Intra-household insurance, leverage constraints and housing decisions.

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Abstract

This paper analyzes how households make joint decisions on housing tenure (home owner vs. renter) and time use under the assumption that they make joint decisions through bargaining. Furthermore, I also study how households insure themselves against income and unemployment shocks given the aforementioned features. Both the heterogeneity in housing tenure and the intra-household distribution of bargaining power is shown to have an impact on household decisions. Using micro-level panel data from the British Household Panel Survey (BHPS), I first provide reduced form evidence that intra-household bargaining power matters for the ability of households to use the secondary earner's labor supply to insure themselves against shocks. Next, I build and structurally estimate a life cycle model where household members bargain over joint resources and use it to explain certain empirical features from the data and do some counterfactual analysis by changing the structure of the borrowing constraints home owners face.

JEL codes: D15, J22, R21.
Keywords: Life cycle models; labor supply; collective households; housing demand; added worker effect

1 Introduction

How do households insure themselves against income and unemployment shocks in the presence of borrowing constraints? And how does the fact that household members make joint decisions through bargaining affect self-insurance? These questions are the focus of the present paper. The former question naturally arises out of an extensive literature

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which studies household's self-insurance against shocks, in particular the use of female labor supply within the household as an insurance mechanism (e.g. Attanasio et al. (2005) and Low (2005)). One important recent insight is that the household's ability to mitigate unexpected shocks is partly affected by the composition of their balance sheets (Kaplan and Violante (2014)). In particular, when households incur debt to buy a house, they will face leverage based borrowing constraints on the amount of debt they incur and hence there will be differences in terms of the need to make use of costly labor supply from the secondary earner to smooth consumption. Given the repercussions on the real economy and on household finances of the Great Recession, the question on how households are able to insure themselves against shocks in the presence of such leverage based constraints did receive some recent attention in the literature. However, these studies don't address the precise manner through which shocks affects the household decision making proces. To the best of my knowledge, all papers that study the relationship between housing and labor supply decisions of households assume that the household can be modelled as a single individual. However, there is ample evidence in favor of the more realistic assumption that household members make joint decisions through (cooperative) bargaining ('collective households'), it is important to understand how results change when taking this bargaining process explicitly into account. Consider a household where the primary earner becomes unemployed. In this case, the potential earnings of the household head will be reduced after some time, in which case a collective household model would predict a shift in bargaining power to the secondary earner. If the secondary earner's disutility of work is relatively high, (s)he will not be willing to supply more labor. This effect counteracts the case where the same household owns a house and the adverse income shock is too large such that the household can't fulfill its (leverage based) borrowing constraints anymore and hence has to rely on the added worker effect (AWE), i.e. an increased labor supply from the secondary earner. From this example, it is clear that the bargaining proces and the household's balance sheet will interact in interesting ways to influence the household's response to income and employment shocks. The extend to which households are able to mitigate shocks by making use of the secondary earner's labor supply is also relevant from a policy perspective. As some papers have pointed out, there is a clear link between the public unemployment insurance (UI) system and the responsiveness of labor supply from the secondary earner. [1] Following on this, it seems that there is scope to analyze optimal UI schemes for individuals depending on the household structure in which they live (i.e. whether they are single or married). For example, the paper by Choi and Valladares-Esteban (2016) shows that UI is only welfare improving for single individuals as their married counterparts have sufficient means for self-insurance via the pooling of resources and the added worker effect. However, an important aspect of their

[1] E.g. Cullen and Gruber (2001) and Ortigueira and Siassi (2013) provide empirical evidence for the crowding-out effects of unemployment insurance.

model is full income pooling, i.e. both spouses have full access to the joint household resources. Relaxing this assumption will impact the scope for self-insurance and therefore alter the sharp conclusions regarding welfare implications of UI between singles and married individuals. It is therefore paramount to look at a more realistic decision proces within the household. In particular, to have a better quantification of the AWE.

There are other policy relevant reasons to explicitly incorporate intra-household bargaining within the household decision process for labour supply and housing status. Many governments, especially before the Great Recession, were often implementing policies to stimulate home ownership. The latter, as we will see, necessitates for certain households room for the presence of sufficiently responsive labor supply from the secondary earner in order to service the outstanding debt pertaining to the house. If this responsiveness of the secondary earner's labor supply is limited (e.g. because of the particular way household resources are shared within the household), it might not be welfare enhancing to stimulate housing demand for these households. Again there is a clear need to address the interaction between intra-household bargaining process and the borrowing constraints faced by households.

My contribution. The contribution of my paper is twofold: first, using data of married or cohabiting couples from the BHPS, I exploit information on subjective expectations and evaluations from respondents on their financial position to construct an indicator whether the household received a financial shock. Next, I extend the notion of Bartik-type instrumental variables to construct an exogenous measure of potential relative wage of the secondary earner within the household, which I interpret as a measure of the secondary earner's relative bargaining power. Using these, I can empirically assess the importance of taking into account heterogeneity in relative bargaining power for the secondary earner. I show that, in the absence of such controls, there is not much evidence in favor of a higher responsiveness in labor supply to shocks in the presence of borrowing constraints. The latter negative result has been shown earlier by Benito and Saleheen (2013), and which is typically seen as a rejection of the importance of leverage based borrowing constraints on the responsiveness to shocks. However, including the measure for relative potential bargaining power, I do find significant responses of labor supply in the presence of shocks across different balance sheet positions. Furthermore, and in accordance with the hypothesis that intra-household bargaining plays a role, I find that the gap in household work between the primary and secondary earner within the household responds heterogeneously to shocks across different positions w.r.t. the leverage based constraints and relative bargaining positions of the secondary earner. This implies that household members reallocate time use, where the secondary earner is compensated for incurring the disutility to increase labor supply via the primary earner taking up more household chores. In the second part of the paper I build upon this empirical evidence and build an inter temporal collective household model, that extends the standard life cycle models with the assumption that household members cooperatively come to decisions, where the particular bargaining weights are changing over time in response to unexpected shocks. In the model, secondary earners face two impediments on increasing labor supply: first, they have a disutility from working and second, in case of the presence of young children, child care costs. Furthermore, I include housing decisions in my model following Bottazzi (2007) and Attanasio et al. (2012) which causes households to differ in terms of their ability to incur more debt. More precisely, when the household buys a house, it will face a borrowing constraint formulated as the upper limit of two measures of mortgage leverage: the Loan-to-Value (LTV) and the Loan-to-Income (LTI) ratios. The LTV is the ratio of the outstanding mortgage obligation to the value of the house, whereas the LTI is the ratio of the outstanding mortgage payments to the (yearly) household income. Both ratios are quite common indicators to assess a household's financial position in terms of its housing assets and are indeed also used when assessing whether households are credit worthy (in terms of the ability to pay back the loan). I calibrate the model to match the model's predictions with certain stylized features in terms of time use and home ownership rates in the data. Finally, I use the model to study counterfactual scenarios with different bounds pertaining to the LTV and LTI limits.

Related literature My research touches on different fields. First, since the focus of this paper is on labor supply responses from the secondary earner to adverse shocks, it contributes to the large literature which studies this so-called added worker effect (AWE). In the empirical part, I provide some evidence in favor of the existence of an AWE on the extensive and intensive margin of labor supply, when taking into account heterogeneity in terms of intra-household resource sharing and the particular household balance positions. Most of this literature on the AWE provides mixed results. Some find no significant AWE, others find significant but very small effects and others some stronger effects. References on the AWE include Lundberg (1985), Maloney (1987, 1991) and Spletzer (1997). Some papers finding stronger results in favor of the existence of an AWE in terms of the intensive margin of labor supply are Stephens (2002), Kohara (2010) and Gong (2011). Cross-country studies on the AWE also point to the importance of the particular social security system for the extent to which the AWE is present, e.g. Prieto-Rodriguez and Rodriguez-Gutierrez (2003) and Bredtmann, Otten and Rulff (2017).

Methodologically, I use insights from several papers which argue that subjective evaluations of future (financial and economic) outcomes can be used as sources of identification of unexpected shocks. I apply the construction of a financial shock indicator from Benito and Saleheen (2013) to identify the effect on household's labor supply of shocks. Other papers that argue for using subjective expectations of income and/or wealth as sources of exogenous variation include Pistaferri (2001), Manski (2004) and Attanasio et al. (2017).

Finally, I contribute to the large literature that uses life cycle models to study household decisions. Most of the literature has either focussed on housing demand (Iacoviello (2008), Yang (2009), Fernández-Villaverde and Krueger (2011), Attanasio et al. (2012), Bajari et al. (2013), Iacoviello and Pavan (2013) and Druedahl (2015)) or on labor supply of two-earner households (Low (2005), Attanasio et al. (2005,2008,2015), Blundell et al. (2016)). To the best of my knowledge, there are only two papers that incorporate both housing demand and labor supply in two-earner households within a life cycle framework, in particular Bottazi (2007) and Pizzinelli (2018). However, all these papers work within a *unitary* framework, that is, they assume the household members' preferences can be aggregated into a single utility function which is stable over the life cycle. There is, however, a large literature rejecting this assumption and arguing that household members engage in a (cooperative) bargaining process which results in Pareto efficient allocations. Such models are referred to as 'collective household models' and the literature studying the theoretic and empirical implications of intra-household resource sharing on important household decisions (e.g. labor supply, savings etc) is extensive. A good recent overview of this literature is Chiappori and Mazzocco (2017).

Given that I'm interested in the life cycle patterns of household decisions, I have to extend the collective model to an intertemporal framework. There are several papers that have studied such inter temporal collective household models. Typical references include Mazzocco (2007), Mazzocco et al. (2013), Voena (2015) and Lise and Yamada (2018). I contribute to this literature by adding housing tenure choice to a collective life cycle model.

2 Housing and time use in BHPS

In this section, I will describe the data and establish some basic patterns regarding home ownership, leverage and time use patterns over the life cycle. Using the British Household Panel Survey (BHPS), I show the life cycle patterns of several important variables, besides the cross-sectional heterogeneity in two-earner households. The BHPS is a comprehensive longitudinal study for the UK for general use in the social sciences. It consists of yearly individual-level observations which spans from 1991 to 2008. It resembles many features of the US-based PSID in the sense that it tracks individuals across household changes and tries to match the population age distribution by taking a refresher sample of new adults in each wave. The first wave consists of a sample size around 5000 households (10.000 adult interviews). Because of attrition and a net outflow of households, the sample size has decreased. The BHPS contains detailed information regarding income sources, earnings, labor histories, housing status and mortgages.[2]

[2]More information as well as links to access the data is available on https://www.iser.essex.ac.uk/bhps.

I select men and women who are aged between 25 and 65. I impose these age restrictions as I'm not interested in early life choices and behavior (e.g. education) or retirement decisions.[3] I will split my sample into two distinct subsamples: the first is a dataset of individuals which are continuously married or cohabiting, the second consists of a subsample of singles. The former will be the main focus of my analysis, I will return to a description of the second subsample in Section 5 where I will use this subsample to impute a value of the outside options for spouses post-divorce, in order to pin down their initial bargaining power.

I restrict my analysis to the waves from 1993 to 2005 and construct household-year observations where I use the BHPS classification of individuals within a household as either being a 'household head' or 'secondary earner'. The household head is defined as the member who is legally and financially responsible for accommodation or the elder of two people who share the responsibility.

As already mentioned, the BHPS also registers the housing tenure of individuals. In particular, there are three broad categories: *owned outright, renter* or *home ownership with mortgage*. Since I'm interested in how households respond to shocks in the presence of leverage-based borrowing constraints, I require information on the latter. Conventional measures for household financial balance analysis are the Loan-to-Value (LTV) and Loan-to-Income (LTI) ratios. The former is defined as the ratio of the leverage ratio in terms of the amount of loan (for purchasing a house) divided by the value of the house, the latter considers the ratio of the loan over the household income. Higher values for these two ratios imply higher leverage for the household.[4] Besides the ordinary LTI ratio, one can also look at another measure of leverage, in particular the *primary-* LTI (p-LTI), which is defined similarly to the standard LTI, but where the denominator is replaced by the income of the primary earner in the household.[5] I trim the sample by dropping all households with a p-LTI ratio above the 90th percentile. All these restrictions leave an unbalanced panel of 3266 households. Of these, approximately 50 % are observed for at least 4 consecutive years and 25 % for at least 8 years.

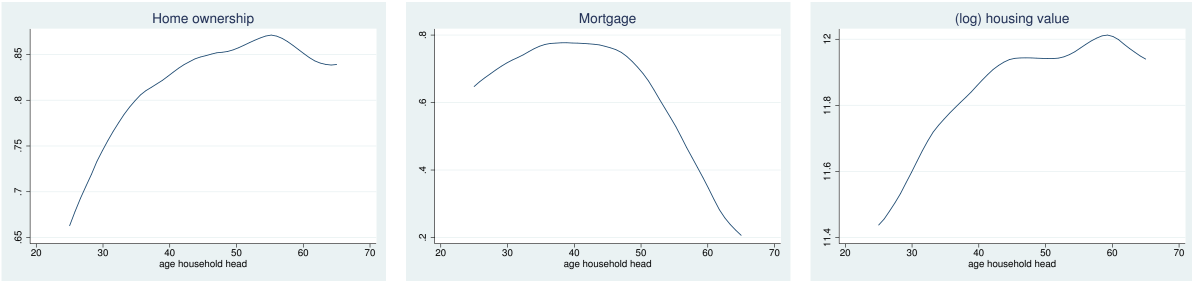
Using this main subsample, Figure 1 shows the main life cycle profiles of housing related variables:

[3] The structural model presented in Section 4 does incorporate retirement in a very stylized way.

