping, respectively, between the least and the most educated households coincides with small changes in the corresponding expenditure shares.

Turning to other activities, the most educated households devote 26.3% of their Leisure time to Eating and Personal Care and Hobby and Entertainment. In contrast, the least educated households allocate only 17% of their Leisure time to these activities. Eating and Personal Care and Hobby and Entertainment are activities that most likely require a large amount of expenditures. As a result, these two categories are primarily responsible for the larger Leisure expenditure shares of households with more education. The increases in expenditure shares as we move from the lowest education category to the highest are 5 and 4 percentage points for

Eating and Personal Care and Hobby and Entertainment, respectively. In contrast to the decreasing of total leisure time with education, those two categories, however, see a rise in time use of 3 hours and 4.6 hours per week from the least to the most educated groups. The category of Socializing appears not to have significant differences in time use and expenditure shares across education groups.

3.1.2 Analysis By Income

Figure 3 displays expenditures and hours for different income quartiles. Numbers 1 - 4 represent the income quartiles in the ascending order. The cross-sectional patterns for both time use and expenditure shares are consistent with those by education while the magnitude in the differences across groups differs somewhat. The discrepancy of hours devoted to Market Work is even larger by income than by education, with the highest income quartile working 18.6 hours more than the lowest income quartile. This gap is again mirrored almost exactly by the difference in Leisure time of 17 hours between the two groups. As for education, the expenditure share for Non-Market Work decreases and for Leisure increases with income while the differences between groups are slightly smaller. It is also worth noting that time spent on own education and medical care is decreasing with income quartile, reversing its pattern with education. However the differences across groups are small in both cases.

Figure 4 reports time use and expenditures by leisure subcategories. The patterns of weekly hours and expenditure shares by income quartile are quite similar to those by education groups. The only discrepancy that worth noting is the change in time use for Hobby and Entertainment by income is smaller than that by education.

3.2 Time-Series Data Facts

This section examines long-run trends in expenditures and time-use by education. Following Aguiar and Hurst (2007), we hold demographics constant to tease out the contribution of changing demographics on time allocation. The inference obtained mostly translates to when we divide households according to their income level.[8] Table 2 displays the allocation of time and expenditure shares over the six decades when households are broken down by their levels of education. The reported expenditure shares are computed as the shares in the core expenditure. As a reference, Table 2 also reports the share of core consumption expenditure in total expenditure. The core expenditure has dropped by 16% on average over

[8]Please see the Online Appendix for the tables by income.

this period and there does not appear to have notable difference across education groups.

The decline in Market Work, with larger declines for less educated, and the rise in Leisure time, with larger rise for less educated, have been documented by Aguiar and Hurst (2007). The new insights are for the time-series change in expenditure shares by education groups. The table shows that for Non-Market Work the more educated, the larger the decline in expenditure shares but the smaller the decline in time use. Declines in the shares of expenditures range from 5 percentage points (p.p.) for the least educated group to 13 p.p. for the most educated.

The decline in expenditures of Non-Market Work has been mostly reallocated to Leisure and Other categories. As the declines were larger for highly educated households, the increases, particularly in the Leisure category are also larger for that group. The rise in the expenditure share for Leisure is only 4 p.p. for the households without a high school diploma, rising to 7 p.p. for households with at least a college degree. Differences across education groups in the rise of expenditure shares allocated to Other are less dramatic: 1 - 2 p.p. Relative to the cross-sectional variation by education, the time-series differences in expenditure shares also reflect the changes in relative prices of activities over time. The large decline in expenditure shares of Non-Market Work and the rise of expenditure shares in Leisure partly reflect the decrease in the price of consumer goods, especially consumer durable, relative to the price of services in the post-war period, a fact that has been widely documented. Prices of education and health care has increased a lot over this period while we do not see a big increase of expenditure share for the category of Other. This is because we only consider the age group of 21-65 and the CEX only captures the out of pocket expenditures of households.

Table 3 reports the changes in time and expenditures for the Leisure subcategories. The changes in time is largely consistent with those reported by Aguiar and Hurst (2007). Time spent on Watching TV and Sleeping, the relatively inexpensive forms of Leisure, have increased for every education group and the increases are larger for households with less education. Watching TV has increased 9.6 hours for those without a high school diploma and 6.1 hours for those with at least a college degree. People spend less time Socializing than they used to but there are no significant differences by education (between 3 or 4 fewer hours per week). Time spent on Eating and Personal Care decreased by 2.4 hours to 6.7 hours per week with large decreases for less educated groups. Time spent on Hobby and Entertainment has not changed much.

The changes in expenditure shares for the Leisure subcategories are generally small except for Socializing. The expenditure share of Socializing increased by 3 p.p. for the most educated and by 5 p.p. for the other three groups. As a result,

by 2010 expenditure share of Socializing is comparable to those of Eating and Personal Care and Hobby and Entertainment, the two categories with the highest expenditure shares among the Leisure subgroups. The expenditure share of Eating and Personal Care decreased by 1-3 p.p. and the expenditure share of Hobby and Entertainment did not change much. Expenditures associated with watching TV have increased slightly more for the least-educated households but the difference is not large. The changes are 2 p.p for households with a college degree and 3 p.p. for the other three groups.

To summarize, the allocation of time and expenditures varies a lot across activities, education or income, and time. Those variations will help us to identity a Beckerian utility function.

4 Structural Framework

Understanding the importance of separating expenditures and time use across different activities requires a structural approach. In specifying preferences, we face a tradeoff between parsimony and flexibility. Because the nature of the activities we model is different, we want at least to differentiate across elasticities of substitution between market goods and time use across activities. Our chosen specification is a nested CES between time use and market goods for each activity within an overall CES for all activities. Each activity i is produced by a household using time (l_i) and market goods (x_i). We label as c_i the amount a household enjoys of activity i.

The utility function that we map to the data is given by $U(C) = log(C)$, where

$$\begin{aligned} C &= \left(\sum_i \alpha_i c_i^{\frac{\rho-1}{\rho}} \right)^{\frac{\rho}{\rho-1}}, \\ c_i &= \left(\kappa_i x_i^{\frac{\xi_i-1}{\xi_i}} + (1-\kappa_i) \ell_i^{\frac{\xi_i-1}{\xi_i}} \right)^{\frac{\xi_i}{\xi_i-1}}. \end{aligned}$$

The parameters can be divided in four types. First, the set of shares $\{\alpha_i\}$ determines the relative weights of different activities. A second set of shares $\{\kappa_i\}$ determines the weights of market goods in the production of each activity. Third, the vector $\{\xi_i\}$ contains the elasticities of substitution between market goods and time (one per activity). Finally, ρ is the elasticity of substitution between activities.

Because the expenditure on market work is virtually zero, from now on we assume that market work only involves time but not market goods. Each household has one unit of time that can be allocated either to producing activities or market work. The budget constraint for a household that receives a wage w in the labor

market is given by:

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

The point of departure for assessing the implications of Beckerian preferences is an equivalent utility function in which market expenditures and time use are aggregated. This is the typical approach of most of the literature. The aggregated utility function is given by:

$$\begin{aligned} U(C^s) &= log(C^s), \\ C^s &= \left(\phi(x^s)^{\frac{\sigma-1}{\sigma}} + (1-\phi)(\ell^s)^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}, \end{aligned}$$

where the superscript s stands for *standard* because this utility function is consistent with those used commonly in the literature. The budget constraint is simply:

$$x^s = w(1 - \ell^s)$$

This preference is driven by only two parameters. The first, ϕ, drives the relative importance given by the household to market expenditures. The second, σ, gives the elasticity of substitution across the market goods (total expenditures) and time (total leisure). The derivation of the two models are provided in the appendix. We estimate the parameters for both specifications as specified in the next section.

4.1 Estimation of Preferences

The activities considered in the estimation are Non-Market Work, Child Care, Watching TV, Socializing, Eating and Personal Care, and Hobby and Entertainment. We choose not to include Sleeping and the category of Other because the simple structural framework proposed can not capture the biological, educational, and medical decisions of households. The cross-section of households are divided according to their educational attainment. The reason to use education rather than income to obtain the cross-sectional heterogeneity is mainly sample size. We lose a substantial amount of observations because there is much missing income data in the ATUS.

In addition to the time use and expenditure data discussed, we use data on household wages across education groups and prices of market inputs across activities between 2003 and 2014. We use the Current Population Survey (CPS) to construct household wages by education level. The wage is calculated as the ratio between total household income and total household working hours.

We assume all households face the same price and use the Consumer Price Index (CPI), obtained from the BLS, to construct relative prices between market

goods. During the 2000s, the expenditure categories in the CPI and CEX are consistent, and therefore the CPI data can be aggregated into our activity categories using expenditure weights constructed from the CEX.[9,10] Specifically, we first construct the share of expenditures for each household by the detailed CEX categories and then use the shares to aggregate the corresponding CPI indices to a weighted price for each activity at the household level. Finally, we average across households using CEX sample weights to find the aggregate price for an activity in a given year. The Appendix provides details of the construction of wages and prices.

We use a minimum-distance estimator to estimate the model's parameters. Given prices and wages for the four education groups, for all combinations of parameter values, we can calculate optimal allocations for a household of a given education level for each year in our sample. These allocations - for time and expenditure shares- are the moments the estimation procedure targets. Specifically, the targets include allocations of time use and expenditure shares from 2003 to 2014 for each of the education groups and each of the activity categories. The dimension of the vector for time and expenditure share is 288 each.[11] The number of parameters to estimate is 18.[12] The standard errors are obtained by boostrapping the individual-level data sets. Although we use both time series and cross-sectional data for estimating the parameters, the cross-sectional distribution helps identify parameters better than the time series.

Similarly, given wages by education, we estimate the "standard" preference by minimizing the distance between data and model implication on market hours by education and over years. The number of parameters is 2 and the number of moments is 48.

4.2 Estimation Results

Table 4 displays the estimated parameter values. Standard errors, reported in the parentheses, are consistently small. The top panel shows the estimates for the Beckerian utility parameters and the bottom panel the ones for the "standard" preferences.

The first row of the top panel presents the values of the elasticity of substitution

[9] We follow Casey (2010) to construct consistent categories between the CPI and CEX.

[10] We choose not to use data before the 2000s because prior to the 1998 revision CPI is not linked to CEX. The number of CPI categories before the revision is much smaller and one category may cover more than one activity according to our classification. Consequently, constructing consistent price series for the activities is not easy.

[11] The dimension is the product of the 12 years of data, 6 activities, and 4 education groups.

[12] For each activity, we estimate a share of market input and an elasticity of substitution between market inputs and time (12 parameters). We estimate the share of the activity in total consumption, but there are only 5 independent parameters because the sum of all 6 equals one. Finally, we also estimate an elasticity of substitution across activities.

between market goods and time for the six activities considered. All are larger than one, implying that market goods and time are more substitutable than they would be with a Cobb Douglas specification. Time and goods are least substitutable for Non-Market Work – close to a value of 1 – and most substitutable for Child Care. Except for Non-Market Work and Socializing, most numbers hover around a value of 2. The second line displays the weight of market goods on the production of each activity. For example, market goods have a weight of 0.082 in the production of Child Care. Overall, time seems to be a more important input than goods. By far, Non-Market Work has the largest share (0.527) for goods. For the remaining activities, the goods share is about a fifth or less.

The third row reports the share of the activity itself in total consumption. Non-Market Work has again the largest share with a value of roughly 0.3, followed by TV, Eating and Personal Care, and Hobby and Entertainment (all around 0.15 or higher). The remainder two activities have an overall lower weight of 0.1 or less. Finally, consumption activities themselves can be substituted for each other. This elasticity of substitution is given by the parameter ρ. Its estimated value is 1.22, which is more substitutable than a Cobb-Dougles but only to some extent.

To summarize, the estimation points to time and market goods being rather good substitutes in the production of most activities. Time appears to have a larger weight than goods in the production of activities. There is limited substitution across activities.

The model fits fairly well the cross-section of expenditure shares and time use. Tables 5 - 6 show that allocations in the model and in the data are close. There is one exception in time allocated to Hobby and Entertainment. In the ATUS, higher education is associated with more time devoted to this activity. The model, however, implies a declining time allocation as education rises. In addition, the model has a difficult time matching the inverted-U shape of the expenditure share allocation to TV Watching and the U shape of time allocated Child Care. Chiefly because the small differences across education groups and the small representation of TV in total expenditure and Child Care in total time use.

The bottom of table 4 reports the estimates for the standard utility. The estimation also indicates a low weight on expenditure share and a slightly greater than one elasticity of substitution between expenditure and time.

4.3 Counterfactuals and Welfare Analysis

This section uses the estimation results to understand (a) the implications of Beckerian preferences for the response of hours to a change in wages, and (b) the implications of these preferences for the recent evolution of inequality and welfare.

We begin by studying how hours worked respond to a change in the wage across the two specifications. Starting from the baseline allocation in the Beckerian preferences, we drop wages in the two models from several values up to a maximum drop of 60%.[13] The results of this experiment are shown in Figure 12

The horizontal axis shows the percentage drop in wages. The baseline case corresponds to a 0 percent change and the maximum drop is 60% relative to the baseline. The four starred lines show the drop in market time when wages decline and preferences are of the Beckerian type. Each of the four lines represents an education level. The solid lines – again, four of them corresponding to as many education levels – represent the standard preferences. As is apparent from the figure, the response of hours worked to a change in wages is more pronounced with Beckerian preferences than with standard preferences. The difference is due to the larger number of margins of adjustment with Beckerian preferences than with standard preferences. The difference in the response is larger for workers with more education. For instance, for the lowest education group, the difference in labor supply when wages drop 60% is 0.01, while it's about 0.04 for those with most years of schooling.

While the experiment is illustrative, a drop of say 20% in the wage does not represent the same drop in the opportunity cost of time. The reason is because the change in the *relative* wage is not the same across the two models. By relative wage we refer to the wage divided by a price index of goods. To see this clearly, let's construct a measure for the relative wage in the two models. This measure helps comparing across models in a systematic way.

Begin with the Beckerian preferences and rewrite the budget constraint as follows:

$$C_j \sum_{i=1}^{6} \frac{p_i}{M_{ij} G_{ij}} = w_j (1 - \sum_{i=1}^{6} l_{ij}). \tag{1}$$

The variables M_{ij} and G_{ij} are functions of parameters, wages, prices and allocations (see Appendix). We can define a relative price P_j as the sum of prices of goods p_i weighted by the factor $\frac{1}{M_{ij} G_{ij}}$

$$C_j P_j = w_j (1 - \sum_{i=1}^{6} l_{ij}) \tag{2}$$

Hence, for each education category j the left hand side represents total expenditures: an aggregate measure of consumption C_j multiplied by an aggregate price index P_j.

In a similar manner, for the standard preferences we can rewrite the budget

[13] To make the comparison more fitting, for the baseline case we choose wages in the standard preferences to match the market time allocation of the Beckerian preferences.

constraint as,

$$C_j^s \frac{1}{Q_j^s} = w_j^s(1 - l_j^s), \tag{3}$$

where, again, Q_j^s is a function of parameters and the wage of group j. Defining P_j^s to be $\frac{1}{Q_j^s}$, we can rewrite the constraint in a similar way as with the Beckerian preferences.

$$C_j^s P_j^s = w_j^s(1 - l_j^s), \tag{4}$$

For a more apt comparison across the two models, we now force the relative wage to change by the same amount. The relative wage is defined as w/P. Given the drop in wages from 0 to 60% in the Beckerian preferences, we compute the change in w/P for each of change in w. We then ask: what is the change in wages in the standard model needed so that the change in the relative wage w/p is the same across the two models for each education group? The results of this experiment are shown in Figure 14. The horizontal axis shows the change in the relative wage. The wage w in the standard model has to rise in order for the relative wage to change by the same amount across the two models. As a result, labor supply rises.

We turn to examining the implications for welfare inequality across the two models. We measure welfare for education group j by C_j and C_j^s respectively for the two types of preferences. The experiment we perform is to feed in wage changes over the 2003-2014 period for both models, and the price changes too for the Beckerian model. We compare welfare changes in the model quantities $\frac{C_{jt}}{C_{1t}} - \frac{C_{j1}}{C_{11}}$ for each education group j. In other words, we measure welfare relative to the lowest education group and relative to $t = 1$.

