Household Time Use Among Older Couples: Evidence and Implications for Labor Supply Parameters*

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Abstract

Using the Consumption Activities Mail Survey (CAMS) module in the HRS we document how individual time allocations change when one or more members transitions from full time work to not working. We find that the ratio of home production to leisure time is approximately constant for both family members. Using a model of household labor supply to understand the implications of this finding, we conclude that the elasticity of substitution between the leisure of the two members is quite large. This elasticity plays a key role in models of household labor supply and is important for understanding how changes in relative wages and taxes affect household labor supply.

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1. Introduction

Labor supply elasticity parameters are important for a variety of positive and normative issues. Although most labor is supplied by multimember households, most estimates of labor supply elasticity parameters have historically come from settings in which household labor supply is not jointly determined.[1] In this paper we study household choices for time use in a standard life cycle setting. We derive a robust relationship linking differential changes in time use by household members to some key labor supply elasticity parameters and estimate this relationship using household level panel data on time use from the CAMS (Consumption Activities Mail Survey) module in the HRS (Health and Retirement Study). Our estimates suggest that households have a high willingness to substitute leisure across members. In the context of commonly used specifications for family utility, our estimates also suggest a relatively high willingness for these households to substitute leisure across time.

The starting point for our analysis is an empirical examination of how household time allocation changes when one or more of its members move from full time work to no work. This transition necessarily frees up a substantial amount of time that must be allocated to other uses, notably home production or leisure. Knowing how a household responds turns out to be revealing about important labor supply parameters. Most time use data sets, including the ATUS, are indi-

[1] Classic references are MaCurdy (1981), Browing et al (1985) and Altonji (1986) for studies focusing on male labor supply, and Heckman and MaCurdy (1980) for female labor supply. More recently, Attanasio et al (2008) and Attanasio et al (2015) study female labor supply taking male income as exogenous. See Chiappori and Mazzocco (2017) for a review of work that estimates models of household labor supply.

vidual based and do not include a panel component, and so cannot directly speak to this issue. The CAMS module that we use provides information on time use for both members of a household and also contains a panel component.

We document four key facts. First, at any point in time there is substantial heterogeneity across households in the allocation of nonmarket discretionary time between home production and leisure. Second, these differences are persistent over time. Third, dispersion across individuals is greater than dispersion across households. And fourth, relatively little happens to this allocation in a relative sense at either the household or individual level when one or more individuals in the household retire. That is, although total nonmarket discretionary time increases significantly, the share of this time devoted to home production changes very little. We confirm that our key facts are also apparent in the ATUS if we use it to construct a synthetic cohort. We also show that the CAMS generates aggregate statistics that closely match those from the ATUS along several dimensions.

We then develop a structural model to help us interpret our main empirical finding. The model features a two person household that makes choices about market consumption and savings, as well as the time allocation of each individual between market work, home production and leisure. The choices are linked through a single budget equation as well as a home production function in which the two time inputs are imperfectly substitutable. We derive a relationship that links relative changes in home production and leisure time of the two members to two key elasticity parameters: the elasticity of substitution between the two member's times in home production and the elasticity of substitution between the two member's leisure times in household preferences. This expression is essentially the first differenced version of the static optimality condition requiring the marginal rate of substitution between member's leisure to be equal to the marginal rate of transformation between their two times in home production. For some common preference specifications, the elasticity of substitution between the two member's leisure times is also the intertemporal elasticity of leisure for the household. Importantly, the expression we derive is robust to many details of the model specification.

This expression gives rise to a simple benchmark calculation. If relative allocations of nonmarket discretionary time do not change when one or more members transition from full time work to not working, then the above two elasticity parameters must be equal. Assuming that time inputs into home production are substitutes rather than complements implies a lower bound of unity for the leisure elasticity parameter.[2] When we use our expression to interpret the modest changes in time allocation that we observe after a typical transition out of full time work, we find that the leisure elasticity is about two thirds as large as the home production elasticity. We also estimate the ratio of the two elasticities directly from the micro data rather than based on a typical experience involving a transition out of full time work. While measurement error precludes any strong conclusions, these results are not inconsistent with the inference based on a typical transition.

We also examine time use data from the MTUS (Multinational Time Use Sur-

[2] Knowles (2013) estimated the elasticity of substitution between the two members time in home production to be 3, though as we describe later, this estimate relies on some strong underlying assumptions.

vey) to examine whether the salient patterns observed in the US data also appear in the data for other countries. Because these data do not have a panel component, we cannot replicate our analysis using the CAMS data. But we can examine whether there are large changes in the average allocation of nonmarket discretionary time over the age range where market work decreases dramatically due to retirement. While there is variation across countries, with a few experiencing changes that are somewhat larger than what we found for the US, the average response is quite similar to that found in the US data.

Our exercise yields important information about the parameterization of the benchmark models used to study family labor supply in macroeconomic settings. One issue these models address is the driving forces behind secular changes in the gender gap in labor supply. See, for example, Olivetti (2006), Heathcote et al (2010) and Fukui et al (2018). Another issue they address is the interaction of tax systems with household labor supply. See, for example, Guner et al (2012) and Bick and Fuchs-Schundeln (2018). Our estimates are based on individuals who are older than 50. While it is common to assume that the parameters we estimate are stable across the life cycle, we note that even if one is not willing to assume this, this age group is very important from a policy perspective given recent concerns about the labor supply of older households and how it is affected by Social Security provisions.

Our paper relates to several strands of the literature. Aguiar and Hurst (2005) also study changes in time use at retirement, though their focus was on distinguishing between changes in consumption and changes in consumption expenditure. Aguiar et al (2013) study how a decrease in market work is allocated to leisure and home production, though their focus was the large decrease in market work during the Great Recession. Laitner and Silverman (2005) use information on changes in allocations at retirement to infer preference parameters, though their focus was on changes in consumption rather than changes in time use. Our analysis is perhaps most related to Rogerson and Wallenius (2016), who use the ATUS to study changes in time allocation at retirement to infer preference parameters. Their analysis did not have panel data and considered individuals rather than households, so could not speak to parameters characterizing household labor supply. Additionally, their expression used to infer preference parameters was based on a dynamic first order condition, whereas the current analysis only requires static first order conditions to hold.

There is an extensive literature on various aspects of household labor supply, one that is too large to reference.[3] By providing evidence on the substitutability of leisure between household members our paper relates to the subliterature that studies how households respond to shocks. A notable recent contribution to this literature is Blundell et al (2016), which relates to the earlier literature on the so-called "added worker effect". See, for example, the papers by Lundberg (1985) and Cullen and Gruber (2000).

A brief outline of the paper follows. The next section describes the CAMS dataset. Sections 3 and 4 report the key findings regarding how time use changes during a transition out of full time work, both at the individual and the household

[3] We refer the reader to three recent survey papers: Doepke and Tertilt (2016), Chiappori and Mazzocco (2017) and Guner et al (2017).

level. Section 5 presents the model that we use to interpret the salient patterns found in the data, and Section 6 reports the implications for the two key elasticity parameters. Section 7 reports evidence from the MTUS and Section 8 concludes.

2. A Panel Data Set on Household Time Use

The American Time Use Survey (ATUS) is widely regarded as the highest quality data on individual time use. Nonetheless, it has two key limitations. First, because it is an individual based survey and not a household based survey, it does not provide information on the home production time of other household members. Given the potential for substitution among household members, the lack of household data is potentially critical. Second, it does not have a panel component. In the presence of individual heterogeneity, deriving inferences from a pure cross-section can be very difficult.

In this section we describe an alternative data set that provides panel data on household time use–the Consumption and Activities Mail Survey (CAMS). The following two sections will document some key patterns in the changes in time use at both the individual and household level during the retirement process.

2.1. The CAMS Dataset

The Consumption and Activities Mail Survey (CAMS) is a module sent to a subset of participants from the Health and Retirement Study (HRS).[4] The HRS

[4] The HRS (Health and Retirement Study) is sponsored by the National Institute on Aging (grant number NIA U01AG009740) and is conducted by the University of Michigan.

is a large nationally representative panel survey of individuals in the US aged 50 and older, administered every second year, starting in 1990. The CAMS module was added in 2003 and is also administered every other year. Importantly, the HRS is a household survey, i.e., it obtains information for both spouses in the case of married individuals who are living together. This feature is also true for the CAMS module, but only starting in 2005. For this reason we restrict our analysis to the data in the CAMS modules for the years 2005, 2007, 2009, 2011 and 2013.

The CAMS module provides information on both time use and consumption spending. We focus solely on the time use component. In contrast to the ATUS and other time use surveys that rely on a diary method and have individuals detail all of their activities over a single day, the CAMS asks people to recall how much time was allocated to a set of activities over the previous week. For a subset of activities which are thought to be performed on a more occasional basis the survey asks about time allocated to them in the last month. For a more extensive discussion of the CAMS data we refer the reader to Hurd and Rohwedder (2007).