[4] In the data, there is information on the amount of the outstanding mortgage, which I use as proxy for the numerator in the leverage ratios. The data also contains self-reported housing value, which I use as denominator of the LTV ratio.

[5] In practice, I compute this by taking the total household income, including labor earnings and non-labor income and subtracting the female labor earnings.

Figure 1



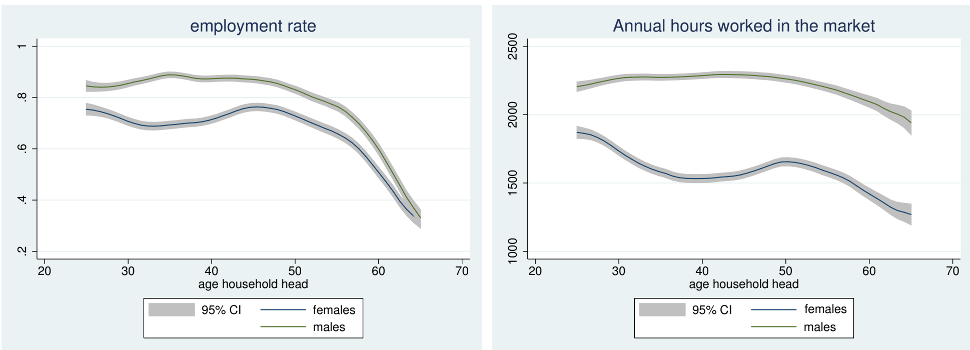
(a) Home ownership (b) Mortgagor rate (c) (log) Home value

Figure 1: Source: BHPS waves 1993-2005. Sample includes married or cohabiting couples. Age refers to the age of the household head. The graphs are obtained by local polynomial smoothing. Housing values are deflated by the 2005 UK CPI.

We notice home ownership rate for households where the household head is at the age of 25 of around 60 % and increases until the household head is aged close to 50 and it levels of around 85 %. The fraction of households having outstanding mortgage (mortgagor rate) follows a hump shaped pattern: younger households take out mortgages and gradually repay over their lifetime. Finally, the housing value also increases over time, meaning older households having a larger amount of housing assets.

I now turn to show some main facts regarding employment rates and time use.

Figure 2



(a) Employment rate (b) Annual hours

Figure 2: Source: BHPS waves 1993-2005. Sample includes married or cohabiting couples. Age refers to the age of the household head. The graphs are obtained by local polynomial smoothing. I included 95 % confidence bands. Hours worked refers to the sum of contractual hours and overtime, multiplied by the number of weeks worked during a year.

Figure 2 shows there are a couple of life cycle patterns which emerge: women[6] participate in the labor market at a lower rate than men. The latter being active in the labor

[6]Notice that in the data, approximately 90 % of the household heads are male, which means that in this dataset, for most households female labor supply will serve as the first means of household's self-insurance, which is also common in the literature.

market at a stable continuous rate. Females' employment rate drops a bit between 25 and 35 and then take up again until 50, when transitions into retirement start. Besides looking at the extensive margin of labor supply, Figure 2 also presents a picture for the intensive margin. In particular, I plot the average annual hours worked over the life cycle. Similar to the extensive margin, for females there is a decrease in hours worked over the first period, likely due to fertility. From the age of 40-45, there is a slight increase again in the intensity of labor market work and then from the age of 50 there is a decrease in hours worked. In contrast, males' hours worked stay more or less constant over the entire life cycle and only starts to slightly decrease towards the later third of the life cycle, again due to retirement transitions.

3 Empirical analysis

We now use our main dataset on couples to provide some empirical evidence to study how time use decisions (in particular labor supply and household work) is related to leverage based ratios and whether measures of intra-household bargaining power have an impact on the responses of households to shocks. There are multiple challenges in trying to address these questions in a regression framework. In particular, one needs to obtain good measures of both shocks and bargaining weights within the household.

There have been a couple contributions to show that labor supply is related to leverage based constraints (e.g Bottazzi (2004, 2007) and Pizzinelli (2018). In the Appendix, I replicate some of these results. Like Pizzinelli, I find that there is a monotonic relationship in the extensive margin of labor supply and the p-LTI measure and a negative correlation with the LTV (see A.2). However, there has not been much research on the interaction between shocks and leverage based constraints on the labor supply of the secondary earner. On the other hand, as I already mentioned, there has been a substantial literature studying the labor supply responses of secondary earners (mostly women) on the primary earner's unemployment. Most of these studies are event studies: they exploit a displacement event of husbands as exogenous variation for changes in their wives' labor supply. A nice feature of the BHPS is that it also asks respondents on their financial expectations for the coming year and in the subsequent wave it asks on the change of their financial situation.[7] Hence, this allows me to construct an indicator of a negative financial shock[8], $NFS_{i,t} = 1$ if expected financial situation of household i for t was that it would improve, whereas evaluation of financial change from t to $t+1$ was that it

[7]In the survey, respondents have to give a qualitative evaluation of expectations and evaluations. In particular, they have to state whether they expect their financial position to improve, stay the same or deteriorate over the coming year and the same for the evaluation of the past year: whether it improved, stayed the same or deteriorated.

[8]I will focus here on negative financial shocks, the exercise can also be done with positive financial shock.

stayed the same or deteriorated.[9] In the appendix, I regress the incidence to receive a negative financial shock on several household characteristics as a validation exercise (see Table A.2). I find that the likelihood to receive a negative financial shock is negatively correlated with the growth in primary household income (i.e. all household income excluding the wife's labor earnings). Recall that $NFS_{i,t}$ was defined through the difference in subjective expectations in the previous year for the current year and the actual change in financial situation, hence we can regard this as exogenous variation. Combined with the observed negative correlation with primary household income implies that $NFS_{i,t}$ seems to be a decent proxy for exogenous variation in primary household income, which is a type of shock this paper focusses on. Also reassuringly I find there is a positive and strongly significant coefficient on the household head being unemployed in the past year, which further strengthens the use of the dummy $NFS_{i,t}$ as a proxy for real economic shocks hitting the household in a given period.

The focus of this paper is on time use decisions in response to shocks, in presence of leverage based constraints. Therefore, I'm estimating the following empirical model:

$$\Delta Y_{i,t} = \mathbf{X}'_{i,t}\beta + NFS_{i,t} + LTI^p_{i,t-1} + LTV_{i,t-1} + NFS_{i,t} \times LTI^p_{i,t-1} + NFS_{i,t} \times LTV_{i,t-1} + \alpha_i + \epsilon_{i,t}. \tag{1}$$

Where $Y_{i,t}$ is the outcome variable of interest for household i in year t. $\mathbf{X}_{i,t}$ is a vector of household characteristics, including year and region dummies. Besides the indicators for receiving a negative financial shock and the levels of the leverage based constraints (both the p-LTI and LTV), I also include interactions between them. The latter are interesting because they allow me to capture heterogeneous responses in the outcome variable across the particular position of leverage based constraints. Also notice the timing of the variables included in the empirical specification: the p-LTI and LTV variables are lagged by one period. This is to reduce the simultaneity problem, since I'm interested in how the variable Y responds w.r.t. a financial shock. Since the latter will likely also affect the p-LTI and LTV measures, there would be a clear endogeneity problem if I include these variables contemporaneously. Hence, I use the lagged values in order to ease such concerns. From (1), we can compute the marginal effects of increasing the p-LTI and LTV levels, in the presence of a shock, on labor supply and the gap in household work between the spouses:

[9] The same construction of a financial shock indicator from the BHPS has been used by Benito and Saleheen (2013) to study the AWE in response to such shocks.

Table 3.1: Marginal effects of negative financial shock on time use

	$\text{Employment}_{i,t}$	$\text{Hours worked}_{i,t}$	$\text{Gap}_{i,t}$
$\text{LTI}^{p}_{i,t-1}$	0.00385	0.00932**	- 0.318
	(0.00305)	(0.0037)	(0.195)
$\text{LTV}_{i,t}$	-0.080	-0.0479	0.349
	(0.0496)	(0.0524)	(1.52)
Year	✓	✓	✓
Regions	✓	✓	✓
Household FE	✓	✓	✓
Education	✓	✓	✓
Observations	17.879	10.494	17.256

Robust standard errors in parentheses.*** p<0.01, ** p<0.05, * p<0.1

Sample includes households where both primary and secondary earners are between 25 and 65 years old.

Controls include Age, Age^2, number of children.

I find a small and significant positive effect of the financial shock on the intensive margin of the secondary earner's labor supply when the p-LTI increases, but it is estimated to be very small. For the LTV ratio, I obtain estimated negative coefficients for labor supply. The sign of this coefficient is in line with the predictions from the model from Pizzinelli (2018). He points out that higher LTV households are households who want to avoid the disutility of making use of the secondary earner's labor supply and therefore accumulate more debt. Notice that these coefficients are insignificant though. Overall, these results are in line with the findings by Benito and Saleheen (2013), who only find very weak evidence in favor of a strong interaction between the leverage based ratios and (female) labor supply. [ADD: ROBUSTNESS WRT 2ND JOB]

Households also differ in terms of the way they share joint resources amongst themselves, indeed a large literature is devoted to studying the way households make decisions on consumption and time use allocations given that they have different preferences.[10] The standard assumption in this literature is that households make Pareto efficient decisions.[11] Formally, such models imply that the household maximizes a weighted sum of utility functions of the household members, where these weights are allowed to change over time in response to changes in household members' outside options from the current agreement of how to share the joint resources.[12] The intuition in the present setting to include intra-household bargaining power, e.g. the wife's relative say in household decisions, is that it might directly impact the magnitude of the household response. In

[10] Such models are called 'collective household' models. See Chiappori and Mazzocco (2017) for a recent overview of the related literature.

[11] In Section 4, I will discuss more technical details on the formalization of such models.

[12] In many collective models this is taken to be divorce, but it could also be some noncooperative outcome.

particular, when the household head gets displaced from his job, the secondary earner's labor supply can be increased to compensate for the earnings loss, which is costly from the perspective of the secondary earner. Hence, it's likely that when the secondary earner has a relatively higher bargaining power that this increase in labor supply will be dampened compared to a case where (s)he would have a lower share in total household resources.[13]

In the next section, I will develop and structurally estimate an inter temporal collective household model, but to provide some empirical evidence in favor of the importance of intra-household bargaining in terms of the response of households to shocks, I will extend the empirical specification in (1) to include a measure of the wife's bargaining power. The important challenge is to find a reasonable estimate for the wife's bargaining power. Variables often considered to be factors determining bargaining power within the household are education differences between the spouses, divorce laws, relative earnings etc. An important problem with relative earnings is that this is directly related to outcomes of the household decision proces and, therefore, highly endogenous. A better alternative would be relative (observed) wages[14], though as noted by Pollak (2005, 2011) and Olafsson and Thörnqvist (2018), it's expected relative wages which should pin down (relative) bargaining power.[15] Following this discussion, I therefore opt for an instrumental variables (IV) approach where I use exogenous variation in the outside options of the household members to try to identify the causal effect of changing the wife's bargaining power on the marginal effect of shocks on time use.

One class of instruments which has received a substantial amount of attention in the empirical labor literature is the so-called Bartik instrument (Bartik (1991), Aizer (2010)). Bartik instruments exploit the fact that different sectors in the economy have different gender ratios, therefore changes in labor demand have differential effects across different sectors and for people of different ages (and education levels), and therefore directly alters the outside options for the affected individuals (hence on their bargaining power within their household). In contrast to previous uses of such Bartik-type instruments, I construct an instrument for the distribution of wages within a household, thereby taking

[13]Blundell et al. (2017), in a paper studying time allocations and consumption insurance note the following: "Adoption of a collective framework of behavior would introduce a further reason for observing a relationship between husband and wife leisure. For example, under limited commitment, negative wage shocks (especially permanent ones) faced by the husband reduce his Pareto weight, implying that the partner gains in terms of consumption of all goods, including the consumption of leisure. This effect runs opposite to the added worker effect that we find dominates empirically. We leave the analysis of this further channel to future work."

[14]Though most realistic models of human capital formation assume human capital is influenced by labor force participation and, hence, wages would be again endogenous.