We begin by comparing changes in welfare only due to changes in wages. In other words, for the two models and all the education groups we feed in the actual wage changes and solve for allocations.[14] The evolution of welfare in this case is shown in Figure **??**. On average welfare drops for all groups as a consequence of the post-recession drop in income. Welfare drops relatively more for the high education groups. However, what's important is the comparison across the two preferences. Because of the higher number of substitution margins, welfare drops less for all groups with the Beckerian preferences than with standard preferences. Because this drop is relative to the lowest education group it means that welfare inequality post-recession is lower in the Beckerian framework. Within the latter preferences we can examine the welfare inequality effects by education groups of

[14]For this experiment we keep all other prices fixed at their 2003 value.

changing wages and prices separately. The results are shown in Figure **??**. Changes in prices observed during the period considered improve welfare for all groups, while changes in wages reduce it. When putting the results in both figures together, we get the total effects from prices and wages in both models. The result is shown in Figure **??**. In the Beckerian framework, the change in welfare is small – inequality changes little – when both prices and wages are fed. Income and welfare changes can be compared by looking at Figure **??**. The left-hand-side figure shows that income differences by education group are small. This is because differences in hours worked within education groups across the two models are not large. The right hand side shows that welfare is less dispersed *across* education groups. However, it is even less dispersed for the Beckerian framework. This result shows that the more margins of adjustment that framework allows Finally, the drop in income is orders of magnitude larger than the drop in welfare. The scale in the income graph shows drops as large as 0.15. The largest drop in welfare is only 0.025. This highlights the importance of taking into account non-work activities when measuring inequality. And again, the drops in welfare under Beckerian preferences are about less than half in magnitude than those under standard preferences.

How do allocations change when the price of Hobbies and Entertainment rises? The results of this counterfactual are shown in Figure 37. Each subfigure plots the allocation for a particular activity (expenditure share on the vertical axis and hours on the horizontal axis). We plot the baseline allocations, as well as allocations after doubling and tripling the price of Hobbies and Entertainment. The allocations for Child Care, Watching TV, and Socializing, barely move. As the price of H&E rises, expenditure shares in that category falls for all education groups. Time use rises. The fall in shares is about the same across groups, however the rises in time use is proportionally larger for high education groups. Non market work shares and time use rise for all four education groups, in roughly the same magnitude.

5 Conclusion

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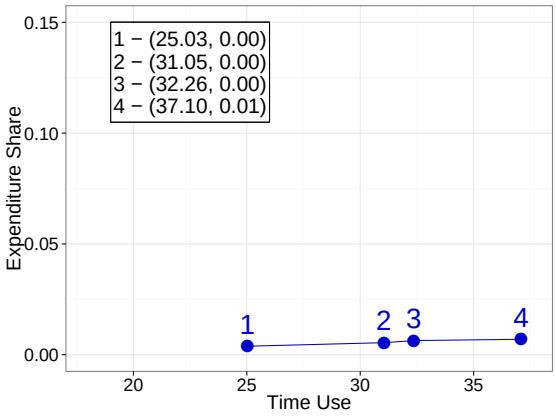
Figure 1: Major Categories by Education



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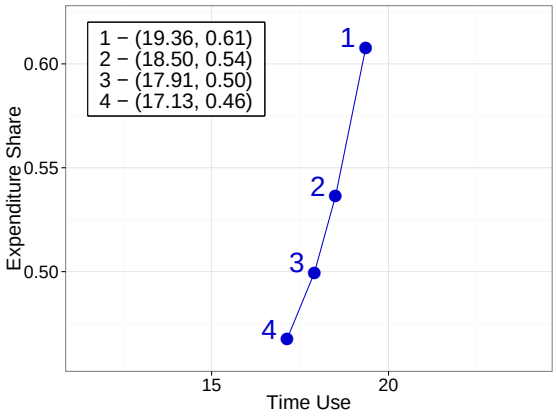

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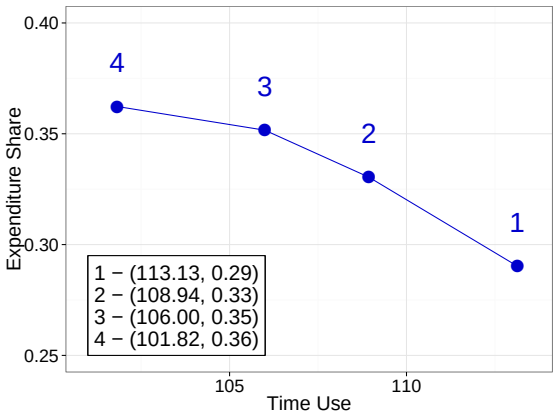

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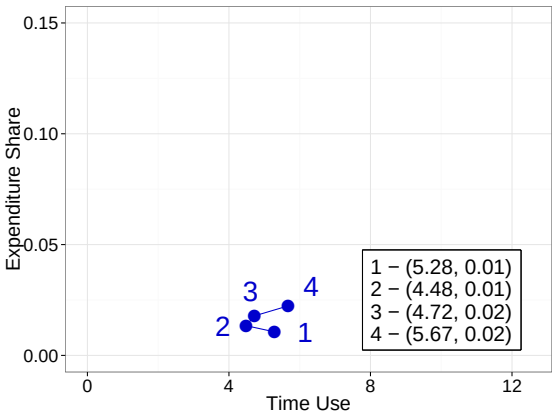

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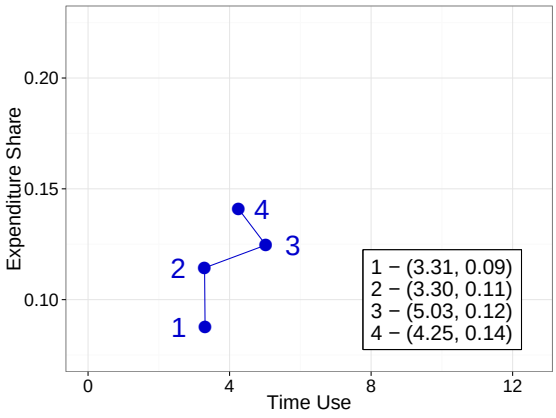

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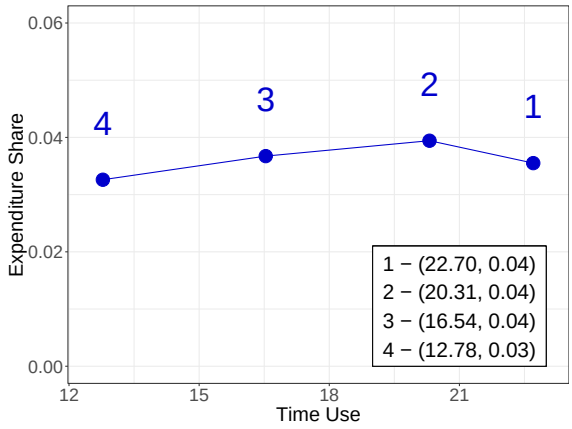
Figure 2: Leisure Categories By Education



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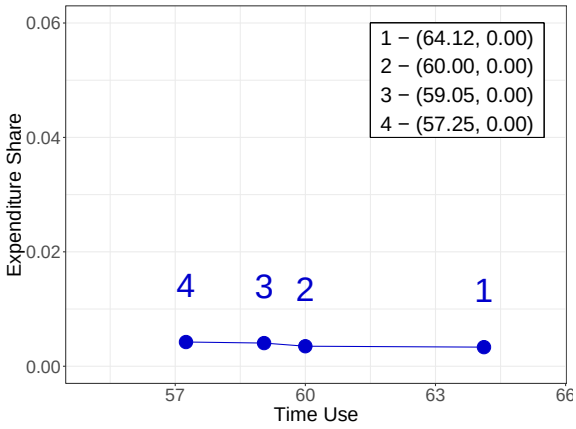
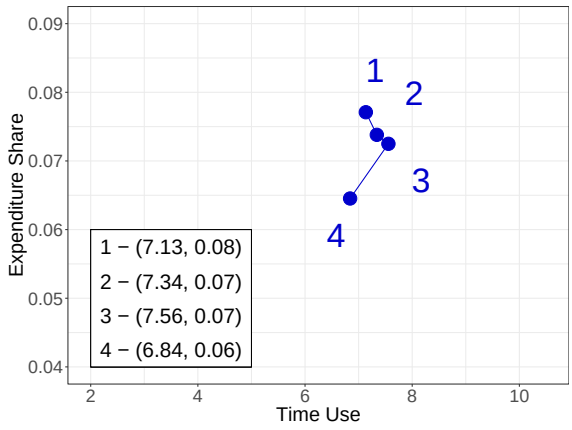


(b) Sleep



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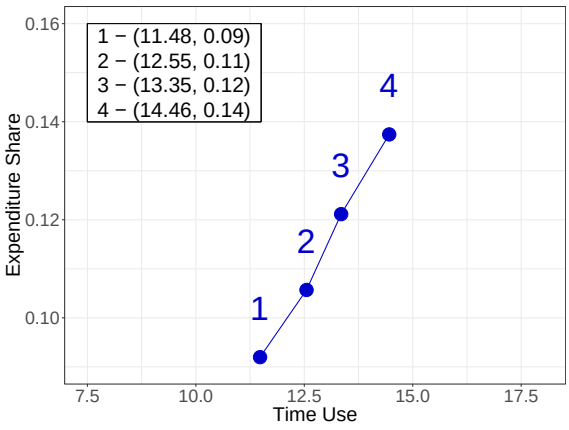

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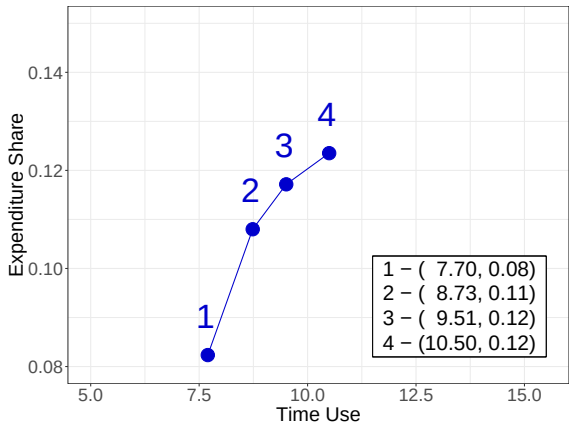
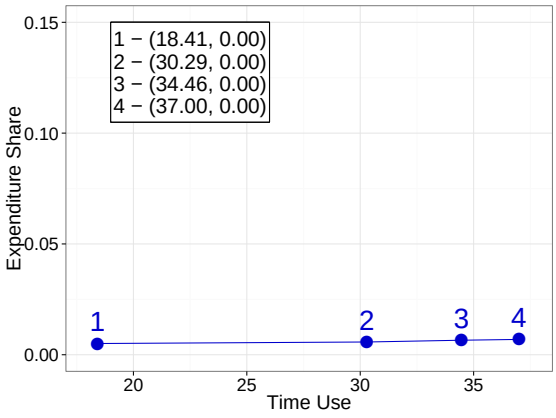
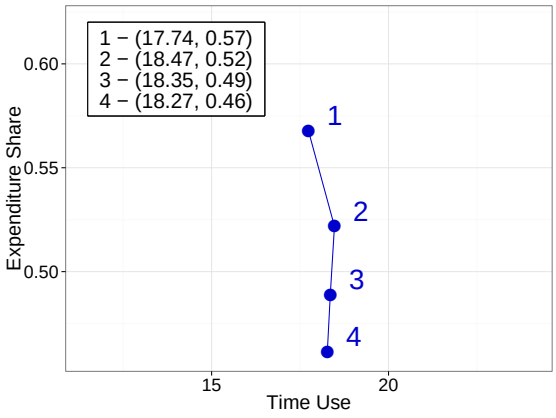


(e) Hobby and Entertainment

Figure 3: Major Categories by Income



(a) Market Work



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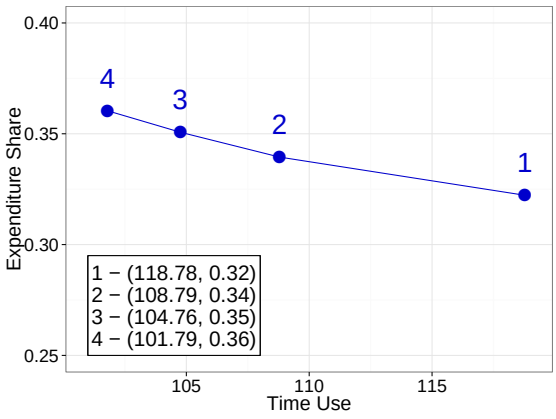

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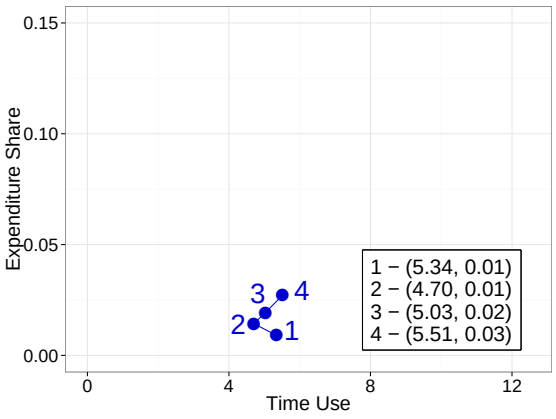

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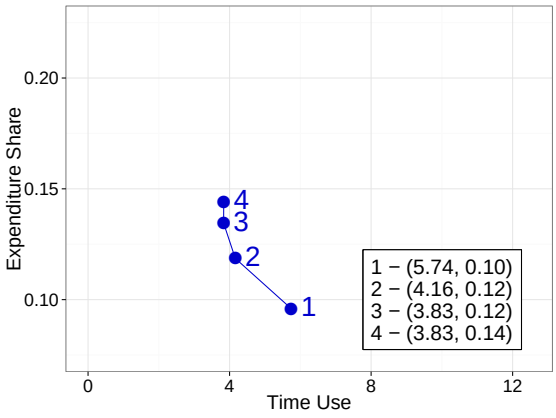
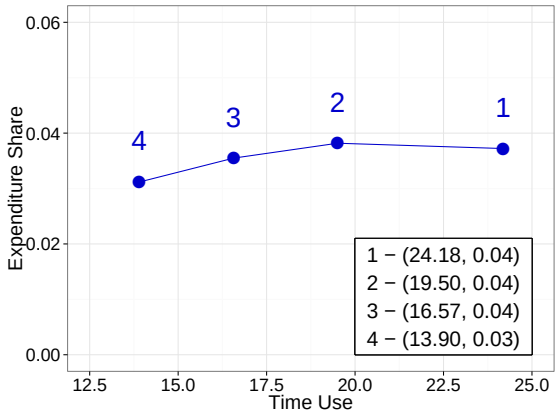


(e) Other

Figure 4: Leisure Categories By Income



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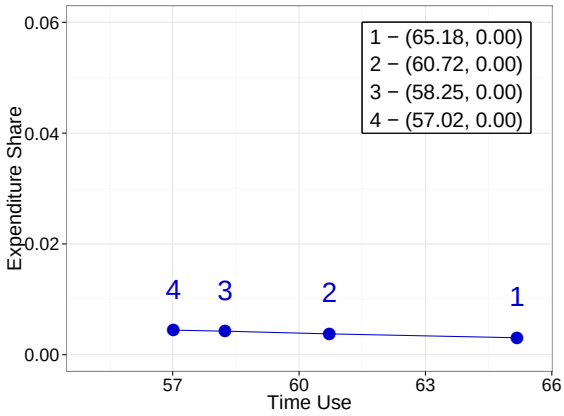

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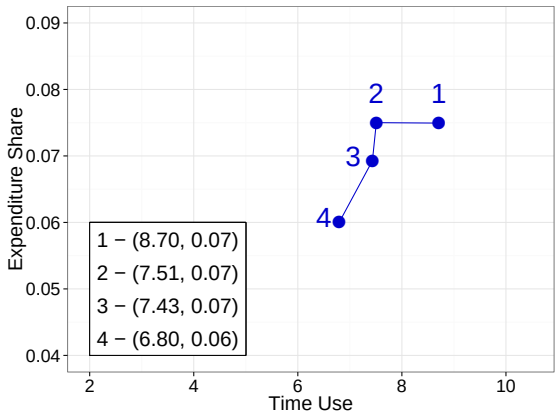

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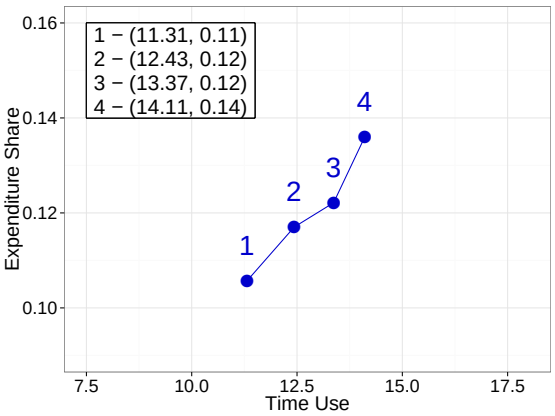

