Housing, borrowing constraints, and labor supply over the life cycle

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January 16, 2018

Abstract

Leverage-based borrowing constraints are important determinants of labor supply and homeownership over the life cycle. In this paper, I develop a life cycle model of a two-worker household with female labor supply and housing, where leverage constraints are formulated as upper limits of the Loan-To-Value (LTV) and Loan-To-Income (LTI) ratios. The model has two key implications. First, changes in the values of the LTV and LTI limits affect households' labor supply decisions, which can either amplify or mitigate their impact on homeownership. Second, leverage constraints restrict households' ability to buffer income fluctuations and generate large heterogeneity in females' labor supply response to income shocks. Finally, using micro-data from the British Household Panel Survey, I find evidence for the model's predictions on the relationship between leverage and the employment of households' secondary earners.

JEL Classification: D91, J22, R21.
Keywords: life cycle models, labor supply, housing demand, leverage.

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*I would like to thank Árpád Ábrahám, Charles Gottlieb, Jesús Fernández-Villaverde, Christopher Roth, Michalis Rousakis, and Francesco Zanetti, as well as seminar participants at the European University Institute, the University of St. Gallen, the University of Oxford, and the Workshop on Dynamic Macroeconomics (Vigo, Spain) for useful comments. I would like to acknowledge the use of the University of Oxford Advanced Research Computing (ARC) facility in carrying out this work (http://dx.doi.org/10.5281/zenodo.22558). Please address correspondence to Carlo Pizzinelli, University of Oxford, Department of Economics, Manor Road, Oxford, OX1 3UQ, UK; Email: carlo.pizzinelli@economics.ox.ac.uk.

1 Introduction

Households' ability to mitigate unexpected shocks and smooth consumption over the life cycle is crucially affected by the composition of their balance sheets (Kaplan and Violante, 2014). To ensure aggregate stability, policymakers therefore pay close attention to the mortgage market and constrain households' access to debt by setting limits to their financial leverage. Most households face high levels of leverage at young ages, when they purchase houses through mortgages, and extinguish their debts over their working lives. In this process, labor supply provides a key margin of adjustment to finance house buying, repay mortgage debt, and smooth consumption. In fact, several empirical studies establish that households adjust the labor supply of secondary earners in response to mortgage market reforms that facilitate access to credit (Del Boca and Lusardi, 2003), and in reaction to changes in their ability to repay housing debt (Fortin, 1995). The aim of this paper is to develop a life cycle model that isolates the key channel for the interaction between leverage-based borrowing constraints and labor supply decisions, drawing important conclusions for credit policies.

I build a model extending a life cycle framework *à la* Attanasio et al. (2012), calibrated to the United Kingdom (UK), which features a two-worker household with uninsurable income risk, housing preferences, and female labor supply.[1] I assume that females function as secondary earners and face empirically relevant, age-varying labor supply costs. Moreover, exogenous borrowing constraints are formulated as upper limits of two measures of mortgage leverage: the Loan-to-Value (LTV) and the Loan-to-Income (LTI) ratios.

The LTV represents the ratio of a household's outstanding mortgage to the value of housing assets, while the LTI is the ratio of the outstanding mortgage to yearly income. These ratios are the most common measures of housing leverage and are used by banks to set limits on their customers' ability to borrow. This feature of the model thus captures the institutional framework of the UK as well as other developed economies. Furthermore, the structure of mortgage markets and longstanding empirical evidence on intra-household risk-sharing make the life cycle dimension the most informative lens to study the relationship between housing debt and female labor supply. Mortgage contracts can entail repayment periods of up to 35 years, hence affecting agents' choices throughout a significant segment of their lives. Meanwhile,

[1] Similar to previous studies, I model two-earner households as composed of one male and one female. Henceforth, the term "couple" is employed assuming a household where the two earners are of opposite sex.

a large literature shows that, within multi-earner households, female labor supply is the principal margin of adjustment to insure consumption against income shocks to the primary earner -a mechanism known as the "added worker effect" (Lundberg, 1985; Stephens, 2002).

I show that leverage-based borrowing constraints crucially affect the household's decisions on debt and labor supply over the life cycle. The presence of such constraints imply that the household's ability to access debt is dependent on the earnings of both members and on the female's decision to work. Furthermore, this relationship has two important implications. First, the quantitative impact of changes in the credit constraints on homeownership depends on their interaction with households' labor supply choices. Second, the response of female labor supply to unexpected income shocks exhibits large heterogeneity across different levels of leverage.

In the model, employment of the secondary earner is negatively correlated with the LTV ratio and positively correlated with the LTI computed using the primary earner's income - which I denote as p-LTI. The earnings of the two workers, and their expected growth over the life cycle, underpin these cross-sectional relationships. In particular, the LTV- and LTI-based constraints interact with two opposing channels. On the one hand, when labor supply costs are high, a household has a motive to avoid female employment and instead finance consumption and housing through borrowing. On the other hand, if male earnings are low, female labor supply can provide a key source of income and relax the LTI-based debt constraint. Intuitively, young households anticipate growing income and falling labor supply costs later in life. When purchasing a house, and in the following years, they have an incentive to avoid female work by accumulating debt, which increases their LTV ratio. However, if the male's earnings are sufficiently low, the LTI limit becomes binding first, even for low levels of debt, unless the female also works. Hence, it is only households with high male earnings that can obtain a high LTV ratio. Among these, only those with low female potential earnings will choose to accumulate debt instead of supplying costly labor. Meanwhile, a high p-LTI reflects the need for female labor to sustain debt repayments and relax a credit constraint when the male's income is low, leading to high employment.

Leverage-based borrowing constraints are crucial to establish a direct link from the credit market to households' decisions. Macroeconomic policies often directly target LTV and LTI limits to address homeownership and financial stability objectives.[2] If households' labor supply

[2]For instance, in 2013 the UK government launched the "Help-to-Buy" policy to allow new homebuyers to obtain subsidized mortgages with a maximum LTV of 0.95. Meanwhile, in 2014, following the advice of the Bank

decisions depend on their ability to access debt, policies setting leverage limits will propagate through the labor market, affecting the employment of "marginal" workers. The overall impact of changes in the leverage constraints on homeownership will therefore depend on their interaction with the labor supply choices of secondary earners.

To evaluate these predictions and their policy implications, I consider counterfactual scenarios with alternative values of the LTI limit and the LTV limit, respectively. A tightening of the LTI limit causes a fall in homeownership for young households as well as a fall in aggregate female labor supply that persists over the life cycle. The decrease in labor supply originates from those households with low wealth and high female wage who rely on female labor supply to access the debt needed for homebuying. For a 10 percentage-point fall in the homeownership rate of the youngest cohort in the life cycle, this groups comprises about 15 percent of those households who delay homebuying. A comparable contraction of the LTV limit does not directly interfere with the returns to labor supply and does not lead to a fall in employment at the aggregate level. Overall, households' ability to adjust the secondary earner's labor supply amplifies the effect on homeownership of credit loosening and mitigates that of a tightening. Furthermore, leverage limits are particularly relevant for young households, which are the most likely to be affected by the binding leverage limits.

A critical policy question is whether the response of female labor supply to permanent income shocks varies with households' leverage levels. I find that the labor supply of high-LTV households greatly adjusts to income shocks compared to that of low-LTV ones. The former group includes those households with low female wages and high male earnings, who can afford to borrow up to the LTV limit. They thus exhibit the largest fall in employment after a negative shock to female wages as they can easily substitute away from costly female work. However, they also experience a large rise in employment after a drop in male earnings because the fall in primary income impairs their main channel for financing consumption.

To assess empirically the predictions of the model, I use data from the 2001-2006 British Household Panel Survey (BHPS). I follow the survey's definition of "head of household" to identify couples' secondary earners, which in 90 percent of the cases are female. In line with the model, I show through a linear probability regression that the probability of the secondary earner being employed is negatively related to the household's LTV ratio and positively related

of England, the Financial Conduct Authority issued rules on the maximum share of high-LTI mortgages that banks should issue (FCA, 2014).

to the p-LTI. The results are robust to alternative sample selections and to an extended time interval. Furthermore, I find that falls in primary earnings account for a large fraction of cases of high p-LTI, indicating circumstances in which secondary labor acts as a means of insurance.

This paper is related to the large literature that uses life cycle models to separately study housing demand or female labor supply. I contribute to this literature by developing a model that shows the strong interaction between the two channels, which is relevant for both fields. On housing demand, seminal works include Iacoviello (2008), Yang (2009), Fernández-Villaverde and Krueger (2011), Attanasio et al. (2012), Bajari et al. (2013), and Iacoviello and Pavan (2013). While these works consider leverage constraints, I extend their results by showing that the endogeneity of leverage choices to the labor supply of secondary earners entails key dynamics not otherwise captured. Studies on two-earner households include Low (2005), Attanasio et al. (2005, 2008, 2015), Blundell et al. (2016), and Wu and Krueger (2016). These papers highlight the role played by female labor as a means of consumption insurance, which is particularly relevant in the presence of borrowing constraints. However, by abstracting from housing, they only consider constraints on net wealth. I show that leverage-based debt limits imply that households need not be poor to be close to a borrowing constraint. Consequently, some households with high wealth may exhibit a large added worker effect in response to income shocks.[3]

To the best of my knowledge, the only work that combines female labor supply and housing demand within a life cycle framework is Bottazzi et al. (2007). While adopting a similar approach, my paper traces a direct link between life cycle expectations and leverage-based constraints to explain the empirical relationships between female labor supply and different measures of leverage. I further extend the analysis by assessing the relevance of the labor supply channel for the effect of changing leverage limits on homeownership.

The rest of the paper is structured as follows. Section 2 provides empirical evidence on the life cycle profiles of homeownership, employment, and leverage. Sections 3 and 4 outline the model and the calibration, respectively. Section 5 presents the main results and discusses the model's key dynamics. Section 6 evaluates the importance of the labor supply channel with respect to changes in leverage limits. Section 7 analyzes the implications for the response of female labor supply to income shocks. Using the BHPS, Section 8 finds empirical support for the model's main predictions. Section 9 concludes.

[3] Using the definition of Kaplan and Violante (2014), this study explores the labor supply dimension of "wealthy hand-to-mouth" households.

2 Housing, employment, and leverage in the BHPS

In this section, I provide stylized empirical evidence to motivate the joint analysis of homeownership, leverage, and labor supply. Using the British Household Panel Survey (BHPS), I show that these variables exhibit both marked life cycle patterns and large cross-sectional variation for two-earner households.

Mortgage repayments are a form of "committed consumption", implying that part of the household's budget cannot be adjusted in response to income fluctuations. Additionally, homeowners with an outstanding mortgage have lower housing equity and hence lower ability to further borrow against their housing stock to insure against earning fluctuations. The size of the mortgage relative to the flow of income is also indicative of how difficult it may be for the household to extinguish its debt over the years. Reflecting these concepts, two conventional measures of household leverage are the Loan-to-Value and the Loan-to-Income ratios. Higher values of these two metrics indicate a higher leverage.

The BHPS is comprised of yearly individual-level observations with a longitudinal dimension from 1991 to 2008. For the analysis, I use the survey waves for the years 2001 to 2006. I choose this time interval because, despite the sustained house price growth, it was a period of general macroeconomic stability in the UK, marked by a stable unemployment rate just above 5 percent and moderate real earnings growth.[4] I consider all households formed by couples, either married or in a cohabiting relationship, where the secondary earner is between 23 and 65 years old.[5] A large literature has showed that the secondary earner's extensive margin is the main margin of labor supply adjustment for most households.[6] I define as secondary earner the member of the couple who is not classified as the head of household by the BHPS in each wave.[7] Based on this selection criterion, in the 2001 wave of the BHPS almost 90 percent of secondary earners in prime-age couples are female.[8]

Using this sample, the first row of panels in Figure 1 shows the life cycle profiles of housing

[4]House prices began to fall in 2007 and in 2008 the unemployment rate rose from 5 percent to 8 percent, while average earnings fell. The results of the following analysis, however, are robust to including the years 2007 and 2008 in the sample.