[15]Classical example of the problem of using observed wages to determine bargaining power is the case of a highly educated wife who spends most of her productive time devoted to household work. The observed relative wage in this household would be severely skewed towards the husband. However, the wife is likely to count on a high wage in case she would again be active on the labor market. Hence, using observed wages would be a biased measure of the wife's intra-household bargaining power.

into account matching patterns. I first compute:

$$\bar{W}_{j,i,g,a,s,t} = \frac{\sum_{i=1}^{N_{g,a,s,t}} W_{j,-i,g,a,s,t}}{N_{g,a,s,t} - 1}, \tag{2}$$

where $N_{g,a,s,t}$ denotes the total number of workers of gender g in age category a, working in sector s in year t.[16] Notice that for individuals within a household, I remove their observations to compute the average wage of workers of the same gender, within the same age category and working within the same industry. This prevents endogeneity associated with household-specific characteristics, i.e. by removing the household under consideration, we remove any variation which might be caused by any characteristics from this particular couple.

I can then compute the instrument for the wife's relative wage within the household, $B_{i,t}$ as the ratio of her average outside wage computed from (2), divided by the equivalent for her husband's wage. I now proceeds in two stages: in the first stage I regress observed relative wages on $B_{i,t}$ and a set of controls[17], then I extend (1) by including the predicted relative wages and interact these with $NFS_{i,t}$ and the leverage ratios. Figure 3 plots the marginal effects on the outcome variables of interest between husband and wife of increasing the p-LTI level when there is an adverse shock hitting the household's finances.

Figure 3

(a) Gap home hours (b) hours worked (c) employment

Source: BHPS waves 1993-2005. Sample includes married or cohabiting couples. 95 % confidence bands are included. I evaluated the marginal effects on several grid points within the support of the empirical distribution of the predicted relative wages.

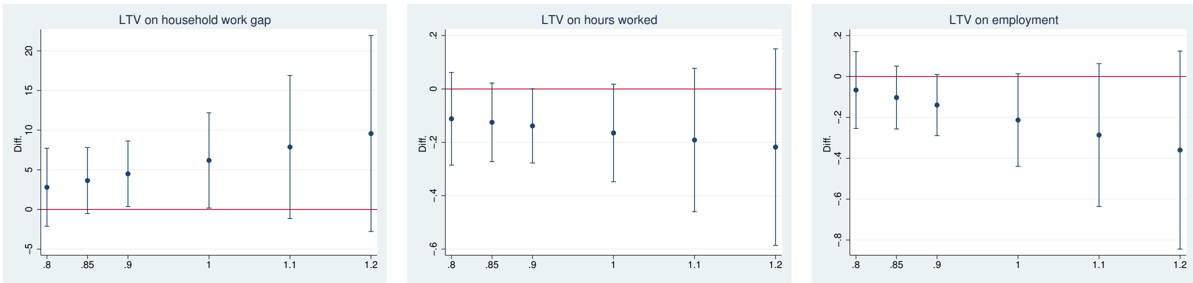
In subfigure (a), the outcome variable is the gap in household work between the wife and the husband. Notice that, there seems to be a decrease in the gap from increasing the p-LTI, monotonically in the (predicted) relative bargaining power of the wife. Also notice that we do find a significant AWE on the intensive margin (subfigure (b)) for those households where the wife has relatively lower bargaining power, which makes sense, as

[16] Age is here grouped in 4 categories: between 25 and 35 years, 35 and 45, 45 and 55 and 55 to 65. Sectors refer to the divisions from the standard industrial classification 1980, available in all waves of the BHPS.

[17] In particular, household income and wave dummies

in such households the need to compensate for the likely income loss from the adverse shock dominates the cost of increasing the wife's labor supply, since the latter is weighted relatively less when the wife's bargaining power is smaller. On the extensive margin, there is no noticeable effect. Figure 4 provides the equivalent results for the LTV:

Figure 4



(d) Gap home hours (e) hours worked (f) employment

Source: BHPS waves 1993-2005. Sample includes married or cohabiting couples. 95 % confidence bands are included. I evaluated the marginal effects on several grid points within the support of the empirical distribution of the predicted relative wages.

Higher LTV levels, in the presence of an adverse shock give rise to positive predicted coefficients on the gap in household work, where the latter effect is monotonic in the wife's bargaining power. However, notice that only at the lower levels of relative bargaining power for the secondary earner this effect is significant. For the intensive and extensive margin, we obtain results in line with the predictions from the model by Pizzinelli (2018) for lower levels of the wife's bargaining power, however these negative effects on labor supply become insignificant at higher levels of relative bargaining power. These results point towards the importance of intra-household bargaining in order to estimate the response of (female) time use allocations from shocks, interacted with particular leverage positions the household under consideration finds itself in. In order to obtain more insight into the mechanisms generating these empirical findings, the next section will develop and estimate a structural model of household life cycle decisions.

4 Life cycle model without commitment

This section presents a life cycle collective model of household time allocations, public good consumption, saving decisions and housing decisions, with wage and employment uncertainty. There are two household decision makers, though I allow children to be present within the household, even though, for tractability of the model, I leave the fertility process exogenous. Each spouse is characterized by their gender-specific preferences.

To be more precise, I assume preferences for household member j ($j = 1, 2$) can be represented by,

$$U_j\left(Q, L_j, H\right), \tag{3}$$

where Q denotes the level of public consumption good within the household, which I assume is produced domestically via a home production function,

$$Q = f\left(K, T_1, T_2\right) \tag{4}$$

in which K denotes public expenditures and T_j denote the amount of household work done by household member j. In the present setting, I think of Q as a clean house, food at home etc.[18] The time available for (private) leisure is given by L_j. Finally, H refers to the housing tenure of the household, in particular, $H = 0$ indicates the household rents the place it lives in, whereas $H = 1$ means it owns the house. The life cycle for each household member is split into two distinct periods: the *working phase*, $t < T_r$ and the *retirement phase*, $t \geq T_r$. Each individual dies in period T.

I assume that household members make joint decisions over the planning horizon through a dynamic bargaining process. A crucial limitation for households is the absence of formal contracts which impose commitment over time to a particular allocation rule. Hence, each household member can, in every period *renegotiate* the current sharing of joint resources. Therefore, outcomes of such dynamic bargaining will only be constrained efficient. More formally, this implies that I assume the household maximizes, during the working phase of the life cycle,

$$\max_{\{Q_t, A_t, L_{j,t}, T_{j,t}, H_t\}_{t=0,\dots,T_r-1; j=1,2}} E_0\left[\sum_{t=0}^{T_r-1} \beta^t U_1\left(Q_t, L_{1,t}, H_t\right)\right], \tag{5}$$

subject to the constraints,

$$E_0\left[\sum_{t=0}^{T_r-1} \beta^t U_2\left(Q_t, L_{2,t}, H_t\right)\right] \geq V_2, \tag{6}$$

$$U_j\left(Q_t, L_{j,t}, H_t\right) \geq \bar{U}_j\left(\mathbf{z}_{j,t}\right), \forall\ t = 0, 1, ..., T_r - 1 \text{ and } j = 1, 2. \tag{7}$$

$$\begin{aligned} A_t + K_t + CC_t\left(N_{2,t}, ageych_t\right) + p \times \left(H_t - H_{t-1}\right) + F \times p \times \left|H_t - H_{t-1}\right| + q \times \left(1 - H_t\right) \\ = (1 + R) \times A_{t-1} + W_{1,t} \times N_{1,t} + W_{2,t} \times N_{2,t}, \end{aligned} \tag{8}$$

[18] In some applications of collective household models one often interprets expenditures to children as public goods, e.g. Blundell, Chiappori and Meghir (2005).

$$Q_t = f\left(K_t, T_{1,t}, T_{2,t}\right), \tag{9}$$

$$A_{t+1} \geq \Upsilon\left(H_{t-1}, H_t, A_t, N_{1,t}, N_{2,t}\right). \tag{10}$$

Where I assume both household members share the same discount factor β.[19] This implies that I assume the household maximizes the expected utility of the first household member over the working phase, under the constraint that household member 2's expected utility over the working period doesn't drop below a certain guaranteed minimum level, given by V_2 (condition (6)).[20] The conditions in (7) are the participation constraints for the spouses. They state that each household member's period utility cannot fall below their outside option, $\bar{U}_j\left(\mathbf{z}_{j,t}\right)$.I will interpret this outside option as the case of divorce, which is consistent with much of the literature, e.g. Chiappori et al. (2002) and Voena (2015). I assume that these outside options are functions of a set of variables called *distribution factors* in the literature on collective households. A distribution factor is a variable which shifts the outside options of household members, but doesn't affect the preferences or the budget constraint directly.[21] The exogeneity of the distribution factors is important to preserve the property of (ex post) Pareto efficiency and also for identification of the model.[22] The sequential budget constraint is given by (8). The left hand side are all the expenditures in period t: housing expenditures are either equal to the price of the house, p in case it buys the home ($H_t = 1$) or the renting price, q in case the household chooses to rent, $H_t = 0$. Furthermore, we assume that housing expenditures are characterized by *adjustment costs*. In particular, whenever $H_t \neq H_{t-1}$ the household must pay a transaction cost, which is proportional to the value of the house, $F \times p$.[23] Furthermore, the household also decides on the level of (net financial) assets[24] A_t public expenditures K_t. $CC_t\left(N_{2,t}, ageych_t\right)$ denotes costs of childcare which

[19]Adams et al. (2014) shows that heterogeneity in discount factors might be important empirically to explain deviations from time consistency. However, in order to focus on the dynamic bargaining process, I will impose homogeneity and stability of the discount factors of household members. I leave a study of how heterogeneity in time preferences impact housing decisions and risk sharing as an avenue for future research.

[20]In principle, this minimum guaranteed level of expected lifetime utility could depend on variables which are determined before the start of the marriage, e.g. education levels of the spouses, or the expected values of the variables affecting the bargaining power within the household. For simplicity, I will here abstract from such dependencies.

[21]Examples of distribution factors used in the literature are changes in divorce legislation, the sex ratio, being assigned to a conditional cash transfer program like PROGRESA. See e.g. Chiappori et al. (2002), Voena (2015) and Attanasio and Lechene (2014).

[22]Indeed, assume on the contrary that outside options depend on the individual's choices, e.g. the outside option is monotonic in the household member's labor earnings, then the individual would choose to supply much more labor supply in order to gain more relative say in the household resource allocations. Furthermore, making both preferences and outside options depend on labor supply complicates identification of the household structure.

[23]Example of transaction costs are administrative fees etc. In principle these transaction costs can be asymmetric depending on whether the household is buying or selling a home, like in Pizzinelli (2018). However, in the current setting, I will impose that the transaction costs for buying are equal to those of selling. I refer to Section 4.1 for the particular choice for the value of this parameter.

[24]Given that I assume households can borrow, assets can be negative.

I assume is a function of the secondary earner's labor supply, $N_{2,t}$ and the age of the youngest child in the household, $ageych_t$ I refer to Section 4.1 for further details on how I model these childcare costs.

The amount of public good that is consumed within the household is specified by (4), this feasibility constraint is restated in (9). Notice that the wage spouse j earns in period t is given by $W_{j,t}$.[25] Finally, there is a borrowing constraint (10), which requires a separate discussion. A crucial aspect of the model is that the amount a household can borrow in each period is a function of the current housing status, the previous housing tenure (i.e. whether the household owned or rented the house in the last period), the (net financial) asset position at the start of the period and the labor supply from both spouses. It is useful to rewrite the model in terms of debts, $D_t = -A_t$. Renters are not allowed to have debt, whereas homeowner can hold debt subject to a set of collateral constraints. In particular, when buying a house, the household cannot borrow more than the smallest of the two aforementioned leverage based, i.e. the LTV and LTI ratios. The LTV limit is given by $\lambda_H \times p \times H$, i.e. a fraction of the value of the house, whereas the LTI limit equals a weighted sum of the spouses' earnings $\lambda_y \times W_{1,t}N_{1,t} + W_{2,t}N_{2,t}$, where the relative weight on the primary earner's earnings is given by the factor $\lambda_y \geq 1$. After buying the house, the household can make use of the housing property as collateral to keep borrowing, so long as the amount of debt doesn't exceed the LTV and LTI limits. If the debt level does exceed the collateral constraints, the household cannot increase its debt level, but doesn't need to comply instantly to the leverage limits. The only requirement in this case is that the debt level decreases until the leverage limits are reached (i.e. they at least pay the interest payments on the outstanding debt stock). Summarizing, this implies:

$$\begin{aligned} D_t \leq & -\Upsilon\left(H_{t-1}, H_t, A_t, N_{1,t}, N_{2,t}\right), \\ & = \max\left\{D_{t-1}, \min\left\{\underbrace{\lambda_H p}_{\text{LTV limit}}, \underbrace{(\lambda_y W_{1,t} N - 1, t + W_{2,t} N_{2,t})}_{\text{LTI limit}}\right\}\right\}. \end{aligned} \tag{11}$$

I follow Bottazzi (2007) and Pizzinelli (2018) by assuming net liquid savings is a single continuous variable and not allow for a separate choice of mortgage contract and deposits.[26] Allowing for the latter would seriously increase the computational complexity and make the model less tractable. Notice that, not imposing a fixed mortgage repayment schedule, but rather allow the household in each period to choose (net liquid) assets A_{t+1} under the constraint (10) is economically equivalent to assuming there is a yearly renegotiation of the mortgage contract. This makes sense for the UK as there is the

[25] The precise dynamics of wages will be discussed in subsection 4.1.