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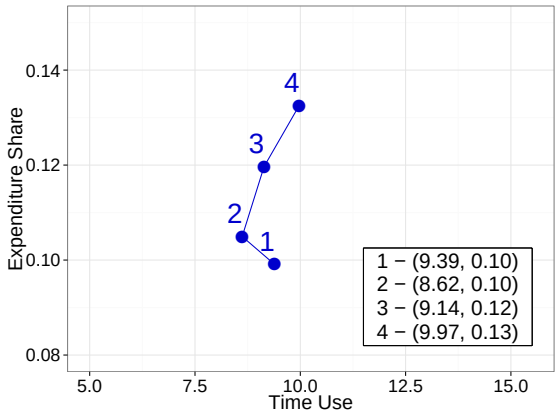
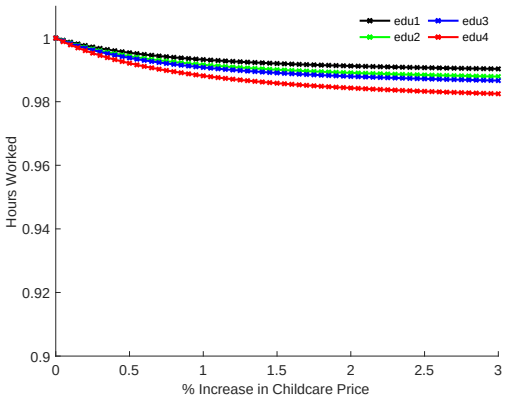


(e) Hobby and Entertainment

Figure 5: Becker Model with Unique Prices:
Response of Hours Worked to an Activity Price Change



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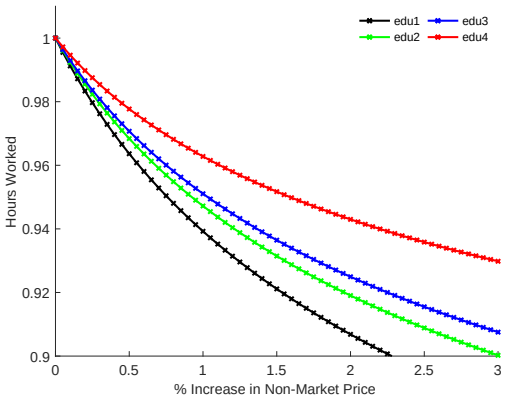

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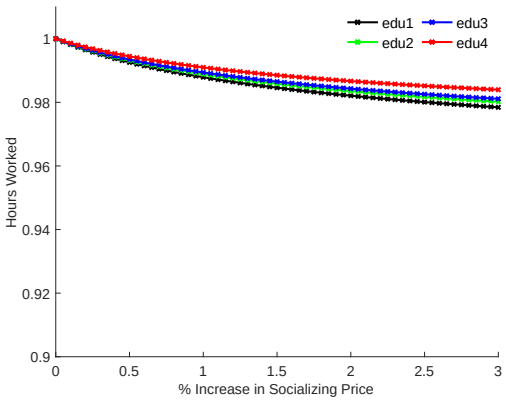

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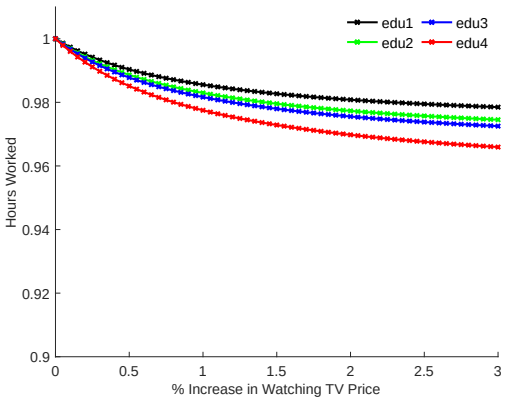

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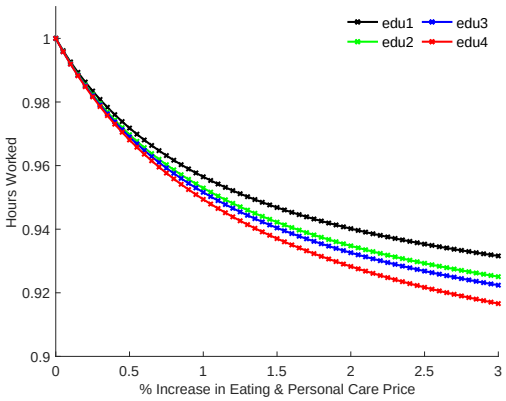
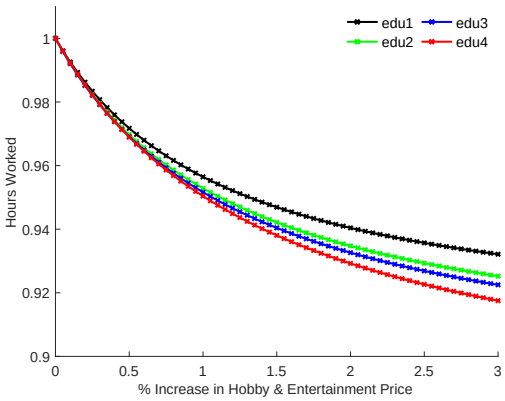
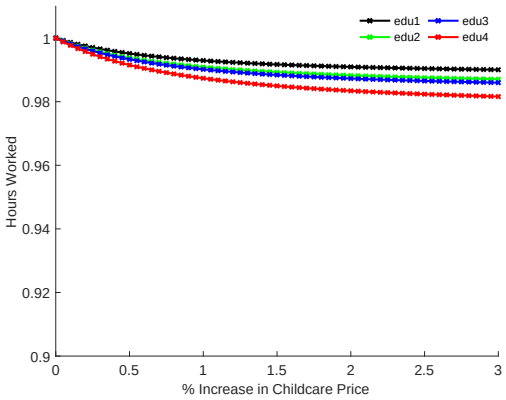


(e) Eating and Personal Care



(f) Hobby and Entertainment

Figure 6: Becker Model with Prices by Education:
Response of Hours Worked to an Activity Price Change



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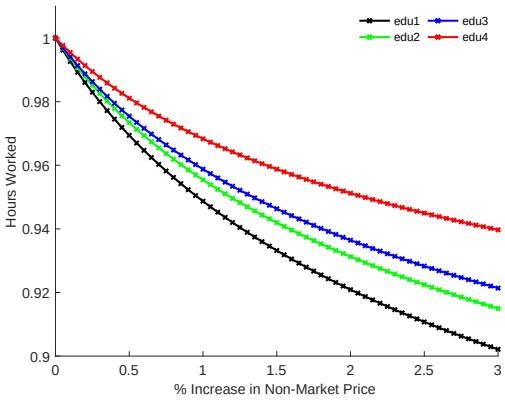

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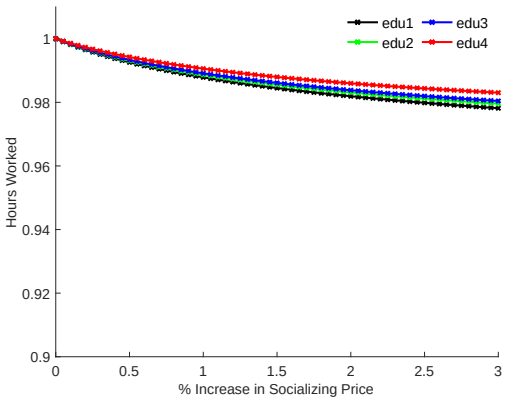

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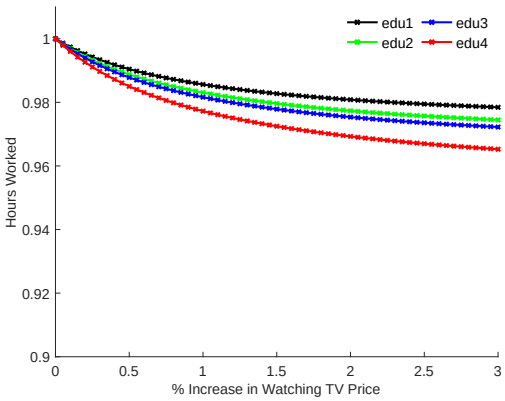

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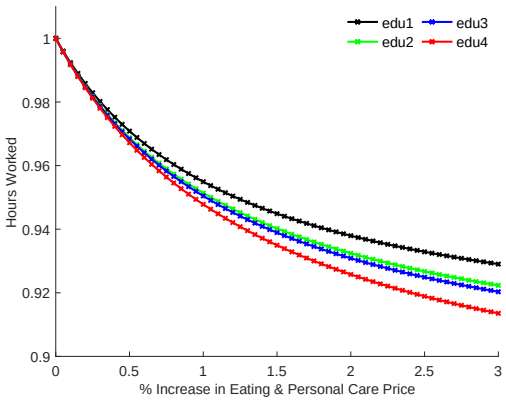

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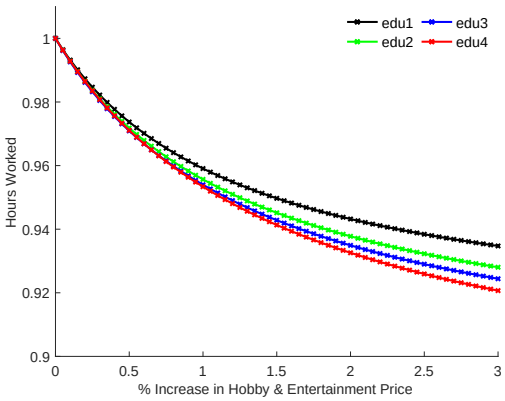


(f) Hobby and Entertainment

Figure 7: Becker vs. Multiple Goods Model
Labor Supply Response to a Change in Wages – Unique Price

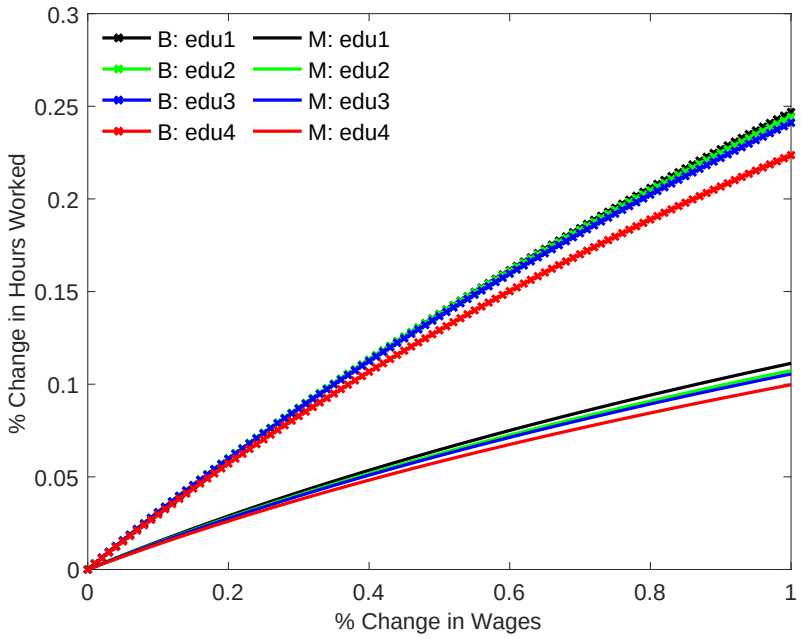


Figure 8: Becker vs. Multiple Goods Model
Labor Supply Response to a Change in Wages – Price varies by Edu

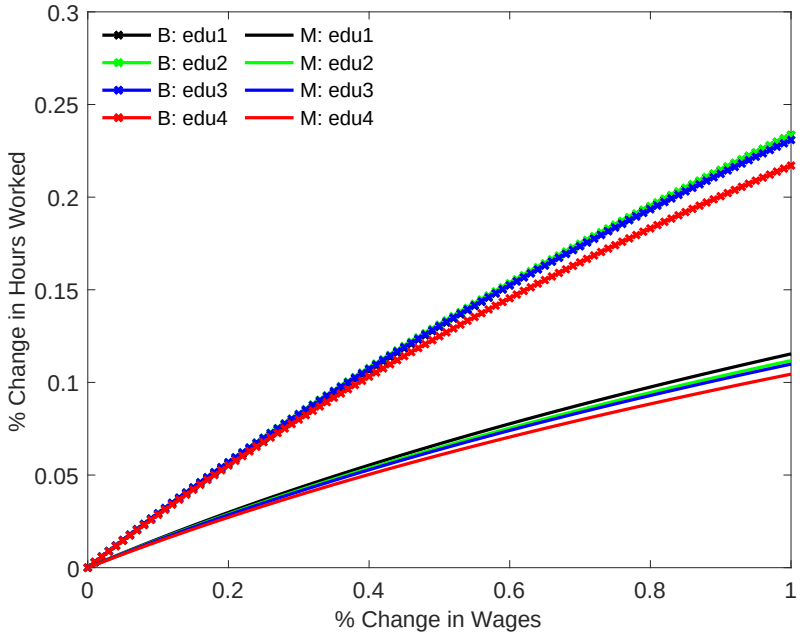
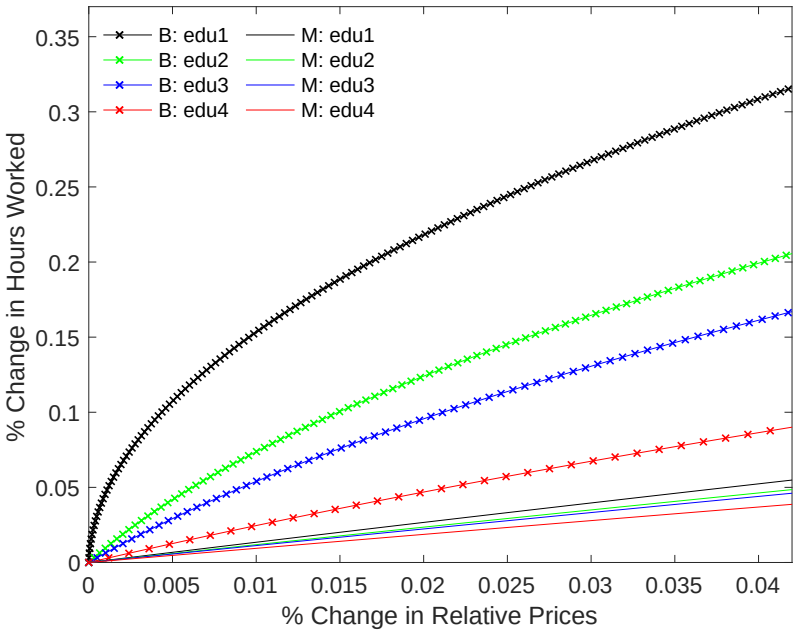


Figure 9: Becker vs. Multiple Goods Model
Labor Supply Response to a Change in Relative Prices – Unique Price



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Labor Supply Response to a Change in Relative Prices – Price varies by Edu

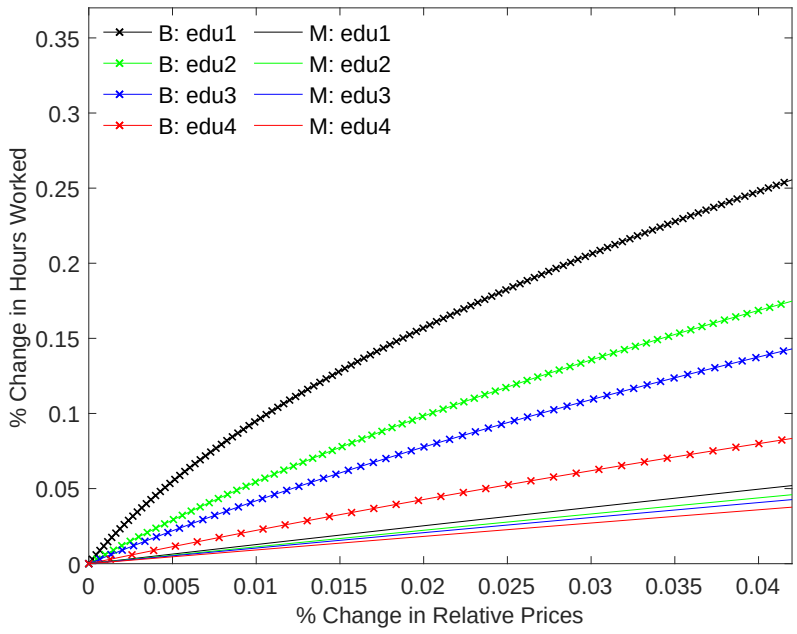

Figure 11: Becker vs. Standard Model
Labor Supply Response to a Change in Wages – Unique Price