We aggregate the time use categories in the CAMS into five broad categories of time use: market work, homework, leisure, personal care, and a residual category.[5] For individual j at time t we will denote these five values by $\tilde{m}_{jt}$, $\tilde{h}_{jt}$, $\tilde{l}_{jt}$, $\tilde{p}_{jt}$ and $\tilde{r}_{jt}$ respectively. A time diary survey allocates each interval over the course of a day to some activity and so will necessarily have total time allocated equal to the total time available. This is not necessarily true in the CAMS, which is based on recall. Total time reported varies both across households at a point in time and

[5] The appendix describes how we aggregate time use activities into these five categories, both in the CAMS as well as the ATUS and the MTUS.

across time for a given household. If we were to focus on levels of time use as reported in the CAMS, cross-sectional and time-series variation would be driven both by the extent of differences in total time reported and true differences in time use. To deal with this issue we will express time use as a fraction of total reported time. Letting T_{jt} denote total time allocation reported by individual j at time t we define:

$$m_{jt} = \frac{\tilde{m}_{jt}}{T_{jt}},\ h_{jt} = \frac{\tilde{h}_{jt}}{T_{jt}},\ l_{jt} = \frac{\tilde{l}_{jt}}{T_{jt}},\ p_{jt} = \frac{\tilde{p}_{jt}}{T_{jt}},\ r_{jt} = \frac{\tilde{r}_{jt}}{T_{jt}}$$

In the online appendix A1 we show that when time use categories in the CAMS are scaled in this way, the resulting series for averages across individuals by age closely match the behavior of the same averages in the ATUS, giving us some confidence in this way of interpreting the data. We also show that median values display similar changes with age, and that the pattern of cross-correlations between market work, home production and leisure are similar across four age subgroups.

We will be particularly interested in how time allocations change when one or more members of a household move from full time work to not working, since this is a case where we know there are large changes in the total time being allocated between leisure and home production, thereby increasing the signal to noise ratio. For ease of exposition we will refer to such transitions as "retirement", though of course they could simply reflect temporary fluctuations in work due to a variety of factors and so not necessarily indicate retirement. Importantly, from the perspective of the model that we will use to interpret the data, this is not an issue. What matters most for our purposes is to isolate a situation in which we think there is a high signal to noise ratio in terms of changes in total non-market discretionary time.

Nonetheless, we will consider two different criteria for "retirement". The first criterion will identify someone as working full time if they report working at least 35 hours per week in the initial wave, and identify them as being retired in the subsequent wave if they report working no more than 5 hours per week. The second criterion will examine market work over three consecutive waves and require that the individual work at least 35 hours per week in the initial wave, and then no more than 5 hours per week in *each* of the next two waves. When applying this criterion we lose any retirements occurring between the last two waves since we cannot check whether the decrease in market work is persistent. Using the first criterion, the number of retiring individuals in each of the pairs of surveys is 202, 188, 158, and 215. Using the second criterion the corresponding numbers of retiring individuals are 134, 125, and 105 for the 2005-2007-2009, 2007-2009-2011 and 2009-2011-2013 periods. Some of the difference between these sample sizes reflects missing observations associated with extending the panel. Conditioning on individuals with data for all three consecutive surveys, roughly three-quarters of the retirements satisfy the stricter criterion.

We specifically focus on how the time freed up by retirement is allocated to home production and leisure, and will capture this with a simple statistic: the ratio of home production time to the sum of home production plus leisure time. That is, we examine how discretionary time not allocated to market work is allocated between home production and leisure. In standard models that abstract from home production all of this time is viewed as leisure time, and explicitly modelling home production amounts to adding this dimension to the time allocation problem. More importantly, later on in the paper we will show that the behavior of this particular statistic is theoretically interesting in terms of conveying information about important household labor supply parameters. In what follows we use the letter z to refer to the ratio of nonmarket discretionary time devoted to home production, i.e.,

$$z_{jt} = \frac{h_{jt}}{l_{jt} + h_{jt}}.$$

Note that the value of z_{jt} would be unaffected by using the reported values $\tilde{h}_{jt}$ and $\tilde{l}_{jt}$ since both are scaled by the same total time endowment.

Although the CAMS module is a household survey, our first set of results does not utilize the household feature of the data and just reports statistics at the individual level. This provides an opportunity to assess whether the key patterns we document also appear in the ATUS, which does not have the measurement issue noted above.

In terms of cleaning the data we drop observations if homework is greater than 100 hours per week, if market work is greater than 100 hours per week, or if any of homework, market work or leisure is missing.[6] We apply respondent weights for the individual level analysis and household weights for the household level analysis, and in all cases use the weights from the initial year when looking at

[6] If a particular subcategory of home production or leisure is missing, we simply replace it by a zero. But if all subcategories are missing, or leisure is zero, we delete the individual from the sample.

individuals or households over time. Note that because the CAMS is a subsample of the HRS and is conducted in between the main HRS surveys, the weights for the 2005 CAMS are the 2004 weights from the HRS. After cleaning the data and matching individuals across consecutive waves we have 4646, 4563, 4250, and 5029 observations for the 2005-2007, 2007-2009, 2009-2011 and 2011-2013 pairs of waves, respectively.

3. Patterns for Individuals

In this section we document some key patterns for changes in the allocation of nonmarket discretionary time at the individual level. We first report patterns found in the entire sample, and then consider the sample consisting of individuals who transition to retirement.

3.1. Patterns in the Overall Sample

We begin by examining what happens to the variable z across consecutive surveys for individuals that we can match across consecutive pairs of surveys. Results are in Table I, presented separately for males and females.

Several patterns emerge. Because they are so similar for males and females, here we focus on the results for males. First, the average value of z is remarkably stable over time, both for a fixed group of males from one survey to the next (i.e., going from the first to the second column) and samples (i.e., moving down the rows of either the first or second column). Second, there is substantial dispersion of this ratio in the population, with a coefficient of variation equal to roughly .60

for males. Keeping in mind that the data on time use is essentially for one week and that time amounts based on recall are expected to be noisy, one might suspect that a large part of the dispersion simply reflects a combination of measurement error and sampling variation. However, the fourth column of the table shows that the correlation of these ratios at the individual level two years apart is strongly positive, suggesting that a substantial amount of the dispersion reflects true dispersion, and is persistent. The one difference between males and females in Table I is that the value of z is higher for females by about .05, though the standard deviations are effectively identical.

To provide more information about the nature of the properties of z_{it} we create a balanced panel of individuals who are in all five surveys. When we examine the cross-correlations of z across the five surveys, we find that the correlation of consecutive first differences is strongly negative, in the range of $-.40$ to $-.45$. But for first differences that are not consecutive, the correlation is very close to zero. This is suggestive of a process for z_{it} that features a permanent component and an iid transitory component. More formally, we can estimate a variance decomposition model that decomposes z into permanent and transitory components. The results of this exercise imply that the standard deviation of the permanent component is 0.115,accounting for more than two thirds of the standard deviation in the cross-section and that the transitory component is very close to iid, with an AR(1) coefficient of 0.09 and a standard error of 0.03. The standard deviation of the permanent component implies a very substantial degree of dispersion in the value of z across individuals, with a $90 - 10$ ratio in excess of 2.

3.2. Patterns in the Retiree Subsample

We now examine the behavior of z for retiring individuals. Here we present the results based on the first criterion, which only requires a transition from more than 35 hours per week to no more than 5 hours per week across consecutive surveys. The summary statistics for this group are presented in Table II, once again presented separately for males and females. The sample sizes are 97, 100, 89, and 111 for males over the four pairs of waves, and 105, 88, 88, and 104 for females.

Remarkably, the same basic patterns found in Table 1 for the overall sample also appear when restricting attention to retiring individuals. In particular, both the mean and standard deviation of z change very little as the sample moves from working full time to retirement; there is a modest increase in the mean of z for males, and an even smaller increase for females. The standard deviation seems effectively unchanged by retirement. Notice also that the statistics for individuals who are about to retire are almost identical to the population averages in the sample. Lastly, it remains the case that z at the individual level is positively correlated between the two periods, though the correlation is somewhat lower than for the overall population.

Roughly three-quarters of our retiring individuals also satisfy our more stringent retirement criterion, i.e., also have less than five hours of market work in the third survey. We have also repeated our analysis for these individuals, comparing the value of z in the initial period in which they worked in the market for at least 35 hours with the value of z two surveys later. Because the results are virtually unchanged from those reported in Table II we do not report them in any detail and simply summarize them here. Pooling across all individuals, the initial average value of z is .27 and the average two surveys later is .29.[7]

To document these patterns more formally we pool the data from all of the surveys and run a panel regression of the following form:

$$z_{it} = \bar{z}_i + \beta I_{iRt} + \varepsilon_{it} \tag{3.1}$$

where $\bar{z}_i$ is an individual fixed effect, and I_{iRt} is an indicator function which takes on the value of 1 if individual i satisfies our criterion for being retired in period t. We run this specification for samples constructed using each of our two criteria of retirement. Specifically, in the first sample, we consider all of the individuals in the sample used to generate Table II, i.e., all consecutive pairs of observations for an individual that moves from at least 35 hours per week in the initial period to five or fewer hours in the second period. For males the estimated value of β is .027 with a standard error of .009, and for females the estimated value of β is .007 with a standard error of .011. Consistent with our summary of results in Table II, these estimates suggest a modest increase in z for retiring men and no statistically significant change for retiring women.

The second sample focuses on individuals who meet our second criterion for retirement. For this criterion, the results are basically the same; the estimated value of β for males is .034 with a standard error of .010, while for females it is

[7] Considering the results separately for males and females we see that for males z increases from .25 to .28 whereas for females z is constant at .31.

.002 with a standard error of .014.