[5]For comparability with the model presented below, I exclude same-sex couples in the baseline sample. However, sensitivity analysis shows that the empirical results hold equally when including them.

[6]See for instance Lundberg (1985),Stephens (2002), and Mankart and Oikonomou (2017).

[7]In the BHPS, the head of the household is identified as the member who is legally and financially responsible for accommodation or the elder of two people who share the responsibility.

[8]Table A.1 reports the sex of the household head and the secondary earners. The table also shows that the secondary earner is more likely to be involved in family care or other non-employment activities. Furthermore, for couples with children, the secondary earner is more likely to be solely responsible for childcare activities.

Figure 1: Life cycle profiles (3-year moving averages) for homeownership, employment, average (log) house value, percentage of mortgagors, average LTV, LTI, and p-LTI using the 2001-2006 waves of the BHPS.

Note. Source: BHPS waves 2001-2006. The sample includes married couples and those in permanent partnerships aged 23 to 65. All series are reported as 3-year centered moving averages. The solid line in Panel 6 reports the LTI based on the full household income, while the dashed line reports the average value using all household income except for the secondary worker's earnings. In Panel 3, house values are deflated to 2001 prices using the UKHPI series.

assets and the employment rate of females and males within couples.[9] Keeping in mind that these profiles do not account for endogenous marriage and separation decisions, clear age trends are visible in all series. The homeownership rate starts just below 60 percent and rises until age 45, after which it stabilizes around 85 percent. As the average log value of the primary residence shows (Panel 3), older homeowners also tend to accumulate larger amounts of housing assets.[10] As shown in the second panel of Figure 1, female labor supply evinces a more pronounced life cycle profile than male employment. The percent of females in employment gradually rises from 70 percent at age 25 to its peak just above 80 percent in the late 40's, and subsequently falls until age 65. Meanwhile, male employment is higher at all ages and almost constant until age 50, when transitions into retirement begin.

The lower row of Figure 1 focuses on debt and leverage. Panel 4 shows that the proportion of households with an outstanding mortgage has a hump-shaped profile over age, implying that

[9] The employment panel plots the employment rate against the age of the member of the respective sex. The other panels use the age of the secondary earner.

[10] For the entire analysis in this paper, variables in British pounds are deflated to 2001 levels using the UK Consumer Price Index, unless otherwise stated.

almost all young homeowners have a mortgage, which they progressively repay throughout their working years.[11] The last two quadrants of Figure 1 focus on households' financial position in terms of LTV and LTI ratios for those with outstanding mortgages. Both measures of leverage show a clear downward path, indicating that young mortgagors have on average a larger portion of their house used as collateral and their outstanding mortgage is high relative to their flow of income. The last panel plots the LTI computed with the full household income and based only on primary labor earnings and other income (i.e. the p-LTI). The gap between the two series highlights the importance of labor income from the secondary earner to lower the overall ratio, which may be necessary to avoid a leverage limit.[12]

The 6-year period used for the analysis featured sustained growth in house prices, which may be the main driver of younger households' leverage decisions. As A.1 in the Appendix shows, rising prices in the decades before the 2008 recession imply that younger cohorts of homeowners had higher LTI levels than older ones.[13] I therefore check whether the age profiles in the period of interst are not the result of spurious year or cohort effects. Figure A.2 reports the age effects obtained from the regression method proposed by Deaton and Paxson (1993), which confirm the trends from Figure 1.

Besides differences across age groups, homebuyers make different choices on the leverage they take up at the time of purchase and sustain over the following years. Figure 2 shows the large variation in the LTV and (p-)LTI values chosen by new homeowners in the year of purchase. This variation originates from the the value of the house, the size of the mortgage, and income, which are all chosen by households based on their future prospects. In the next section, I develop a life cycle framework to establish how expectations of earnings and labor supply costs determine choices of leverage and work.

3 Model

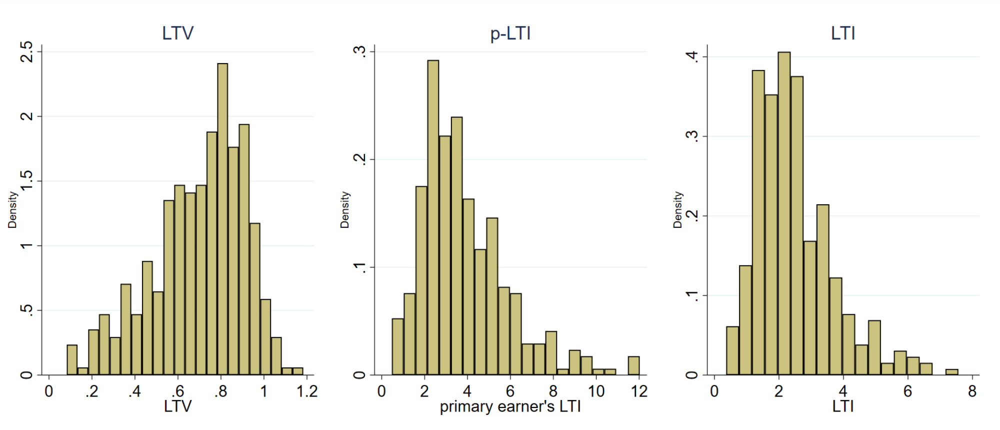
To assess the stylized facts from Section 2, I develop a model of a unitary household with two earners: a male and a female. The main features of the model follow the lines of Bottazzi

[11] Since the BHPS does not specifically ask about available Home Equity Lines of Credit (HELOCs), this measure may underestimate the proportion of households with outstanding debt secured against their house.

[12] Interestingly, the rise in primary earner's LTI after age 55 may be underpinned by selection in the type of households who have an outstanding mortgage late in their working lives.

[13] To provide a clearer picture of the long-run differences across cohorts, this figure is produced using the full 1991-2008 BHPS sample.

Figure 2: Distribution of LTV, p-LTI, and LTI among new homeowners in the BHPS waves 2001-2006.



Note. Source: BHPS waves 2001-2006. The sample includes new homeowners where the secondary earner is aged 23 to 65.

et al. (2007) and Attanasio et al. (2012). Given that 90 percent of secondary earners in the BHPS are females, I assume for explanatory purposes that the female acts as secondary earner. The household faces idiosyncratic income shocks to both male earnings and female wages over a finite lifetime. Households accumulate assets to smooth consumption and purchase discrete units of housing. Those who do not own any housing must pay rent. The purchase of housing can be partly financed through a mortgage, hence holding negative liquid assets. Homeowners can also borrow against the value of their house, up to a limit, after the period of purchase. After a finite working life, agents retire and receive a fixed income stream. Death occurs at the end of the retirement period. The model is in partial equilibrium: house prices and interest rates are exogenous and deterministic.[14]The computational solution of the model is described in Appendix B.

The life cycle lasts J_D periods of one year each. From period $j = 1$ to period J_{R-1} households are active in the labor force and receive an income y_j for the male and a wage w_j^f for the female, both of which exhibit stochastic fluctuations around a deterministic age trend. For the male, income shocks include the possibility of temporary involuntary unemployment. From age J_r to J_{R-1}, females face the possibility of retiring permanently. From J_R to J_{D-1}, both earners in the household are retired and receive pensions b and b^f, respectively. Upon reaching period J_D, households cease to live and must repay all their debt.[15]

[14]The absence of these two features may be a limitation for an exhaustive analysis of housing, but neither of them is essential for the key mechanisms studied in this work. A following section of the paper discusses the effect of unanticipated price shocks.

[15]I assume they derive no utility from leaving bequests. I also choose not to model household destruction

Except for involuntary unemployment, the male always works. The female decides whether to work ($0 < n^f \leq 1$) or not ($n^f = 0$) based on her preference for leisure and on the additional age-varying cost $\xi(j)$ incurred if employed.

Housing is a discrete variable $h_j \in \{0, ..., \overline{h}\}$. When $h_j = 0$, the household is renting at a cost q. Housing units have a price p and their trading is subject to proportional transaction costs F_b and F_s for each unit bought and sold, respectively.

Net financial assets a_j are a continuous variable receiving a per-period interest r, and can be traded at no cost. A negative value of a_j signifies an outstanding mortgage. Debt for next period is constrained by a borrowing limit $\phi(h_j, y_j, w_j^f, n_j^f)$ or by the current outstanding debt. Details of this constraint are provided further below.

Household preferences are a function of consumption c_j, housing h_j, female labor n_j^f, and age. Future periods are discounted with a constant factor $0 < \beta < 1$. Given my interest in how the "lumpiness" of housing affects other household choices, I adopt a specification of preferences where such discreteness enters directly into the agents' utility. I use a specification similar to that of Attanasio et al. (2012) in setting $\overline{h} = 4$, where $h = 1$ equals a small house and $h = 4$ represents the largest house size.[16] Households derive utility from consumption, housing, and leisure as follows:

$$U(c, n^f, h, j) = \frac{c^{(1-\sigma)}}{1-\sigma} + \theta_f \frac{(1-n^f)^{1-\psi}}{1-\psi} + \mathbb{I}\{h > 0\}\mu(h, j),$$

where $\mathbb{I}\{h > 0\}$ is an indicator function for homeownership and the preferences for housing are represented by the function $\mu(h, j)$, which has the following form:

$$\mu(h, j) = \chi(j) \left(\mu_h + \phi_h \frac{h-1}{\overline{h}-1} \right).$$

The first term $\chi(j)$ is a deterministic age-varying weight that implies a change in the preference for housing over the life cycle. The constant μ_h represents the preference for a small house, while the slope coefficient ϕ_h represents the marginal preference for larger houses.

through early death or divorce for simplicity. The possibility of both events has important repercussions for savings decisions and for intra-household risk sharing but are beyond the direct scope of this work. The interaction of these channels with the relationship studied in this paper constitutes an important direction for future research.

[16] More simply, it can be interpreted as a larger amount of housing services, not necessarily indicating greater size, but also location or any factor increasing value.

For $j < J_R$, male earnings follow the process

$$\log y_j = \alpha_0 + \alpha_1 j + \alpha_2 j^2 + \log z_j \ ,$$
$$\log z_j = \rho_z \log z_{j-1} + \epsilon_j, \quad \epsilon_j \sim \mathrm{N}(-\frac{\sigma_\epsilon^2}{2}, \sigma_\epsilon^2).$$

The first component of earnings is a deterministic quadratic function of age, the second one is a stochastic process.[17] Furthermore, with some probability π_u, each period the male may be jobless and receive unemployment insurance y^u. Earnings become constant once the male retires, so that $y_j = b$, for $J_R \leq j \leq J_D$. Retirement income is assumed to be a constant proportion of the earnings received in the final period of work. Female wages follow a similarly structured process:

$$\log w_j^f = \alpha_0^f + \alpha_1^f j + \alpha_2^f j^2 + \log z_j^f \ ,$$
$$\log z_j^f = \rho_z^f \log z_{j-1}^f + \epsilon_j^f, \quad \epsilon_j^f \sim \mathrm{N}(-\frac{\sigma_{\epsilon^f}^2}{2}, \sigma_{\epsilon^f}^2).$$

Females face no involuntary unemployment risk but incur a per-period retirement probability π_r between J_r and $J_R - 1$, or retire with certainty at J_R if still active.[18] At retirement, they receive income b^f equal to a fraction of their final wage times the average hours worked by females in the economy. When the female works, the household pays an age-dependent childcare cost $\xi(j)$.

The household's age-j value function V_j depends on whether the female is active or retired. Denoting $X_j = [a_j, h_{j-1}, y_j, w_j^f]$ as the vector of relevant states, the problem for a couple with

[17] I approximate the stochastic component with a finite vector of states $z \in [\underline{z}, ..., \overline{z}]$ and a set of transition probabilities $\pi_{z_j|z_i}$.