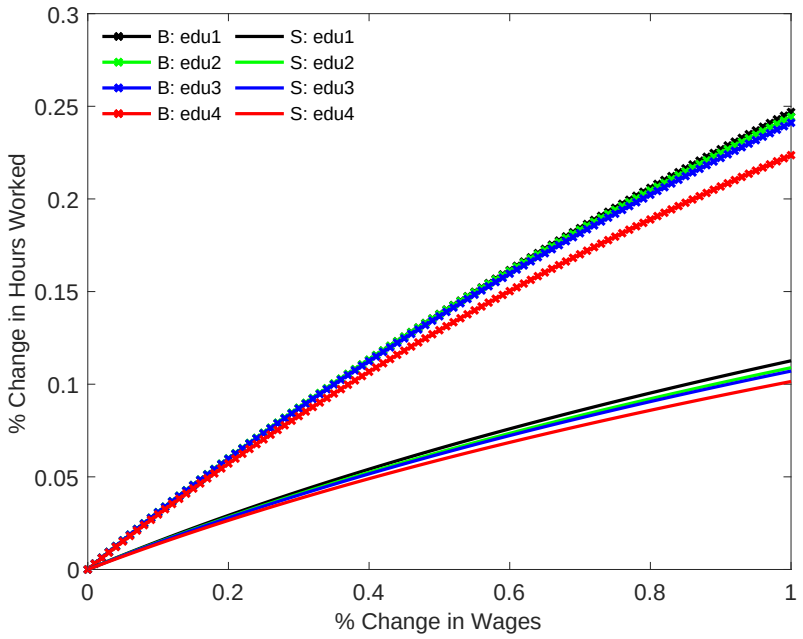

Figure 12: Becker vs. Standard Model
Labor Supply Response to a Change in Wages – Price varies by Edu

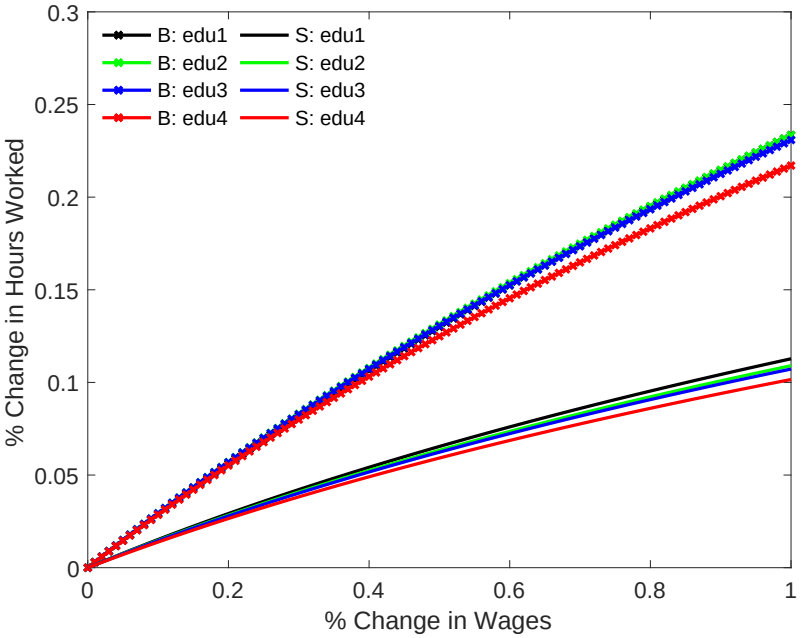

Figure 13: Becker vs. Standard Model
Labor Supply Response to a Change in Relative Prices – Unique Price

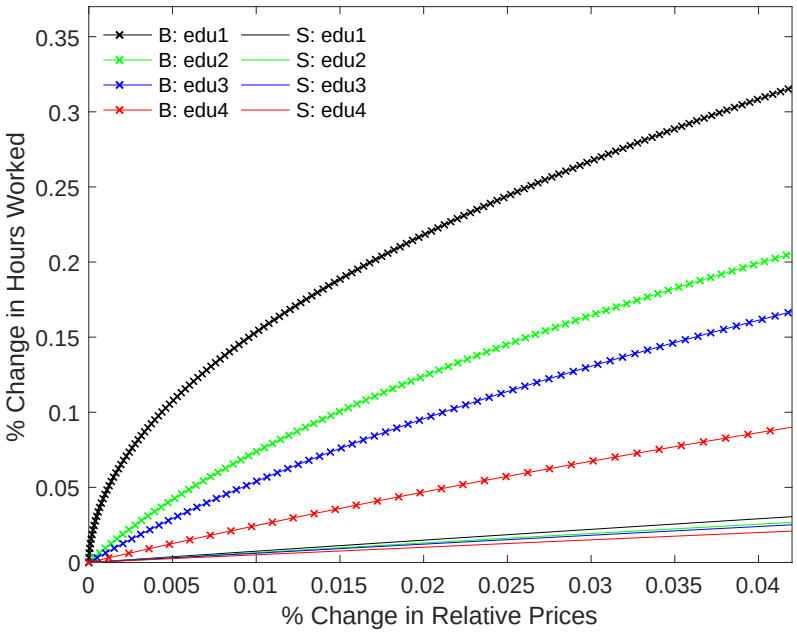

Figure 14: Becker vs. Standard Model
Labor Supply Response to a Change in Relative Prices – Price varies by Edu

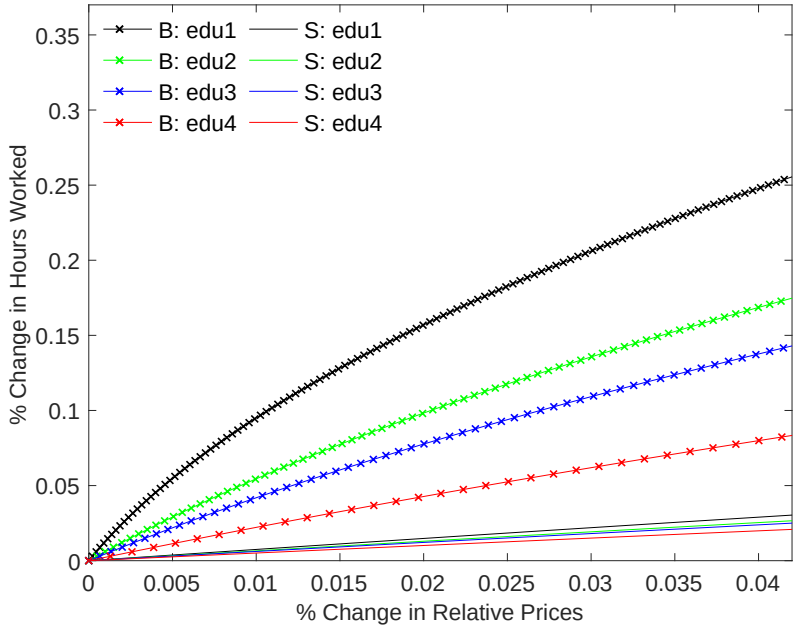

Figure 15: Becker vs. Multiple Goods vs. Standard Model:
Wage Changes Associated with Relative Price Changes – Unique Price

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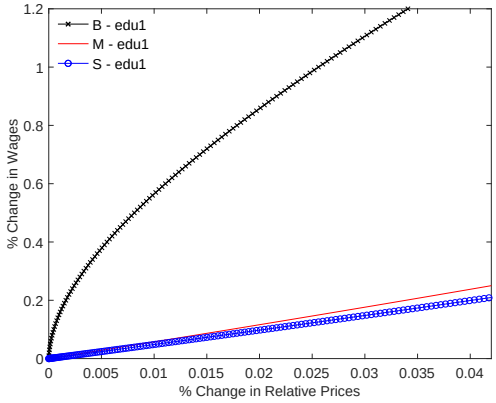

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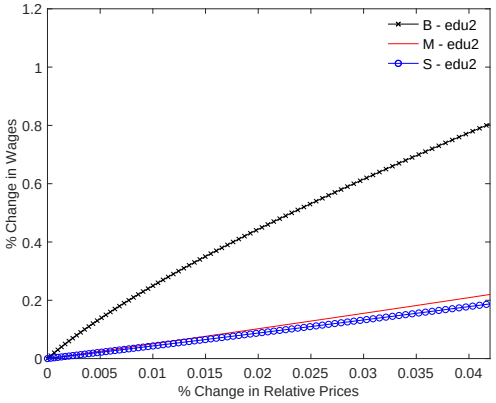

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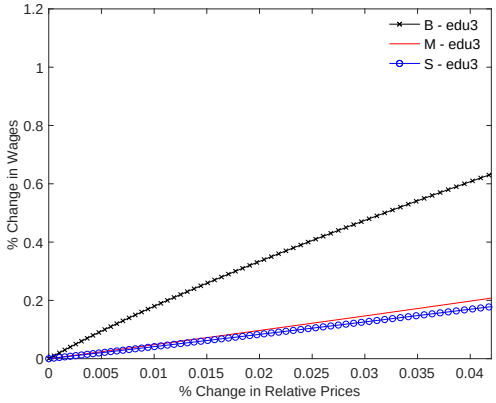

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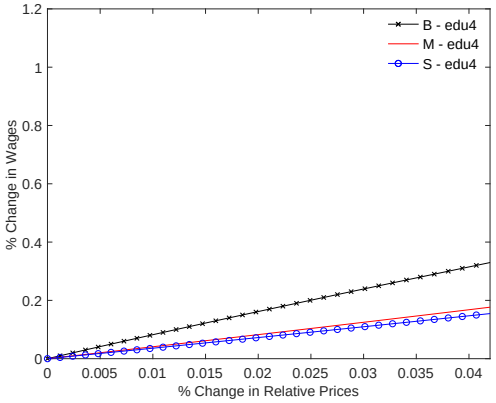
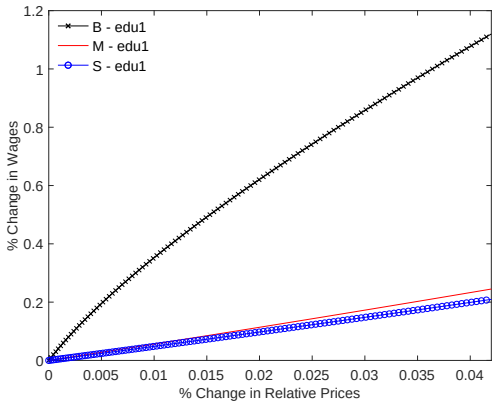
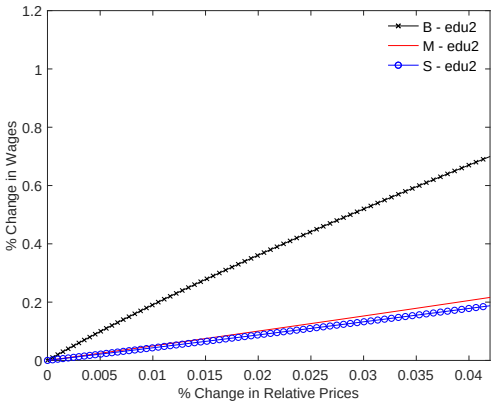


Figure 16: Becker vs. Multiple Goods vs. Standard Model:
Wage Changes Associated with Relative Price Changes – Price varies by Edu

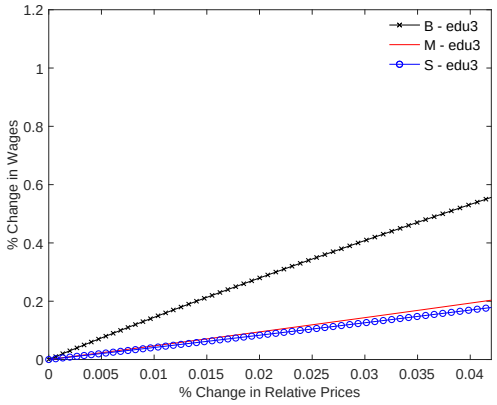
(a) Edu 1



(b) Edu 2



(c) Edu 3



(d) Edu 4

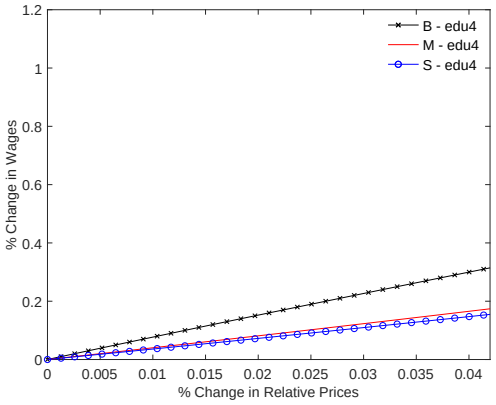


Figure 17: Data
Activity Price Changes – Unique Price

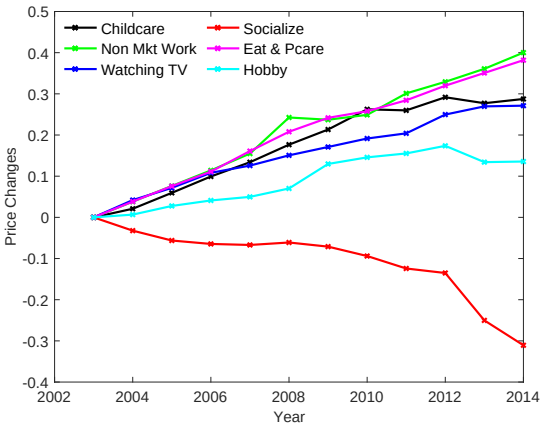
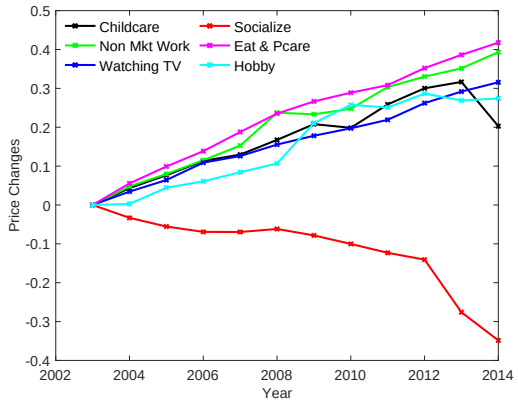
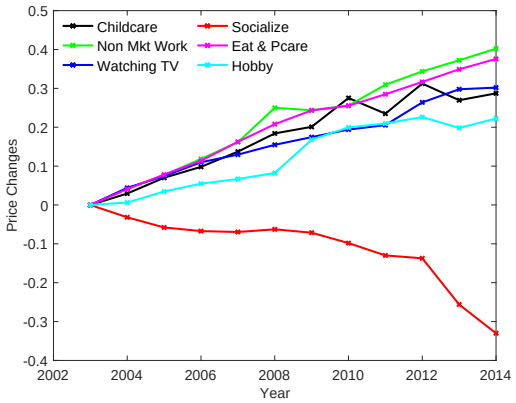


Figure 18: Data
Activity Price Changes – Price varies by Edu

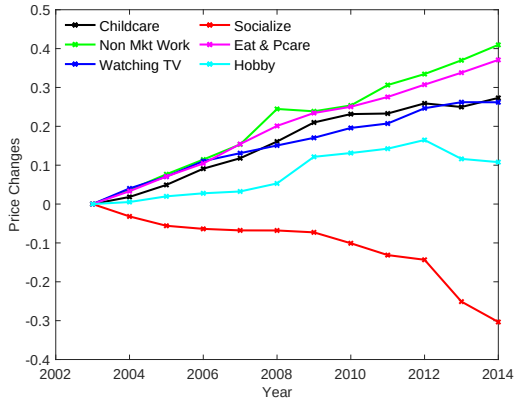
(a) Edu 1



(b) Edu 2



(c) Edu 3



(d) Edu 4

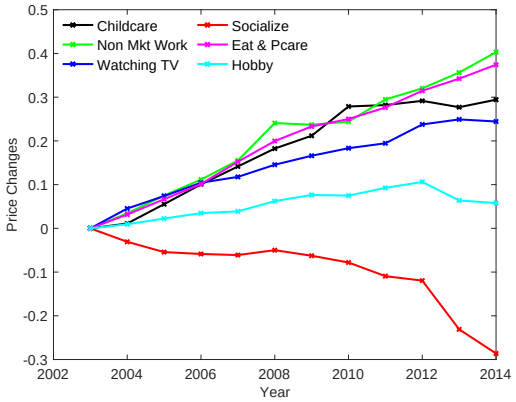


Figure 19: Becker Model
Welfare Change: Wage and Price Effect – Unique Price

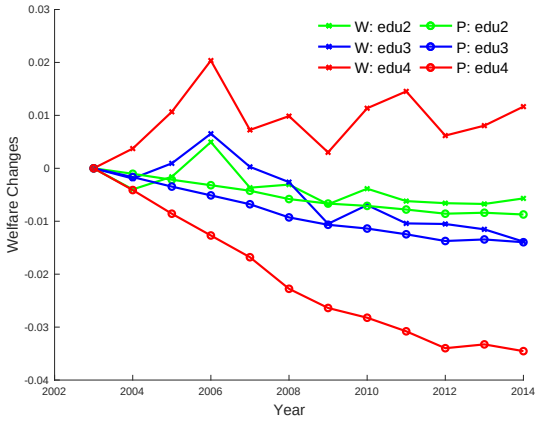


Figure 20: Becker Model
Welfare Change: Wage and Price Effect – Price varies by Edu