[26] Druedahl (2015) does allow for separate choices on types of assets.

availability of so-called 'interest-only mortgages'.[27] The expression of the leverage limits in (11) also explicitly shows the sensitivity of the ability of households to borrow. In particular, consider the case where the household satisfies the leverage limits but the primary earner gets displaced or faces a large negative wage shock such that the debt level is larger than the leverage limits. In this case, the household cannot expand borrowing and either has to reduce debt or compensate through using the labor supply of the secondary earner.

In order to solve the household's optimization problem, it is useful to rewrite the above dynamic optimization problem through the use of a formulation involving a Lagrangean. Denoting by ν_2 the Lagrange multiplier related to constraint (6) and by $\nu_{j,t}$ the Lagrange multipliers pertaining to the participation constraints, (7), the housheold's problem during the working phase can be rewritten as:

$$\max_{\{Q_t, A_t, L_{j,t}, T_{j,t}, H_t\}_{t=0,\ldots,T_r-1; j=1,2}} E_0 \left[\sum_{t=0}^{T_r-1} \beta^t \left(\mu_{1,t} U_1 \left(Q_t, L_{1,t}, H_t \right) + \mu_{2,t} U_2 \left(Q_t, L_{2,t}, H_t \right) \right) \right], \tag{5'}$$

where $\mu_{1,t} = \left(1 + \frac{\nu_{1,t}}{\beta^t}\right)$ and $\mu_{2,t} = \left(\nu_2 + \frac{\nu_{2,t}}{\beta^t}\right)$, subject to the constraints (8), (9) and (10). Imposing the normalization $\mu_{1,t} + \mu_{2,t} = 1$, I can interpret these weights as bargaining weights. This reformulation of the household's optimization problem in (5') allows us to directly link outside options to the bargaining power of household members. First, notice that if the participation constraints (7) doesn't bind, the bargaining weights $\mu_{j,t}$ remain constant[28] When the participation constraint from one of the spouses binds, then the bargaining weights $\mu_{j,t}$ change. Hence, the bargaining weights are also affected by the distribution factors through the impact the latter have on the outside options, $\bar{U}_j$. Summarizing, the bargaining weights can be written as:

$$\mu_{j,t} = \mu_{j,t} \left(\mathbf{z}_{1,t}, \mathbf{z}_{2,t} \right). \tag{12}$$

Some further remarks are in order. As I already mentioned, in case the participation constraints would not be present, the weights $\mu_{j,t}$ would remain constant and fully pinned down, this is called *full commitment* in the literature. In such a full commitment case, households select allocations on the ex ante Pareto frontier, whereas I allow for revisions of bargaining power with the revelation of new information, through the distribution

[27] Such mortgages require debtors to make regular interest payments while they accumulate savings in a separate endowment fund to repay the principal at maturity, which provides households quite some flexibility to choose the timing of debt repayment.

[28] But as mentioned earlier, could be determined by variables that pin down the minimum expected lifetime value guaranteed to household member 2, i.e. (6). These variables impact overall bargaining power (e.g. education) and beginning-of-time expectations about characteristics which might determine bargaining power in the future.

factors $\mathbf{z}_{j,t}$. Notice however that, although ex ante Pareto efficiency is lost, I do impose that household's choices are ex post Pareto efficient. The latter means that the household cannot find an alternative allocation of resources s.t. both spouses would be better off, without violating the prevailing participation constraints once all shocks in period t are realized. This formulation follows Mazzocco (2007) and Lise and Yamada (2018).

In order to solve the household's problem during the working phase, I'll use a recursive formulation. Let $\mathbf{S}_t = (\mathbf{z}_{1,t}, \mathbf{z}_{2,t}, ageych_t)$ the set of exogenous state variable at time t, the current period assets and the previous period housing tenure , A_{t-1} and H_{t-1} are the endogenous state variables. Furthermore, let $\mathcal{C}_t = (K_t, L_{1,t}, L_{2,t}, T_{1,t}, T_{2,t})$ be the choice variables, where we add next period assets A_t and the new housing tenure, H_t. Finally, I denote with $\mathcal{U}$ the weighted sum of the spouses' utility functions, where the weights are given by (12) and we recall that they add up to one, i.e.

$$\mathcal{U}(\mathcal{C}_t, H_t) = \sum_{j=1}^{2} \mu_j(\mathbf{z}_{1,t}, \mathbf{z}_{2,t}) U_j(Q_t, L_{j,t}, H_t). \tag{13}$$

Using this notation, I can now rewrite (5') recursively as:

$$V_t(A_t, H_{t-1}, \mathbf{S}_t) = \max_{\mathcal{C}_t, A_{t+1}, H_t} \left[\mathcal{U}(\mathcal{C}_t, H_t) + \beta E_{\mathbf{S}_{t+1}|\mathbf{S}_t} V_{t+1}(A_{t+1}, H_t, \mathbf{S}_{t+1})\right], \tag{14}$$

subject to the constraints (8), (9) and (10). V_t is the value function of the household in period t. $E_{\mathbf{S}_{t+1}|\mathbf{S}_t}$ is the expectation over the realization of the state vector in the next period, conditional on its realization in period t. Given that I don't model divorce explicitly, I don't require to solve for the value of divorce and hence, I don't specify the value function for divorcees. In order to solve the recursive problem, I need to initialize bargaining power, for which I will use the subsample of divorcees to impute lifetime earnings post-divorce and to infer the initial bargaining power, see Section 5 for more details. I now turn to the parameterization of the main parts of the model.

4.1 Parameterization

In the implementation of the dynamic optimization problem facing the household I consider a period as a year. Time in the model will coincide with the age of the household head.[29]

Time choices Because of computational reasons, I only allow for a discrete set of choices for time allocations. Each household member is assumed to have 16 productive hours available, i.e. I assume individuals require 8 hours for sleep. Individuals can then select time allocations according to the following:

[29] Hence, I abstract from age differences between spouses. The mean age difference between spouses in the main sample equals about 2 years.

Table 4.1: Time choices

Activity	Intensity(Abbrev.)	Daily hours
	no work (NW)	0
market work	part time (PT)	4.9
	full time (FT)	8
	low (L)	0.4
household work	middle (M)	1.6
	maximum (MAX)	4

The numbers in the table are obtained from a discretization of the empirical distributions over the time choice contained in the main sample. To further simplify the computations, I will make the choice sets specific to the role within the household, in particular, I assume that the household head can either be unemployed (cfr. infra) or work full time (FT). For household work, I restrict the choices for the primary earner to either 'low' (L) or 'middle' (M). Correspondingly, the secondary earner can either choose not to work (NW), part time work (PT) or full time work (FT). These restrictions imply that the household head's leisure time is between 6.4 and 15.6 hours, whereas the secondary earner's leisure lies between 4 and 14.4 hours per day.

Preferences and home production The preferences for the household members are assumed to be heterogeneous, in particular, I assume preferences for household member j can be represented by a utility map which has the following functional form:

$$U_j\left(Q_t, L_{j,t}, H_t\right) = \frac{Q_t^{1-\gamma}}{1-\gamma} \times \exp\left(h_j\left(L_{j,t}, N_{j,t}\right)\right) + \theta H_t, \tag{15}$$

where $\gamma > 1$ is the coefficient of relative risk aversion. Notice that I assume, following most of the literature, non-separable preferences between consumption and leisure. In particular, the map h_j captures how the marginal utility of consumption changes with leisure (hence household work and labor market work). Since h_j depends on the time allocation of spouse j, and the fact that the choice sets for time use are heterogeneous makes (15) different for the spouses. The precise functional form for h_j is given by:

$$h_j\left(L_{j,t}, N_{j,t}\right) = \begin{cases} \kappa_{1,1} \times 1[T_{1,t} = M], \text{ if } j = 1, \\ \kappa_{2,1} \times 1[N_{2,t} = PT] + \kappa_{2,2} \times 1[N_{2,t} = FT] + \kappa_{2,3} \times 1[T_{2,t} = MAX], \text{ if } j = 2. \end{cases} \tag{16}$$

Notice that, given $\gamma > 1$, a positive coefficient $\kappa_{j,l}$ implies that, compared to the lowest amount of household and market work spouse j can provide, exerting the particular activity associated to this coefficient lowers the utility for j. Turning to the household production function, I assume a constant returns to scale between public expenditures and household work from the spouses, i.e.,

$$Q_t = K_t^{\phi} \left(\pi T_{1,t}^{\psi} + (1 - \pi) T_{2,t}^{\psi} \right)^{\frac{1-\phi}{\psi}} . \tag{17}$$

The majority of the preference and household production technology parameters will be kept fixed based on reasonable values or estimates in the rest of the literature. The others will be obtained from internal calibration to match certain moments in the data (see Section 5 for details). In particular, I will calibrate the parameters pertaining to time use in the utility function and the housing preference parameter, i.e. $\kappa_{1,1}, \kappa_{2,1}, \kappa_{2,2}, \kappa_{2,3}$ and θ.

Wages and employment shocks The uncertainty in the model comes from two sources: (i) permanent productivity shocks which affect the wages of the spouses, (ii) employment shocks hitting the male (primary) earner. I follow the majority of the literature and assume that log wages for spouse j in period t follow the process:

$$\log W_{j,t} = F_{j,t} + \xi_{j,t} + u_{j,t}, \tag{18}$$

where $F_{j,t}$ is a deterministic component, based on observable characteristics, and captures the standard life cycle evolution of wages over the life cycle (in particular, a quadratic term in age). Next, $\xi_{j,t}$ denotes the permanent productivity shock and $u_{j,t}$ is a transitory shock. Following the convention in most life cycle models, I assume that the permanent productivity shocks follow a unit root process, that is, $\xi_{j,t} = \xi_{j,t-1} + \varepsilon_{j,t}$ (where I set $\xi_{j,0} = 0$) and $\varepsilon_{j,t} \sim N\left(\frac{-\sigma_{\varepsilon}^2}{2}, \sigma_{\varepsilon}^2\right)$. The variances of these shocks, as well as the deterministic component (in particular the quadratic in age) are estimated on the main sample, following the approach of Blundell et al. (2008), which I describe in more detail in A.4 in the Appendix. I normalize average male earnings to one. Furthermore, in the model, I also allow for exogenous employment shocks for the male spouse. In particular, every period I assume the probability for a male to become unemployed is equal to 5.5 %, which is about the average unemployment rate in the UK over the later part in my sample, 2001-2005. In case the household is hit by an unemployment shock, then the unemployed male spouse receives an unemployment insurance, b^u, which I set to 30 % of the average male earnings in the sample. Furthermore, with the complementary probability of reemployment equal to 94.5%, I assume that, when returning to employment, an individual faces the conditional transition probabilities from his pre-unemployment wage level. Intuitively, this means that I assume an individual who had a high earnings potential before unemployment, he will have keep a higher earnings potential after the unemployment period. This best fits the model I present in this paper as I abstract from human capital accumulation, hence being out of the labor market doesn't depreciate potential wages in my model.

A potentially important aspect for the question of risk sharing within the household is the amount of assortative matching and intra-household correlation of the income processes.[30] Relatedly, the productivity shocks might also be correlated between spouses, due to positive assortative matching. I follow Pizzinelli (2018) and address these issues by drawing initial incomes of spouses from a joint distribution with a positive correlation. I also take the value of 0.2, which is computed by Lise and Seitz (2011) as the intra-household correlation of income in the UK in 2000. For the correlation in the permanent shocks, I take the value in Attanasio et al. (2015) of 0.25.

Pareto weights The covariates potentially impacting the bargaining weights of the spouses consist of $\mathbf{z}_t = (\mathbf{z}_{1,t}, \mathbf{z}_{2,t})$. That is, the covariates affecting the minimum guaranteed expected life cycle and the distribution factors. The former are fixed over time and pin down initial bargaining power (i.e. at the start of marriage/cohabitation). The distribution factors incorporate changes or deviations from expectations regarding variables that impact initial bargaining power.Therefore, such innovations might change bargaining power over time since I allow household members to renegotiate in each period. Given that I normalize the bargaining weights and therefore, these have to be contained in the unit interval, I use the following functional form:

$$\mu_{1,t} = \frac{\exp\left(\eta\left(\mathbf{z}_t\right)\right)}{1 + \exp\left(\eta\left(\mathbf{z}_t\right)\right)}, \tag{19}$$

for the bargaining weight for the male spouse and hence, $\mu_{2,t} = 1 - \mu_{1,t}$. Furthermore, the map captures how the components of $\mathbf{z}_t$ are translated into bargaining power for the spouses. For computational reasons, I will restrict the flexibility of this dependence. In particular, in the present setting, I will leave empty the vectors $\mathbf{x}_j$. This implies that I don't explicitly condition bargaining power on education. Given that I don't model education choices, this assumption is not overly restrictive.[31] With respect to the distribution factors, I set[32]

[30]Indeed, Hyslop (2001) studies the intra-spousal correlation between permanent shocks and how this translates in household earnings inequality. Juhn and Potter (2007) find that the value of marriage as a risk sharing institution has been diminished due to an increase in correlation of employment among couples.