[18] Although a thorough analysis of retirement decisions is beyond the scope of this work, modeling heterogeneity in retirement timing and pension income, even if in a stochastic way, is important to match the life cycle profile of earnings and labor supply.

an active female expressed in terms of the value $V_j^A(X_j)$ for all $j < J_r$ is

$$V_j^A(X_j) = \max_{c_j, h_j, a_{j+1}, n_j^f} \Big\{ U(c_j, h_j, n_j^f, j) + \beta \mathbb{E}_j V_{j+1}(X_{j+1}) \Big\} \tag{1}$$

$$\begin{aligned}
&\text{subject to:}\\
&h_j \in \{0, ..., \overline{h}\}\\
&a_{j+1} + c_j + ph_j + \Phi(h_j, h_{j-1}) + q\mathbb{I}\{h_j = 0\}\\
&\qquad = (1+r)a_j + y_j + w_j^f n_j^f - \xi(j)\mathbb{I}\{n_j^f > 0\} + ph_{j-1}\\
&a_{j+1} \geq \min\{a_j, \phi(h_j, y_j, w_j^f, n_j^f)\}\\
&n_j^f \in [0, 1],
\end{aligned}$$

where the indicator function $\mathbb{I}\{h_j = 0\}$ is equal to one when the household rents and $\mathbb{I}\{n_j^f > 0\}$ equals one when the female works. Expectations for the future are taken with respect to income and wages.

Denoting $X_j^R = (a_j, h_{j-1}, y_j, b^f)$ as the relevant state vector, the problem for a couple with a retired female is

$$V_j^R(X_j^R) = \max_{c_j, h_j, a_{j+1}} \Big\{ U(c_j, h_j, 0, j) + \beta \mathbb{E}_j V_{j+1}^R(X_{j+1}^R) \Big\} \tag{2}$$

$$\begin{aligned}
&\text{subject to:}\\
&h_j \in \{0, ..., \overline{h}\}\\
&a_{j+1} + c_j + ph_j + \Phi(h_j, h_{j-1}) + q\mathbb{I}\{h_j = 0\} = (1+r)a_j + y_j + b^f + ph_{j-1}\\
&a_{j+1} \geq \min\{a_j, 0\}.
\end{aligned}$$

where male earnings y_j are stochastic until $J_R - 1$ but become constant afterwards.

Between ages J_r and $J_R - 1$ female retirement can happen with some probability between two periods, so that the relevant objective function is

$$V_j^A(x) = \max_{c_j, h_j, a_{j+1}, n_j^f} \Big\{ U(c_j, h_j, n_j^f, j) + \beta \Big[(1 - \pi_r)\mathbb{E}_j V_{j+1}^A(X_{j+1}) + \pi_r V_{j+1}^R(X_{j+1}^R) \Big] \Big\} \tag{3}$$

subject to the same constraints as (1).

In the last period of life, the household must extinguish all debts and consume all remaining income and wealth.

The transaction costs function $\Phi(h_j, h_{j-1})$ is asymmetric with respect to selling and buying:

$$\Phi(h_j, h_{j-1}) = \begin{cases} ph_{j-1}F_s + ph_jF_b & \text{if } h_j \neq h_{j-1} \\ 0 \quad \text{if } h_j = h_{j-1} \end{cases}$$

The borrowing constraint function $\phi(h_j, y_j, w_j^f, n_j^f)$ is a key component of the model. Its specification builds on that of Attanasio et al. (2012), by assuming it depends on both the value of real estate holdings, previous financial assets, and current income. To illustrate its functioning, it is useful to express the household problem in terms of debt, $d_j = -a_j$. The borrowing constraint then becomes

$$d_{j+1} \leq \max\{d_j, \hat{\phi}(h_j, y_j, w_j^f, n_j^f)\},$$

$$\hat{\phi}(h_j, y_j, w_j^f, n_j^f) = \min\Big\{ \underbrace{\lambda_h ph_j}_{\text{LTV limit}}, \underbrace{(\lambda_y y_j + w^f \bar{n}\mathbb{I}\{n^f > 0\})}_{\text{LTI limit}} \Big\} \tag{4}$$

Renters are not allowed to have debt. Homeowners can hold debt subject to a set of collateral constraints. Specifically, buyers can finance the purchase of a housing unit through debt up to the minimum between the LTV limit $\lambda_h ph_j$ and the LTI limit $\lambda_y y_j + w^f \bar{n}\mathbb{I}\{n^f > 0\}$, where $\bar{n}$ is the average hours of full-time work. The indicator function $\mathbb{I}\{n^f > 0\}$ implies that, by supplying labor, females can increase the LTI limit. Moreover, households can use their house as collateral to borrow further at any time, as long as their current level of debt already satisfies the two leverage ceilings. If not, they are unable to increase their debt. However, they are not forced to immediately satisfy the leverage limits whenever these are violated, although they must at least repay interests on the outstanding debt. Similarly, I assume retirees are allowed to pay off their debt gradually but not to borrow any further.

Representing net liquid savings as a single continuous variable is motivated by the need to model mortgage-related borrowing constraints without having a decoupled choice of both deposits and an individual mortgage contract within the household's balance sheet. In reality, most households hold both positive liquid assets and a mortgage contract. However, modeling these two separately would imply doubling the continuous dimension of the state-space for assets, which is computationally cumbersome.[19] Allowing the household to choose any value of a_{j+1} subject to some constraint, rather than imposing a fixed debt repayment schedule, is equivalent to a yearly renegotiation of mortgage terms. This assumption is tenable given the UK's flexible institutional framework and the availability of "interest-only mortgages".[20]

The specification of the leverage limits allows for homeowners to suddenly become borrowing-constrained after an income shock, even without a change in assets. For instance, a household may obtain a mortgage at the time of purchase that satisfies both the LTV and LTI constraints. However, an income fall in the following period may suddenly imply that debt is above the LTI limit. The main implication is that a household with high net worth but also high debt can become borrowing-constrained. The LTI limit also entails that female employment can act to relax the borrowing constraint, although the secondary income carries less weight in the function. As discussed in the calibration section, this formulation captures the main features of mortgage contracts.

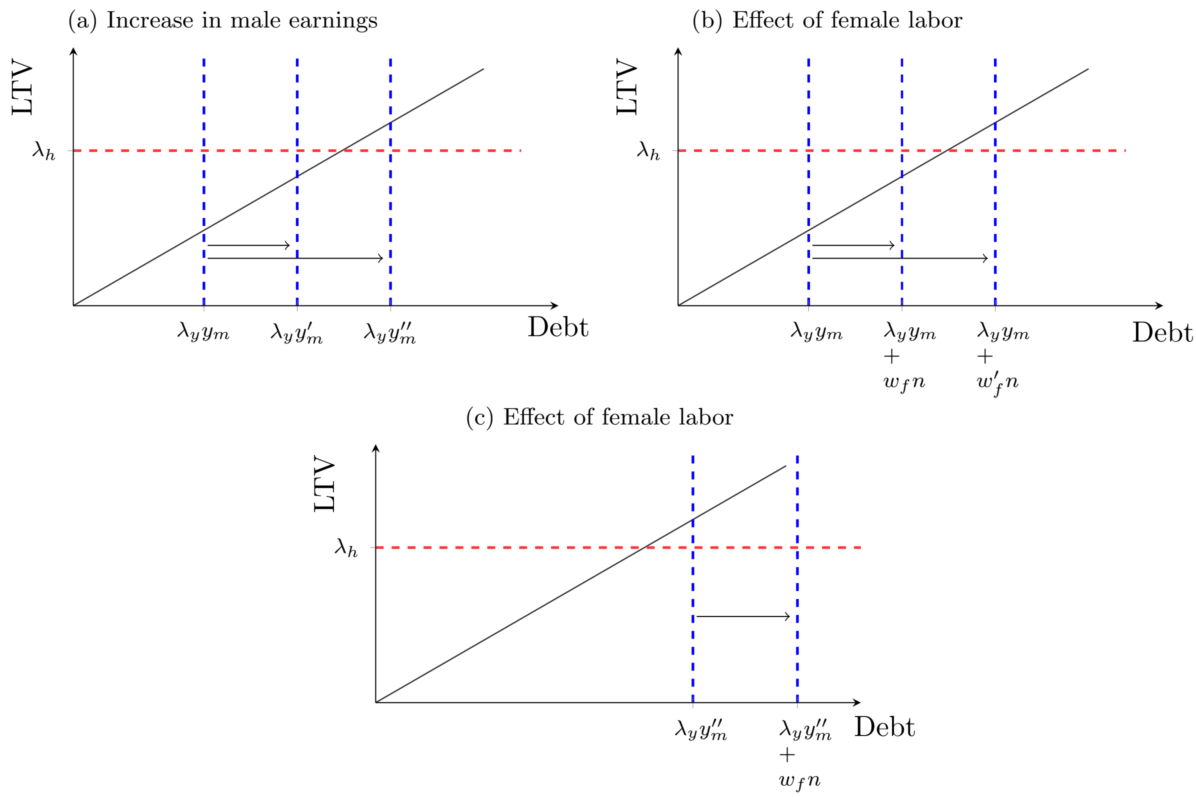
Figure 3 provides graphic intuition for the mechanics of the constraints. The solid black line represents the relationship between debt (x-axis) and LTV (y-axis), for a given quantity of housing assets that a household owns (or purchases). The horizontal red dashed line at λ_h is the fixed LTV limit. The vertical blue dashed lines represent the LTI limit, which depends on the male's and female's incomes and on the female's labor decision.

Panel (a) shows the effect of higher male earnings in the case of a female not working. Assuming $y_m < y'_m < y''_m$, the LTI limit shifts to the right, allowing the household to access more debt. The change from y_m to y'_m moves the household debt limit to $\lambda_y y'_m$. However, since $\lambda_h ph < y''_m$, the LTV constraint becomes the binding limit for y'', and the higher income does not translate one-to-one into greater borrowing capacity. Panel (b) shows how female employment relaxes the borrowing constraint. In the first case, the constraint is represented by the LTI limit $\lambda_y y_m + w_f n$. In the second case, female wages are so high that employment allows the household to raise the debt ceiling only up to the LTV ceiling, which binds before the LTI limit. Finally, in Panel (c) female employment has no impact on the borrowing constraint since male earnings are very high and the LTV limit already binds.

[19]See Druedahl (2015) for an analysis of this scenario.

[20]Also known as "endowment mortgages", these require debtors to make regular interest payments while also accumulating savings in a separate endowment fund to repay the principal at maturity. This set-up gives households flexibility over the timing of debt repayment.

Figure 3: Examples of LTV and LTI constraints for a given level of housing.



4 Calibration

The majority of the parameters are calibrated externally, while the parameters concerning housing preferences, leisure, and childcare costs are chosen through an internal calibration.

4.1 Externally calibrated parameters

The period length is one year. I assume agents start working at age J_1 =25 and die at $J_D = 80$. Females start retiring with some probability at age $J_r = 50$, and mandatory retirement begins at $J_R = 65$ for both members.

Following the convention of many life cycle models, I assume that the stochastic parts of both male log earnings and female log wages are unit roots. The variances of the innovations, as well as the coefficients of the quadratic trends are estimated on BHPS data following the approach of Blundell et al. (2008), as described in Appendix A.[21] Average male earnings are normalized to 1. For males, I also assume that the probability of being unemployed in any period is 0.055, which approximates the average unemployment rate for the UK in the period

[21] Note that modeling earnings as a random walk implies that all shocks are permanent. Furthermore, while the distribution of the innovations remains constant, the overall variance of earnings increases with age.