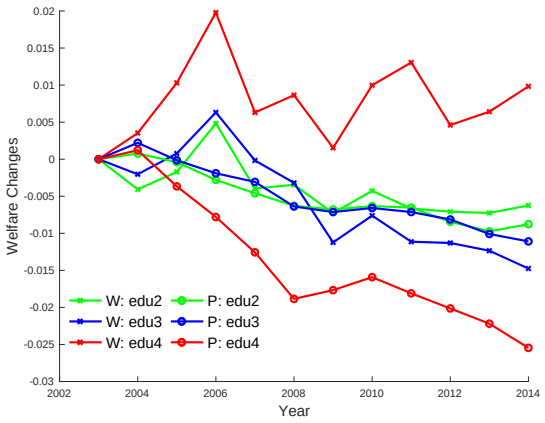


Figure 21: Becker vs. Multiple Goods Model
Welfare Change: Wage Effect – Unique Price

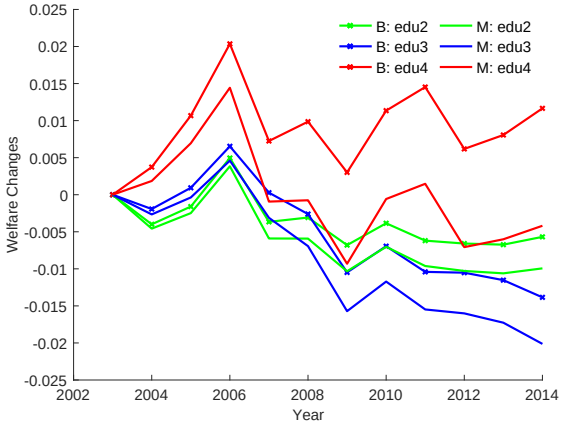


Figure 22: Becker vs. Multiple Goods Model
Welfare Change: Wage Effect – Price varies by Edu

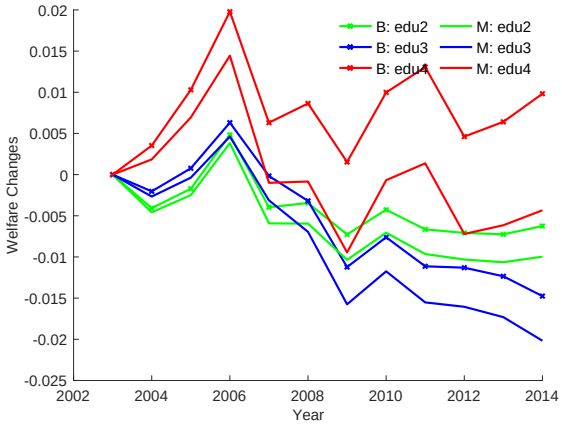


Figure 23: Becker vs. Multiple Goods Model
Welfare Change: Total Effect – Unique Price

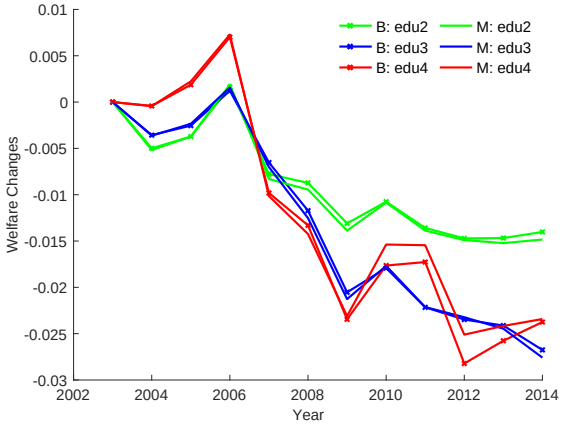


Figure 24: Becker vs. Multiple Goods Model
Welfare Change: Total Effect – Price varies by Edu

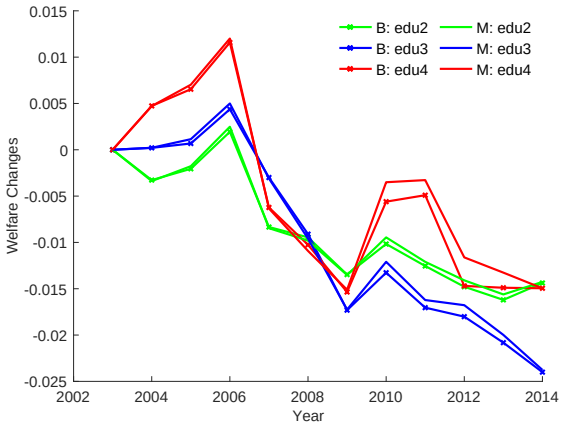
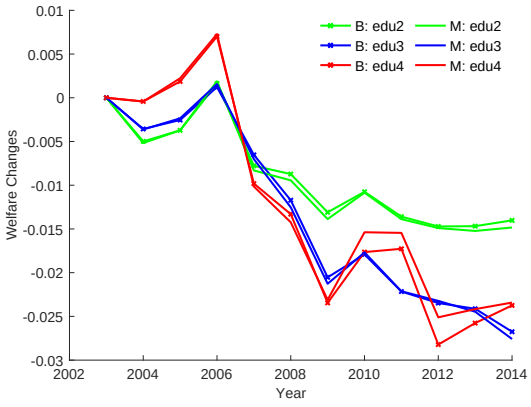


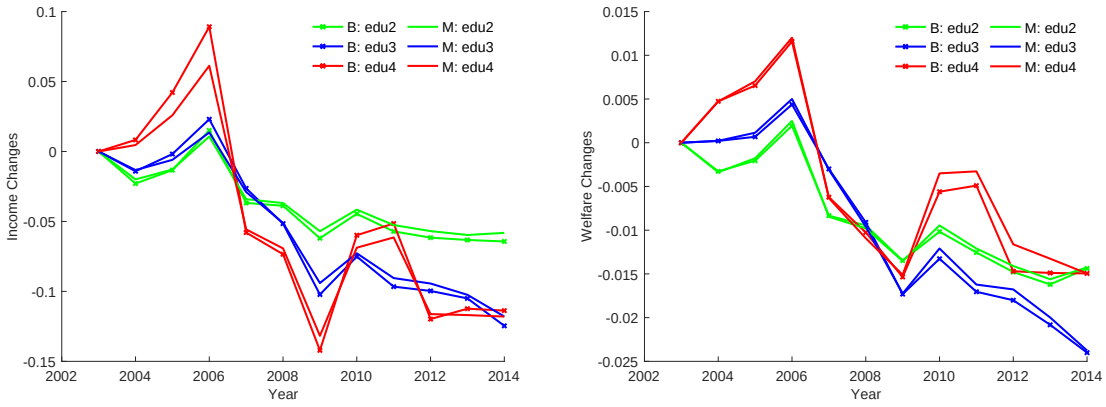
Figure 25: Becker vs. Multiple Goods Model
Income and Welfare Comparison – Unique Price

(a) Income



(b) Welfare

Figure 26: Becker vs. Multiple Goods Model
Income and Welfare Comparison – Price varies by Edu



(a) Income (b) Welfare

Figure 27: Becker vs. Standard Model
Welfare Change: Wage Effect – Unique Price

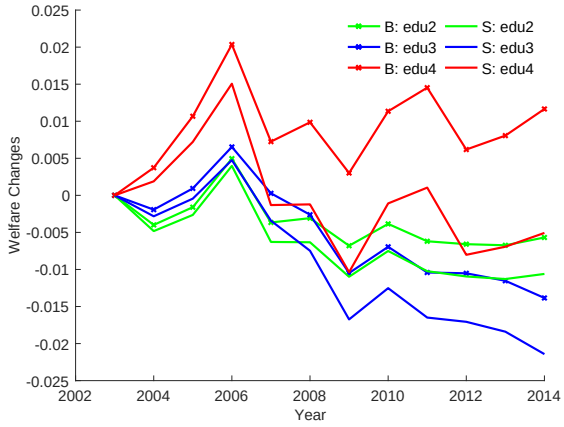


Figure 28: Becker vs. Standard Model
Welfare Change: Wage Effect – Price varies by Edu

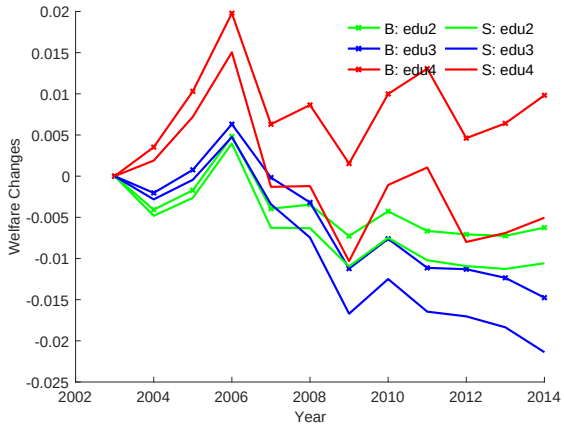


Figure 29: Becker vs. Standard Model
Welfare Change: Total Effect – Unique Price

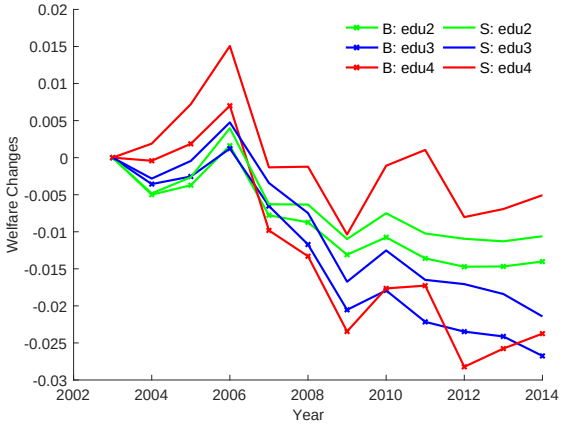


Figure 30: Becker vs. Standard Model
Welfare Change: Total Effect – Price varies by Edu

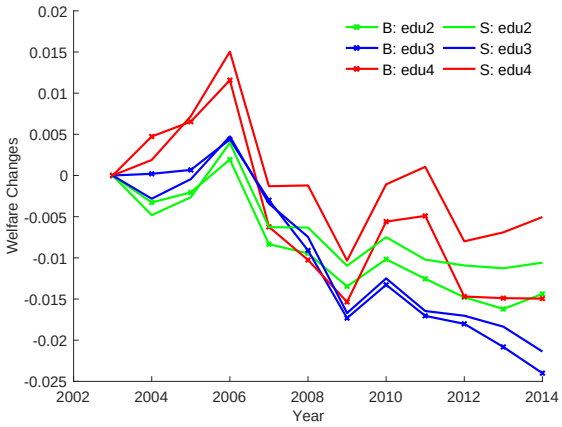
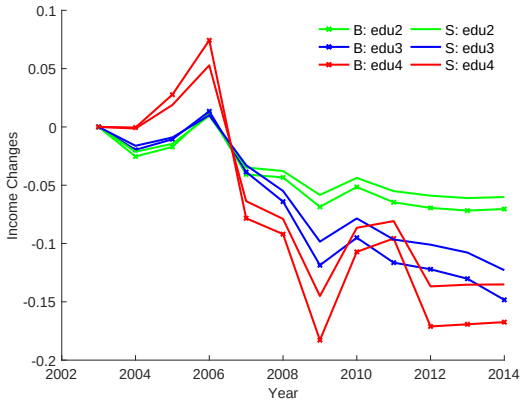
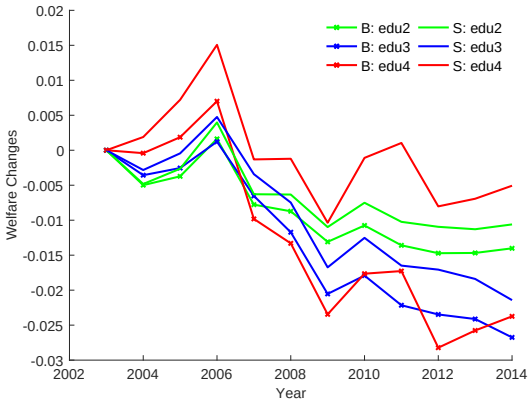


Figure 31: Becker vs. Standard Model
Income and Welfare Comparison – Unique Price

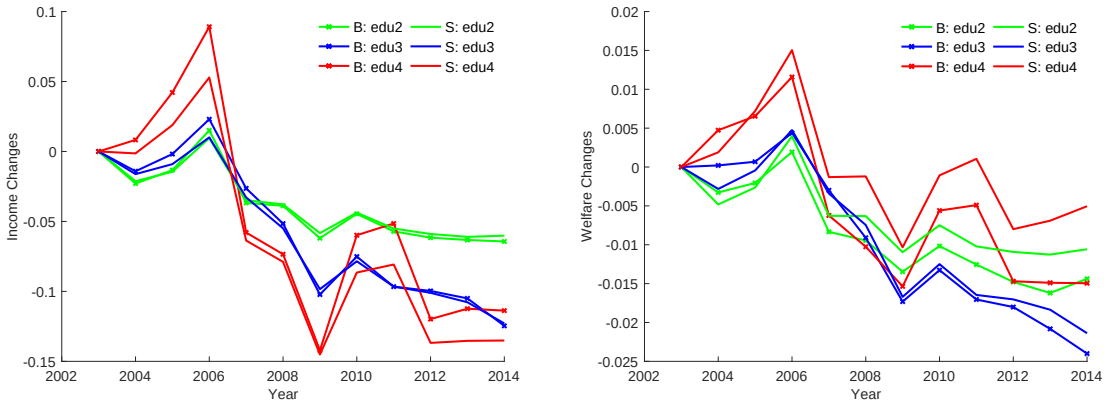


(a) Income



(b) Welfare

Figure 32: Becker vs. Standard Model
Income and Welfare Comparison – Price varies by Edu



(a) Income (b) Welfare

Figure 33: Becker vs. Standard Model
Welfare Change Relative to 2003: Wage Effect – Unique Price

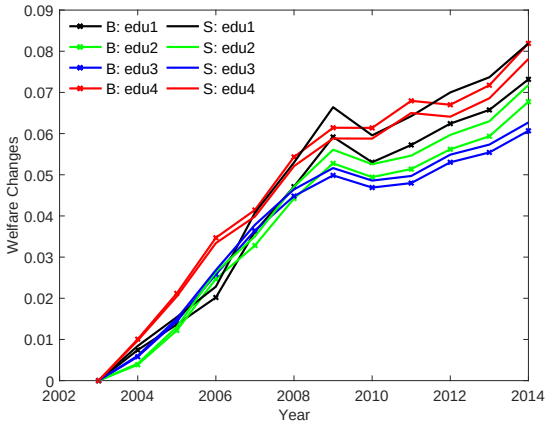


Figure 34: Becker vs. Standard Model
Welfare Change Relative to 2003: Wage Effect – Price varies by Edu

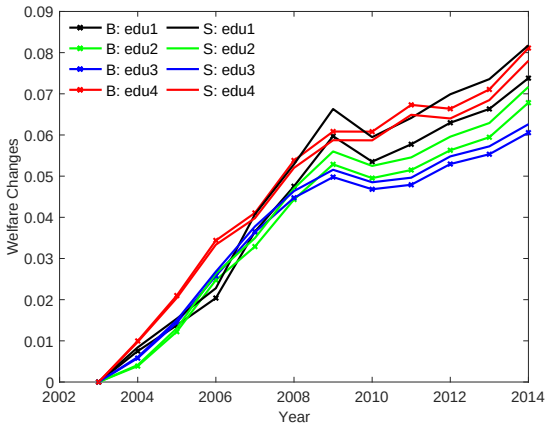


Figure 35: Becker vs. Standard Model
Welfare Change Relative to 2003: Total Effect – Unique Price