The picture that emerges is that very little seems to happen to the value of the z when an individual moves from working full time to retirement. It is important to emphasize that this transition necessarily involves a sharp decrease in the amount of time devoted to market work and so also involves a substantial increase in the amount of discretionary time that individuals allocate between leisure and home production. The fact that z is roughly constant does not imply that there is no change in overall time allocation; rather, it simply implies that time spent in leisure and home production increase proportionately.

3.3. Additional Checks

As noted earlier, the total time reported across all activities varies over time for a given individual in the CAMS. One potential concern with the above finding is that it would emerge in the extreme case in which individuals are simply reporting fewer hours of market work without adjusting any of the other time use categories. In fact, retiring individuals do experience a drop in total reported time, but the situation falls far short of the extreme situation just described. On average individuals report an increase of more than 20 hours per week in activities other than market work. But to provide a further check on this concern we pool all of the individuals and then break them into quartiles based on the change in total non-market work time reported. If we pool the data for all of the individuals who experience retirement, the average value of z is .28 in the initial period and .30 in the second period. When we report this change by quartiles of the change in total non-market work time reported the results are virtually identical across all four quartiles.[8] We conclude that the result is not driven by this spurious measurement issue.

As another check on the reasonableness of this result, it is of interest to look more closely at changes in time allocated to various subcategories of home production and leisure. Pooling across all of waves, Table III shows the level of hours for various subcategories before and after retirement.

The table shows that the increase in home production is spread across several categories, with housework, shopping and cooking constituting the three largest increases. For the case of leisure the dominant category is watching TV, accounting for more than half of the total increase, with socializing and relaxing also experiencing significant increases. The patterns revealed in this table strike us as quite reasonable, and so do not lead us to question the basic finding.

3.4. Patterns for Individuals in the ATUS

As noted previously, time use measures derived from surveys that rely on time diaries are typically viewed to be more reliable than those that rely on recall. This argument would suggest that patterns found using the ATUS are more reliable than patterns found using the CAMS. Because the ATUS does not contain a panel component, we cannot replicate the above analysis. However, in this subsection we argue that patterns found using the ATUS strongly support the key patterns we have highlighted in the CAMS data. We view this as evidence in favor of

[8] The first and second period averages of z are .27 and .29 for the first quartile, .28 and .30 for the second quartile, .28 and .29 for the third quartile and .28 and .30 for the fourth quartile.

taking the patterns for the behavior of z at retirement in the CAMS data at face value.

To pursue this we use the ATUS to create a synthetic panel. Table IV shows the behavior of mean market work (μ_m), mean z (μ_z) and the standard deviation of z (σ_z) by age using pooled data from the ATUS samples for the years 2003-2015, both in aggregate as well as separately for men and women.[9]

Notably, Table IV shows that mean market work decreases dramatically with age, especially between the ages of 60 and 67. Rogerson and Wallenius (2016) show that the dominant source of this decrease in market hours is the movement of individuals from full time work to retirement. It follows that examining the changes in z with age are effectively providing information on the changes in z associated with retirement. Interestingly, we see the same two features in the synthetic cohort constructed from the ATUS that we saw in the panel component of the CAMS: both the mean and standard deviation of z are virtually constant in the face of the dramatic decrease in time devoted to market work as individuals leave full time work. This is true both in the aggregate as well as for each gender considered separately.

Although the ATUS data possesses the same qualitative properties found using the CAMS data, we note two quantitative differences. First, mean z is slightly higher in the ATUS than in the CAMS, with this effect being a bit larger for

[9] The components of each time use category are provided in Appendix 1. Our data extract from the ATUS is created using ATUS-X extractor. (Sandra L. Hofferth, Sarah M. Flood, and Matthew Sobek. American Time Use Survey Data Extract Builder: Version 2.7 [Machine-readable database]. College Park, MD: University of Maryland and Minneapolis, MN: IPUMS, 2018. https://doi.org/10.18128/D060.V2. https://www.atusdata.org).

females. As noted previously, the two surveys use very different methods, and these statistics suggest that there are some systematic differences in levels of home production and leisure in the two surveys. Second, the standard deviation of z is higher in the ATUS. This difference is to be expected, at least at a qualitative level. The reason is that the unit of observation in the ATUS is one person for a particular day of the week. It follows that at least part of the standard deviation reflects variation across days of the week. In contrast, the unit of observation in the CAMS module is one person for a week (and to some degree the month). It follows that dispersion due to variation across days of the week is implicitly removed in the CAMS, leading one to expect a smaller standard deviation. Of course, to the extent that measurement error is larger in the CAMS there is also a factor leading to the opposite pattern.

The ATUS cannot speak to all of the patterns that we found using the CAMS. In particular, the ATUS cannot tell us if the near constancy of the mean of z reflects persistence for a given individual over time as opposed to simply a constant distribution over time with individuals moving within the distribution. Our analysis using the CAMS data found evidence for the former. But the key message that we take away from our analysis of the ATUS is that despite some concerns with data quality in the CAMS, the key pattern that we have documented and will make use of going forward appears to be robust.

While the constancy (or near constancy) of z is the key fact that we wanted to corroborate using the ATUS, it is also of interest to document the extent to which other patterns in the ATUS and the CAMS coincide to gain further confidence in the CAMS data. As noted earlier, Appendix A1 in the online appendix examines in greater detail how time use varies with age in the two data sets. We first show that both data sets imply very similar changes in the allocation of time across the five broad categories: market work, homework, leisure, personal care and the residual category. We then look in more detail at the changes within both the leisure and homework categories. Here again we find that the two data sets are in close agreement on the nature of changes.

4. Patterns for Households

In this section we proceed to use both the panel and household features of the CAMS to examine what happens to household time allocation when one or more members of the household retire. For this analysis we use the same criterion as before applied to the household unit. That is, we only include data for two member households and we require that both individuals satisfy our criterion in both periods. Some individuals are removed from the sample because they are not part of a two member household, and others are removed because their partner has missing observations. The resulting sample of matched two member households contains 1382, 1346, 1205, and 1400 observations for the 2005-2007, 2007-2009, 2009-2011 and 2011-2013 pairs of waves. As before, we will also focus on households in which at least one member experiences a move from full time work to retirement.

We begin by documenting some properties of the household's aggregate time allocation, i.e., the ratio of total household home production time to the sum of total household home production time plus total household leisure time. Results are presented in Table V.

Perhaps not surprisingly, the key finding in this table is that the same patterns found in the individual level data are also present at the household level, i.e., both the mean and standard deviation are unchanged across surveys and the level of z at the household level is highly positively correlated across surveys. Note that the standard deviation at the household level is about one third smaller than at the individual level, suggesting that a significant part of the variation found in the individual data is across individuals within households.[10] To the extent that the time of different members are substitutes in household production and there is some comparative advantage for market versus home work across household members, this is to be expected. Nonetheless, the data still indicate a very significant degree of dispersion in the level of the z across households. Repeating the same simple calculation as earlier to estimate the part of the dispersion that is not due to measurement error implies a standard deviation of around .08.

Next we consider in more detail what happens inside the household when one or both members retires. Five different cases are possible. One case is when both members move from full time work to retired. The other cases involve one member retiring but conditioned on whether the other member is retired or working full time.[11] As we cut the sample of retirees into finer categories the sample sizes tend

[10] It is also the case that if measurement error is iid across household members, the variance of household level measurement error will be smaller in a two member household.

[11] There are also cases in which one or both members are working an intermediate number of hours in the market, i.e., between 5 and 35 hours per week. These observations are excluded from the table.

to become somewhat small, so in what follows we pool the observations across the four pairs of consecutive waves. Results are shown in Table VI.

Several patterns are present. When the male retires there is a modest increase in his z. Similarly, when the female retires, there is a modest increase in her z in two of the three cases, with effectively no change in the third. When the female retires and the status of the male is unchanged, there is a modest decrease in the value of z for the male. A similar pattern is found for the female z when the male retires and the status of the female is unchanged, though the decrease is even more modest. The mean value of z is greater for females than males in all cases. This gap decreases when the male member retires and increases when the female member retires. The gap is greatest when the male member is working and the female member is not working.

To document these effects more formally, we next present results from a panel regression analysis similar to what we did in the case of individuals, though here we focus on the largest group in the above table.[12] Specifically, we pool all of the household level data across surveys and focus on households in which the male moves from full time work to retired while the female is retired in both periods. For these households we then run a fixed effects regression for the z of the male and female members. That is, we run a regression of the form:

$$z_{it} = \bar{z}_i + \beta I_{iRt}^m + \varepsilon_{it} \tag{4.1}$$

where $\bar{z}_i$ is an individual fixed effect and I_{iRt}^m is a dummy variable equal to one

[12] Results for the other groups are basically similar, with modestly larger standard errors.

if the male member of the household to which individual i belongs meets our criterion for retirement in period t. Once again we consider samples based on both of our retirement criterion. Based on criterion 1, the estimated value of β is .027 for males and $-.004$ for females, with standard errors of .017 and .019 respectively. Based on the second criterion, the estimated values of β are .036 for males and $-.006$ for females, with standard errors of .015 and .019 respectively. Importantly, the standard errors are quite small.

In summary, when the male member of a household moves from working full time to retired in a household in which the female household member is not working, the point estimates suggest a very modest increase in the male z and a very modest decrease in the female z, though only with the more stringent retirement criterion is the male estimate statistically significant at the 5% level. In the next section we develop a model to help us infer the implications of this finding.