[31]E.g. in the model studied by Blundell et al. (2016) does include education choices before the working phase of the household in a unitary setting.

[32]One important assumption is that I don't allow net liquid assets or housing status as distribution factors. This restriction implies that household preferences are inter temporally separable (see Mazzocco (2007)). Though it makes the model much more tractable, it does impose a serious restriction in the sense that it doesn't allow home ownership to have a direct impact on intra-household bargaining power. Given that I'm implicitly assuming divorce as the outside option for spouses, and since housing is a public commodity which has to be divided post divorce, home ownership status could potentially affect the outside options of household members. However, this would make separate identification of preferences and bargaining power much more problematic, as housing will affect both. Therefore, in the current setting, I will abstract from this channel and leave such an extension for further research.

$$z_t = \frac{\exp(\xi_{1,t})}{\exp(\xi_{2,t})}. \tag{20}$$

From (18) it can be seen that (ignoring measurement errors or transitory shocks): $W_{j,t} = \exp(F_{j,t}) \times \exp(\xi_{j,t})$, hence, I can interpret $\exp(\xi_{j,t})$ as the (multiplicative) productivity factor for spouse j. Consequently, the distribution factor reflects the relative productivities of the spouses. Furthermore, since $\xi_{j,t} = \sum_{k=0}^{t} \epsilon_{j,k}$, z_t contains the ratio of the accumulated innovations to spouses' productivities. I specify:

$$\eta(\mathbf{m}_t) = \eta_0 + \eta_1 \times z_t. \tag{21}$$

The parameters η_0 and η_1 will be internally calibrated. A natural question in collective household models is how the bargaining process can be identified separately from preferences. I will discuss the identification of the model in Section 5.

Credit market parameters For the transaction costs, I choose the value of $F = 6\%$, which was estimated by Bottazzi (2007). This value lies in the range of the parameters chosen by Pizzinelli (2018), who allows for asymmetric transaction costs between selling and buying, resp. 7 % and 2.5 %. Following Bajari et al. (2013), I let the interest rates depend on whether the net liquid assets are positive or negative. In the former case $R_s = 0.03$, in the latter $R_d = 0.07$, which is close to the historic average interest rate on mortgages from 1982-2006.[33] I select $\lambda_y = 3$ and $\lambda_H = 0.9$, i.e. a household can remortgage up to 3 times the income of the primary earner plus the income earned by the secondary earner. The total loan taken out for a mortgage cannot exceed 90 % of the value of the house.[34] For the price of the house, I divide the (real) value of the house by the average yearly male earnings, which gives 4.6.

Childcare costs I don't include endogenous fertility choices by the household in my model, but I do condition for changes in household composition as the household faces childcare costs when the secondary earner is active on the labor market. These costs are a function of the age of the youngest child, which after the birth of a new child is reinitialized to zero. The birth of new children is estimated outside the model by a Probit model, where the covariates include whether the mother is highly educated[35], age of the mother (grouped in intervales of 10 years), interaction terms between age groups and dummy whether the secondary earner is highly educated and the presence of children in

[33] Based on the report from the Financial Services Authority (FSA), October 2009.

[34] These parameters are based on the FSA Guide to Mortgages from 2004: "typically, the maximum mortgage a lender offers is three times the main earners income plus one times any second earners income, or two-and-a-half times your joint income. Some lenders offer more, some less." W.r.t. the LTV it states: "It is possible to borrow up to 100 % of the propertys value. But a loan of more than 75 % of the property value often costs extra." These parameter values are also chosen by Bottazzi (2007) and Pizzinelli (2018).

[35] Which I define as having A level or a college degree.

the previous year. I then use fitted values of the model as an input in the simulations. I refer the reader to A.5 for the estimates of this Probit model. Childcare costs are specified as follows:

$$CC_t\left(N_{2,t}, ychild_t\right) = \begin{cases} ccrate \times N_{2,t} \text{ if } ageych_t \leq 5 \text{ and } N_{1,t} = FT, \\ ccrate \times 3.6 \text{ if } 5 < ageych_t \leq 10 \text{ and } N_{1,t} = FT, \\ 0 \text{ if otherwise.} \end{cases} \tag{22}$$

Where *ccrate* denotes the hourly rate for childcare. I assume preschool children always need childcare whenever no adult is at home, where school-aged children only require childcare outside of school, as education is publicly provided. This specification follows closely Blundell et al. (2016) who use a similar formulation for childcare costs. I also take over their number for the hourly rate of childcare cost, i.e. I set $ccrate = 2.6$ pounds.[36]

Retirement The model incorporates a retirement phase, in order to match some stylized features of savings and labor supply behavior. During retirement, individuals will likely have a lower need to accumulate assets and possibly will work less. In order to then be able to match the moments of time use choices (in particular labor supply decisions), the parameters pertaining to the disutility of work will have to be pushed to zero in order to rationalize large proportions of full time and part time labor supply.

In the model, I assume that individuals are in retirement in period $t = T_r$, which lasts until period $t = T_d$ at which they die.[37] During retirement, spouses make no time allocation decisions: they are out of the labor force and no longer engage in home production activities. Hence, all consumption comes from public expenditures. I also impose that during the retirement phase, the household cannot incur new debts and therefore must extinguish all debts throughout this last phase. In particular, (11) is now adapted to:

$$D_t \leq \max\left\{D_{t-1}, 0\right\}. \tag{23}$$

That is, debt can be positive, but has to decrease monotonically over time during retirement. Income during retirement is no longer stochastic and I assume each individual receives a fraction, b_j of their final wage times average hours worked by the same-gender individuals in the economy. In the simulations I will set $b_j = 0.5$, i.e. each retiree receives

[36]In the simulation, since I normalize male average earnings, I'll express this hourly rate as a fraction of male wages, $W_{1,t}$. To be more precise, I express *ccrate* as a fraction of the average (real) wages for males in my main sample. This calculation gives me that the hourly rate is approximately 16 % of the average (real) wage for male workers.

[37]I assume both spouses retire jointly. More realistically, females start retiring earlier than males. The latter is also clear from Figure 2, where female labor supply starts to decrease slightly earlier than for males. The extension to retirement choices by households in the current setting is left for further research.

50% of their final-year income.The optimization problem for households during retirement is then:

$$\max_{\{Q_t, A_t, H_t\}_{t=0,\ldots,T_r-1; j=1,2}} \sum_{t=T_r}^{T_d} \beta^t \mu_{1,T_r} U_1 \left(Q_t, L_{1,t}, H_t\right) + \mu_{2,T_r} U_1 \left(Q_t, L_{1,t}, H_t\right), \tag{24}$$

subject to the constraints,

$$\begin{aligned} & A_t + Q_t + F \times p \times |H_t - H_{t-1}| + q \times (1 - H_t) \\ & = (1 + R) \times A_{t-1} + B_1 + B_2, \end{aligned} \tag{25}$$

$$A_t \geq \min \{A_{t-1}, 0\}. \tag{26}$$

Where $B_j = b_j \times W_{j,T_r-1} \times \bar{N}_j$ the income of spouse j during retirement ($\bar{N}_j$ are the average hours worked on the labor market of the same gender individuals in the economy). Furthermore, I also impose that at the end of the retirement phase all debt has been extinguished, i.e. $A_{T_d} = 0$. Notice that, since income for both spouses is fixed during retirement, the bargaining weights remain constant and therefore, the household behaves like a standard unitary household during retirement.[38] Similar as in the working phase, I can reformulate the problem during retirement in an easier, recursive way:

$$V_t^r \left(A_t, H_{t-1}, \mathbf{S}_t^r\right) = \max_{Q_t, A_{t+1}, H_t} \left[\mathcal{U}\left(Q_t, H_t\right) + \beta V_{t+1}^r \left(A_{t+1}, H_t, \mathbf{S}_{t+1}^r\right)\right], \tag{27}$$

where $\mathbf{S}_t^r = (B_1, B_2)$ is the set of exogenous state variables at time t during the retirement phase.[39] Net liquid assets A_t and housing tenure H_{t-1} are the endogenous state variables. Furthermore, $\mathcal{U}\left(Q_t, H_t\right) = \mu_{1,T_r} U_1 \left(Q_t, L_{1,t}, H_t\right) + \mu_{2,T_r} U_1 \left(Q_t, L_{1,t}, H_t\right)$.

To conclude this section, Table 4.2 gives an overview of the externally calibrated parameters:

[38] In fact, because there are also no time choice decisions, the model turns into a simple 'cake-eating' problem.

[39] Notice that all these components in the state vector are constant and therefore, they are practically unimportant for the solution to the retired household's problem. However, they do play a role in pinning down the bargaining power at the start of the retirement phase, i.e. μ_{j,T_r} and therefore I include them in the recursive formulation.

Table 4.2: Fixed parameters

Parameter	Value	Description	target/source
Preferences			
β	0.95	discount factor	
γ	1.5	coefficient of relative risk aversion	Attanasio et al. (2008)
ϕ	0.8	output elasticity of public expenditure	Lise and Yamada (2018)
π	0.5	share of male time household production	Lise and Yamada (2018)
φ	0.5	scale parameter of spousal time	Lise and Yamada (2018)
Wage dynamics			
$\sigma^2_{\varepsilon_1}$	.0137	variance of permanent shock: primary earner	BHPS
$\sigma^2_{\varepsilon_2}$	.0117	variance of permanent shock: secondary earner	BHPS
$Corr\,(\varepsilon_1, \varepsilon_2)$	0.25	correlation of shocks	Hyslop (2001)
ω	0.8	gender earnings gap	
π_u	0.055	probability of male unemployment	UK unemployment rate
b^u	0.3	unemployment insurance	
Housing market			
F	0.06	transaction costs of buying/selling home	Bottazzi et al. (2007)
λ_H	0.9	LTV borrowing limit	Attanasio et al. (2012)
λ_Y	3	LTI-limit	FSA (2004)
R_s	0.03	interest rate on savings	
R_d	007	interest rate on debt	FSA (2009)
p	9	normalized house price	BHPS
q	0.097	rental cost	
Retirement			
b_j	0.5	replacement rate	
$\bar{N}_1$	0.5	average hours males	
$\bar{N}_2$	0.38	average hours females	

5 Identification and Estimation

The remaining parameters will be estimated by an internal calibration exercise. There are 7 in total: the parameter related to the preference for housing, θ, the parameters pertaining to time use choices for both the male and female spouse, $\kappa_{1,1}, \kappa_{2,1}, \kappa_{2,2}$ and $\kappa_{2,3}$ and finally the parameters regarding the bargaining weight, η_0 and η_1. Estimation now proceeds as follows. For a given set of parameter values I solve the life cycle problem and simulate 16.330 households (5 replications of the 3266 households in the dataset). I compute a number of moments regarding time use (labor supply, household production) and housing decisions in the simulated dataset and compare this with these same moments from the actual dataset. I use the sum of the squared distances between the actual and simulated moments as the loss function which I then try to minimize by choosing the 7 parameters.

The moments I want to fit are directly related to the parameters and the way they influence results within the model. In particular, I fit the proportion of:

– average homeownership rate ($30 \leq \text{age} \leq 55$),

– proportion of secondary earners in part time work ($25 \leq \text{age} \leq 35$),

– proportion of secondary earners in part time work ($35 < \text{age} \leq 45$),

– proportion of secondary earners in part time work ($45 < \text{age} \leq 55$),

– proportion of secondary earners in full time work ($25 \leq \text{age} \leq 35$),

– proportion of secondary earners in full time work ($35 < \text{age} \leq 45$),

– proportion of secondary earners in full time work ($45 < \text{age} \leq 55$),

– average hours market work secondary earners ($25 \leq \text{age} \leq 55$),

– average hours household work household head ($25 \leq \text{age} \leq 55$),

– average hours household work secondary earners ($25 \leq \text{age} \leq 55$),

which gives us a total of 10 moments.

The main idea for identification is as follows: I fix the bargaining power in the initial 10 years of the working phase. This allows me to recover preferences over time choices, i.e. $\kappa_{1,1}, \kappa_{2,1}, \kappa_{2,2}$ and $\kappa_{2,3}$ and the preference for housing, θ.[40] After the first 10 years, i allow household members to renegotiate their intra-household resource sharing and the gap between the predicted profiles (given initial bargaining power) and the actual choices can be closed by adapting the parameters governing the bargaining weight, η_0, η_1.