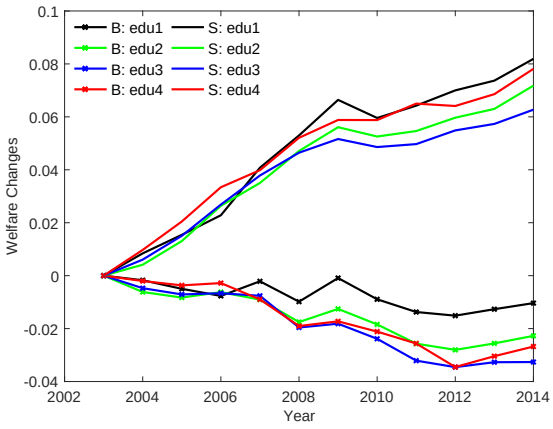


Figure 36: Becker vs. Standard Model
Welfare Change Relative to 2003: Total Effect – Price varies by Edu

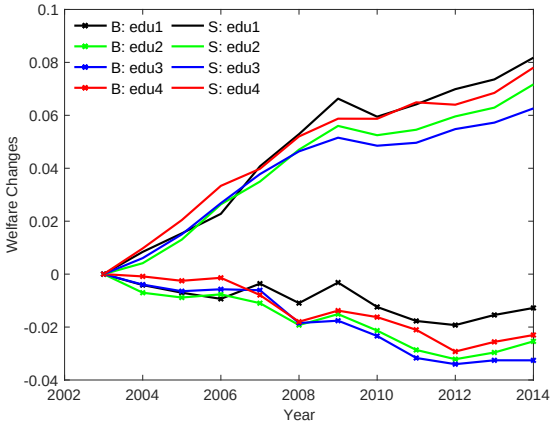


Figure 37: Becker vs. Multiple Goods Model
Welfare Change Relative to 2003: Wage Effect – Unique Price

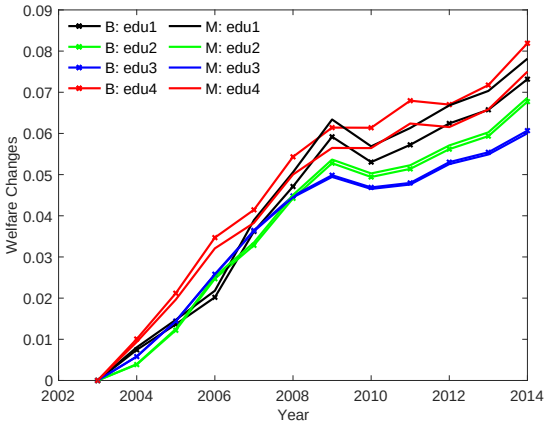


Figure 38: Becker vs. Multiple Goods Model
Welfare Change Relative to 2003: Wage Effect – Price varies by Edu

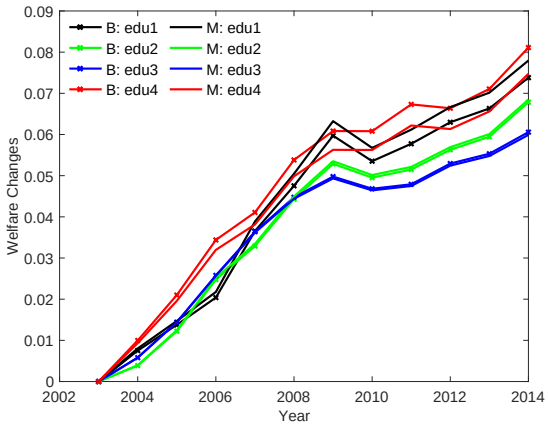


Figure 39: Becker vs. Multiple Goods Model
Welfare Change Relative to 2003: Total Effect – Unique Price

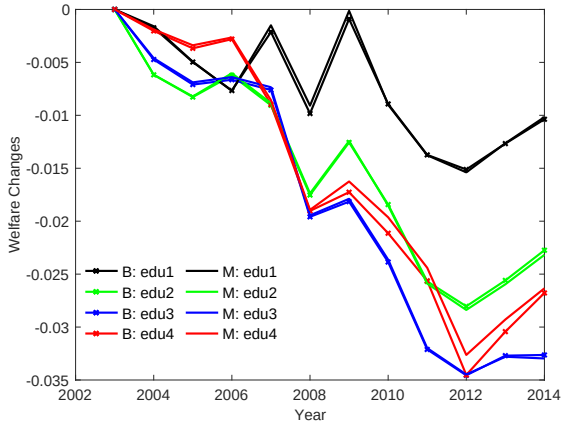


Figure 40: Becker vs. Multiple Goods Model
Welfare Change Relative to 2003: Total Effect – Price varies by Edu

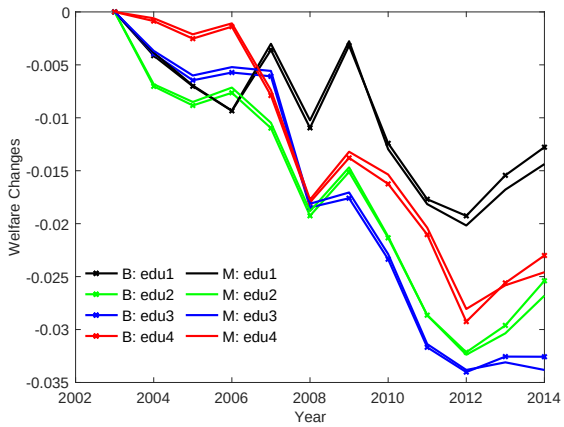
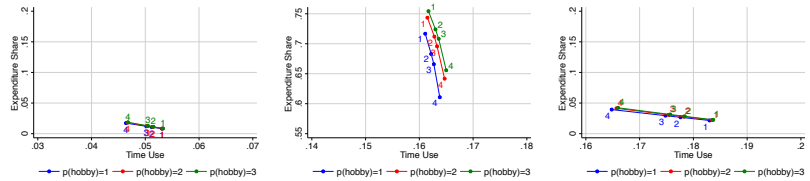
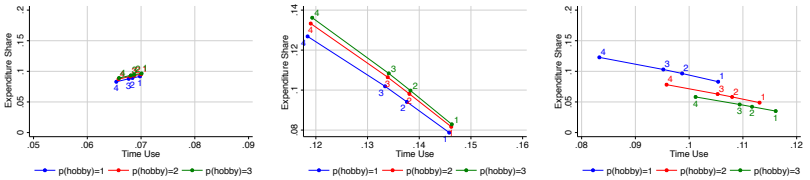


Figure 41: Responses of Allocations to Price Increases in Hobbies and Entertainment



(a) Childcare (b) Non-Market (c) Watching TV



(d) Socializing (e) Eating & Pcare (f) Luxury Leisure

Table 1: **Expenditure Share**

category	1960	1970	1980	1990	2000	2010	$\Delta_{2010-1960}$
Core consumption	0.62	0.58	0.53	0.56	0.52	0.53	-0.09
Transportation	0.15	0.21	0.26	0.19	0.2	0.18	0.03
Housing	0.21	0.21	0.21	0.25	0.28	0.28	0.07

Table 2: **Core Categories: Time Use and Expenditures by Education**

Category	Survey	1960	1970	1980	1990	2000	2010	Δ
				Less Than High School				
Market Work	Time Use	34.03	31.32	28.96	31.66	24.82	22.76	-11.27
	Expenditure	0.00	0.01	0.00	0.00	0.01	0.00	0.00
Child Care	Time Use	3.21	3.16	3.32	2.62	4.55	5.92	2.71
	Expenditure	0.00	0.01	0.01	0.01	0.01	0.01	0.01
Non-Market Work	Time Use	24.13	21.67	23.47	19.56	20.88	18.83	-5.30
	Expenditure	0.65	0.62	0.63	0.63	0.63	0.60	-0.05
Total Leisure	Time Use	104.51	108.58	109.75	111.88	113.10	114.82	10.31
	Expenditure	0.26	0.25	0.26	0.26	0.27	0.30	0.04
Other	Time Use	2.12	3.14	2.19	2.24	3.33	3.42	1.30
	Expenditure	0.09	0.11	0.10	0.09	0.09	0.09	0.00
Core Consumption	Time Use	-	-	-	-	-	-	-
	Expenditure	0.73	0.63	0.62	0.63	0.58	0.58	-0.15
				High School				
Market Work	Time Use	34.92	31.92	31.30	30.35	31.96	29.96	-4.96
	Expenditure	0.00	0.01	0.01	0.01	0.01	0.01	0.01
Child Care	Time Use	4.34	2.99	4.07	3.26	5.51	5.59	1.25
	Expenditure	0.00	0.01	0.02	0.02	0.02	0.02	0.02
Non-Market Work	Time Use	24.52	22.05	22.29	20.68	19.16	17.89	-6.63
	Expenditure	0.62	0.57	0.58	0.57	0.55	0.56	-0.06
Total Leisure	Time Use	101.30	107.66	107.49	110.17	107.03	109.22	7.92
	Expenditure	0.29	0.29	0.30	0.31	0.32	0.33	0.04
Other	Time Use	2.91	3.36	2.69	3.47	3.19	3.25	0.34
	Expenditure	0.10	0.11	0.09	0.10	0.10	0.10	0.00
Core Consumption	Time Use	-	-	-	-	-	-	-
	Expenditure	0.71	0.60	0.60	0.59	0.56	0.56	-0.15
				Some College				
Market Work	Time Use	36.82	32.97	34.05	33.33	32.68	32.12	-4.70
	Expenditure	0.00	0.02	0.01	0.01	0.01	0.01	0.01
Child Care	Time Use	2.95	3.31	3.15	3.53	5.24	5.04	2.09
	Expenditure	0.00	0.01	0.02	0.02	0.02	0.02	0.02
Non-Market Work	Time Use	21.90	20.05	21.97	19.76	18.49	17.09	-4.81
	Expenditure	0.59	0.53	0.53	0.53	0.50	0.50	-0.09
Total Leisure	Time Use	99.95	106.20	105.56	106.61	104.89	107.02	7.07
	Expenditure	0.30	0.32	0.34	0.33	0.35	0.35	0.05
Other	Time Use	6.39	5.14	3.21	4.73	5.17	4.50	-1.89
	Expenditure	0.11	0.12	0.10	0.10	0.12	0.12	0.01
Core Consumption	Time Use	-	-	-	-	-	-	-
	Expenditure	0.71	0.59	0.59	0.58	0.55	0.55	-0.16
				College and Above				
Market Work	Time Use	39.08	39.91	34.08	39.08	36.91	36.76	-2.32
	Expenditure	0.00	0.02	0.01	0.01	0.01	0.01	0.01
Child Care	Time Use	2.96	2.65	3.66	2.93	6.12	5.82	2.86
	Expenditure	0.00	0.01	0.02	0.02	0.02	0.03	0.03
Non-Market Work	Time Use	19.92	18.80	20.00	15.86	18.35	16.39	-3.53
	Expenditure	0.57	0.50	0.51	0.50	0.48	0.46	-0.11
Total Leisure	Time Use	101.12	102.32	105.79	106.56	101.17	102.50	1.38
	Expenditure	0.32	0.34	0.36	0.36	0.36	0.37	0.05
Other	Time Use	4.92	4.24	4.47	3.52	4.03	4.29	-0.63
	Expenditure	0.12	0.12	0.10	0.11	0.13	0.13	0.01
Core Consumption	Time Use	-	-	-	-	-	-	-
	Expenditure	0.68	0.58	0.57	0.56	0.52	0.53	-0.15

Notes: *Market Work* includes time spent on the job, other income-generating activities and job search. *Non-Market Work* includes home production, home ownership activities, obtaining goods and services and other care. *Total Leisure* includes watching TV, sleeping, eating and personal care, socializing and hobby and entertainment. *Other* includes education, civic and own medical. Expenditures are reported as fraction of core consumption expenditures, i.e. all expenditure that are assigned to categories with a direct time use counterpart.

Table 3: **Leisure Categories: Time Use and Expenditures by Education**

Category	Survey	1960	1970	1980	1990	2000	2010	Δ
				Less Than High School				
Watching TV	Time Use	13.31	16.68	18.54	21.82	22.69	22.97	9.66
	Expenditure	0.01	0.01	0.01	0.02	0.03	0.04	0.03
Socializing	Time Use	10.64	8.97	7.50	8.53	7.51	6.81	-3.83
	Expenditure	0.02	0.04	0.05	0.06	0.08	0.07	0.05
Sleep	Time Use	56.13	58.48	56.79	59.23	63.08	65.14	9.01
	Expenditure	0.01	0.01	0.00	0.00	0.00	0.00	-0.01
Eating & Pers. Care	Time Use	17.13	17.12	18.04	13.31	11.76	11.44	-5.69
	Expenditure	0.13	0.09	0.09	0.08	0.07	0.10	-0.03
Hobby & Entertainment	Time Use	7.30	7.32	8.89	8.99	8.06	8.46	1.16
	Expenditure	0.09	0.09	0.09	0.09	0.08	0.08	-0.01
Total Leisure	Time Use	104.51	108.58	109.75	111.88	113.10	114.82	10.31
	Expenditure	0.26	0.25	0.26	0.26	0.27	0.30	0.04
				High School				
Watching TV	Time Use	10.28	15.28	16.29	19.69	18.98	19.81	9.53
	Expenditure	0.01	0.02	0.02	0.02	0.03	0.04	0.03
Socializing	Time Use	11.73	9.33	8.42	7.72	7.79	7.42	-4.31
	Expenditure	0.02	0.05	0.06	0.06	0.07	0.07	0.05
Sleep	Time Use	54.07	57.65	55.30	57.62	59.40	61.65	7.58
	Expenditure	0.01	0.01	0.01	0.00	0.00	0.00	-0.01
Eating & Pers. Care	Time Use	16.73	15.56	17.46	15.01	12.55	12.22	-4.51
	Expenditure	0.15	0.11	0.11	0.10	0.09	0.11	-0.04
Hobby & Entertainment	Time Use	8.49	9.85	10.03	10.12	8.31	8.12	-0.37
	Expenditure	0.10	0.11	0.11	0.11	0.11	0.10	0.00
Total Leisure	Time Use	101.30	107.66	107.49	110.17	107.03	109.22	7.92
	Expenditure	0.29	0.29	0.30	0.31	0.32	0.33	0.04
				Some College				
Watching TV	Time Use	8.29	13.55	11.86	15.74	15.74	16.88	8.59
	Expenditure	0.01	0.01	0.02	0.02	0.03	0.04	0.03
Socializing	Time Use	11.21	9.24	8.55	8.17	7.62	7.56	-3.65
	Expenditure	0.03	0.05	0.06	0.06	0.07	0.07	0.04
Sleep	Time Use	54.04	56.53	55.80	57.15	58.39	60.30	6.26
	Expenditure	0.01	0.01	0.01	0.01	0.01	0.00	-0.01
Eating & Pers. Care	Time Use	16.89	17.84	16.94	15.17	13.38	13.00	-3.89
	Expenditure	0.15	0.12	0.14	0.12	0.11	0.13	-0.02
Hobby & Entertainment	Time Use	9.53	9.03	12.42	10.39	9.77	9.28	-0.25
	Expenditure	0.10	0.12	0.12	0.12	0.12	0.11	0.01
Total Leisure	Time Use	99.95	106.20	105.56	106.61	104.89	107.02	7.07
	Expenditure	0.30	0.32	0.34	0.33	0.35	0.35	0.05
				College and Above				
Watching TV	Time Use	6.96	11.29	11.52	13.85	12.23	13.12	6.16
	Expenditure	0.01	0.01	0.01	0.02	0.03	0.03	0.02
Socializing	Time Use	11.98	8.01	7.57	7.64	7.24	7.11	-4.87
	Expenditure	0.03	0.05	0.06	0.07	0.07	0.06	0.03
Sleep	Time Use	54.88	54.63	55.03	56.25	56.68	58.13	3.25
	Expenditure	0.01	0.01	0.01	0.01	0.00	0.00	-0.01
Eating & Pers. Care	Time Use	16.63	17.09	17.35	15.96	14.39	14.17	-2.46
	Expenditure	0.16	0.14	0.15	0.13	0.12	0.16	0.00
Hobby & Entertainment	Time Use	10.66	11.30	14.32	12.85	10.64	9.98	-0.68
	Expenditure	0.11	0.13	0.13	0.14	0.13	0.11	0.00
Total Leisure	Time Use	101.12	102.32	105.79	106.56	101.17	102.50	1.38
	Expenditure	0.32	0.34	0.36	0.36	0.36	0.37	0.05

Notes: The column Δ reports the difference between 2010 and 1960. Each cell displays the average and across all households in a given education group of time use and expenditure. All averages are computed using sample weights. In addition, day weights are applied to the time use data and equivalence scales to the expenditure data. Expenditures are reported as fraction of core consumption expenditures, i.e. all expenditure that are assigned to categories with a direct time use counterpart.