2001-2006.[22] I set the average wage of females compared to males to 0.8. In other words, assuming a labor supply of 35 hours ($\bar{n} = 0.35$), the average wage for females is 80 percent of average male earnings.[23]

The issues of assortative matching in household formation and intra-household income correlation are potential concerns for the calibration. A way to exogenously model assortative matching is to impose correlation in the earnings of the male and the female. Several studies model households where each member is either "high-skill" or "low-skill", and account for assortative forces by choosing the probability that both members belong to the same skill group. A related issue concerns the idiosyncratic earnings shocks to the two members, which may also be due to assortative matching. Instead of explicitly modeling permanent skills, I address the issue by drawing the starting earnings of the two members from a joint distribution with positive correlation. Specifically, I set the initial correlation in earnings to 0.2, in line with the findings of Lise and Seitz (2007) for the intra-household correlation of income in the UK in 2000. As the earnings processes are unit roots, this approach creates some persistence in earnings correlation over the life cycle. Furthermore, I allow the shocks to the two processes to be correlated. I choose the correlation to be 0.25, as used by Attanasio et al. (2015), a value estimated by Hyslop (2001). Although this value is estimated on US data, it is a tenable assumption to apply it to the UK, a similar economy, on a similar time period. Additionally, this value of the correlation in the *shocks* results in a correlation in the *level* of earnings within each age group of 0.2 on average, which is consistent with the initial target.[24]

The probability of retirement for females, π_r, is set based on the retirement rates from the BHPS for ages 50 and 65. Only 1 percent of females is retired at age 50, while 72 percent are retired by age 65. Hence $\pi_r = 1 - ((1 - 0.72)/.99)^{(1/15)} = 0.082$. This approximation matches the general retirement trend from age 50 in a linear way. The replacement rate of retirement earnings is 0.5, implying that workers receive retirement income equal to half of their final-year income, for males, or of the full-time equivalent income (i.e. assuming $\bar{n} = 0.35$) for females.

[22] This assumption abstracts from the important issue of persistence in labor market status. However, it increases clarity in terms of distinguishing the effect of temporary versus permanent income risk.

[23] There is a large literature on the estimation of the gender gap, mainly attempting to correct for selection bias in observed wages. This issue is beyond the scope of the current work. The value of 0.8 is in line with estimates of the female pay gap in gross hourly earnings in the early 2000's from the UK's Annual Survey of Hours and Earnings, administered by the Office of National Statistics. The gap has been following a downward trend and is closer to 0.9 in recent years (ONS, 2016).

[24] Sensitivity analysis, however, shows that the main results of the model are not strongly dependent on the level of intra-household earnings correlation.

Following Bajari et al. (2013), I let the the interest rate depend on whether the household's assets are positive or negative, reflecting the fact that returns on deposits are usually lower than interest rates for mortgages. I set a 3 percent return on savings ($r_s = 0.03$) and a 7 percent interest rate on debt ($r_d = 0.07$). The latter is close to the historical average nominal interest rate on new mortgages in the early 2000's in the UK (FSA, 2009).

I allow for four distinct amounts of housing assets: i.e. $h \in \{0, 1, 2, 3, 4\}$, where 0 represents renting. With some abuse of notation, instead of setting a unit price for housing assets, I set increasing prices for the four house sizes $p = [p_1,\ p_2,\ p_3,\ p_4]$. This formulation, although effectively equivalent, allows for a more intuitive internal calibration, as shown below. Using the sample of couples where the secondary earner is aged 23 to 65 in the 2001 wave of the BHPS, I set the prices based on different percentiles of the distribution of house values, normalized by the mean yearly income of working males in the 2001 wave of the BHPS, which is 18,448 GBP. I set $p_1 = 3.2$ to represent the 25^{th} percentile, $p_2 = 4.34$ for the 45^{th}, $p_3 = 6.17$ for the 65^{th}, and $p_4 = 9.7$ for the 85^{th}. I assume no price growth over time. Renting for one period costs one percent of a large house ($q = 0.097$). Following Yang (2009), when buying a house, 2.5 percent of the value has to be paid in costs ($F_b = 0.025$), while when selling it there is a cost equal to 7 percent of the value ($F_s = 0.07$).

The values of the leverage-based borrowing constraints are set to replicate in a parsimonious way the main features of the UK institutional environment in the mid-2000's, in line with Bottazzi et al. (2007) and Attanasio et al. (2012). I set $\lambda_h = 0.9$, so that a minimum downpayment of 10 percent of the house price is required for a purchase. This value is close to the typical maximum LTV ratio for the UK in the early 2000's.[25] For the LTI limit there is greater variation across lending institutions, and the maximum LTI often depends on whether the loan is undersigned by only one member of the household or both. The FSA's 2004 *Guide to Mortgages* states: "Typically, the maximum mortgage a lender offers is three times the main earner's income plus one times any second earner's income, or two-and-a-half times your joint income" (FSA, 2004). I therefore set $\lambda_y = 3$. Given the model's assumption that the male is the primary earner, a household's joint LTI limit is three times the male income plus one times the female's full-time equivalent income (if she works).

I set the CRRA parameter of consumption utility $\sigma = 2$ and the discount factor $\beta = 0.95$,

[25]However, in the years preceding the 2008 recession, mortgage rules were looser and higher LTV's were frequent.

which are standard values in the literature. The parameter ψ of leisure preferences is set to obtain a Frisch elasticity of labor supply of 0.3. In this case, defining $l = 1 - n^f$, $\epsilon_n^f = \frac{U_l}{U_{ll} * n^f} = \frac{1-n^f}{\psi n^f} = 0.3$, which implies $\psi = 6.19$ for full-time hours worked $\bar{n} = 0.35$.

The time-varying component of housing preferences $\chi(j)$ is computed based on the average number of children by age of the secondary earner in the BHPS, adjusted by the OECD equivalization scale. Details are contained in Appendix A.3. Finally, I calibrate the initial distribution of financial assets for the simulations on the empirical distribution of net worth for couples in the 2000 BHPS, leaving the details to Appendix A.4.[26]

Table 1 reports all the externally calibrated parameters and their values.

Table 1: Externally calibrated parameters.

Parameter	**Value**	**Description**	**Target/Source**
Preferences			
β	0.95	discount factor	
σ	2	CRRA parameter	
ψ	6.19	leisure elasticity parameter	Frisch elasticity =.3
$\chi(j)$	see App. A.3	equivalization coefficient	average household size
Life cycle and earnings			
J_1	25	starting age	
J_r	55	starting age of early retirement	
J_R	65	age of mandatory/male retirement	
J_D	80	final age	
ρ_z	1	persistence parameter of earnings	Attanasio et al. (2012)
σ^2_ϵ	.0133	variance of income shock - males	BHPS (Appendix A)
$\sigma^2_{\epsilon^f}$	.0148	variance of income shock - females	BHPS (Appendix A)
corr(ϵ, ϵ^f)	0.25	correlation of income shocks	Hyslop (2001)
$\alpha_1,\ \alpha_2$	.0576, -0.000834	income profile coefficients - males	BHPS (Appendix A)
$\alpha^f_1,\ \alpha^f_2$	.0384, -0.000468	income profile coefficients - females	BHPS (Appendix A)
b	$0.5 * y_{J_{R-1}}$	retirement income	
ω_f	0.8	gender earnings gap	
π_u	0.055	probability of male unemployment	UK unemployment rate
y^u	0.3	unemployment insurance	
π_r	0.082	retirement probability, $j = 50, .., 65$	BHPS
Housing market			
F_b, F_s	0.025, 0.07	buying / selling transaction costs	Yang (2009)
λ_h	0.9	LTV borrowing limit	Attanasio et al. (2012)
λ_y	3	p-LTI limit	FSA (2004)
r_s	0.03	interest rate on savings	
r_b	0.07	interest rate on debt	FSA (2009)
$p_1,\ p_2,\ p_3,\ p_4$	3.2, 4.24, 6.17, 9.7	price of housing units	BHPS
q	0.097	rental cost	

4.2 Internal Calibration

The two housing preference parameters ϕ_h and μ_h are internally calibrated to match the empirical average homeownership rate of 82 percent for households between the ages of 25 and

[26] The BHPS only provides information on savings and unsecured debt every five years. I use the 2000 wave as it is the closest to the beginning of the sample.

50 and to obtain an average value of housing assets of 5.4 in the same age range.

Using a standard approach, as done in Borella et al. (forthcoming), I assume that female labor supply costs follow a quadratic function in age:

$$\xi(j) = \xi_1 j + \xi_2 j^2.$$

The parameters ξ_1 and ξ_2 are then calibrated to match the employment rate of females in the age groups 25-29, 30-34, 35-39, 40-44, 45-49. The resulting function, displayed in Figure C.1, has a hump-shaped path with a negative slope after age 30. The linear coefficient of the leisure preferences θ^f is calibrated to match an average of 35 hours worked for employed females (i.e. $n^f = 0.35$), equivalent to standard full-time contracts in the UK.

I focus the internal calibration on aggregate moments up to age 50 because I do not aim to explain dynamics specific to retirement decisions. Furthermore, I explicitly calibrate moments that are not related to housing debt levels and leverage. Table 2 reports the internally calibrated parameters. Table C.1 reports the targeted moments and the corresponding values obtained from 10,000 simulations of the exogenous earnings processes and an equal number of draws from the distribution of initial wealth.

Table 2: Internally calibrated parameters.

Parameter	**Value**	**Description**
μ_H	.25	Housing preference constant
ϕ_H	.35	Housing size preference
ξ_1	0.026	Labor cost, linear coefficient
ξ_2	0.00045	Labor cost, quadratic coefficient
θ^f	0.17	Linear coefficient for leisure

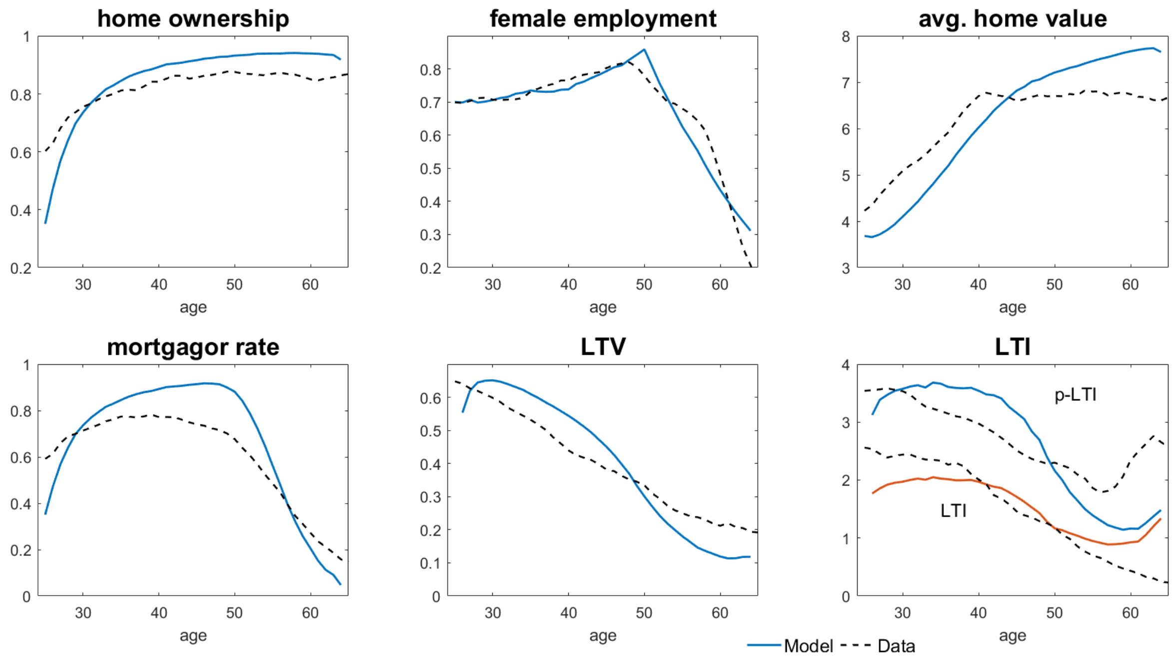
5 Results

This section presents the baseline results of the model. After showing how the simulations match the aggregate profiles from the BHPS, I examine the cross-sectional relationship between leverage and employment.

5.1 Aggregate life cycle profiles

The upper plots of Figure 4 report the average profiles for homeownership, female employment, and house value from the 10,000 simulations. Overall, the model captures the main life cycle dynamics of the BHPS. The homeownership profile starts lower in the model than in the data and eventually overshoots, leading to an overall steeper profile but matching the shape of the path well. Female employment peaks at 50 in the model, when the retirement transitions start, while in the data it peaks slightly earlier. The quantity of housing has a very similar upward trend, although it levels off in the data.

Figure 4: Average simulated life cycle profiles for homeownership rate, home size, female employment, net worth, LTV, LTI, and p-LTI.