I normalize initial bargaining power in the following manner. As aforementioned, in most applications of collective households divorce is considered to be the outside option. Since I don't model divorce directly in the present framework, I'll incorporate information on divorcees in a reduced form way in the model. To be more precise, I follow Blundell et al. (2017) and Theloudis (2018) to estimate (expected) lifetime earnings, I collect all earnings of divorcees across years and ages and separated by gender. Earnings of these divorcees are then regressed on characteristics (separately by gender),

$$Y_{j,g,t} = \mathbf{X}'_{j,1}\beta_{1,g} + \mathbf{X}'_{j,2,t}\beta_{2,g} + \epsilon_{j,g,t}, \tag{28}$$

where $Y_{j,k,t}$ denotes the earnings of (divorced) indvidual j of gender g in year t, $\mathbf{X}'_{j,1}$ denotes the set of covariates/attributes which are constant over time, whereas $\mathbf{X}_{j,2,t}$ contain variables such as a quadratic polynomial in age and interactions with educational attainment. By making use of the estimated coefficients[41] from (28), I can forecast earnings over the life cycle, i.e. $\hat{Y}_{j,g,t+s} = \mathbf{X}'_{j,1}\hat{\beta}_{1,g} + \mathbf{X}'_{j,2,t+s}\hat{\beta}_{2,g}$, which I use to compute an estimate of the expected lifetime earnings (human wealth) post-divorce,

[40]Given that preferences remain stable.

[41]I include the regression results from the estimation of (28) in A.6.

$$Human\ Wealth\ Divorced_{j,t} = \sum_{s=0}^{\infty} \frac{E_t\left[Y^d_{j,t+s}\right]}{(1+\rho)^s}. \quad (29)$$

Then I can construct a measure of initial bargaining power:

$$\mu_{1,0} = \frac{Human\ Wealth\ Divorced_{1,t}}{Human\ Wealth\ Divorced_{1,t} + Human\ Wealth\ Divorced_{2,t}}. \quad (30)$$

The summary statistics of the imputed initial bargaining power in (30) across households are as follows:

Table 5.1: bargaining power men

	mean	median	standard dev.	minimum	maximum
men's bargaining power	.6658	.6592	.1256	.4895	.98

Further computational details on the calibration are contained in A.7 and A.8.

6 Results

In this section, I first provide some results in terms of fit of the calibrated model with the data, study some cross-sectional features of the simulated data, in particular the relationship between the leverage based constraints and time use decisions from households.

6.1 Time use and leverage based constraints

Before studying in more detail the relationship in the simulated data between labor supply, time devoted to home production and leverage based constraints, I first present the basic quality of fit in terms of the targeted moments. Table 6.1 gives the comparison between the moments in the data and the simulated counterparts[42]:

[42]Time is normalized by the total amount of productive hours available to each individual, which I assume is 16 hours. Hence full time work implies a value of 0.50 for labor hours in the model.

Table 6.1: Matched moments

Moment	Simulated	Data
home ownership rate	.79	.83
proportion of secondary earners in part time work (25 ≤ age ≤ 35)	.23	.22
proportion of secondary earners in part time work (25 < age ≤ 45)	.20	.27
proportion of secondary earners in part time work (45 < age ≤ 55)	.17	.23
proportion of secondary earners in full time work (25 ≤ age ≤ 35)	.76	.80
proportion of secondary earners in full time work (25 < age ≤ 45)	.80	.75
proportion of secondary earners in full time work (45 < age ≤ 55)	.75	.79
average hours market work secondary earners (25 ≤ age ≤ 55)	.43	.40
average hours household work household head (25 ≤ age ≤ 55)	.09	.08
average hours household work secondary earners (25 ≤ age ≤ 55)	.22	.21

Notice that the model slightly underestimates the average home ownership rate. This is likely due to the additive separability of preferences in terms of home ownership. In that sense, I restrict any channel for complementarity between housing status and consumption or leisure, which would strengthen the decision to own a house. The overall fit of the proportions across the different age categories are quite good, though the model predicts a delayed decrease in labor supply of the secondary earner compared to the model. This is also a feature specific to the additivity of the taste for home ownership.

I now turn to a further decomposition of time use in the model across the leverage based constraints. Table 6.2 shows the proportions of part time work and full time work of the secondary earner in the bottom 80% of the distribution for the p-LTI and the top 20 %, while Table 6.3 shows the equivalent breakdown for the LTV ratio.

Table 6.2: Employment and p-LTI

	Part time		*Full time*	
	Simulated	Data	Simulated	Data
Bottom 80 % p-LTI				
25≤age≤35	.12	.17	.82	.81
35<age≤45	.20	.21	.67	.78
45<age≤55	.16	.17	.67	.82
Top 20 % p-LTI				
25≤age≤35	.01	.10	.20	.88
35<age≤45	.036	.12	.90	.87
45<age≤55	.02	.09	.97	.90

Note: All these results are produced from the same set of 5 replications of the joint Markov proces for wage process of 3266 households from the BHPS. This gives a total of 16.330 simulated households. Initial assets are drawn from the calibrated initial distribution of net worth.

Table 6.3: Employment and LTV

	Part time		*Full time*	
	Simulated	Data	Simulated	Data
Lower 80 % LTV				
25≤age≤35	.10	.18	.83	.82
35<age≤45	.17	.20	.73	.79
45<age≤55	.15	.17	.70	.83
Top 20 % LTV				
25≤age≤35	.13	.12	.63	.88
35<age≤45	.10	.15	.76	.84
45<age≤55	.04	.10	.91	.89

Note: All these results are produced from the same set of 5 replications of the joint Markov proces for wage process of 3266 households from the BHPS. This gives a total of 16.330 simulated households. Initial assets are drawn from the calibrated initial distribution of net worth.

A feature noticeable from both the simulation as well as from the data is that those households characterized by higher leverage ratios (both p-LTI and LTV) also have lower proportions of secondary earners in part time work and higher in full time work, compared to the households with lower p-LTI and LTV ratios. The model fits these proportions relatively well, which can be seen as an external validation of the model, as these moments are non-targeted by the internal calibration. The overall pattern of decrease in part time work and increase in proportion of full time work by moving up in the distribution of the leverage ratios is also consistent across the three age groups. In order to better understand these features, I also report the average wages, $\left(\bar{W}_1, \bar{W}_2\right)$ in the simulated data, both across age groups and for both types of leverage ratios.

Table 6.4: Wages and leverage constraints

	p-LTI	*LTV*
Bottom 80 %		
25≤age≤35	$(.64, .82)$	$(.61, .82)$
35<age≤45	$(1.09, .94)$	$(.92, .93)$
45<age≤55	$(1.38, 1.01)$	$(1.28, 1.02)$
Top 20 %		
25≤age≤35	$(.78, .94)$	$(.89, .95)$
35<age≤45	$(.59, .96)$	$(1.28, 1.01)$
45<age≤55	$(.56, .83)$	$(.97, .80)$

Note: All these results are produced from the same set of 5 replications of the joint Markov proces for wage process of 3266 households from the BHPS. This gives a total of 16.330 simulated households. Initial assets are drawn from the calibrated initial distribution of net worth.

Unsurprisingly, the high p-LTI households are characterized by relatively lower average wages for the household head. In contrast, household head's wages are on average higher for households having a higher LTV ratio. As such, and considering the borrowing constraint (11), those households are more likely to hit the LTV limit. Since labor supply is costly for the secondary earner, such households should have lower use for secondary earner's labor supply. However, as clear from Table 6.3, this is not reflected in lower proportions of full time work. However, the proportion of secondary earners in part time work does decrease, where both features are also captured by the model. For the high p-LTI households, who should be closer to the LTI limit and therefore more likely to make use of the secondary earner's labor supply, also have higher proportions of secondary earners in full time market work, this increase is well captured by the model for the latter two thirds in the working phase of the life cycle (ages between 36 and 55). As noted by Pizzinelli (2018), it is important to consider the joint distribution of the p-LTI and LTV ratios in order to study the impact of these ratios on the labor supply of secondary earners. In particular, households with low p-LTI and high LTV can generally sustain higher debts with the higher expected stream of the household head's earnings, therefore making utility gains by not having to use (costly) labor supply of the secondary earner. Hence, the empirical relationship between labor supply and the leverage ratios is also impacted by the comovement between the latter. In the case of the sample used in the paper for the internal calibration, I observe strong positive correlations between the p-LTI and LTV ratios across the different age groups.[43] This positive correlation implies that moving up the LTV ratio also means the household generally has higher p-LTI ratios, which makes the p-LTI ratio more likely to bind, thereby dampening the negative effects of the higher LTV ratio on the secondary earner's labor supply. This partially explains the higher proportions of full time market work associated with the higher LTV ratios.

6.2 Role of bargaining

One motivation for the paper was to study to what extent bargaining matters for labor supply decisions in the presence of leverage based constraints. The structural model presented here allows me to study the relative importance of this bargaining channel. In particular, I can compute the proportions for secondary earners in part and full time labor supply in case households would be characterized by full commitment. As aforementioned, the latter means that households can commit to fixed resource allocation rules and hence,

[43]For the first age category between 25 and 35 the correlation $Cor\left(p-LTI, LTV\right)=0.92$, for $35 < age \leq 45$, $Cor\left(p-LTI, LTV\right)=0.74$ and finally, for ages between 46 and 55, $Cor\left(p-LTI, LTV\right)=0.78$.

household members don't renegotiate the sharing rule. Practically, this means that the participation constraints (7) in the household's optimization problem are never binding and can therefore be ignored. As I discussed in Section 4, the bargaining weights of the household members are fixed in this case. For this exercise, I fix the bargaining weights over the life cycle according to the calibrated initial bargaining, i.e. $\mu_1 = 0.65$. Table 6.5 gives the difference in proportions between the limited commitment and the full commitment for part time and full time hours, split according to the p-LTI ratio:

Table 6.5: Bargaining and p-LTI

	Part time	*Full time*
Bottom 80 % p-LTI		
25≤age≤35	.01	0
35<age≤45	.07	-.09
45<age≤55	.04	-.07
Top 20 % p-LTI		
25≤age≤35	-.54	.02
35<age≤45	.036	-.09
45<age≤55	.02	-.01

Note: All these results are produced from the same set of 5 replications of the joint Markov proces for wage process of 3266 households from the BHPS. This gives a total of 16.330 simulated households. Initial assets are drawn from the calibrated initial distribution of net worth.

And Table 6.6 presents the resuls for a decomposition across ages and the LTV ratio:

Table 6.6: Bargaining and LTV

	Part time	*Full time*
Bottom 80 % LTV		
25≤age≤35	.01	0
35<age≤45	.05	-.08
45<age≤55	.04	-.06
Top 20 % LTV		
25≤age≤35	-.01	0
35<age≤45	.035	-.07
45<age≤55	.011	-.02

Note: All these results are produced from the same set of 5 replications of the joint Markov proces for wage process of 3266 households from the BHPS. This gives a total of 16.330 simulated households. Initial assets are drawn from the calibrated initial distribution of net worth.

From these decompositions, it is clear that, in comparison with the case of full commitment, allowing for renegotiations generates lower proportions of secondary earners in full time market work.

6.3 Response to income shocks

I now turn to the question of how intra-household bargaining impacts, in the presence of leverage based constraints time use decisions, which also allows me to address the way the added worker effect is affected by the limited commitment within the household. In order to do this, I solve the model again under the counterfactual that the primary earner's (potential) wage receives a permanent one-standard deviation at a given age. I then compare the resulting paths of labor supply in the baseline case and the case including the permanent income shock. In practice, I compute shocks at different stages in the life cycle, in particular, at age=40, 45 and 50.[44]

I break down the responses of labor supply from the secondary earner by the level of p-LTI and the level of LTV. In particular, Tables 6.7 and 6.8 show the proportions of secondary earners moving from part time to full time work, contemporaneously with the age at which the permanent shock in the household head's earnings occurs.

[44]Recall that in the identification strategy, I assume that in the first 10 years of the working phase in the life cycle, households commit themselves to initial bargaining weights and therefore, there is no difference observable between full and limited commitment in terms of labor supply responses to shocks.

Table 6.7: AWE and p-LTI

	Limited commitment	*Full commitment*
Bottom 80 % p-LTI		
age=40	.1842	.1327
age=45	.2964	.1345
age=50	.1716	.1281
Top 20 % p-LTI		
age=40	.0063	0.0089
age=45	.013	.01
age=50	.042	.042

Note: All these results are produced from the same set of 5 replications of the joint Markov proces for wage process of 3266 households from the BHPS. This gives a total of 16.330 simulated households. Initial assets are drawn from the calibrated initial distribution of net worth.

Table 6.8: AWE and LTV

	Limited commitment	*Full commitment*
Bottom 80 % p-LTI		
age=40	.1487	.1082
age=45	.174	.1345
age=50	.172	.1281
Top 20 % p-LTI		
age=40	.13	0.0933
age=45	.013	.011
age=50	.049	.0464

Note: All these results are produced from the same set of 5 replications of the joint Markov proces for wage process of 3266 households from the BHPS. This gives a total of 16.330 simulated households. Initial assets are drawn from the calibrated initial distribution of net worth.

Households with lower p-LTI ratios have relatively lower wages for secondary earners and higher wages for household heads. As Table 6.5 highlights, under limited commitment there are fewer secondary earners in full time work, hence the ability of such households to mitigate an adverse income shock of the household head is improved. For the LTV ratio, we see stronger effects for households with lower values of LTV. In such households secondary earners have relatively high wages, which implies that, in the baseline (and compared to full commitment), there is a lower level of secondary earners in full time work. Furthermore, with a higher relative share in total household resources (because of the higher bargaining power), the income loss of the household under an adverse income shock in the household head has a higher impact on those secondary earners. As a consequence, the response in labor supply is stronger in this case. Overall, these results confirm the reduced form evidence presented in this paper and shows that intra-household bargaining does matter in terms of the ability of households to mitigate shocks.