5. A Model of Household Time Allocation

In this section we present a model of household time allocation for a multi-member household and derive an implication for the optimal profile of home production and leisure across household members and how it changes over time. Our analysis focuses entirely on first order conditions that characterize static choices within a given period for time spent on home production. In particular, we do not make use of the first order condition for hours of market work and so do not assume that observed hours of market work reflect optimal labor supply choices taking the wage rate as given. For this reason our analysis can accommodate a great deal of generality along several dimensions. For ease of exposition we first develop the key relationship of interest in the context of a fairly standard deterministic formulation of the household life cycle optimization problem, and later discuss robustness to allowing for many alternative features.

5.1. Model

We consider a household that consists of two members, that we refer to as the male and female members. The period utility function for household i is written as:

$$u^i(c_{it}, \frac{\alpha_{im}}{1-(1/\gamma)} l_{imt}^{1-\frac{1}{\gamma}} + \frac{\alpha_{if}}{1-(1/\gamma)} l_{ift}^{1-\frac{1}{\gamma}})$$

where c_{it} is the flow of consumption services for the household in period t, and l_{imt} and l_{ift} are male and female leisure in period t respectively.[13]

The function u^i is allowed to vary across households and is assumed to be C^2, increasing in each argument, weakly concave jointly in both arguments and strictly concave in each argument individually. The parameters α_{im} and α_{if} are household specific positive constants. While this functional form imposes some structure on how leisure enters into the utility function, it is very flexible in terms of how the leisure aggregate and consumption interact. In particular, we do not impose separability between household consumption and household leisure. One

[13] This specification assumes that household consumption is a public good. In Appendix A2 of the online appendix we show that our key estimating equation remains intact if we assume that consumption is perfectly private or contains elements of both private and public consumption.

special case of interest is:

$$u(c_{it}) + \frac{\alpha_{im}}{1-(1/\gamma)} l_{imt}^{1-\frac{1}{\gamma}} + \frac{\alpha_{if}}{1-(1/\gamma)} l_{ift}^{1-\frac{1}{\gamma}}.$$

This specification has dominated the macroeconomics literature that studies household labor supply. Prominent examples of papers that adopt this specification would include Olivetti (2006), Heathcote et al (2010), Guner et at (2012), Bick and Fuchs-Schundeln (2018) and Fukui et al (2018). See also the survey by Greenwood et al (2017). In this specification the parameter γ governs both the elasticity of substitution between leisure of the two household members as well as the intertemporal elasticity of substitution of leisure.[14]

A slightly more general specification would be:

$$u(c_{it}) + v\left(\frac{\alpha_{im}}{1-(1/\gamma)} l_{imt}^{1-\frac{1}{\gamma}} + \frac{\alpha_{if}}{1-(1/\gamma)} l_{ift}^{1-\frac{1}{\gamma}}\right)$$

where v is some increasing and concave function, in which case γ governs the elasticity of substitution between leisure of different members but not necessarily the intertemporal elasticity of substitution, as this would depend both upon the curvature in $v(\cdot)$ as well as the parameter γ. We note however, that even in this case the value of γ is still central for understanding how time allocation within the household changes in response to changes in relative wages of household members, and the implications of defining the tax unit at the individual level versus the

[14] This special case raises the possibility that one might want to consider gender specific values of γ. We carry out an exercise later in the paper that allows for gender specific values of γ and find no evidence to support this.

household level.[15]

The flow of household consumption is a CES aggregate of household expenditure (g_{it}) and household efficiency units of home production time (h_{it}):

$$c_{it} = [a_i g_{it}^{1-\frac{1}{\eta}} + (1-a_i) h_{it}^{1-\frac{1}{\eta}}]^{\frac{\eta}{\eta-1}}$$

Efficiency units of home production time at the household level are in turn a CES aggregate of male and female home production time, denoted by h_{mt} and h_{ft} respectively:

$$h_{it} = [A_{im} h_{imt}^{1-\frac{1}{\rho}} + A_{if} h_{ift}^{1-\frac{1}{\rho}}]^{\frac{\rho}{\rho-1}}$$

where $\rho \geq 0$ is the elasticity of substitution between the time of the two members in household production. Although this specification nests the special case of perfect substitutes, i.e., ρ tending to infinity and $A_{im} = A_{if}$, it allows for much more generality. The special case of perfect substitutes is empirically problematic because it creates a tendency for corner solutions in home production time, a property that is not found in the data.

As emphasized with our notation, we allow the α, a, and A parameters to all be household specific. The α's can reflect true differences in preferences for leisure across individuals within the household, or could reflect the differential weights that the household places on the utility of its different members. Similarly, dif-

[15] See, for example, the analysis in Guner et al (2012) and Bick and Fuchs-Schundeln (2018). Alesina et al (2011) also study gender based taxation in a model of household labor supply. Their individual preferences are consistent with our specification but they assume bargaining within the household.

ferences in a across households could reflect differences in their ability to combine goods and home production time or differences in preferences.

We normalize the total amount of discretionary time to equal unity for each member of the household, so that leisure is equal to one minus the sum of time spent in market work (m) plus home production (h)[16]:

$$l_{ijt} = 1 - m_{ijt} - h_{ijt},\ j = m, f$$

We assume that the household maximizes utility over a T period horizon, using a discount factor β. The discount factor can be household specific. The household faces a sequence of budget constraints given by:

$$g_{it} + a_{it} = w_{imt}m_{imt} + w_{ift}m_{ift} + (1 + r_t)a_{it-1}$$

where w_{ijt} is the wage for member j in household i in period t, and m_{ijt} is hours of market work for member j in household i in period t.

5.2. Optimal Home Production Decisions

In what follows we focus entirely on the implications of the optimal choice of home production time in a given period taking as given the choices for market work and spending on goods. As we discuss in greater detail below, while this approach does not utilize all of the structure of the household problem, its advantage is that it is

[16] More generally we can assume that the amount of discretionary time varies over time without affecting any of our analysis. This is relevant as our previous analysis indicates that time devoted to personal care does tend to increase with age.

robust to a wide variety of specifications regarding some aspects of the household problem, including some that may be controversial and/or complicated.

In each period the household chooses how much time each member should allocate to home production given all of the other variables, yielding two first order conditions, one for h_{imt} and one for h_{ift}. Assuming interior solutions for each of these choices and abstracting from the household index i for notational convenience, these two first order conditions are:

$$\begin{aligned} h_{mt} &: u_1(c_t, l_t)(1-a)c_t^{\frac{1}{\eta-1}} h_t^{\frac{1}{\rho}-\frac{1}{\eta}} A_m h_{mt}^{-\frac{1}{\rho}} = u_2(c_t, l_t)\alpha_m(1-m_{mt}-h_{mt})^{-\frac{1}{\gamma}} \quad (5.1) \\ h_{ft} &: u_1(c_t, l_t)(1-a)c_t^{\frac{1}{\eta-1}} h_t^{\frac{1}{\rho}-\frac{1}{\eta}} A_f h_{ft}^{-\frac{1}{\rho}} = u_2(c_t, l_t)\alpha_f(1-m_{ft}-h_{ft})^{-\frac{1}{\gamma}} \end{aligned}$$

where $l_t = \frac{\alpha_{im}}{1-(1/\gamma)} l_{imt}^{1-\frac{1}{\gamma}} + \frac{\alpha_{if}}{1-(1/\gamma)} l_{ift}^{1-\frac{1}{\gamma}}$.

Dividing the two first order conditions by each other and recalling that $1 - m_{jt} - h_{jt} = l_{jt}$ gives:

$$\frac{\alpha_m}{\alpha_f}[\frac{l_{mt}}{l_{ft}}]^{-\frac{1}{\gamma}} = \frac{A_m}{A_f}[\frac{h_{mt}}{h_{ft}}]^{-\frac{1}{\rho}} \tag{5.2}$$

This equation reflects a purely static condition for household optimization: the marginal rate of substitution between leisure of the two members must equal the marginal rate of transformation between the two members' time spent in home production. While the above expression imposes some structure, provides no information if we allow for heterogeneity in the α_j's and A_j's and the only data we have is from a single cross-section. To see this, note that given any values for

γ and ρ, we can rationalize any pattern of time allocation within the household by appealing to an appropriate profile of the α_j's and the A_j's.

However, the situation is very different if we have access to panel data on time allocations. To see why, take logs of equation (5.2) and rewrite it as:

$$\frac{1}{\gamma}\log[\frac{l_{mt}}{l_{ft}}] - \frac{1}{\rho}[\frac{h_{mt}}{h_{ft}}] = \log[\frac{\alpha_m}{\alpha_f}\frac{A_f}{A_m}] \tag{5.3}$$

Taking first differences we have:

$$\Delta \log l_m - \Delta \log l_f = \frac{\gamma}{\rho}[\Delta \log h_m - \Delta \log h_f] + \varepsilon. \tag{5.4}$$

where $\varepsilon = \gamma\Delta\log[\frac{\alpha_m}{\alpha_f}\frac{A_f}{A_m}]$.