Note: The solid lines represent the average values from the simulated model. The dashed lines represent the moving average of the empirical life cycle profiles from the BHPS. For the LTI panel the upper blue solid line reports the p-LTI, i.e. the LTI computed only using the male's earnings, which is compared against the empirical LTI computed using earnings from the primary earner and other income sources. The lower red line represents the LTI computed with the entire household income, which is compared against its corresponding series from the BHPS. The simulated profiles are computed as averages from 10,000 simulations of individual income processes and draws from the calibrated initial distribution of net worth.

The lower plots of Figure 4 focus on households' leverage, which are not targeted by the internal calibration. The percentage of mortgagors follows a similar path to the empirical one from the BHPS, although its peak occurs later than in the data and exceeds it in value. The average LTV tracks the empirical series closely. The p-LTI (the higher series in the last subplot) overall tracks the empirical counterpart well, initially exceeding it but later falling below it in value. The household's joint LTI (the lower red series) starts slightly below the empirical one but, because of its flatter slope, eventually overshoots. Overall, the life cycle paths and the average levels of the ratios are well captured by the model.

5.2 Female employment and leverage ratios

To elaborate on the cross-sectional relationship between leverage and labor, Table 3 provides household summary statistics divided by levels of leverage and across 10-year age groups, focusing on mortgagors. The upper panel divides households into those in the bottom 80 and the top 20 percent of the LTV distribution for each age group, while the lower panel similarly divides households based on the p-LTI.

The high-LTV households have a lower employment rate than the low-LTV group at all ages, with the difference being particularly large for young and mid-life ones. Those in the high-LTV group also have higher average male earnings and lower female wages. Given the unit-root nature of earnings, high (low) current earnings imply high (low) expected future earnings. The interaction of the leverage constraints with the workers' earnings is central to the results. For a given level of housing, accessing debt up to the LTV limit is only possible if the LTI limit does not bind first. Hence, households with high primary earnings are able to access higher LTV's without the need for female labor. Furthermore, within this group, those with low potential female wages are those who choose to avoid costly female labor in exchange for debt. The high-LTV group therefore includes those who have a high motive to substitute away from female labor and a high capacity to borrow at early ages thanks to high expected primary earnings.

As the lower panel of Table 3 shows, households in the top 20 percent of the p-LTI distribution have a higher employment rate than those with a low p-LTI. On average, they also have higher female wages and much lower male earnings. The difference in earnings across the two groups reflects the two main mechanisms driving high levels of p-LTI. First, households with low male income can use female labor income to relax the LTI constraint and access more debt. Second, by construction, a fall in male income leads to a rise in the p-LTI. As reported in the fourth and fifth rows of the lower panel, negative income shocks to the primary earner underlie high levels of the p-LTI: households in the top 20 percent have a negative average income growth and high unemployment. Female labor supply thus acts as a means of insurance against the adverse shocks to primary earnings that lead to high p-LTI's.

To render the relationship graphically, Figure 5 displays a surface plot of the employment rate over the LTV and p-LTI ratios from the simulations using the same 10-year age groups. The plots clearly show that the negative relationship of employment with the LTV and its positive one with the p-LTI hold over the life cycle. More interestingly, the nonlinear relationship

Table 3: Summary statistics by LTV and p-LTI levels across 10-year age groups.

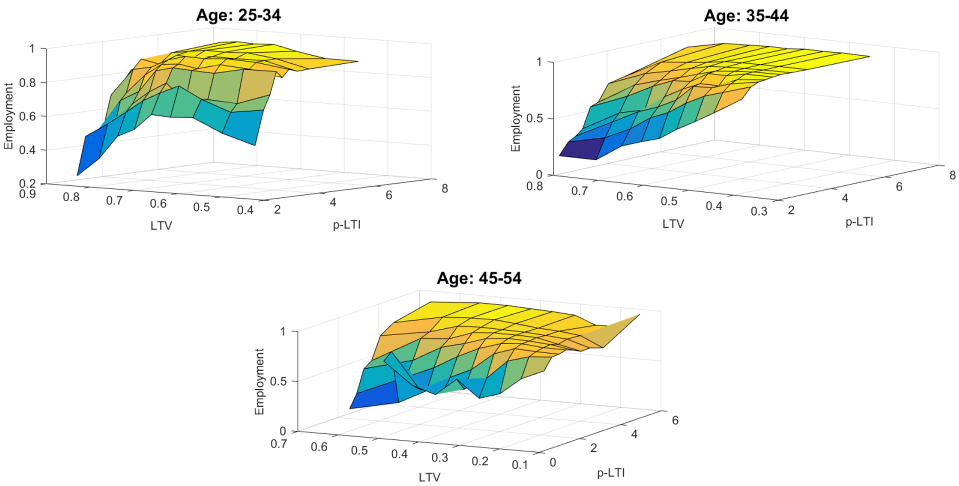
	LTV					
	Age 25-34		**Age 35-44**		**Age 45-54**	
	Bottom 80%	**Top 20%**	**Bottom 80%**	**Top 20%**	**Bottom 80%**	**Top 20%**
Employment	0.82	0.62	0.85	0.56	0.79	0.74
Avg. w^f	0.73	0.56	0.92	0.52	1.02	0.58
Avg. y^m	0.78	0.86	1.06	0.98	1.20	1.13
Avg. $\%\Delta y^m$	0.04	0.02	0.03	0.01	0.03	0.00
% Male Unemployed	0.06	0.05	0.05	0.06	0.05	0.06
	p-LTI					
	Age 25-34		**Age 35-44**		**Age 45-54**	
	Bottom 80%	**Top 20%**	**Bottom 80%**	**Top 20%**	**Bottom 80%**	**Top 20%**
Employment	0.74	0.92	0.75	0.93	0.75	0.90
Avg. w^f	0.68	0.74	0.83	0.90	0.92	0.96
Avg. y^m	0.87	0.50	1.17	0.54	1.33	0.63
Avg. $\%\ \Delta y^m$	0.09	-0.17	0.08	-0.18	0.06	-0.14
% Male Unemployed	0.00	0.26	0.00	0.27	0.02	0.21

Note. All results are produced using the same set of 10,000 simulations of individual income processes and draws from the calibrated initial distribution of net worth.

between the three variables emerges from the plots. For instance, the negative relationship between employment and LTV is steeper at lower levels of the p-LTI while it is almost absent for high p-LTI's. Similarly, the upward slope of the relationship with the p-LTI is steeper for high LTV values. This result is consistent with the intuition explained above. For example, a household with a high LTV and a low p-LTI has a greater ability to substitute future consumption for current leisure than one with a high LTV and a high p-LTI.[27] In the appendix, Figure C.4 shows how the relationship with the LTV ratio holds across different levels of housing, and is hence not driven by net wealth. For a given level of wealth, the owner of a small house has a lower LTV compared to the owner of a larger one. In the regions of the net wealth axis where smaller and larger owners overlap, the latter have a lower employment rate. Therefore, the negative correlation between LTV and employment holds at all levels of housing, implying that leverage is the main driver of employment decisions rather than net wealth.

[27]Figures C.2 and C.3 in the appendix show this more clearly by plotting the employment rate over the distribution of the LTV (p-LTI) among households with a p-LTI (LTV) above the median value for the respective age group.

Figure 5: Surface plots of employment, LTV, and p-LTI across 10-year age groups.



Note. All results are produced using the same set of 10,000 simulations of individual income processes and draws from the calibrated initial distribution of net worth.

6 The effect of changes in the constraints

In this section, I discuss the propagation of leverage limits from the housing market to labor supply choices. I consider how changes in the LTV and LTI constraints may exert different effects on homeownership and labor supply over the life cycle. Not only do the two constraints interact differently with households' decisions, but also households who are close to either constraint differ with respect to their earnings composition and will therefore have distinct responses. To answer this question, I solve the model under alternative values for the leverage limits and compare the resulting life cycle profiles to the baseline.

6.1 Changes in the LTI constraint

I consider the case where the weight of female earnings within the LTI constraint is tightened (relaxed) enough to produce a fall (rise) in the homeownership rate of 10 percentage points for households at age 25 (i.e. the youngest age). Specifically, I allow the debt limit to be equal to λ_y times the male's income plus λ_y^f times the female's full time earnings (if she works). In other words:

$$\text{LTI limit} = \lambda_y y_j + \lambda_y^f w_j^f \bar{n} \mathbb{I}\{n_j^f > 0\},$$

where $\lambda_y^f < 1$ in case of a tightening and $\lambda_y^f > 1$ for a loosening compared with the baseline calibration. The two values leading to 10 percentage-point falls and rises in homeownership in the first age group are 0.18 and 1.55, respectively.

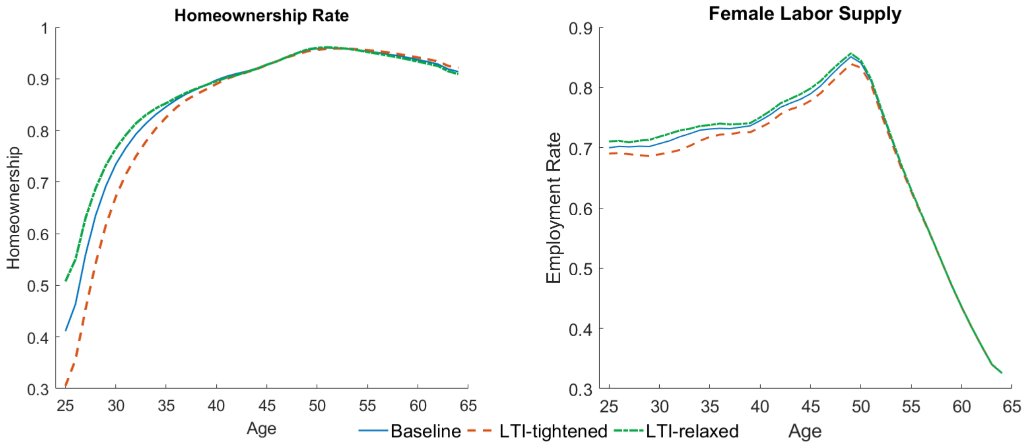
A change in the limit alters credit availability in two ways. First, holding female labor supply constant, it lowers (raises) the LTI-based debt limit for households where the female is employed. Second, it may alter the labor supply decisions of some households. For instance, a LTI loosening induces some females who previously were not employed to work in order to obtain credit and purchase a house. Similarly, a lower λ_y^f decreases the returns to work for some females and induces a decrease in labor supply at the extensive margin.

The left panel of Figure 6 shows the alternative life cycle profiles of homeowenrship. In both cases, the difference with the baseline profile at age 25 is 10 percentage points. However, the gaps closes up between ages 35 and 40, implying that the leverage limit has a strong impact on young households but not on middle-aged and old ones. The right panel shows the profiles of labor supply. Female employment rises slightly in the case of the relaxed limit and falls under the tightened scenario. Both changes in the initial age are between 1 and 2 percentage points. However, the difference also persist farther into the life cycle than for homewonership. The persistence is due to the implications of the leverage limit for mortgagors' debt level: e.g. higher ability to access credit at younger ages implies a larger debt level for older households and in turn a higher labor supply.

To focus on the marginal households affected by the change, I divide the simulations into three groups based on the tenure status at age 25. The first group includes those who own a house in both the baseline and the counterfactual-LTI model, the second group is formed by those who change their tenure status at age 25. For the LTI loosening case, these are households who become owners (i.e. "new owners"), while they become renters in the case of a LTI tightening (i.e. "new renters"). The third group includes those who are renters in both cases.

Table 4 reports summary statistics by tenure group. The "new renters" and the "new owners" groups, within each respective exercise, are indicative of the interaction between the extensive margin of labor supply and the LTI limit. Both groups are characterized by high female wages, male earnings close to average, and low initial assets, indicating the need to borrow to purchase a house, and with a high potential to do so through female earnings. In fact, in both cases, these "marginal" groups account for the main change in aggregate employment. For the tightening, the employment rate of new renters falls by almost 14 percentage points. Meanwhile,

Figure 6: Homeownership and female employment in the baseline model and in the model with the tightened/relaxed LTI constraint.