6.4 Changes in the leverage constraints

In this section, I will use the structural model to study how changes in the parameters determining the leverage limits impact the household labor supply and compare the outcomes on the labor supply from the secondary earner in the case of limited and full commitment within the household, which allows me to analyze the impact of bargaining on labor supply responses under policy changes.

6.4.1 Changes in the LTI limit

The first counterfactual experiment is to change the LTI limit. Recall from (11) that the household head's labor earnings get weighted by a factor of λ_y in the income-related borrowing constraint. I now consider changes in the weight placed on the earnings from the secondary earner. To be more precise, I follow Pizzinelli (2018) by rewriting the LTI constraint as follows:

$$\text{LTI-limit} = \lambda_y \times W_{1,t} \times N_{1,t} + \tilde{\lambda}_y \times W_{2,t} \times N_{2,t}, \tag{31}$$

where $\tilde{\lambda}_y$ will be the policy parameter that is the subject of a change in the counterfactual exercise. In terms of interpretation, when $\tilde{\lambda}_y > 1$, increasing the labor supply of the secondary earner will have more return in terms of loosening the LTI constraint and, hence, the borrowing constraint faced by households considering to buy a house. This, in turn, will stimulate both home ownership and labor supply for certain households closer to the LTI constraint. In contrast, when $\tilde{\lambda}_y < 1$ the same level of labor supply will have a reduced impact on the LTI constraint, and therefore, it is harder to satisfy the income-related borrowing constraint with the use of labor supply from the secondary earner. In that sense, $\tilde{\lambda}_y$ can be interpreted as a paramater which indicates the return to the secondary earner's labor supply in terms of the ease to which the household satisfies the income-related part of the borrowing constraint. I will consider both a tightening and a loosening of the LTI constraint. In the first case $\tilde{\lambda}_y = 0.2$, while in the second case

$\tilde{\lambda}_y = 1.6$.

In the case of an LTI tightening, home ownership decreases. At the age of 30, this tightening has the effect that there are around 14 % of households who are home owners both before and after the tightening. Around 74 % of households are renters in both cases and there are about 12 % of households who used they be homeowners and after the LTI tightening choose to rent. These proportions are not significantly different between the case of limited and full commitment. For the LTI loosening, around 28 % of households are home owners in both cases, 64 % of households are renting before and after the loosening of the LTI limit and approximately 8 % of the households change from renting to homeownership. Again, these fractions are very similar both in the full and limited commitment case. However, the effects of the change in terms of labor supply are different in the case of limited and full commitment. Given that the largest changes of the policy interventions are for those households changing their home ownership status, I report the results for those groups in both the LTI tightening and loosening cases:

Table 6.9: LTI limit changes

LTI tightening	$\Delta 1[N_{2,t} = PT]$	$\Delta 1[N_{2,t} = FT]$
Limited commitment		
New renters	0.13	-0.14
Full commitment		
New renters	0.099	-0.12

LTI loosening	$\Delta 1[N_{2,t} = PT]$	$\Delta 1[N_{2,t} = FT]$
Limited commitment		
New homeowners	-0.0241	0.0313
Full commitment		
New homeowners	-0.0124	0.0173

Note: All these results are produced from the same set of 5 replications of the joint Markov proces for wage process of 3266 households from the BHPS. This gives a total of 16.330 simulated households. Initial assets are drawn from the calibrated initial distribution of net worth.

Table 6.9 shows that as a consequence of the LTI tightening, which makes secondary earner's labor supply less relevant in terms of meeting the income related borrowing constraint, there is a shift from the proportion of secondary earners (in the affected group w.r.t. home ownership status) from being in full time work to part time work. Notice that quantitatively, there is a stronger effect under limited commitment, compared to fixed bargaining weights (full commitment). Households shifting home ownership status are those closer to the LTI constraint which, as Table 6.4 made clear, are typically households with higher (potential) wages for the secondary earner. Given that bargaining power is a function of the accumulated permanent productivity shocks, and the latter determine the wage level, households with limited commitment put relatively more weight on the disutility of labor of the secondary earner. The latter is then reflected by a larger decrease in full time work in this case. In case of the loosening of the LTI limit, there is an increase in the proportion of secondary earners working full time. Again, the sensitivity is bigger in the case of limited commitment compared to fixed bargaining weights. Here, the policy change makes labor supply of the secondary earner more profitable in terms of allowing the household to satisfy the LTI limit, which incentivizes households to increase secondary earner's labor supply. In this case, the potentially relatively higher bargaining power for secondary earners (compared to the case where bargaining power is fixed to initial expectations) creates a clear trade-of for the household: increasing labor supply allows the household to satisfy the income-related constraint to buy a house, where the latter is an additional public good with positive utility for the spouses. However, increasing labor supply is costly for the secondary earner. Given the calibration results, the former seems to outweigh the latter for those households on the margin between buying and renting a house.

6.4.2 Effect of LTV tightening

I now turn to the LTV limit. In particular, I will consider a tightening of the LTV constraint, which in practice means a higher required downpayment to obtain a mortgage. Similar to an LTI tightening, there are three groups: those households that are home owners both before and after the policy change (which is approximately 16 % of households), households that are renters in both cases, around 77 % and finally those households that sell their house and become renters, which is approximately 7 %. I will again focus attention on the latter group of households affected by the policy (in terms of housing tenure).

Table 6.10: LTV tightening

LTV tightening	$\Delta 1[N_{2,t} = PT]$	$\Delta 1[N_{2,t} = FT]$
Limited commitment		
New renters	0.0184	-0.0505
Full commitment		
New renters	0.0178	-0.0425

Note: All these results are produced from the same set of 5 replications of the joint Markov proces for wage process of 3266 households from the BHPS. This gives a total of 16.330 simulated households. Initial assets are drawn from the calibrated initial distribution of net worth.

Similar to tightening of the LTI limit, an LTV tightening reduces the labor supply in terms of lower proportions of households where the secondary earner is in full time work. The intuition is clear: since a higher downpayment reduces homeownership rates, there is less need to make use of labor supply from the secondary earner. Given that the group of marginal households changing home ownership status are closer to the LTV limit and, given the information in Table 6.4, these households have relatively higher potential wages for the household head. Therefore, the household head will, both under full and limited commitment, have a higher relative say in time use decisions by the household. This is reflected by the smaller differences between limited and full commitment in terms of effects on proportions in full or part time market work.

7 Conclusion

This paper studied the relationship between intra-household bargaining, and the responses of households to adverse income and employment shocks in the presence of leverage based constraints. I both use a reduced form empirical analysis where I show that heterogeneity in intra-household bargaining matters to determine the extent to which there are significant responses in labor supply from secondary earners to shocks. Next, I extended a collective life cycle model of the household with housing tenure decisions, where the latter imposes leverage based constraints to the household and hence, affects their financial position. Using the model, I showed that labor supply responses are affected by both the financial position of the household in terms of the leverage ratios and its interaction with bargaining power. In particular, household heads of households with lower p-LTI ratios have high wages, hence can make use of the secondary earner's labor supply more easily. For households with lower LTV ratios, secondary earners have on average high wages, which reduces the proportion of such secondary earners in full time work, which provides sufficient scope for increasing (along the intensive margin) labor supply in response to adverse income and employment shocks from the household head. Furthermore, the adverse income effects of such shocks also affect secondary earners more than in households where they have lower wages as the relative share of total household resources is higher for the former. These interactions between changes in bargaining power and leverage constraints also help to rationalize the relative symmetrical proportions of time use across the different positions within the leverage ratio distributions. Finally, I used the model to conduct several counterfactual exercises, in particular I studied how changing the borrowing constraint parameters pertaining to the LTI and LTV ratios affects the labor supply decisions of households under limited commitment. Tightening the LTI and the LTV constraint reduce the proportion of secondary earners in full time work and substitutes these away towards part time work. It is shown that in the limited commitment case these effects are more pronounced than under full commitment, indicating that the intra-household bargaining proces amplifies the responses to changes in the credit market. There are many avenues for future research. In the present paper, I abstract from the endogeneity of wages w.r.t. labor force participation, including the channel of human capital depreciation subsequent to job loss in a collective life cycle model with leverage based constraints could shed light on how unemployment duration impacts both intra-household bargaining and the added worker effect, in particular in presence of borrowing constraints. Another important avenue for future research is the question of optimal unemployment insurance when households don't share resources fully, which, as the present paper has shown, does impact the ability of households to mitigate shocks.

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A Appendices

A.1 Descriptive statistics

A.2 Leverage ratios and employment rates

In order to investigate the relationship between labor supply and the leverage based constraints, I adopt the empirical strategy based on Disney and Gathergood (2013) and Pizzinelli (2018) by estimating regressions of employment status (extensive margin) on quintiles of the p-LTI and LTV ratios. In particular:

$$Emp_{i,t} = \beta_0 + \beta'\mathbf{X}_{i,t} + \gamma_1'\mathbf{q}_{i,t-1}^{LTI} + \gamma_2'\mathbf{q}_{i,t-1}^{LTV} + \alpha_i + \delta_{region} + \delta_t + \epsilon_{i,t}, \tag{32}$$

where $\mathbf{q}_{i,t-1}^{LTI}(\mathbf{q}_{i,t-1}^{LTV})$ contains dummies related to quintiles of the p-LTI (resp. LTV), lagged one period since labor supply and leverage ratios are chosen simultaneously. Hence, lagging one period allows me to interpret the dummies for the p-LTI and LTV quintiles as the beginning-of-period state variables used to determine labor supply. I estimate (32) on the main subsample of all married an cohabiting individuals. The results are as follows:

Table A.1: Employment and leverage based constraints

Employment$_{i,t}$					
$q^{LTI,1}_{i,t-1}$	0.0396*	0.0385*	0.0416**	0.0386*	0.0524**
	(0.0209)	(0.0217)	(0.0207)	(0.0211)	(0.0233)
$q^{LTI,2}_{i,t-1}$	0.0465**	0.0417*	0.0475**	0.0495**	0.0566**
	(0.0232)	(0.0244)	(0.0232)	(0.0237)	(0.0254)
$q^{LTI,3}_{i,t-1}$	0.0473**	0.0370	0.0496**	0.0479*	0.0517*
	(0.0239)	(0.0256)	(0.0240)	(0.0246)	(0.0266)
$q^{LTI,4}_{i,t-1}$	0.0660***	0.0560**	0.0683***	0.0626**	0.0692**
	(0.0249)	(0.0269)	(0.0250)	(0.0258)	(0.0275)
$q^{LTI,5}_{i,t-1}$	0.0741***	0.0717**	0.0753***	0.0688**	0.0749***
	(0.0262)	(0.0284)	(0.0263)	(0.0271)	(0.0286)
$q^{LTV,1}_{i,t-1}$	-0.00312	-0.0104	-0.000258	-0.00588	-0.0184
	(0.0215)	(0.0228)	(0.0215)	(0.0218)	(0.0229)
$q^{LTV,2}_{i,t-1}$	-0.0222	-0.0257	-0.0202	-0.0245	-0.0478*
	(0.0241)	(0.0259)	(0.0239)	(0.0247)	(0.0255)
$q^{LTV,3}_{i,t-1}$	-0.0255	-0.0218	-0.0251	-0.0230	-0.0368
	(0.0248)	(0.0270)	(0.0246)	(0.0256)	(0.0267)
$q^{LTV,4}_{i,t-1}$	-0.0354	-0.0313	-0.0317	-0.0335	-0.0378
	(0.0261)	(0.0292)	(0.0259)	(0.0273)	(0.0281)
$q^{LTV,5}_{i,t-1}$	-0.0217	-0.0190	-0.0176	-0.0133	-0.0155
	(0.0275)	(0.0312)	(0.0273)	(0.0287)	(0.0298)
age$_{i,t}$	0.0750***	0.0823***	0.0738***	0.0388**	0.0679***
	(0.00831)	(0.0100)	(0.00827)	(0.0169)	(0.00827)
age$^2_{i,t}$	-0.000925***	-0.000991***	-0.000919***	-0.00104***	-0.000815***
	(8.14e-05)	(8.97e-05)	(8.13e-05)	(8.99e-05)	(9.17e-05)
Nr.child$_{i,t}$	-0.0897***	-0.0903***	-0.0922***	-0.100***	-0.0942***
	(0.00823)	(0.00868)	(0.00841)	(0.00894)	(0.00891)
renter$_{i,t}$	0.0161	0.00662	0.0253	-0.00558	0.0365
	(0.0331)	(0.0383)	(0.0336)	(0.0366)	(0.0337)
(log) prim. income$_{i,t}$	-0.0430***	-0.0390***	-0.0438***	-0.0131*	-0.0259***
	(0.00757)	(0.00827)	(0.00757)	(0.00713)	(0.00724)
Wave	✓	✓	✓	✓	✓
Regions	✓	✓			
Household FE	✓	✓	✓	✓	✓
Education	✓	✓			
Sample		married		female secondary earner	HH head employed
Observations	17,261	15,007	17,423	15,706	13,778
R-squared	0.048	0.049	0.043	0.049	0.036

Sample includes women who are divorced and aged between 25 and 65 years old. Significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors in parenthesis.