In words, equation (5.4) states that the relative change in leisure across household members should be proportional to the relative change in home production time. The key point is that given access to panel data on time allocations, the household specific values can be removed by first differencing, and the theory imposes quite a bit of structure on the changes in household time allocations over time and the two elasticity parameters γ and ρ.[17]

One might think that a multi-member household makes analysis more complicated. But interestingly, it is the assumption of a multi-member household that is key to deriving a condition that involves only changes in time allocation and the

[17] It is notable that this expression includes a curvature parameter from both preferences and technology. As Gronau (1997) noted in his survey paper, there is a fundamental identification problem in the home production literature that has often been avoided by abstracting from curvature in the home production function. Although our specification of the home production function is constant returns to scale, it does feature curvature with regard to each of the individual time inputs.

two preference parameters γ and ρ based purely on static first order conditions. In Rogerson and Wallenius (2016) we performed a similar analysis in the context of a single individual household. But in that case our final expression involved both time allocations and consumption expenditure (i.e., g_t), and required that the household's choices satisfied the consumption Euler equation.

We will be interested in applying equation (5.4) to the case of a household in which one of the members is retiring. In this case, a key assumption will be that the change in the right hand side is not correlated with the change in market hours that defines retirement. To justify our empirical analysis it is important to provide more detail on the error term ε in equation (5.4). Letting x_i refer generically to either $\log \alpha_i$ or $\log A_i$, we will assume:

$$x_{it} = \bar{x}_i + f(O_t) + \delta_{it}$$

where $\bar{x}_i$ is an individual fixed effect, O_t refers to time varying individual and/or household characteristics that directly affect x_{it}, and δ_{it} is a mean zero iid error term. Examples of time varying characteristics in O_t would include health status and household composition. This specification is supported by our earlier analysis of the stochastic properties of the z_{it}. In particular, in Section 3.1 we examined the stochastic structure of z_{it} in a balanced panel of individuals who were present in each survey and found that this process is well approximated as a constant plus an iid error term. In the context of our model, the z_{it} will inherit the persistence properties of $\log[\frac{\alpha_m}{\alpha_f}\frac{A_f}{A_m}]$, so this specification is internally consistent with our model. This specification implies that the first difference of $\log x_{it}$ is a function of differences in observables and an iid term.[18]

As one special case, note that if we assumed perfect substitutes in home production, i.e., the limiting case as ρ tends to infinity, then equation (5.4) implies:

$$\Delta \log l_m - \Delta \log l_f = \varepsilon \tag{5.5}$$

and the parameter γ disappears from the expression. This expression is inconsistent with the main finding from the previous section.[19]

More generally, equation (5.4) implies a value for γ/ρ given changes in time allocations. Given an estimate for ρ we can then recover the implied value for γ. For given changes in time allocations, the implied value of γ is increasing in the value of ρ, so that the further we move away from perfect substitutes the smaller is the implied value for γ.

The result that a higher value of ρ implies a higher value of γ holding the changes in time use fixed is intuitive and straightforward. Suppose we have a pair of values for γ and ρ such that equation (5.4) holds, and assume the nature of the change over time is that both home production and leisure time increase for the male member of the household. At the given values of γ and ρ the male choices are such that the increase in household utility from marginally higher male leisure is exactly equal to the increase in household utility from a marginal increase in male home production time. If we consider a higher value of ρ then the marginal

[18] Alternatively, if δ_{it} is a random walk this same result would hold. But in this case the distribution of the z_{it} should be spreading out over time, which is not supported by the data.

[19] It is important to recall our previous comment about the tendency for perfect substitutes to lead to corner solutions, given that this expression assumes interior solutions. Recall, however, that we take market hours as given in this derivation.

utility from increasing male home production increases as the extent of decreasing returns is lessened. To maintain equality we must have that the marginal utility of leisure must also increase, which means less curvature in leisure.

5.3. Extensions

In this section we note a variety of extensions to which our key estimating equation is robust. This includes a large number of extensions which are now well known to have first order effects on estimates of γ in other contexts.[20] While some of the robustness in the current framework mirrors the discussion in Rogerson and Wallenius (2016), the fact that our current analysis does not rely on any dynamic choices renders it robust to even more factors. First, our equation depends in no way on the set of choices for market hours that household members face (e.g., indivisible labor), whether the observed choices for market hours are optimal (i.e., whether individuals are on their labor supply curve for market work), whether market work is associated with human capital accumulation, and whether there are non-linearities in the compensation structure.

Because our analysis does not rely on dynamic first order conditions, it is also invariant to the presence of credit constraints. Although we formulated the household problem without any sources of randomness, our approach is robust to allowing for stochastic market opportunities and whether there are incomplete

[20] See for example, Imai and Keane (2004) and Wallenius (2011) for analyses with human capital accumulation, Domeij and Floden (2006) for an anlysis with credit constraints, Low (2005) for an analysis with incomplete insurance markets, Chang and Kim (2006) and Rogerson (2011) for analyses with restrictions on working hours, and Ham and Reilly (2013) for an analysis with implicit contracts. See also the survey in Keane and Rogerson (2015).

markets to insure against randomness in market prices. In particular, our key equation is robust to embedding our analysis in the standard Aiyagari style model.

Our model description did not include any tax and transfer programs, but our key equation is invariant to any form of tax and transfer policies that are functions of market work and market income. In particular, given that we will be focusing on older individuals and the transitions that they make when retiring, it is important to know that the presence of a realistic social security system has no impact on our key equation.

5.4. Discussion

As the previous subsection emphasized, our key equation (5.4) is derived without making many standard yet strong assumptions. In particular, we do not need to assume that observed hours of market work reflect optimal labor supply choices. This generality does come with a cost, in that our key equation imposes a restriction on the ratio γ/ρ and so does not directly tell us about the level of γ.

If we were to assume that the observed wage is the correct measure of the marginal value of work, and that observed hours of market work reflect optimal labor supply choices taking the wage as given, then one could use the first order conditions for hours of market work from the benchmark model introduced above and derive the following equation:

$$\Delta \log h_m - \Delta \log h_f = \rho[\Delta \log w_f - \Delta \log w_m] \tag{5.6}$$

This equation is intuitive: if both individuals can freely adjust time spent working in the market and at home, then changes in relative market wages should lead the household to adjust the time allocation of the two members between market work and homework, with the extent of the adjustment determined by the extent of substitutability in home production. Using this expression on panel data would allow one to derive an estimate of ρ. But this exercise is subject to all of the critiques that have been leveled at the literature that uses observed hours of market work and wages to directly infer values of γ and for this reason we do not think this is a reliable source of information on ρ.[21]

Having said this, we note that Knowles (2013) effectively used equation (5.6) with low frequency changes in household time allocation and wages to infer a value for ρ. In particular, he used changes in the average wages of married males and females and average changes in home production time of married couples between 1975 and 2003. This resulted in an estimate of ρ of approximately 3. One might argue that the assumptions underlying equation (5.6) are somewhat more palatable if applied to low frequency changes, as one is basically assuming that average hours of work reflect desired labor supply given average wages. On the other hand, comparing averages across long periods of time implies that compositional changes are combined with changes at the individual level. This issue notwithstanding, we view this estimate as an upper bound for ρ since this calculation assumes that there were no other factors that influenced the change in relative home production times over this 28 year period.

[21] Suppose, for example that this exercise led to an estimated value of ρ equal to zero. Does this mean that there is no substitutability in home production or simply that the individuals were not able to adjust their hours of market work, in violation of the assumptions underlying the derivation of the estimating equation?

While the estimate from Knowles (2013) is useful as an upper bound, it will be of greater interest to have a lower bound for the value of ρ, since given a value for γ/ρ, a lower bound for ρ will also establish a lower bound for γ. We think it is hard to argue that members' times in home production are not substitutes, and hence view unity as a conservative lower bound for ρ. We will see later on that even this conservative lower bound will generate interesting implications for implied values of γ.

To close this subsection we relate our analysis to Aguiar and Hurst (2005). They were also interested in identifying parameters in a model with home production, in particular the parameter η in our model. Importantly, they specifically chose not to impose that households were on a labor supply curve in which the wage was the marginal value of time. Instead, they cleverly used information on shopping time and prices to infer the life cycle profile for the marginal value of time for the household. From this, they were able to derive an estimate of η. Importantly, their series for the marginal value of household time varied quite dramatically from the life cycle profile of wages. We make two points in reference to the analysis of Aguiar and Hurst (2005). First, we think it plausible that future researchers will devise a clever strategy for estimating ρ directly without imposing strong assumptions about wages and market work. Second, we do not make any effort to produce estimates of η from our data given as we do not feel we would be able to provide a more compelling estimate than theirs.

6. Implications for Parameter Values

In this section we use the CAMS data and our model of household decision-making to generate information on the joint values of γ and ρ. Our basic strategy is to focus on households in which one or more members transitions from full time work to not working and interpret the resulting changes in time use using equation (5.4). The logic of this strategy is that when one or more individuals in the household retires from full time work, there is a significant amount of time freed up that needs to be allocated to alternative uses. Examining how the household chooses to respond along different margins reveals information about the parameters γ and ρ.

The first subsection discusses our key identification assumption. The next two subsections use different methods to produce estimates using equation (5.4). The first method will use the key property documented earlier: the relative constancy of the z values for both household members when one of the members transitions from working to retired. We will show that this "average response" has a sharp prediction for the value of γ/ρ. The second method generates estimates of γ/ρ by directly estimating equation (5.4) using the full set of household observations. A key issue for this second method is the concern that the CAMS data features significant amounts of measurement error.