Table 4: Parameter Values

	Child	Non-market	TV	Social	Eat & Pcare	L Leisure
Beckerian Utility						
ξ	2.192	1.066	2.000	1.216	1.977	1.915
	(0.028)	(0.020)	(0.024)	(0.012)	(0.016)	(0.018)
κ	0.082	0.527	0.094	0.219	0.144	0.154
	(0.001)	(0.014)	(0.000)	(0.005)	(0.001)	(0.002)
α	0.071	0.309	0.195	0.107	0.177	
	(0.002)	(0.008)	(0.002)	(0.001)	(0.001)	
ρ	1.221					
	(0.028)					
Standard Utility						
σ	1.251					
	(0.011)					
ϕ	0.287					
	(0.005)					

Table 5: Model Fit – Expenditure

Educ	Child	Non-market	TV	Social	Eat & Pcare	Hobby & Ent
Expenditure Share – Data						
1	0.011	0.674	0.039	0.085	0.099	0.091
2	0.015	0.614	0.045	0.085	0.119	0.122
3	0.020	0.577	0.042	0.084	0.141	0.136
4	0.027	0.549	0.037	0.076	0.162	0.149
Expenditure Share – Model						
1	0.013	0.655	0.031	0.087	0.107	0.107
2	0.017	0.617	0.038	0.083	0.124	0.120
3	0.018	0.599	0.042	0.082	0.132	0.126
4	0.025	0.544	0.054	0.076	0.156	0.143

Table 6: Model Fit – Time

Educ	Child	Non-market	TV	Social	Eat & Pcare	Hobby & Ent
Time – Data						
1	0.047	0.173	0.203	0.064	0.102	0.069
2	0.040	0.165	0.181	0.066	0.112	0.078
3	0.042	0.160	0.148	0.067	0.119	0.085
4	0.051	0.153	0.114	0.061	0.129	0.094
Time – Model						
1	0.049	0.163	0.173	0.067	0.130	0.093
2	0.047	0.164	0.166	0.066	0.120	0.085
3	0.045	0.164	0.162	0.065	0.115	0.081
4	0.040	0.164	0.149	0.062	0.097	0.068

A Definition of time use and consumption expenditure categories

The individual data from the American Time Use Survey (ATUS) and the Consumer Expenditure Survey (CES) cannot be linked at the micro-level. We therefore impose a common structure onto both surveys to compare the time spent on household activities with their associated expenditures. First, we limit the sample in both surveys to reference persons between 21 and 65 years of age. In doing so, we try to exclude students as well as retirees, whose time allocation decisions have a strong intertemporal component to it. Second, we restrict the sample to people who are “in the labor force". In the ATUS, this includes the employed, people absent from work, as well as unemployed people either on layoff or looking for a job. The CES 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 report to have worked at least one week, we include them in our sample.

The time use categories proposed by Aguiar and Hurst (2007) provide a natural starting point for our analysis. Three major categories account for 93% - 96% of the total time use and for 79% - 89% of total expenditures: “Market Work", “Non-market work" and “Leisure". “Non-market work" activities include home production, home ownership activities, obtaining goods and services as well as care for others. “Leisure" summarizes time spent watching TV, socializing, sleeping, eating and personal care, and hobby and entertainment. The categories “Child Care" and “Other" play a negligible role in the overall time allocation and account for at most 20% of total expenditures. The bulk of these expenditures can be attributed to education or own medical care.

To compare results across surveys, we define consumption expenditure categories that match the time use categories as closely as possible. With the exception of “Other Income-generating Activities" and “Job Search", we are able to define an expenditure category for every time use category. The CES also collects information on the purchase and sale of assets. We group information about investments into housing or the usage and purchase of vehicles into five additional categories. These expenditures are reported separately, as they cannot be linked to a particular activity. Notice that the additional expenditure categories only contain outlays related to the acquisition of new assets. Expenditures associated with the maintenance or repair of goods, that the CU already owns, are matched with a corresponding time use category.

Table 7 summarizes and contrasts the categories for both surveys.

Category	Time Use Surveys	CES
I. Matched Time Use and Expenditure categories		
Total Market Work	Market Work Other Income-Generating Activities Job Search	Market Work
Child Care	Child Care	Child Care
Non-market Work	Core Home Production Home Ownership Obtaining goods and services Other Care	Core Home Production Home Ownership Obtaining goods and services Other Care
Leisure	Watching TV Socializing Sleep Eating and Personal Care Hobby and Entertainment	Watching TV Socializing Sleep Eating and Personal Care Hobby and Entertainment
Other	Education Civic Own Medical Unclassified	Education Own Medical
II. Additional Expenditure categories		
		Transportation Ownership Transportation Usage Housing Home Investment Real Home Investment Financial

Table 7: **Comparison of categories across surveys**

B Time Use Surveys 1965-2014

We closely follow the method of Aguiar and Hurst (2007) to compute time use averages for each category across surveys. We drop observations if the respondent is a student or retired. We further limit the age of the respondent to be between 21 and 65 years of age. Finally, we only consider responses with a complete time use diary. The table below reports the initial sample size for each survey as well as the size of the sample used for analysis. In the paper, we refer to the decade in which the survey was conducted instead of the actual survey year due to the differences between the Time use surveys and CEX in the 1960's and 1970's.

B.1 Americans' Use of Time 1965-66

B.2 Time Use in Economic and Social Accounts 1975-76

This survey consists of four waves with time use responses for both the survey respondent and the spouse. Following Aguiar and Hurst (2007), we restrict the

Survey	Survey period	Total sample	Analysis sample
Americans' Use of Time	1965-66	2,001	1,854
Time Use in Economic and Social Accounts	1975-76	2,399	1,673
Americans' Use of Time	1985	4,939	1,370
National Human Activity Pattern Survey	1992-1994	9,190	5,347
American Time Use Survey	2003-04	34,693	25,138
American Time Use Survey	2013-14	22,977	16,040

Notes: Analysis sample refers to the number of observations from each survey used to generate the time use averages reported in the paper.

Table 8: **Sample Size of Time Use Surveys**

analysis to the first survey wave and only use data from survey respondents (not spouses) due to the high attrition rate in subsequent interviews.

B.3 Americans' Use of Time 1985

B.4 National Human Activity Pattern Survey 1992-1994

The National Human Activity Pattern Survey does not contain any information on household income and wages or the type of household that the respondent lives in. Hence, we drop this survey from the analysis when

B.5 American Time Use Survey 2003-2014

Following Aguiar, Hurst and Karabarbounis (2013), we divide the total time for every individual in the American Time Use Survey into 17 categories. These categories can be aggregated into three major time use categories: "Market Work", "Non-market Work" and "Leisure". Individuals allocate less than 7% of their time to "Child Care" and "Other" activities. The ATUS indicates whether a time diary was recorded on a weekday or a weekend (or holiday). o obtain a representative estimate of the weekly time allocated to one activity, we weight weekday records by $\frac{5}{7}$ and weekend or holiday records by $\frac{2}{7}$. Table 9 documents the underlying ATUS activity codes for every category.

The ATUS data can be supplemented with information from the Current Population Survey (CPS). A subset of households interviewed in the CPS are selected to participate in the ATUS. If a household is selected, one individual keeps a time diary. We combine the time use data with information on household earnings from the CPS. However, the CPS interview is conducted two to five months prior to the ATUS interview and, in some cases, might not reflect current household earnings.

Category	ATUS activity code
Market Work	05-01, 05-02, 05-99, 18-05-01, 18-05-02, 18-05-99
Other Income-Generating Activities	05-03, 18-05-03
Job Search	05-04, 18-05-04
Child Care	03-01, 03-02, 03-03, 04-01, 04-02, 04-03, 18-03-01, 18-03-02, 18-03-03, 18-04-01, 18-04-02, 18-04-03
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
Home Ownership Activities	02-03-01, 02-04, 02-05, 18-02-04, 18-02-05
Obtaining Goods and Services	07, 08 (excl. 08-04), 09,10, 18-07, 18-08 (excl. 18-08-04), 18-09, 18-10
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
TV Watching	12-03-03, 12-03-04
Socializing	12-01, 12-02, 12-03-07, 12-05-01, 12-05-02, 16, 18-12-01, 18-12-02, 18-16
Sleep	01-01
Eating and Personal Care	01-02, 01-04, 01-05, 01-99, 11, 18-01, 18-11
Hobby 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
Education	06, 18-06
Civic	14, 15, 18-14, 18-15
Own Medical	01-03, 08-04, 18-08-04
Unclassified	50, 18-18, 18-19

Table 9: **ATUS 2003-14 categorization**

C Consumer Expenditure Survey

The Consumer Expenditure Survey 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 month 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 interview 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. Only CUs that report to be “in the labor force" are part of this study.

The CES 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. We re-classify these codes by expenditure purpose to construct 14 consumption expenditure categories and four investment categories. 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 our expenditure categories. For every summary variable, we check the underlying UCCs and, if necessary, refine the categorization. Table 11 provides a description of the expenditures associated with each category, while table 12 documents the corresponding UCCs.

Our derived consumption expenditure measures differ from the ones computed by the Bureau of Labor Statistics (BLS) along certain dimensions. First, we ignore any of the expenditures reported in the ITBI files. The BLS accounts for cash contributions for person in the CU (UCC 800801), gifts, contributions to charity and other organizations as well as any kind of deduction (UCC 800810-800940). Since to goal of our analysis is to match consumption expenditures to activities, we abstract from these expenditures entirely. Second, the BLS defines any investments into housing as changes in household assets. The associated expenditures are not included in total consumption expenditures. In contrast, we include a subset of these reported expenditures into our investment categories 20 and 21. Due to these differences, our derived measures for total consumption expenditures deviates from the BLS provided measure.

The expenditure categories without a time-use counterpart (category 17 to 21) can contain UCCs that represent movements in asset positions. This is typically the case for category 20 and 21, which capture real and financial investment into housing.

CES Category	**Description of variables**
I. 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. Child Care	Infant’s equipment; babysitting and child day care; school books for day care centers and nursery schools; school meals for preschool and school age children

3. 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)
4. 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
5. Clothing	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
6. Other Care	Care for invalids or elderly persons; adult care centers; care in nursing home (net outlay)
7. TV	Cable services; TVs; video streaming; satellite dishes; repair, rental and installation of TV and satellite equipment
8. Socializing	Catered affairs; live entertainment; party supplies; telephone services and devices; watches; jewelry; dating services
9. Sleep	Bedroom linens; mattresses and new springs; nightwear
10. 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
11. Hobby 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
12. Education	Food or board at school; housing at school; private school bus; educational expenses such as tuition and school books (excl. books for day care center); encyclopedia; test prep and tutoring services; support for college students
13. Own Medical	prescription drugs; health insurance; medical services (excl. care in nursing home); medical supplies

14. Transportation Usage	Gasoline and motor oil, maintenance and repairs and vehicle insurance for any type of vehicle; public transportation; vehicle registration; driver's license; vehicle inspection; auto and truck or van rental; lease charges; parking fees; tolls; vehicle equipment and services; GPS; automobile club membership
II. Investments	
15. Transportation Ownership	Outlays for new, used and other vehicle purchases; outlays for motored and non-motored recreational vehicles
16. Housing	Rent of dwelling; ground rent; fire and extended coverage insurance; homeowners' insurance; property taxes; mortgage interest; parking; rent as pay
17. Home Investment Real	Original carpeting; addition, alteration or new construction of dwellings; New dishwasher, garbage disposal or range hood; Management, security, parking; special assessment fees
18. Home Investment Financial	Closing costs, special mortgage payments; reduction of mortgage principal; reduction of principal on home equity loan; special assessment for roads, streets

Table 11: **Definition of CES categories**

CES Category	**Universal Classification Codes (UCCs)**
I. Expenditures	
1. Market Work	320901 360110 360901 380510 380902 690115 800700 900002
2. Child Care	320130 340211 340212 660901 670310 660900 790430
3. 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
4. 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

5. Clothing	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
6. Other Care	340906 340910 570220
7. TV	270310 310110 310120 310130 310140 310240 310334 340610 340902 690320 690330
8. Socializing	190902 270101 270102 270103 270104 270105 320232 430110 430120 680310 680320 680904 690210
9. Sleep	280120 290110 360320 370212 380410 390310 410140
10. Eating and Personal Care	640130 640420 650110 650210 650310 650900 190903 190904 200900 790310 790320 790330 790410 790420
11. Hobby 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
12. Education	190901 210310 530902 660110 660210 660310 660410 660902 670110 670210 670410 670901 670902 670903 800804
13. Own Medical	540000 550110 550320 550330 550340 560110 560210 560310 560330 560400 570110 570111 570210 570230 570240 570901 570903 580111 580112 580113 580114 580311 580312 580400 580901 580903 580904 580905 580906 580907
14. Transportation Usage	450311 450411 470111 470112 470113 470211 470212 470220 480110 480213 480214 490110 490211 490212 490221 490231 490232 490311 490312 490313 490314 490318 490319 490411 490412 490413 490501 490502 490900 500110 520110 520111 520112 520310 520410 520511 520512 520521 520522 520531 520532 520542 530110 530210 530311 530312 530411 530412 530510 530901 480212 480215 520541 520550 520560 620113
II. Investments	
15. Transportation Ownership	870101 870102 870103 870104 870201 870202 870203 870204 870301 870302 870303 870304 870401 870402 870403 870404 870501 870502 870503 870504 870605 870606 870607 870608 870701 870702 870703 870704 870801 870802 870803 870804
16. Housing	210110 210901 210902 220111 220112 220121 220122 220211 220212 220311 220312 220901 220902 350110 800710

17. Home Investment Real	220511 220512 220513 220611 220612 220615 220616 220614 790600 790610 790611 790620 790630 790640
18. Home Investment Financial	790730 790910* 790920* 790940* 810301 810302 830101* 830102* 830201* 830202* 830203* 830204* 840101 840102 880120* 880220* 880320*

Table 12: CES categorization

Notes: UCCs change across survey waves. 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. We exclude UCC 790220 (Food and nonalcoholic beverage purchases at grocery stores) as it is a subset of UCC 790210 (Total purchases at grocery stores). We also exclude UCC 790240 (Average food and non-alcoholic beverage expenses) to avoid double counting of expenditures. To approximate expenditures related to the purchase of vehicles, we use UCCs 870101-870804. Since UCCs 450110-460908 also report costs associated with vehicle acquisitions, we drop them. A small set of expenditures are reported as negative values. The associated UCCs are indicated with a star. Hence, all expenditures in category 18 are converted to negative values such that expenses do not cancel out when being summed up.

C.0.1 Consumer Expenditure Survey 1960-61

The 1960 Consumer Expenditure Survey samples both urban, non-farm and rural, farm households in an attempt to provide a complete picture of consumer expenditures in the United States. Personal interviews were conducted in 1960 and 1961 (and a small number in 1959) with 9,476 urban families, 2,285 rural non-farm families, and 1,967 rural farm families, for a total of 13,728 consumer units interviewed. We only have access to the Public-use summary files instead of the detailed expenditure files. In these summary files, expenses are not reported at the UCC level, but in the form of summarized categories. We do our best to match these summary variables consistently with our pre-defined expenditure categories. However, individual expenditure categories might not be matched perfectly with the categorization that uses UCC codes. In particular, the categories 'Market Work', 'Child Care' and 'Other Care' have no counterpart in the Public-use summary files. Even though expenses might not be matched perfectly across all 18 expenditure categories, we are confident in the match with the more comprehensive expenditure categories 'Non-Market Work', 'Leisure' and 'Other'. Notice that the expenditures assigned to 'Leisure' subcategories such as 'TV', 'Sleep' or 'Hobby and Entertainment' correspond with other survey years, except for expenditures on luggage items. In the 1960's survey, luggage is part of a summary category which is assigned to Core Home Production. All expenditures are reported annually.

Survey	Survey period	Reporting	Total sample	Analysis sample
Consumer Expenditure Survey	1960-61	annual	13,728	11,180
	1972-73	annual	19,975	15,916
	1985	monthly	68,519	15,884
	1993/1994	monthly	136,916	36,757
	2003/2004	monthly	205,792	51,808
	2012/2013	monthly	172,803	37,916

Notes: Analysis sample refers to the number of observations from each survey used to generate the consumption expenditure averages reported in the paper.