Throughout the different specifications I always include wave and region dummies and household fixed effects. From the table, it is clear that there is indeed a significantly positive and monotonic relationship between the p-LTI ratio and the likelihood to be employed. I estimate a negative coefficient on the LTV quintiles, but these are not significant. In column 2, I restrict the sample to married couples, since there might be a difference in terms of commitment between cohabiting and married couples (as in the former separation from one's partner is less costly), but I don't observe a qualitative difference. In column 4 I restrict the sample to those couples where the household head is male (approximately 90 % of the sample), again, the same qualitative results arise. An important remark here is that there might be a confluence of the p-LTI quintiles and employment status for the secondary earner due to the primary earner being unemployed. In order to control for this, in column 5, I estimate (32) on the subsample of couples where the household head is employed. Again, the same relationship appears.

A.3 Negative financial shocks

As I mentioned in the main text, the negative financial shock is defined as a dummy equal to one when the expectations for the financial situation for the next year are to improve, whereas the actual change in financial situation is that it stayed the same or deteriorated. I regress the dummy to receive a negative financial shock on several household characteristics, region and wave dummies:

Table A.2: Likelihood to receive negative shock

Negative financial shock	
Commercial $QF_{i,t}$	0.00159
	(0.00843)
O $level_{i,t}$	0.0175**
	(0.00868)
A $level_{i,t}$	0.0133
	(0.00919)
Other higher $qf_{i,t}$	0.0169**
	(0.00758)
$Age_{i,t}$	-0.00179***
	(0.000226)
$\Delta \log Y^p_{i,t}$	-0.00768**
	(0.00390)
Unemployed last $year_{i,t}$	0.0774***
	(0.0130)
Δ $N.Children_{i,t}$	-0.00157
	(0.00729)
Observations	20,116
R-squared	0.021
Year	✓
Regions	✓
Wife's Education	✓

Sample includes households where both primary and secondary earners are between 25 and 65 years old. Significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors in parenthesis.

There seems to be some higher likelihood to receive an adverse financial shock in the past year in case the household head has an O level education or some form of higher qualification. Furthermore, as I described in the main text, there is a negative and significant correlation with the growth in primary household income, which is total household income minus the wife's labor earnings, indicating that our dummy for receiving a negative financial shock is related to changes in earnings of the husband or the household's non-labor income.

A.4 Wage processes

Given the parameterization of 18, it follows that the second moments of the shocks can be easily identified from using information regarding spouses' contemporaneous, lagged and lead wage growths (see e.g.Meghir and Pistaferri (2004)). In particular, since the transitory shocks $u_{j,t}$ are assumed to be serially uncorrelated, the variance of the permanent shocks can be identified from a single moment:

$$Var\left(\varepsilon_{j,t}\right) = Cov\left(\Delta w_{j,t-1} + \Delta w_{j,t} + \Delta w_{j,t+1}, \Delta w_{j,t+1}\right). \tag{33}$$

where $w_{j,t} = \log W_{j,t} - F_{j,t}$ denotes the unexplained part of earnings. The second moments of the transitory shock can then also be identified:

$$Cov\left(\Delta w_{j,t}, \Delta w_{j,t+s}\right) = \begin{cases} Var\left(\varepsilon_{j,t}\right) + Var\left(\Delta u_{j,t}\right) & \text{if } s = 0, \\ Cov\left(\Delta u_{j,t}, \Delta u_{j,t+s}\right) & \text{if } s \neq 0. \end{cases} \tag{34}$$

In this paper, I don't include transitory shocks. Estimation proceeds as follows: first, I obtain the deterministic component of wages for both males and females by regressing the log of hourly wages on a set of covariates, in particular I include a quadratic polynomial in age, education and regional dummies and number of children in the household. I also control for selection for females in the labor market, in particular, denote with P a dummy indicating whether the individual is active on the labor market. I include a selection equation:

$$P_{2,t} = \mathbf{Z}'_{2,t}\gamma + \delta_{2,t},\ \ \delta_{2,t} \sim N\left(0,1\right).$$

Where I use primary household income as excluded variable for the selection equation. The probability of the female spouse being active on the labor market in year t is then given by:

$$\begin{aligned} Prob\left(P_{2,t} = 1\right) &= Prob\left(\delta_{2,t} > -\mathbf{Z}'_{2,t}\gamma\right) \\ &= \Phi\left(\mathbf{Z}'_{2,t}\gamma\right). \end{aligned} \tag{35}$$

Adapting (33) to include selection into the labor market for females ($j = 2$), the parameters of the wage processes are then obtained as solutions to the following system:

$$\begin{cases} E\left[\Delta w_{2,t}\left(\Delta w_{2,t-1}+\Delta w_{2,t}+\Delta w_{2,t+1}\right)|P_t=1,P_{t-1}=1,P_{t+1}=1,P_{t-2}=1\right]= \\ \sigma^2_{\varepsilon_2}+\sigma^2_{\varepsilon_2,\delta}\frac{\phi\left(\mathbf{Z}'_{2,t}\gamma\right)}{1-\Phi\left(\mathbf{Z}'_{2,t}\gamma\right)}, \\ E\left[\Delta w_{2,t}\left(\Delta w_{2,t-1}+\Delta w_{2,t}+\Delta w_{2,t+1}\right)\right]=\sigma^2_{\varepsilon_1}. \end{cases}$$

I estimate this system by NLS.

A.5 Fertility

The stochastic process of family composition is assumed to be exogenous and estimated by a probit model,

$$Prob\left(ageych_t=0|t,HE_t,child_{t-1}\right), \tag{36}$$

where $child_t$ is a dummy variable indicating the presence of a child in the household in the previous year. The variable HE_t is a dummy indicating whether the mother is highly educated. Table A.3 give sthe results of estimating (36):

Table A.3: Probability of birth

Fertility	
$25 \leq age_{i,t} \leq 35$	0.321***
	(0.0674)
$35 < age_{i,t} \leq 45$	0.198***
	(0.0637)
$45 < age_{i,t} \leq 55$	-0.136*
	(0.0721)
child$_{i,t-1}$	0.382***
	(0.0843)
ageych$_{i,t-1}$	-0.114***
	(0.00780)
Observations	9,679

Sample includes women who are married or cohabiting and aged between 25 and 65 years old. Significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors in parenthesis.

A.6 Initial bargaining

The regression results of estimating (28) on female and male divorcees are as follows:

Table A.4: Earning regressions divorcees

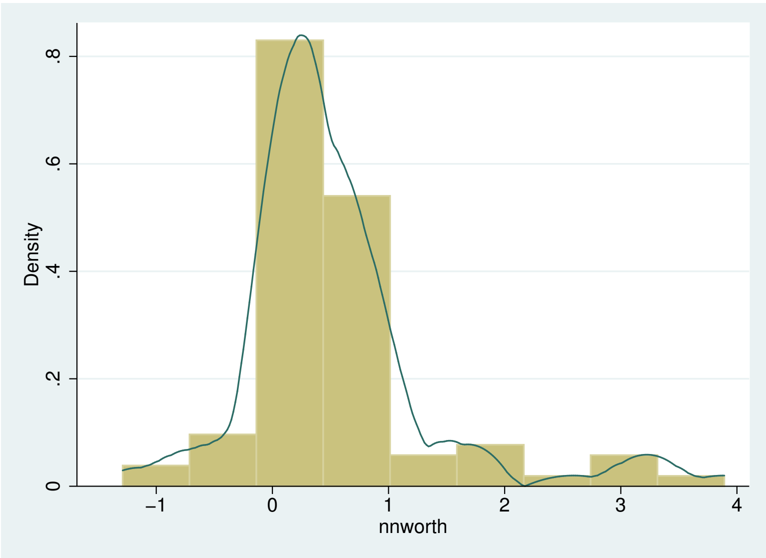
	Female divorcees	Male divorcees
$\text{age}_{i,t}$	2,426***	1,229*
	(457.8)	(730.9)
$\text{age}^2_{i,t}$	-30.83***	-15.11*
	(5.020)	(8.158)
$<$ O $\text{level}_{i,t}$	15,405	-8,477
	(12,609)	(18,737)
O $\text{Level}_{i,t}$	6,382	-20,349
	(11,919)	(19,102)
A $\text{level}_{i,t}$	18,809	39,875*
	(13,843)	(22,125)
Other higher $\text{qf}_{i,t}$	6,283	-30,504*
	(12,867)	(18,386)
$<$ O $\text{level}_{i,t} \times \text{age}_{i,t}$	-1,633***	48.45
	(566.0)	(850.0)
O $\text{Level}_{i,t} \times \text{age}_{i,t}$	-980.8*	930.7
	(542.1)	(890.1)
A $\text{level}_{i,t} \times \text{age}_{i,t}$	-1,740***	-1,621
	(654.6)	(1,022)
Other higher $\text{qf}_{i,t} \times \text{age}_{i,t}$	-1,113*	1,283
	(592.3)	(844.1)
$<$ O $\text{level}_{i,t} \times \text{age}^2_{i,t}$	22.73***	0.496
	(6.195)	(9.399)
O $\text{Level}_{i,t} \times \text{age}^2_{i,t}$	14.57**	-10.94
	(5.995)	(10.13)
A $\text{level}_{i,t} \times \text{age}^2_{i,t}$	24.82***	15.49
	(7.521)	(11.42)
Other higher $\text{qf}_{i,t} \times \text{age}^2_{i,t}$	18.29***	-12.99
	(6.657)	(9.450)
Observations	2,569	1,394
R-squared	0.170	0.111

Sample includes women who are divorced and aged between 25 and 65 years old. Significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors in parenthesis.

A.7 Initial assets

The BHPS contains information on savings and investments of households for the years 1995, 2000 and 2005. Given the span of my dataset, I'll use the 1995 wave to obtain the empirical distribution of net worth for couples. I consider all individuals who report being married or living as a couple and who are within the age range of 20 and 30. I combine as much as possible information of respondents' their partner in order to obtain a complete view of the couple's net worth. I compute the latter as the sum of (joint) savings, investments, the (self-reported) value of the house from which I subtract the amount of outstanding debt at the date of interview. In the simulations, I assume households start without owning a house, whereas in the data I observe households indicating zero savings, but who do own a house and have some outstanding mortgage debt. In order not to remove information on net worth from these observations, I will keep these observations nonetheless. In the model, I impose that households can't have negative net worth, whereas I do observe a portion of households have a negative computed net worth. In order to resolve this, I censor the (empirical) initial distribution of assets in the simulation at zero, i.e. I assign an initial level of zero for observations with zero or negative net wealth. Finally, I normalize net wealth by dividing by the average household income. The resulting empirical distribution is given in Figure 5:

Figure 5



Source: BHPS wave 1995. Sample includes married or cohabiting couples. All respondents are in the age range of 20-30. Net wealth is sum of (joint) savings, investments, house value minus outstanding mortgage debt.

A.8 Solution method

Because of the endogenous nature of the borrowing constraint, there will be several points of non-differentiability in the value function (Bottazzi et al. (2007), Blundell et al. (2016), Pizzinelli (2018) ...) Computationally fast algorithms such as the endogenous gridpoint method are therefore unfeasible. Therefore, I use the slower but more robust value function iteration (VFI) approach with a fixed discretized grid within the state space. To solve over a square space, I follow Bajari et al. (2013) and Pizzinelli (2018) in transforming the state space for financial assets, A_t. In particular, I define $M_{t-1} =$

$A_{t-1} + \lambda_H p H_{t-1}$ and $M_t = A_t + \lambda_H p H_t$, so that the state space for M_{t-1}, M_t always have 0 as a lower bound. For all possible combinations of H_{t-1}, H_t, I can then solve over $M_t | M_{t-1}$ over a fixed 2 dimensional grid. Then, using the optimal values for M_t, M_{t-1} I can recover A_{t-1}, A_t. The state space consists of (potential) wages for both spouses (the wage processes are discretized by using the method described in Tauchen (1986)). Since the earnings processes are age-dependent (indeed, the overall variance of the permanent wages for the spouses is increasing with time), I need to do the discretization for each age separately. In particular, I use 10 grid points for the spouse's permanent wages and then, following Pizzinelli (2018), I double the grid space to include the contingency of unemployment.

For the remainder of the state space, I use for current assets 40 grid points, logarithmically spaced, 2 points for the housing status at the beginning of the period H_{t-1}, and 12 grid points (0-11 years) for the age of the youngest child (*ageych*). As mentioned in the main text, I simulate 5 replications for each of the 3266 households where I use the empirical distribution of the initial assets for the start-of the life cycle savings and then I simulate the Markov process of joint (potential) wages for the spouses over the life cycle. I can then compute the resulting paths for the choice variables (labor market hours, hours in home production, housing decisions) from which I can compute the simulated counterparts to the empirical moments from the dataset.