6.1. Interpreting Transitions Out of Full Time Work

As we have noted previously, we will be particularly interested in using equation (5.4) to study changes in time allocations in the context of transitions out of full time work. We will interpret the resulting changes in time allocations as being driven by the reduction in hours of market work. But to rationalize this interpretation it is important to discuss in more detail what does and does not drive transitions out of full time work. In particular, it will be important for our analysis that retirement is not systematically correlated with changes in the characteristics O_t that directly affect the α_i's and the A_i's.

We first note some causes of retirement that are not problematic. One possible cause of retirement is an adverse shock to market opportunities. Because our derivation placed no restrictions on how market opportunities change over time, this creates no problem for our interpretation. A second possibility is that transitions out of full time work do not reflect a response to contemporaneous shocks, but instead reflect an optimal path of labor supply over the life cycle in an environment with some sort of "friction" or nonconvexity. For example, Hurd (1996) argued that restrictions on the ability to choose hours are a key driving force behind retirement, and Blau and Shvydko (2011) and Ameriks et al (2017) are recent works supporting this view. Alternatively, the models of French (2005) and Rogerson and Wallenius (2009) generate retirement in response to nonconvexities in the compensation structure. Programs such as Social Security and Medicare become available at specific ages, and may induce retirement. Our derivation placed no restrictions on these features. Our approach is also consistent with behavioral theories of retirement–perhaps individuals retire when they have reached some target level of savings.

Our identifying assumption would not be valid if the transition out of full time work was driven by changes in either the A_i's or the α_i's. If this is the case then the ε in equation (5.4) will not be mean zero and estimates of ρ/γ would be biased. If the transition out of full time work is driven by a health shock then it would be natural to think that the health shock might also systematically affect the value of ε. However, note that health shocks are only a problem if they are *contemporaneous* with the transition out of full time work. In particular, consider an individual of age 55 who "plans" to retire at age 65. Suppose this individual experiences an adverse health shock at age 56 and as a result ends up retiring at age 62 instead of 65. Although the health shock in this case strongly influenced the timing of retirement, this case is not problematic for our strategy as long as health is stable between the ages of 60 and 62. That is, the presence of permanent health shocks per se is not a challenge to our strategy.

Blau and Shvydko (2011) present evidence that very few retirements are the direct result of health shocks. Nonetheless, in order to address this issue we use the self-reported health status question in the HRS to create a subsample in which all individuals are in good health or better.[22] At the individual level, this healthy subsample is about two-thirds of the overall sample. In Appendix A3 of the online appendix we report the equivalent of Tables I, II and V for this subsample, and show that the key patterns remain unchanged. We also repeat the fixed effect regressions using household data for this subsample, and again find that it does not affect our key finding, though the point estimates are a bit larger in absolute value.

[22] The health status question in the HRS ask individuals to rate their current health as excellent, very good, good, fair or poor.

Another event that would be problematic for our identification strategy is if there are changes in household composition that coincide with retirement. The CAMS contains information that allows us to control for this. In particular, the CAMS has information on whether there are kids present in the household, and if so how many. In Appendix A3 of the online appendix we restrict attention to a subsample in which we can confirm that there are no changes in the number of kids present in the household. Because there are several missing values for this information, this restriction shrinks the sample size considerably. But once again we find that our main result holds for this subsample.

These last two robustness exercises consist of trying to condition on potential observable shocks that might drive retirement. As an alternative, we focus on transitions out of full time work in which the final year of work occurs between the ages of 60 and 66, so that the first observed year of retirement corresponds to individuals being between the ages of 62 and 68. This age range includes the critical thresholds for receipt of Social Security and Medicare and previous research has found that these threshold ages are associated with spikes in retirement. (See, for example the work of Rust and Phelan (1997).) Appendix A3 of the online appendix presents an analysis for this subsample of retiring individuals. Once again, there is a reduction in sample size and a corresponding increase in the size of standard errors, but the results are effectively unchanged.

6.2. Estimates Based on a Typical Transition

We begin by asking what an "average" transition implies for the values of ρ and γ. Specifically, we use the fixed effect panel regression results for households presented earlier to impute values for the left and right hand side variables in equation (5.4) and infer a value for γ/ρ.

We start with a benchmark calculation that delivers a very sharp result. In particular, one of the patterns documented in the previous section was that the value for z is very close to constant for both household members, even when one of them transitions from full time work to retirement. Because $z = h/(h+l)$, it follows that a constant value of z implies that the percentage change in h is the same as the percentage change in l, i.e., that for each member of the household $\Delta \log l = \Delta \log h$. It thus follows that $\Delta \log l_m - \Delta \log l_f = \Delta \log h_m - \Delta \log h_f$. Viewed through the lens of equation (5.4) the implication is that $\gamma/\rho = 1$. Note that this conclusion holds independently of what the initial value of $z's$ were for the two household members, what their hours of market work were prior to retirement, and whether there was a change in total discretionary time. If $\gamma/\rho = 1$, and $\rho = 1$ and $\rho = 3$ represent lower and upper bounds on ρ then it follows that γ lies in the interval $[1, 3]$.

The above calculation assumed that z was constant for both individuals. While the evidence in the previous section suggests that the data closely conforms to this pattern, we did provide some evidence of small changes in z that were marginally statistically significant. Here we examine the extent to which allowing for changes in z of the magnitude estimated previously affect the implications for the value of γ/ρ implied by equation (5.4). For concreteness we focus on the case of a household in which the female is not working in both surveys and the male goes from full time work to no work across the surveys. We impute the following values for the variables in equation (5.4) using the information presented previously. Because there is no statistically significant change in z for the female member and by construction she does no market work in either period, we set $\Delta \log h_{ft}$ and $\Delta \log l_{ft}$ equal to zero. For the male household member, we assume that market work when working full time is 40 hours, total discretionary time is 100 hours, the value of z before retirement is .21, and that the increase in z following retirement is equal to .02.

The implied value for γ/ρ is 0.80, so that allowing for a modest increase in z for the male tends to decrease the implied value of γ for any given value of ρ. This estimate is only modestly affected by changes in the other values assumed in this calculation. Assuming that total discretionary time is 90 hours per week instead of 100 hours per week increases the estimate of γ/ρ to 0.82. And increasing the working time before retirement to 45 hours per week produces a change of the same magnitude. Assuming that z increases by .04 instead of .02 implies a value for γ/ρ of .69. Finally, we consider modest increases in the male value of z in combination with a modest decrease in the female value of z. If we consider an increase of .03 for the male and a decrease of .03 for the female, the implied value of γ/ρ is .58. If we consider an increase of .05 for the male and a decrease of .03 for the female the implied value for γ/ρ is .54.It remains true that even very modest values of ρ would suggest values of γ in excess of unity.

We conclude that the key pattern that we document in the CAMS–that the value of z is nearly constant for each gender even when a household member moves into retirement–suggests a reasonably high value for the labor supply elasticity parameter γ. In particular, the implied value of γ is likely at least as high as unity and potentially significantly higher, depending upon the value of ρ.

6.3. Estimates Based on Panel Regression

We now turn to providing estimates of γ/ρ from panel regression estimates of equation (5.4). Recall that our derivation implied that this condition should hold in the face of any changes in the economic environment that generate changes in some component of time allocations holding parameters fixed. In this sense we can run this regression for the entire sample of matched households.

A key issue that we have discussed earlier is that both right and left hand side variables in equation (5.4) are likely to be measured with considerable error. Measurement error in the left hand side variables will of course not bias the estimates, but measurement error in the right hand side variable will bias the estimated coefficient toward zero. As is well known, one can run both the specification in (5.4) as well as the reverse specification with left and right hand sides switched in order to generate an interval of estimates, but this of course does not eliminate the effect of measurement error. Attempts to deal with measurement error will be a major focus of the exercises in this subsection.

Before proceeding we discuss the type of measurement error that our specification can accommodate. One source of measurement error in the CAMS is that total time use need not add up to total time available. We previously suggested that if the extent of this problem were the same across leisure and homework that our variable z would be unaffected on average. Here we want to note that equation (5.4) is robust to a much more general specification of measurement error. In particular, we can assume that each gender and each category have its own proportional error in addition to an iid term that reflects classical measurement error. That is, we can assume for example, that reported time spent in home production by a member of gender g in period t in the survey, denoted by $\hat{h}_{gt}$, is related to true time spent in home production, denoted h_{gt} by:

$$h_{gt} = B_{gh}\hat{h}_{gt}\varepsilon_{hgt}$$

where B_g reflects the fact that only a fraction of total time is reported in this category and $log(\varepsilon_{ght})$ is classical measurement error. Because our estimating equation takes log differences by gender over time, the B_{gh} terms will all cancel, leaving only classical measurement error. More generally, we could even allow for a deterministic trend in the B_{gh} terms to capture some systematic component of measurement error associated with aging by including a constant term in our estimating equation.

As a starting point, we run specification (5.4) using our sample of matched households across consecutive surveys. Each matched pair leads to one observation. A given household that appears in all of the surveys could contribute 4 observations to our sample, subject to there being no missing values that exclude them. The resulting sample size is 5012.

Consistent with the discussion above, we run both the specification in this equation as well as its mirror image with the right and left hand variables reversed. When estimating equation (5.4) we get a point estimate of .138 for γ/ρ with a standard error of .013. When we run the regression with the left and right hand side variables reversed we obtain a point estimate of .280 for ρ/γ with a standard error of .026. Both point estimates are statistically significant and of the appropriate sign, thus supporting the basic economic mechanism in our model. Absent measurement error and assuming that the model were correct, the two point estimates should be the inverse of each other, so that one of the estimates would be smaller than one and the other would be larger than one. The presence of measurement error biases both of them toward zero, and thus can explain why both are smaller than one.