Table 10: **Sample Size of Consumer Expenditure Surveys**

C.0.2 Consumer Expenditure Survey 1972-73

The Consumer Expenditure Survey conducted in the 1970's reports expenditures at a level of detail that cannot met by any of the previous or adjacent survey waves. Expenditures are classified into approximately 2,600 UCCs (instead of 600 as in the 1980's or in recent survey years). Gifts to consumers outside the CU are reported on a very detailed level and aggregated to one single UCC in later survey waves. We exclude all gift expenditures across survey waves as these expenditures are not immediate consumption expenditures of the CU itself. Similarly, we exclude all items received without direct expense by the CU (Group 32). The quarterly interview covers annual expenditures for the calendar year 1972 and 1972

C.0.3 Consumer Expenditure Survey 1985

The Detailed expenditure files of the 1985 wave report expenditures classified into approximately 600 UCCs that are roughly comparable with the most recent Consumer Expenditure Survey files. Notice, however, that the same categories in the more recent waves have UCCs different from the ones used in 1985.

D Linking the results from both surveys

We compare the time allocated to a particular activity and the associated expenditures by partitioning the data of both surveys along the same dimensions. First, we split both samples into five age groups: 21-29, 30-39, 40-49, 50-59, 60-65. The CES reports the age of the reference person in the FMLI files. We merge the data with the MTBI files to compute average expenditures within each age group. In the ATUS, we use the age of the reference person.

Next, we structure the data according to the highest level of educational attainment: less than high school, high school, some college, bachelor, master or

doctorate. In both the ATUS and the CES, the highest level of educational attainment of the reference person determines which education bin the CU is assigned to.

Third, we partition the data by household income. In the ATUS, the combined income of all family members during the last 12 month is reported in bins and not as a continuous variable. We therefore use a two step procedure to create four income groups. We limit household income to four groups because the Time Use survey in 1985 divides income into four income groups only. Notice that the 1990 Time Use survey does not report information on household income at all. We eliminate this survey from the part of the analysis that requires household income information. To construct income groups, we first use the continuous information on family income before taxes from the CEX to construct the 25th, 50th and 75th income percentile in each survey year, accounting for survey weights.

Following Aguiar and Hurst (2007), we construct constant population weights to account for changes in the demographic composition of the population between 1960 and 2010. First, we pool data from all survey years for each survey. Then, we divide both surveys into 36 demographic cells using five age groups (21-29, 30-39, 40-49, 50-59, 60-65), four education groups (Less than high school, High school, Some college, College and above) and whether or not a child lives in the household. Due to the limited number of observations of households that have a child present at the age of 60-65, we do not distinguish these households with respect to the presence of a child. The ATUS interviews one individual of each household, so we simply use the respondent's information to create the demographic cells. The CEX reports expenditures at the household level. We apply the OECD equivalence scale (Oxford scale) to the CEX data to derive the expenditures for an average adult in the household. Next, we create 36 demographic cells according to the characteristics outlined above.

E Model Solution

E.1 Beckerian Preferences

The utility function is $U(C_j) = log(C_j)$, where

$$C_j = \left(\sum_i \alpha_i c_{ij}^{\frac{\rho-1}{\rho}} \right)^{\frac{\rho}{\rho-1}} \tag{5}$$

$$c_{ij} = \left(\kappa_i x_{ij}^{\frac{\xi_i-1}{\xi_i}} + (1-\kappa_i) \ell_{ij}^{\frac{\xi_i-1}{\xi_i}} \right)^{\frac{\xi_i}{\xi_i-1}} \tag{6}$$

The budget constraint is:

$$\sum_i p_{ij}x_{ij} = w_j(1 - \sum_i \ell_{ij}). \tag{7}$$

Each type of household maximizes utility subject to the budget constraint. Let λ_j be the lagrangian multiplier. The F.O.Cs are as follows:

$$\frac{\partial U}{\partial c_{ij}}\frac{\partial c_{ij}}{\partial x_{ij}} = \lambda_j p_{ij} \tag{8}$$

$$\frac{\partial U}{\partial c_{ij}}\frac{\partial c_{ij}}{\partial \ell_{ij}} = \lambda_j w_j \tag{9}$$

Taking the ratio between these two equations gives:

$$\frac{\ell_{ij}}{x_{ij}} = \left(\frac{p_{ij}}{w_j}\right)^{\xi_i}\left(\frac{1-\kappa_i}{\kappa_i}\right)^{\xi_i}. \tag{10}$$

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

$$c_{ij} = x_{ij}\kappa_i^{\frac{\xi_i}{\xi_i-1}}\left(1 + \frac{1-\kappa_i}{\kappa_i}(\frac{\ell_{ij}}{x_{ij}})^{\frac{\xi_i-1}{\xi_i}}\right)^{\frac{\xi_i}{\xi_i-1}}. \tag{11}$$

Plugging equation 10 into the above equation gives:

$$c_{ij} = x_{ij}\kappa_i^{\frac{\xi_i}{\xi_i-1}}\left(1 + (\frac{1-\kappa_i}{\kappa_i})^{\xi_i}(\frac{p_{ij}}{w_j})^{\xi_i-1}\right)^{\frac{\xi_i}{\xi_i-1}} \tag{12}$$

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

From equation 8, we can derive the following equation between activity i and activity 1:

$$\frac{\frac{\partial U}{\partial c_{1j}}\frac{\partial c_{1j}}{\partial x_{1j}}}{\frac{\partial U}{\partial c_{ij}}\frac{\partial c_{ij}}{\partial x_{ij}}} = \frac{p_{1j}}{p_{ij}}. \tag{13}$$

Plugging in the partial derivatives gives:

$$\frac{\alpha_1 c_{1j}^{\frac{-1}{\rho}}(\frac{c_{1j}}{x_{1j}})^{\frac{1}{\xi_1}}\kappa_1}{\alpha_i c_{ij}^{\frac{-1}{\rho}}(\frac{c_{ij}}{x_{ij}})^{\frac{1}{\xi_i}}\kappa_i} = \frac{p_{1j}}{p_{ij}}. \tag{14}$$

Plugging $c_{ij} = M_{ij}x_{ij}$ into the above equation gives:

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

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 (10) give ℓ_{ij} as a function of x_{1j}:

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

The budget constraint can be rewritten as follows:

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

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

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

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

E.1.1 Deriving the Aggregate Price

Using $c_{ij} = M_{ij}x_{ij}$ and (15):

$$\frac{c_{ij}}{c_{1j}} = \left(\frac{p_{1j}}{p_{ij}}\right)^{\rho} \left(\frac{\alpha_i\kappa_i}{\alpha_1\kappa_1}\right)^{\rho} \frac{M_{ij}^{\frac{\rho}{\xi_i}}}{M_{1j}^{\frac{\rho}{\xi_1}}}. \tag{20}$$

The ratio for consumption between any two activities will have a similar form as (20). C_j can be rewritten as follows:

$$C_j = \left[\alpha_1 c_{1j}^{\frac{\rho-1}{\rho}} \sum_i \frac{\alpha_i}{\alpha_1}\left(\frac{c_{ij}}{c_{1j}}\right)^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}} \tag{21}$$

Using (20), C_j can be further rewritten as:

$$C_j = \alpha_1^{\frac{\rho}{\rho-1}} \left[\sum_i \left(\frac{\alpha_i}{\alpha_1} \right)^{\rho} \left(\frac{p_{1j}\kappa_i M_{ij}^{\frac{1}{\xi_i}}}{p_{ij}\kappa_1 M_{1j}^{\frac{1}{\xi_1}}} \right)^{\rho-1} \right]^{\frac{\rho}{\rho-1}} c_{1j}. \tag{22}$$

Let $G_{1j} = \alpha_1^{\frac{\rho}{\rho-1}} \left[\sum_i \left(\frac{\alpha_i}{\alpha_1} \right)^{\rho} \left(\frac{p_{1j}\kappa_i M_{ij}^{\frac{1}{\xi_i}}}{p_{ij}\kappa_1 M_{1j}^{\frac{1}{\xi_1}}} \right)^{\rho-1} \right]^{\frac{\rho}{\rho-1}}$. We have $C_j = G_{1j}c_{1j}$. Similarly $C_j = G_{ij}c_{ij}$ where G_{ij} has a similar form as G_{1j}.

Using $C_j = G_{ij}c_{ij}$ and $c_{ij} = M_{ij}x_{ij}$, the budget constraint can be written as

$$\sum_i p_{ij}x_{ij} \equiv \sum_i p_{ij} \frac{C_j}{M_{ij}G_{ij}} = w_j(1 - \sum_i \ell_{ij}). \tag{23}$$

$$C_j \sum_i \frac{p_{ij}}{M_{ij}G_{ij}} = w_j(1 - \sum_i \ell_{ij}). \tag{24}$$

Define the aggregate price $P_j = \sum_i \frac{p_{ij}}{M_{ij}G_{ij}}$. Because M_{ij} depends on the wage rate of education group j, P_j will also be education specific.

E.2 Standard Preferences – CES

The utility function is $U(C_j^s) = log(C_j^s)$, where

$$C_j^s = \left(\phi (x_j^s)^{\frac{\sigma-1}{\sigma}} + (1-\phi)(\ell_j^s)^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \tag{25}$$

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

$$x_j^s = w_j(1 - \ell_j^s) \tag{26}$$

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

$$(C_j^s)^{\frac{1}{\sigma}} \phi (x_j^s)^{-\frac{1}{\sigma}} = \lambda_j^s \tag{27}$$

$$(C_j^s)^{\frac{1}{\sigma}} (1-\phi)(\ell_j^s)^{-\frac{1}{\sigma}} = \lambda_j^s w_j \tag{28}$$

The ratio between these two equations gives:

$$\frac{\ell_j^s}{x_j^s} = \left(\frac{1}{w_j} \right)^{\sigma} \left(\frac{1-\phi}{\phi} \right)^{\sigma} \tag{29}$$

Plug equation (29) into the budget constraint gives:

$$x_j^s = \frac{w_j}{1 + (w_j)^{1-\sigma}\left(\frac{1-\phi}{\phi}\right)^{\sigma}} \tag{30}$$

E.2.1 Deriving the Aggregate Price

Plug equation (29) into the definition of C_j^s:

$$C_j^s = \phi^{\frac{\sigma}{\sigma-1}}\left[1 + \left(\frac{1-\phi}{\phi}\right)^{\sigma}\left(\frac{1}{w_j}\right)^{\sigma-1}\right]^{\frac{\sigma}{\sigma-1}} x_j^s \tag{31}$$

Define $Q_j^s = \phi^{\frac{\sigma}{\sigma-1}}\left[1 + \left(\frac{1-\phi}{\phi}\right)^{\sigma}\left(\frac{1}{w_j}\right)^{\sigma-1}\right]^{\frac{\sigma}{\sigma-1}}$. Then, $C_j^s = Q_j^s x_j^s$. Define $P_j^s = \frac{1}{Q_j^s}$. We can then rewrite the budget constraint as:

$$P_j^s C_j^s = \frac{C_j^s}{Q_j^s} = x_j^s = w_j(1 - \ell_j^s) \tag{32}$$

E.3 Standard Preferences with Multiple Goods – CES

The utility function is $U(C_j^s) = log(C_j^s)$, where

$$C_j^s = \left(\phi(X_j^s)^{\frac{\sigma-1}{\sigma}} + (1-\phi)(\ell_j^s)^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}} \tag{33}$$

$$X_j^s = \left(\sum_i \mu_i (x_{ij}^s)^{\frac{\eta-1}{\eta}}\right)^{\frac{\eta}{\eta-1}} \tag{34}$$

The budget constraint is:

$$\sum_i p_{ij} x_{ij}^s = w_j(1 - \ell_j^s). \tag{35}$$

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

$$\frac{\partial U}{C_j^s}\frac{\partial C_j^s}{\partial X_j^s}\frac{\partial X_j^s}{\partial x_{ij}^s} = \lambda_j^s p_{ij} \tag{36}$$

$$\frac{\partial U}{C_j^s}\frac{\partial C_j^s}{\partial \ell_j^s} = \lambda_j^s w_j \tag{37}$$

Using (36) between activity i and activity 1, $\frac{x_{ij}^s}{x_{1j}^s}$ can be derived as follows.

$$\frac{\frac{\partial X_j^s}{\partial x_{1j}^s}}{\frac{\partial X_j^s}{\partial x_{ij}^s}} = \frac{\mu_1 (x_{1j}^s)^{-\frac{1}{\eta}}}{\mu_i (x_{ij}^s)^{-\frac{1}{\eta}}} = \frac{p_{1j}}{p_{ij}}, \tag{38}$$

$$\frac{x_{ij}^s}{x_{1j}^s} = \left(\frac{p_{1j}}{p_{ij}}\right)^{\eta} \left(\frac{\mu_i}{\mu_1}\right)^{\eta}. \tag{39}$$

Plugging (39) into the expression for X_j^s gives:

$$X_j^s = \mu_1^{\frac{\eta}{\eta-1}} \left[\sum_i \left(\frac{\mu_i}{\mu_1}\right)^{\eta} \left(\frac{p_{1j}}{p_{ij}}\right)^{\eta-1}\right]^{\frac{\eta}{\eta-1}} x_{1j}^s. \tag{40}$$

Define $M_j^s = \mu_1^{\frac{\eta}{\eta-1}} \left[\sum_i \left(\frac{\mu_i}{\mu_1}\right)^{\eta} \left(\frac{p_{1j}}{p_{ij}}\right)^{\eta-1}\right]^{\frac{\eta}{\eta-1}}$. Hence $X_j^s = M_j^s x_{1j}^s$.

Taking ratio between (36) for activity 1 and (37) gives:

$$\frac{\frac{\partial C_j^s}{\partial X_j^s}\frac{\partial X_j^s}{\partial x_{1j}^s}}{\frac{\partial C_j^s}{\partial \ell_j^s}} = \frac{\phi (X_j^s)^{-\frac{1}{\sigma}} \mu_1 \left(\frac{X_j^s}{x_{1j}^s}\right)^{\frac{1}{\eta}}}{(1-\phi)(\ell_j^s)^{-\frac{1}{\sigma}}} = \frac{p_{1j}}{w_j}, \tag{41}$$

$$\ell_j^s = \left(\frac{p_{1j}}{w_j}\right)^{\sigma} \left(\frac{1-\phi}{\phi\mu_1}\right)^{\sigma} (M_j^s)^{\frac{\eta-\sigma}{\eta}} x_{1j}^s. \tag{42}$$

Plugging (39) and (42) into the budget constraint gives:

$$x_{1j}^s = \frac{w_j}{w_j \left(\frac{p_{1j}}{w_j}\right)^{\sigma} \left(\frac{1-\phi}{\phi\mu_1}\right)^{\sigma} (M_j^s)^{\frac{\eta-\sigma}{\eta}} + \sum_i p_{ij} \left(\frac{p_{1j}}{p_{ij}}\right)^{\eta} \left(\frac{\mu_i}{\mu_1}\right)^{\eta}}. \tag{43}$$

E.3.1 Derive the Aggregate Price

Plugging (42) and $X_j^s = M_j^s x_{1j}^s$ into the expression for C_j^s gives:

$$C_j^s = \phi^{\frac{\sigma}{\sigma-1}} \left[1 + \left(\frac{1-\phi}{\phi}\right)^{\sigma} \mu_1^{1-\sigma} \left(\frac{p_{1j}}{w_j}\right)^{\sigma-1} (M_j^s)^{\frac{1-\sigma}{\eta}}\right]^{\frac{\sigma}{\sigma-1}} M_j^s x_{1j}^s. \tag{44}$$

Define $G_j^s = \phi^{\frac{\sigma}{\sigma-1}} \left[1 + \left(\frac{1-\phi}{\phi}\right)^{\sigma} \mu_1^{1-\sigma} \left(\frac{p_{1j}}{w_j}\right)^{\sigma-1} (M_j^s)^{\frac{1-\sigma}{\eta}}\right]^{\frac{\sigma}{\sigma-1}} M_j^s$. Hence $x_{1j}^s = \frac{C_j^s}{G_j^s}$ and $x_{ij}^s = \frac{C_j^s}{G_j^s} \left(\frac{p_{1j}}{p_{ij}}\right)^{\eta} \left(\frac{\mu_i}{\mu_1}\right)^{\eta}$. The budget constraint can then be rewritten as:

$$C_j^s \sum_i \frac{p_{ij}}{G_j^s} \left(\frac{p_{1j}}{p_{ij}}\right)^{\eta} \left(\frac{\mu_i}{\mu_1}\right)^{\eta} = w_j(1-\ell_j^s). \tag{45}$$

Define the aggregate price as $P_j^s = \sum_i \frac{p_{ij}}{G_j^s} \left(\frac{p_{1j}}{p_{ij}}\right)^{\eta} \left(\frac{\mu_i}{\mu_1}\right)^{\eta}$.