Note. All results are produced using the same set of 10,000 simulations of individual income processes and draws from the calibrated initial distribution of net worth and the policy functions for the baseline model and the alternative calibrations.

under the looser LTI limit, the employment rate of the new owners rises by 17 percentage points.

Table 4: Summary statistics for the three tenure groups with respect to the baseline model and the model with tightened/relaxed LTI model.

LTI Tightening

	% of HH's	Δ Empl. (p.p.)	Avg. w_j^f	Avg. y_j	p-LTI in baseline case	LTV in baseline case	Assets
Homeownwers in both cases	0.26	0.66	0.55	0.62	2.81	0.47	1.97
New Renters	0.10	-13.79	0.62	0.66	3.96	0.79	0.34
Renters in both cases	0.65	-0.05	0.50	0.52	0.00	0.00	0.13
Aggregate	1.00	-1.17	0.52	0.56	3.12	0.55	0.62

LTI Loosening

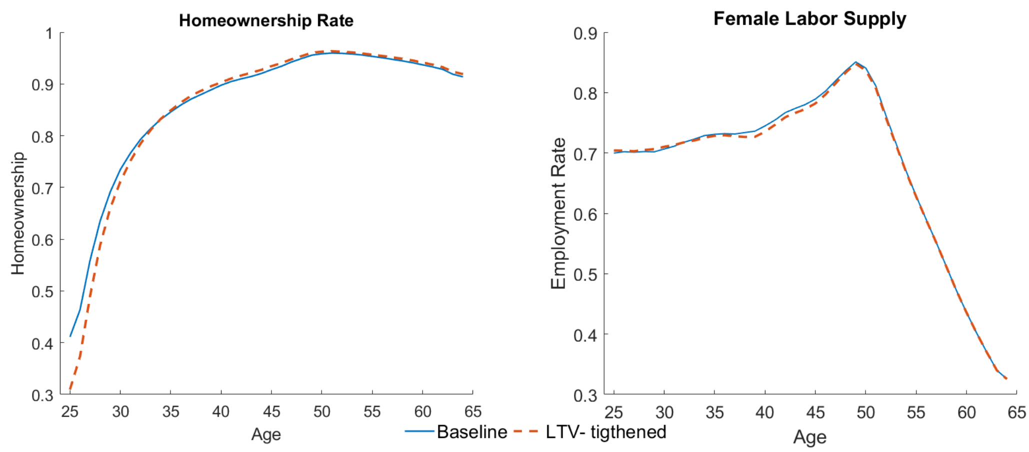
	% of HH's	Δ Empl. (p.p.)	Avg. w_j^f	Avg. y_j	p-LTI in reform case	LTV in reform case	Assets
Homeownwers in both cases	0.35	-0.26	0.57	0.63	3.35	0.57	1.53
New Owners	0.10	17.34	0.60	0.62	4.67	0.85	0.19
Renters in both cases	0.55	-0.02	0.48	0.50	0.00	0.00	0.12
Aggregate	1.00	1.67	0.52	0.56	3.65	0.63	0.62

Note. All results are produced using the same set of 10,000 simulations of individual income processes and draws from the calibrated initial distribution of net worth and the policy functions for the baseline model and the alternative calibrations. The employment change is reported in percentage points.

6.2 Tightening the LTV constraint

The second counterfactual exercise considers the effect of changes in the LTV limit on homeownership and labor supply. For brevity, I focus on the case of a tightening of the LTV constraint only. I choose an alternative value of λ_h equal to 0.675, which yields a fall of 10

Figure 7: Homeownership and female employment in the baseline model and in the model with the tightened LTV constraint.



Note. All results are produced using the same set of 10,000 simulations of individual income processes and draws from the calibrated initial distribution of net worth and the policy functions for the baseline model and the tightened-LTV model.

percentage points in the homeownership rate of households at age 25.[28]

The left panel of Figure 7 shows that the tightening of the LTV limit lowers homeownership in the early part of the life cycle. Compared with the LTI tightening, however, the gap is less persistent and closes up before age 35. The right panel shows that the lower LTV ceiling does not have an effect on the aggregate female labor supply.

As above, I divide the households into three groups based on housing tenure at age 25: owners in both periods, "new renters", and renters in both periods. The middle group accounts for the fall in homeownership. Table 5 shows that the "new renters" are characterized by high female wages, highly above-average male earnings, and low initial wealth. They thus comprise those households with a strong motive to borrow against future income (both male and female) in order to access housing at young ages. Intuitively, because they have very high earnings, the LTV limit is the relevant borrowing constraint for this group. The ability to borrow is impaired by the more restrictive LTV limit, which cannot be affected by females moving into employment. In fact, in the baseline case, their average LTV is 0.85, which is above the new limit.

Interestingly, in the low-LTV scenario, labor supply for the "new renters" falls by 4.8 percentage points while it rises by roughly 1 percentage point or less for the other two groups. Some of the "new renters" switch out of employment because labor supply is no longer needed

[28]The magnitude of the tightenting in the LTV limit, 0.225, is large but realistically relevant. For instance, the UK government's 2013 Help-to-Buy scheme provides interest-free mortgages on 20 percent of the house price.

to access credit. However, the larger downpayment needed for homebuying also induces greater savings motives for the other two groups. The constant aggregate rate therefore masks changes within the tenure groups.

Table 5: Summary statistics for the three tenure groups with respect to the baseline model and the tightened-LTV model.

	% of HH's	**Δ Empl. (p.p.)**	**Avg. w_j^f**	**Avg. y_j**	**p-LTI in baseline case**	**LTV in baseline case**	**Assets**
Homeownwers in both cases	0.25	0.85	0.55	0.58	2.82	0.43	2.12
New Renters	0.10	-4.77	0.63	0.75	3.84	0.85	0.11
Renters in both cases	0.65	1.45	0.50	0.52	0.00	0.00	0.13
Aggregate	1.00	0.68	0.52	0.56	3.12	0.55	0.62

Note. All results are produced using the same set of 10,000 simulations of individual income processes and draws from the calibrated initial distribution of net worth and the policy functions for the baseline model and the tightened-LTV model. The employment change is reported in percentage points.

6.3 Does labor supply amplify or mitigate homeownership changes?

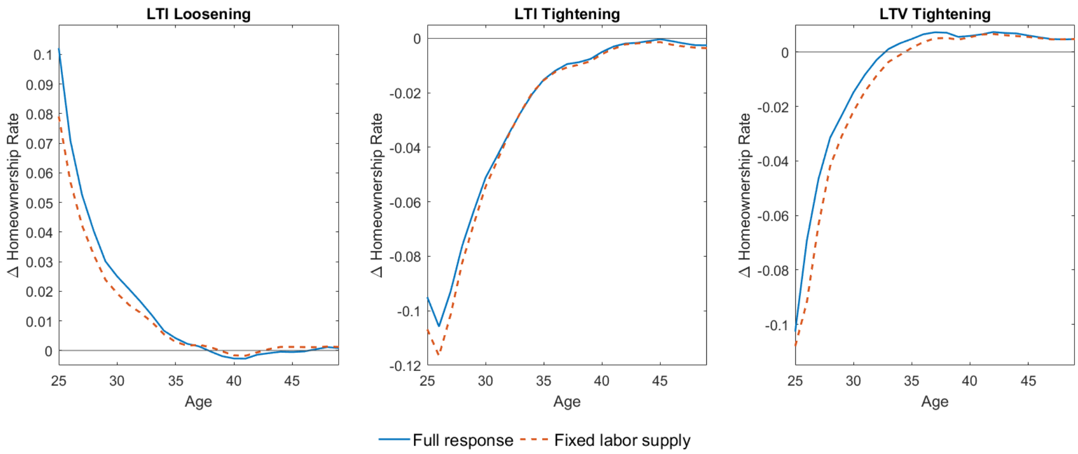
An important question is whether labor supply adjustments to changes in leverage limits are quantitatively important for homeownership. To answer this question, I compute a counterfactual in which households' decisions on housing, consumption, and savings are solved under the alternative values of the leverage limits while the labor supply policy function is held fixed to that of the baseline calibration. This counterfactual exercise reflects the degree to which households can adjust to different leverage limits without altering their labor supply decisions with respect to their other state variables.[29]

For each of the exercises above, Figure 8 plots the change in the homeownership rate compared to the baseline model for both the the full counterfactual calibration (solid blue line) and the counterfactual with fixed labor (dashed red line). The difference between the two lines is between 1 and 2 percentage points at age 25 and it narrows down between ages 30 to 40. In the case of the LTI loosening, the dashed line lies below the blue one, implying that the ability to adjust labor supply amplifies the positive effect of the relaxed leverage limit. In both cases of credit tightening, the initial fall in home ownership with fixed labor supply is larger, implying that labor supply adjustments can moderately mitigate the negative effect of stricter leverage limits. For a fall (rise) of 10 percentage points, a 1 percentage point difference thus implies a

[29]This implies that in the simulated results labor supply can still deviate from the baseline to the extent that households' other decisions change.

mitigation (amplification) of 10 percent.

Figure 8: Change in homeownership rate compared to the baseline in the relaxed-LTI case with changes in labor supply and with fixed labor choices.



Note. All results are produced using the same set of 10,000 simulations of individual income processes and draws from the calibrated initial distribution of net worth and the policy functions for the baseline model and the alternative model. The solid blue line reports the difference in homeownership for the full model while the red dashed line reports the difference for the model with the fixed labor policy function.

7 Response to income shocks

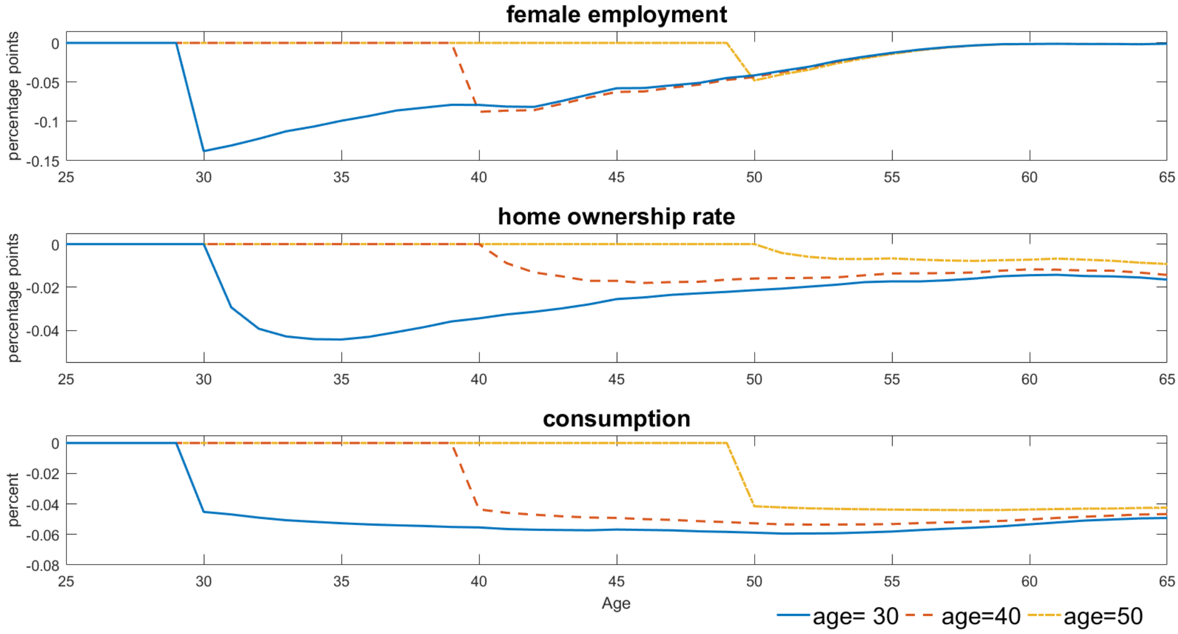
The model can be used to understand how leverage affects the response of female labor supply to unexpected permanent income shocks to female wages and male earnings. Because the shocks change the permanent component of earnings, they alter households' choices not just at the age in which they occur but also in the following years. I thus solve counterfactual models in which either all female or male earnings suffer a one-standard deviation drop at given ages and compare the ensuing average life cycle profiles to the baseline simulation.