The implied range of values for γ is very large, and the lower bound for γ is increasing in the value of ρ. Taking $\rho = 1$ as a reasonable lower bound for ρ, the two implied values for γ would be .138 and 3.57. Note that for a given value of ρ, measurement error biases the implied value of γ toward 0 when running the regression as in equation (5.4), but biases the implied value of γ upward when running the reverse regression. For this reason we regard these two values as natural bounds. For $\rho = 3$, the implied values for γ become .414 and 10.71. To the extent that the latter value is biased upward and we view 3.57 as the lowest upper bound we do not view the 10.71 value as particularly relevant. But the value of the lower number is significant to the extent that it is biased downward and so represents a lower bound.

The sample used to run the above regressions included all observations in which household members could be matched over time. It is perhaps to be expected that a lot of the variation in time allocations in this sample might reflect measurement error. One way to dampen the potential effect of measurement error is to select a subsample where the relative importance of measurement error might be lower. To do this we focus on households in which one of the members transitions from full time work to not working. For such an individual we expect there to be large changes in both leisure and home production, thus hopefully increasing the signal to noise ratio. For this exercise we construct the sample in the following manner. The data for a household from the surveys in t and $t+2$ will be included if the household is in the survey at each of t, $t+2$, and $t+4$, and at least one member works at least 35 hours in the survey at t and no more than 5 hours in the surveys at both $t+2$ and $t+4$. That is, our sample consists of households that experience at least one member moving in a persistent way from from full time work to retirement. Note that we do not place any restrictions on the choice of the other member. The resulting sample size is 188 observations.

We run the same two regressions for this sample as we did for the original sample. When we run the regression as in equation (5.4) we get a point estimate for γ/ρ of .214 with a standard error of .070. When we run the reverse regression we obtain a point estimate for ρ/γ of .422 with a standard error of .100.[23]

The estimates that result from these exercises change in the expected way,

[23] We have also tried using the difference in z between t and $t+4$ as an instrument for the change in z between t and $t+2$ as another way to minimize the effect of measurement error. We obtain an estimate for γ/ρ of .232, with a standard error of .132, and an estimate of .646 for ρ/γ with a standard error of .176. In both cases the first stage is significant.

in that when we make an effort to reduce the effect of measurement error the estimates seem to move away from zero in absolute value. However, in all cases it remains true that both estimates are smaller than one, consistent with the notion that considerable measurement error remains. While it is perhaps disappointing that we do not obtain sharper results from the panel estimation, it is important to note that the results of the panel regression estimates are consistent with the value for γ/ρ that we inferred from simply evaluating equation (5.4) using average values for the changes in time allocations during a transition to retirement.

6.4. Heterogeneous γ by Gender

Earlier in the paper we noted that if one interprets γ as evidence about the intertemporal elasticity of substitution it might be of interest to allow for this value to differ by gender. In this subsection we report the results of one exercise that speaks to this possibility. In the interests of space we do not go through the derivation here, but it is straightforward to show that if we had allowed for heterogeneous values of γ, then going through the same derivation as before we would have ended up with the expression:

$$\Delta \log h_m - \Delta \log h_f = \frac{\rho}{\gamma_m} \Delta \log l_m - \frac{\rho}{\gamma_f} \Delta \log l_f$$

It follows that when estimating the inverse of equation (5.4) on panel data it is straightforward to allow γ to vary by gender. When we estimate this expression allowing for gender specific coefficients we obtain point estimates of .290 and .270 for ρ/γ_m and ρ/γ_f respectively, both with standard errors of .034. We conclude that imposing $\gamma_m = \gamma_f$ is consistent with our data.[24]

7. Evidence from Other Countries

To this point we have focused on time use patterns in the US. Given that time use data is available for many countries it is of interest to ask whether the patterns that we find for the US are also present in other countries. In this section we examine this using time use data from the MTUS covering France, Germany, Italy, the Netherlands, Norway, Spain and the UK.[25] For each of these countries we can carry out an analysis similar to what we did for the ATUS.

For this analysis we concentrate on what happens during the age range from 50 to 65 since this age range covers the most substantial decreases in market work associated with the process of retirement. To assess the extent to which the ratio z changes over this age range we run a simple regression of age specific mean values of z against a constant and age, separately for each gender:

$$z_{acg} = a_{cg} + b_{cg}a + \varepsilon_{acg} \tag{7.1}$$

where a is age, c is country, and g is gender. Table VII presents the results of this regression exercise. The column headed by #obs reflects the average number of observations for each age.

Several aspects of the results are worth noting. First, the dispersion of z among

[24] This result also holds when we consider the other estimation results considered above, though the standard errors become larger when we allow the $\gamma's$ to vary by gender.

[25] See Gershuny and Fisher (2013) for details on this data set.

individuals of a given gender and age in a given country is substantial. The column labeled σ_z presents the average value of the age specific standard deviation of z. This value tends to be in the range of $0.15 - 0.20$, with relatively little variation across gender or country. These values tend to be intermediate between the values we found using the CAMS and the ATUS. Second, although the modal tendency is for male z to increase with age and for female z to decrease with age, the magnitude of these effects is for the most part quite modest. For example, a point estimate for b of .003 implies an increase of .045 for z over a period of fifteen years. To the extent that our age range captures most of the retirement in the data this magnitude is comparable to our point estimate for the change in z for a male moving from full time work to retirement. The point estimates for France and Italy are both a bit larger, while those for Norway and Spain are smaller. The point estimates for females are even smaller in absolute value. Although we do not report the overall mean values in the table, we note that there are large differences by gender and by country. In particular, the gender gap in homework varies quite substantially across countries. However, as the above table shows, despite these large differences in levels, the changes in z over the period that captures most retirement is very similar across countries.

A simple calculation suggests the same message as the CAMS data. In particular, consider a household in which both individuals have discretionary time of 100 hours, the male moves from full time work (40 hours) to retirement, the female moves from part time work to retirement (20 hours), the male z increases from .250 to .295, and the female z stays constant. Using equation (5.4), the implied value for γ/ρ is .75. We conclude that the available data from the MTUS suggests estimates of γ that are similar to those implied by the US data.

8. Conclusion

We study what happens to household time allocations when one or more members retires. Unlike the vast majority of studies of time use, we examine these changes using panel data that contains information about both members in two person households. We find that very little happens to the way that individuals allocate their nonmarket discretionary time between leisure and home production in response to retirement. Additionally, we find that there is considerable heterogeneity across households in the way that this time is allocated, and that this heterogeneity is very persistent.

We then develop a multi-member household model of time use and show how the key pattern found in the data can be used to infer information about two key elasticity parameters: the elasticity of substitution between the time of household members in home production and the elasticity of substitution between the leisure time of household members. In some commonly studied settings, this latter elasticity will also be equal to the household's intertemporal elasticity of substitution for leisure. Our theory places a joint restriction on these two elasticity parameters and changes in household time use. This restriction is robust to a variety of model features, and for what we view as very conservative values for the production elasticity of substitution, we find that the preference elasticity is quite large, most likely greater than unity. Data from several other countries suggests that the key pattern we document in US data appears to hold more generally.

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Appendix: Time Use Categories

In this appendix we describe how we aggregate time use categories in the CAMS and the ATUS. We being with the CAMS data set. Leisure includes the following categories: watch TV, read papers & magazines, read books, listen to music, walk, sports/exercise, visit friends/neighbors/relatives, communicate by phone/letter/email with friends/neighbors/relatives, playing cards or games, attending concerts/movies/museums, attending meetings or clubs, singing or playing instrument, arts and crafts, eating out. Homework includes: house cleaning, laundry, yard work & gardening, shopping & errands, help others, meal prep & clean up, caring for pets, managing household finances, home repairs, and vehicle maintenance. Market work includes the lone category of working for pay. Personal care includes: sleep, grooming, showing affection and managing medical condition. The residual category includes: pray/meditate, volunteer work, and religious attendance. There is a category called computer usage in the CAMS, but we have not included this category as it is not distinct from the activity that one may be performing on the computer. In particular, there is a sharp drop in time spent using a computer that coincides with the movement into retirement.

In aggregating the categories in the ATUS we seek to be as consistent as possible with the categories in the CAMS. Home production is defined to include time spent on housework, food and drink prep, presentation and cleanup, interior maintenance, repair and decoration, exterior repair, maintenance and decoration, lawn, garden and houseplants, helping household and non-household members, animals and pets, vehicles, appliances, tools and toys, household management and shopping, which in turn includes time spent purchasing consumer goods, groceries, professional and personal care services, financial services and banking, medical services, household services, home and vehicle maintenance (not done by self) and government services, plus the time spent commuting to make these purchases. Leisure is defined to include time spent socializing and communicating, attending and hosting social events, relaxing and leisure, arts and entertainment, sports and exercise, as well as eating and drinking. Personal care consists of sleeping, grooming, health related self-care and personal activities.

Here we note a few cases where categories do not perfectly coincide. We map the ATUS category of "purchasing goods and services" into the CAMS category of "shopping and running errands". We map "household management" in the ATUS into "money management" in CAMS. We map "interior & exterior repairs, vehicle maintenance and tool maintenance" into household maintenance in the CAMS. In the ATUS, "help others" includes helping household and non-household members, whereas in CAMS it only includes non-household members, but we treat them identically. In the ATUS, "eating and drinking" includes eating and drinking at home in addition to eating out whereas in the CAMS it is just eating out, and we treat them symmetrically. In the ATUS, market work is work and work related activities, whereas in CAMS it is just called "work for pay". The ATUS includes time spent in education, whereas CAMS does not. We include this in the residual category for the ATUS. Lastly, we note that the ATUS specifically tracks travel time associated with each category. So, travel time associated with leisure will be in the aggregate leisure measure, though not in the subcategories within leisure. CAMS does not have specific questions about travel time associated with activities.

For our analysis using the MTUS we also aggregate categories so as to coordinate with our definitions in the CAMS. In particular, for homework we include: food preparation, cleaning etc., maintenance, shopping for goods and services, petcare, child and elderly care and gardening. We define leisure to include going out, eating and drinking, sports and exercise, leisure, reading, watching television or listening to radio, computer and internet usage.

The specific surveys for the countries used in our analysis are: France 1998-1999, Germany 2001-2002, Italy 2002-2003, Netherlands 1995, 2000 and 2005, Norway 1990-1991 and 2000-2001, Spain 2002-2003 and 2009-2010, UK 1995, 2000-2001 and 2005.

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Table I
Value of z for Matched Individuals

	Males					Females				
	μ_{z_t}	$\mu_{z_{t+1}}$	σ_{z_t}	$\sigma_{z_{t+1}}$	$\rho_{z_t,z_{t+1}}$	μ_{z_t}	$\mu_{z_{t+1}}$	σ_{z_t}	$\sigma_{z_{t+1}}$	$\rho_{z_t,z_{t+1}}$
2005-07	.26	.25	.15	.14	.44	.31	.31	.14	.15	.48
2007-09	.26	.26	.14	.14	.53	.31	.31	.15	.15	.52
2009-11	.25	.25	.14	.14	.54	.31	.30	.15	.15	.54
2011-13	.26	.25	.14	.14	.50	.31	.30	.14	.15	.50

Notes: The data for this table comes from the 2005-2013 waves of the CAMS. z is the ratio of home production time to the sum of home production time plus leisure time. This table summarizes properties of z for our sample of individuals that are matched across consecutive surveys. μ denotes mean, σ denotes standard deviation and ρ denotes the correlation. Time use categories are defined in the Appendix.

Table II
Value of z for Individuals Retiring Across Surveys

	Males					Females				
	μ_{z_t}	$\mu_{z_{t+1}}$	σ_{z_t}	$\sigma_{z_{t+1}}$	$\rho_{z_t,z_{t+1}}$	μ_{z_t}	$\mu_{z_{t+1}}$	σ_{z_t}	$\sigma_{z_{t+1}}$	$\rho_{z_t,z_{t+1}}$
2005-07	.26	.28	.14	.15	.34	.30	.31	.14	.14	.25
2007-09	.25	.28	.13	.15	.50	.31	.32	.14	.15	.31
2009-11	.26	.29	.14	.15	.59	.35	.34	.15	.14	.44
2011-13	.24	.26	.14	.13	.34	.31	.32	.14	.16	.34

Notes: The data for this table comes from the 2005-2013 waves of the CAMS. z is the ratio of home production time to the sum of home production time plus leisure time. This table summarizes properties of z for our sample of individuals that are matched across consecutive surveys and that move from full time work (at least 35 hours per week) to not working (less than five hours per week) across consecutive surveys. μ denotes mean, σ denotes standard deviation and ρ denotes the correlation. Time use categories are defined in the Appendix.

Table III

Time Use Pre and Post Retirement, Pooled (Hrs/Wk)

	Before	After	Change
	Home Production Categories		
Housework	4.80	6.64	1.84
Shopping	2.77	3.88	1.11
Cooking	4.59	5.57	0.98
Yard/Garden	2.05	2.70	0.65
Petcare	2.35	2.92	0.57
Money Mgt.	0.86	0.92	0.06
Maintenance	2.00	2.80	0.80
Help Others	1.04	1.89	0.85
	Leisure Categories		
Watch TV	16.32	22.72	6.40
Exercise	9.41	8.73	−0.68
Socializing	5.00	8.50	3.50
Relaxing	21.97	23.73	1.77

Notes: The data for this table comes from the 2005-2013 waves of the CAMS. This table reports time devoted to each of several activities in hours per week for individuals that transition from full time work in one survey (at least 35 hours per week) to not working in the subsequent survey (less than five hours per week). Numbers reported are averaged across all individuals that experience this transition across consecutive surveys. Pre-retirement refers to the survey in which the individual worked full time, and post-retirement refers to the period in which the individual does not work.

Table IV
Market Work (m) and z in the ATUS (Hrs/week)

	Total			Male			Female		
Age	μ_m	μ_z	σ_z	μ_m	μ_z	σ_z	μ_m	μ_z	σ_z
55	32.8	.32	.23	37.8	.27	.23	28.2	.37	.23
56	29.8	.31	.22	34.3	.25	.21	25.4	.36	.22
57	29.7	.31	.23	32.9	.26	.22	26.5	.36	.22
58	27.1	.32	.22	33.2	.25	.21	21.5	.37	.22
59	26.3	.32	.23	29.8	.26	.22	23.1	.38	.22
60	26.4	.31	.22	31.9	.25	.21	21.2	.36	.23
61	23.0	.31	.23	26.7	.25	.22	19.4	.36	.22
62	21.4	.31	.22	24.7	.26	.21	18.5	.36	.22
63	16.2	.31	.22	18.0	.27	.23	14.6	.35	.22
64	15.6	.31	.22	18.5	.26	.21	13.1	.36	.22
65	12.0	.32	.23	14.0	.26	.22	10.2	.36	.23
66	11.2	.31	.22	12.7	.26	.22	9.8	.35	.22
67	10.4	.30	.22	13.3	.26	.22	7.8	.34	.22
68	9.9	.30	.23	11.4	.26	.22	8.6	.34	.23
69	7.2	.30	.22	9.4	.24	.21	5.3	.34	.22
70	7.3	.29	.23	9.3	.22	.21	5.4	.35	.22

Notes: Data for this table comes from the 2003-2015 waves of the ATUS. z is the ratio of home production time to the sum of home production time plus leisure time. m is hours of market work per week. μ denotes mean and σ denotes standard deviation. Time use categories are defined in the Appendix.

Table V
z for Matched Households

	μ_{z_t}	$\mu_{z_{t+1}}$	σ_{z_t}	$\sigma_{z_{t+1}}$	$\rho_{z_t,z_{t+1}}$
$2005-07$	.30	.30	.11	.11	.52
$2007-09$	.30	.30	.11	.11	.55
$2009-11$	.29	.29	.11	.11	.54
$2011-13$	.29	.28	.10	.11	.46

Notes: The data for this table comes from the 2005-2013 waves of the CAMS. z is the ratio of household home production time to the sum of household home production time plus household leisure time. This table summarizes properties of z for our sample of two member households matched across consecutive surveys. μ denotes mean, σ denotes standard deviation and ρ denotes the correlation. Time use categories are defined in the Appendix.

Table VI
Changes in z for Households With a Retiring Member

	Male		Female		Gap		#obs
	Pre	Post	Pre	Post	Pre	Post	
$M \rightarrow R, F \rightarrow R$	.24	.27	.34	.36	.10	.09	37
$M \rightarrow R, FW$	.26	.29	.33	.32	.07	.03	78
$M \rightarrow R, FR$	.22	.25	.34	.34	.12	.09	112
$F \rightarrow R, MW$	.23	.21	.32	.32	.09	.11	46
$F \rightarrow R, MR$	.30	.28	.32	.33	.02	.05	62

Notes: The data for this table comes from the 2005-2013 waves of the CAMS. z is the ratio of home production time to the sum of home production time plus leisure time. This table reports the mean value of z for each household member in our sample of two member households matched across consecutive surveys in the CAMS in which at least one of the household members transitions from full time work (at least 35 hours/week) to not working (less than 5 hours/week). The arrow in the first column denotes which individual(s) is transitioning to not working. The second entry in the first column indicates the (unchanged) status of the individual who is not transitioning. W indicates working and R denotes not working, M and F refer to male and female.

Table VII
Change in z by Age in the Multinational Time Use Survey

	Male			Female		
	b_{cm}	#obs/age	σ_z	b_{cf}	#obs/age	σ_z
France	.0052	98.5	.181	−.0030	103.3	.166
	(.0008)			(.0010)		
Germany	.0022	241.9	.183	−.0008	246.0	.176
	(.0010)			(.0008)		
Italy	.0048	326.1	.183	−.0016	342.3	.164
	(.0007)			(.0006)		
Netherlands	.0039	286.8	.192	−.0008	355.8	.184
	(.0014)			(.0007)		
Norway	−.0006	90.3	.178	−.0015	85.5	.153
	(.0014)			(.0011)		
Spain	.0002	510.7	.184	−.0018	571.2	.186
	(.0005)			(.0006)		
UK	.0014	175.4	.188	−.0021	189.7	.179
	(.0014)			(.0009)		

Notes: z is the ratio of home production time to the sum of home production time plus leisure time. This table reports the coefficient on age when running the regression in equation (7.1) for individuals aged $50 - 70$. σ_z denotes the standard deviation of z for the sample pooled across ages.