Figures 9 and 10 plot the responses of female labor supply, homeownership, and consumption at ages 30, 40, and 50 to unexpected one-standard deviation permanent falls in female and male earnings, respectively. Both shocks cause a permanent fall in consumption as well as a persistent fall in homeownership. While the percentage fall in consumption is similar in the three ages considered, the fall in homeownership is larger at younger ages.[30]

Labor supply responds negatively to the fall in female wages. For young households, the initial response is very large but progressively winds down over the years. The magnitude of

[30] As homeownership rate for young households is lower than for older ones, the main margin for the fall in the aggregate rate is the postponing of home purchases rather than an increase in home sales.

Figure 9: Response to an unexpected permanent fall in female wages at different ages.



Note. Each plot reports the response of the respective variable in percentage points or percent to an unexpected one-standard deviation permanent fall in female wages occurring at ages 30, 40, and 50. All plots are produced with the same set of 10,000 individual simulations.

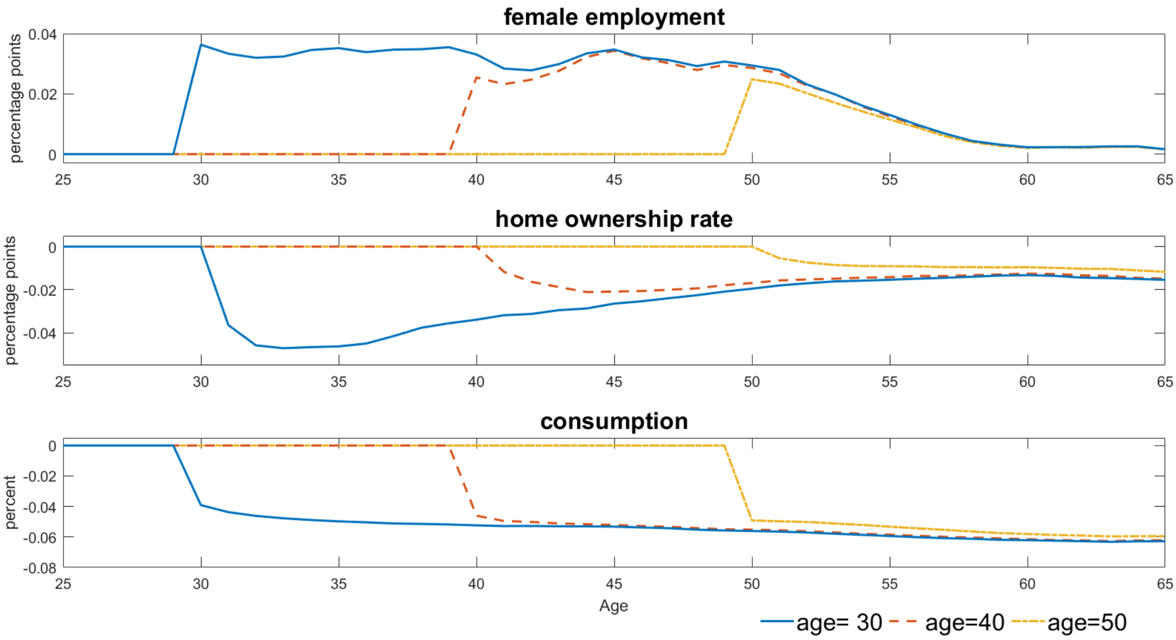
the initial fall decreases with age. As labor supply costs fall with age while wages rise, the drop in earnings becomes a less determining factor for the extensive labor margin.

The fall in male income triggers a persistent added worker effect between 2 and 4 percentage points. The initial jump in employment does not vary strongly with the age at which the shock occurs. Furthermore, the rise in employment starts to wind down only after age 50, when females begin to retire. Despite its presence throughout the work years, the average added worker effect is of modest magnitude compared to the response to a fall in female wages.

7.1 Decomposing the aggregate response

How much heterogeneity do the average responses in labor supply mask? To answer this question, I break down the average response to the income shock along a chosen dimension of leverage for all ages from 30 to 55. I focus on the difference between high-LTV and low-LTV homeowners, choosing as the threshold the value of 0.65, which is close to the 80^{th} percentile of the LTV distribution in the simulations. A similar analysis by high and low p-LTI is left to Appendix D. It must be noted that the composition of these groups and their size change with age: highly leveraged households at age 30 are not the same who are leveraged at 55.

Figure 10: Response to an unexpected permanent fall in male earnings at different ages.



Note. Each plot reports the response of the respective variable in percentage points or percent to an unexpected one-standard deviation permanent fall in male earnings occurring at ages 30, 40, and 50. All plots are produced with the same set of 10,000 individual simulations.

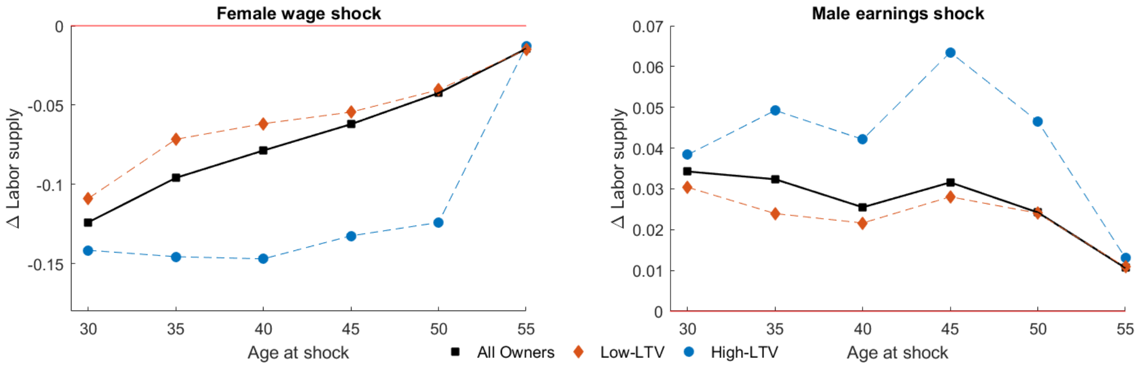
Figure 11 provides a visual representation of how the immediate response of labor supply to an earnings fall differs across groups and across ages. Each point represents the contemporaneous fall of the employment rate in percentage points for a given age group belonging to households with a high or low LTV, as well as for all homeowners.[31]

The left panel decomposes the immediate employment change after a fall in female wages. The immediate fall in labor supply is larger for high-LTV households. Additionally, the response of low-LTV households has a more pronounced life cycle profile. The fall for low-LTV households is 10.5 percentage points at age 30 and only 4.5 at 50. Meanwhile, the corresponding values for high-LTV owners are 14 and 13. It is only after retirement transitions begin that the response of the two groups is comparable. Because the proportion of high-LTV households falls with age (see Figure C.5 in the Appendix), the aggregate response of all homeowners in later stages of the life cycle is progressively closer to that of low-LTV ones.

The result that high-LTV females are the most responsive to wage shocks stems from the intuition outlined above. This group includes households with high male income and low female earnings, and hence with a large propensity to exchange current leisure with future commitments

[31] As similar picture with the breakdown by p-LTI is provided by Figure D.1.

Figure 11: Contemporaneous labor supply response to female and male earnings shocks for low-LTV and high-LTV homeowners across age groups.



Note. Each point reports the response of the extensive margin of female labor supply in percentage points (i.e. the employment rate) to an unexpected one-standard deviation permanent fall in female wages or male earnings occurring at a given age. Households are divided into low-LTV (LTV<0.65), and high-LTV homeowners LTV ($\geq$0.65). The black squares report the response for all homeowners. All plots are produced with the same set of 10,000 individual simulations.

to repay debt.

The right panel reports the case of a shock to male earnings. High-LTV households have a more elastic extensive margin: the added worker effect (in the first period) is always larger for this group than for low-LTV households. This result is also consistent with the previously discussed mechanisms. High-LTV households are those who rely the most on male earnings to avoid costly female work. The fall in male income impairs this channel by lowering lifetime earnings and the ability to amortize outstanding debt. The shock also entails an immediate increase of the p-LTI, which pushes more households above the LTI ceiling and leads more females to work to relax the borrowing constraint. Figure C.6 in the Appendix shows the increase in the percentage of households with a high p-LTI (i.e. greater than 3.5) after the fall in male income. Among the high-LTV group there is a greater rise in the fraction of households who are also facing a high p-LTI, providing a further channel for their larger response.

7.2 Adding house price shocks

So far, the analysis has maintained house prices constant, implying that households do not face exogenous wealth volatility or unexpected changes in their ability to use housing assets as collateral. This is a tenable assumption for normal times, when aggregate prices exhibit only small fluctuations. However, the occurrence of often-unexpected large price falls, like that of 2008-2009, calls for an assessment of the interaction between price drops and recessionary periods.

Using the same framework as above, in this section I consider the effect of a large and persistent price fall on the responses to earning shocks. In particular, my interest lies in whether the price shock affects the female labor supply dynamics ensuing from income drops.

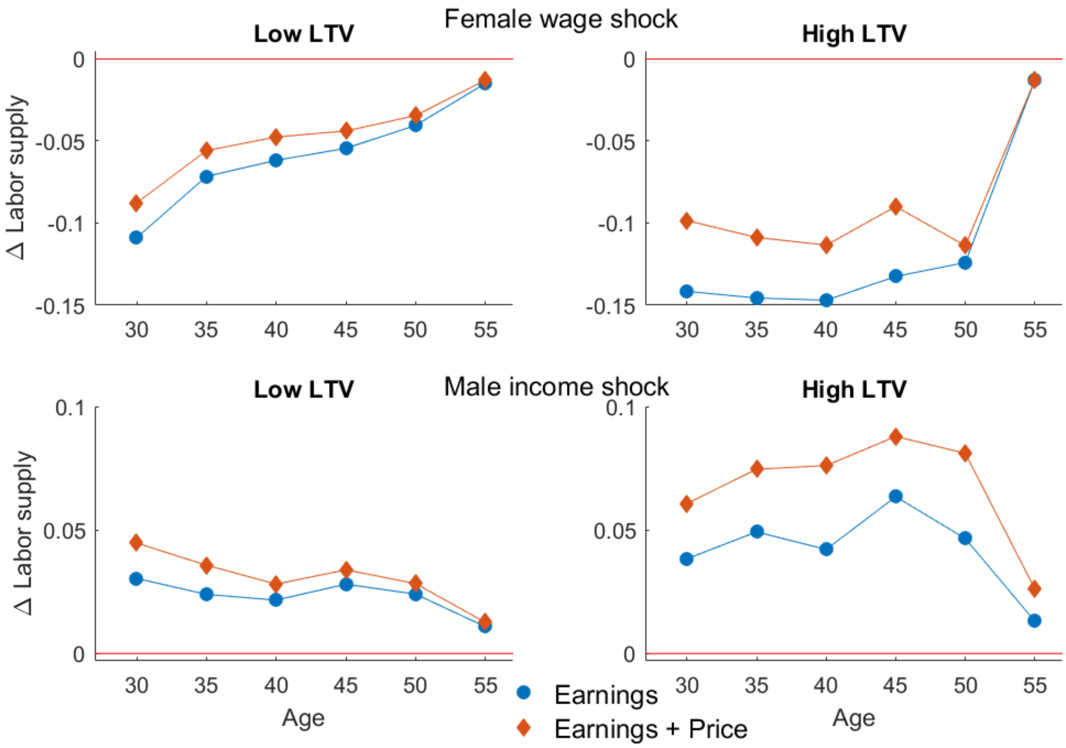
A change in house prices has several effects on households depending on their financial position. For renters, it makes housing cheaper to purchase (assuming no changes in the ability to access debt). For current homeowners, it has a wealth effect that realizes only in the case of a sale. Hence, the fall in wealth only affects those who plan to downscale or upscale their housing assets. The latter group, however, also benefits from the fall in the cost of the future housing they plan to purchase. Finally, the fall in house prices implies a tightening of the LTV limit, diminishing the borrowing ability of households with already high leverage. Given the results of the previous section, the effect of this case on labor supply is worthy of discussion.

To investigate this issue, I simulate an additional counterfactual case in which the earning shocks are combined with a persistent change in house prices. The simulated price fall is 10 percent, a large value which is approximative of the fall in the real UK House Price Index (UKHPI) in the Great Recession. The ensuing path is computed using an AR(1) autoregressive process with a coefficient of 0.94, as calculated by Attanasio et al. (2012) from the detrended deflated UKHPI series. Because in the baseline model prices are taken as deterministic and constant, the shock is modelled as an unexpected fall in prices at a given age. After the change, the path of prices back to the original level is taken as deterministic by the households.

The top panels of Figure 12 report the first-period (i.e. immediate) response of the female employment rate to the wage shock broken down by the LTV position for each age group. The circle points represent the case in which prices do not change and are equal to the plots from Figure 11. The diamond points represent the case in which house prices fall. The response of employment for low-LTV households is almost unchanged at all ages between the two scenarios, with only a minor attenuation. For high-LTV households, however, the difference is substantial. The fall in employment for this group is attenuated by 2 to 3 percentage points at most ages. This result implies that high-LTV households are more strongly affected by the change in house prices. While both groups receive a negative wealth shock, the sudden tightening of the LTV limit only affects the highly leveraged ones.

The same reasoning underpins the results for the case of a shock to male earnings, shown in the bottom panels of Figure 12. The addition of the price drop only modestly amplifies the

Figure 12: Contemporaneous response of female labor supply to earnings shocks with and without the addition of a fall in house prices, across high- and low-LTV groups and ages.



Note. Each circle point reports the response of the extensive margin of female labor supply in percentage points (i.e. the employment rate) to an unexpected one-standard deviation permanent fall in female wages (top row) or male earnings (bottom row) occurring at a given age. The diamond points report the case in which the shock is combined with a persistent fall in house prices of 10 percent, as described in Section 7.2. The left plots consider homeowners with a LTV ratio below 0.65, and the right ones consider households whose LTV is equal or greater than 0.65. All plots are produced with the same set of 10,000 individual simulations.

response of low-LTV households but greatly amplifies the increase in employment for high-LTV females throughout the female's active years.

8 Empirical Analysis

In this sectionm I assess whether stylized facts from the data are consistent with the model's main predictions on the relationship between household leverage and labor supply of secondary earners.

I exploit the panel dimension of the BHPS and use a linear probability model to analyze in reduced form the relationship between the secondary earner's labor decision and the household's financial position, controlling for other variables and age trends. To isolate the role of secondary labor, I focus on the primary earner's LTI (i.e. the p-LTI) rather then the combined income LTI. Following the approach of Del Río and Young (2008), I create a set of dummy variables to classify the household's leverage position as either not having any debt or as belonging to a given quintile from the distribution of the LTV and p-LTI ratios, respectively.[32]

Similar to Disney and Gathergood (2013), I run a linear probability model where a dummy for the secondary worker's employment is regressed on the set of LTV and p-LTI quintile dummies, individual, year, and region fixed effects, and a set of controls: a quadratic in age, number of kids, educational level of both the secondary earner and the head, a dummy for being a renter, and the log of primary household income.[33] The linear equation for household i at time t has the following form:

$$Emp_{it} = \alpha + \beta' X_{it} + \sum_{j=1}^{5} \gamma_j \; q_{ijt}^{LTV} + \sum_{j=1}^{5} \delta_j \; q_{ijt}^{p-LTI} + \eta_i + \zeta_t + \epsilon_{it},$$

where Emp_{it} is a dummy variable for being employed, X_{it} is a vector of household controls, q_{ijt}^{LTV} and q_{ijt}^{p-LTI} are dummies for the LTV and p-LTI quintiles, η_i and ζ_t are household and wave fixed effects, and ϵ_{it} is an error term. The coefficients $\{\gamma_j\}_{j=1}^{5}$ and $\{\delta_j\}_{j=1}^{5}$ can be interpreted as the difference in the employment rate of workers in the j^{th} quintile of LTV and p-LTI, respectively, compared to outright homeowners. Furthermore, because in a given period the amount of outstanding mortgage is an endogenous decision, I use the lag of the mortgage value to compute the LTV and p-LTI dummies. The use of lags can be interpreted as beginning-of-period state variables before decisions on consumption and labor are made. The timing is thus consistent with the fact that all information on income and labor status relates to the period between two waves of the survey.[34] I estimate the regression using the same waves as Secton 2, which include the years 2001-2006.[35]

The first column of Table 6 shows the estimated coefficients of the baseline specification. The coefficients on the dummy variables for the LTV quintiles are moderately declining in value from the first to the last. The coefficient for the fourth quintile is statistically significant at the 10 percent level and the last quntile, with a value of -0.077, is significant at the 5 percent level. Meanwhile, the dummies for the p-LTI are positive and increase monotonically from the first to the last quintile, achieving statistical significance from the second quintile onwards.

[32] Employing a set of dummies over the distribution is useful to allow for the effect of the two debt ratios to be nonlinear without imposing any functional form.

[33] Primary household income includes income from primary labor and all other non-labor earnings.

[34] Unfortunately, the BHPS provides information on non-mortgage debt and on financial savings only for the years 2000 and 2005. Using the 2000 wave of the survey shows that non-housing debt is infrequent and does not constitute a large part of total liabilities. Financial savings, however, do constitute an important part of households' portfolio and, if available, it would be important to control for them.

[35] Since I am using the lag of the outstanding mortgage in the right-hand side, the 2001 wave is excluded.

Everything else constant, a secondary worker in a household where the main earner's LTI is in the top quintile is almost 10 percent more likely to be employed than in a household with no outstanding mortgage. Figure 13 plots the coefficients from Column (1) to provide graphic evidence for the different relations of the LTV and the p-LTI with the probability of secondary earners being employed.

The following columns of Table 6 assess the sensitivity of the results to the inclusion of further controls and restrictions on the sample. Column (2) uses a more parsimonious set of controls, which excludes education dummies and region fixed effects, as both have very low variation over time within households. Column (3) controls for average house prices at the local authority level. Columns (4) and (5) focus on households in which the primary earner is in the labor force and is not in long-term unemployment (LTU), defined as a year or more without a job. Columns (6) and (7) restrict the sample to females and married couples, respectively. The main result on the LTV and p-LTI coefficients holds through all these specifications.

I also check the sensitivity of the results to different selection criteria for the secondary earner. First, the definition of primary earner may depend on exogenous circumstances, such as permanent job loss or adverse health conditions. Therefore, I consider an alternative sample in which the primary worker is identified based on the household head in 2001 and hence at the beginning of the time period used for the regression. Second, since females account for 90 percent of the secondary earner group, I estimate the regression on the sample of all females regardless of whether they are classified as head or not.[36] Tables E.1 and E.2, show that the results are robust to the first change in sample. In the female-only sample the LTV dummies, despite showing a downward trend, do not achieve statistical significance. Finally, the results hold in an extended time period by using the years 1998-2008 of the BHPS (Table E.3).[37]

A second prediction of the model is that high levels of p-LTI are caused by falls in primary earnings, either temporary or permanent. I take a fully nonparametric approach to check this prediction in the data. Figure 14 shows the kernel density distribution of year-on-year percentage changes in household income excluding secondary labor earnings. The left panel focuses on the LTV ratio. The dashed red line represents the nonparametric distribution of income growth for households with a LTV in the bottom 80 percent of the distribution. The

[36] Note that these samples differ in terms of how the age restrictions are satisfied and the latter subsample excludes couples formed after 2001. Hence the sample size differs compared to the baseline specification.

[37] Although not reported in this paper, the results are also robust to using labor force participation, rather than employment, as the dependent variable.

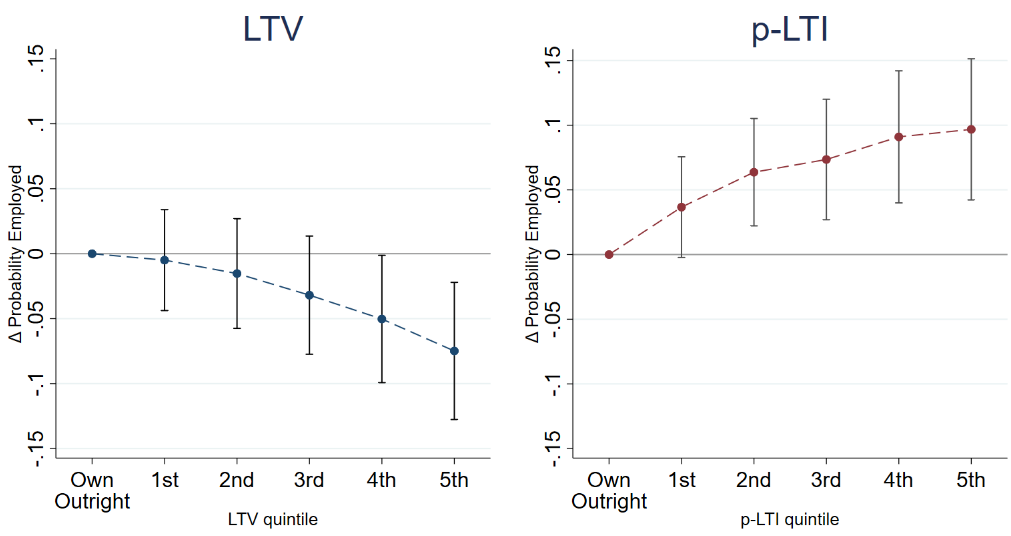
Table 6: Regression of employment of secondary earner on quintiles of LTV and primary earner's LTI, controlling for household characteristics.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
LTV							
LTV < 20th pctile	-0.008	-0.006	-0.012	0.003	0.004	-0.009	-0.026
	(0.024)	(0.024)	(0.024)	(0.027)	(0.027)	(0.024)	(0.024)
20th < LTV < 40th pctile	-0.018	-0.015	-0.023	-0.015	-0.015	-0.020	-0.023
	(0.026)	(0.026)	(0.026)	(0.029)	(0.029)	(0.026)	(0.027)
40th < LTV < 60th pctile	-0.035	-0.032	-0.034	-0.029	-0.028	-0.034	-0.037
	(0.028)	(0.028)	(0.029)	(0.031)	(0.031)	(0.028)	(0.029)
60th < LTV < 80th pctile	-0.053*	-0.049	-0.051	-0.048	-0.047	-0.056*	-0.060*
	(0.030)	(0.030)	(0.031)	(0.034)	(0.034)	(0.030)	(0.032)
80th < LTV	-0.077**	-0.073**	-0.071**	-0.070**	-0.070*	-0.080**	-0.079**
	(0.032)	(0.032)	(0.033)	(0.036)	(0.036)	(0.033)	(0.035)
p-LTI							
p-LTI < 20th pctile	0.038	0.040*	0.039	0.030	0.031	0.037	0.033
	(0.024)	(0.024)	(0.024)	(0.026)	(0.027)	(0.024)	(0.024)
20th < p-LTI < 40th pctile	0.065**	0.066**	0.066**	0.058**	0.059**	0.067**	0.049*
	(0.025)	(0.026)	(0.026)	(0.029)	(0.029)	(0.026)	(0.026)
40th < p-LTI < 60th pctile	0.076**	0.075**	0.083**	0.068**	0.069**	0.076**	0.053*
	(0.028)	(0.029)	(0.029)	(0.032)	(0.032)	(0.029)	(0.029)
60th < p-LTI < 80th pctile	0.093**	0.092**	0.094**	0.090**	0.090**	0.100**	0.068**
	(0.031)	(0.031)	(0.032)	(0.035)	(0.035)	(0.032)	(0.033)
80th < p-LTI	0.101**	0.098**	0.110**	0.091**	0.091**	0.105**	0.081**
	(0.033)	(0.033)	(0.034)	(0.037)	(0.038)	(0.035)	(0.036)
Renter	0.023	0.026	0.031	0.019	0.019	0.026	0.030
	(0.028)	(0.026)	(0.028)	(0.032)	(0.032)	(0.029)	(0.039)
No. children in the HH	-0.086***	-0.087***	-0.083***	-0.090***	-0.092***	-0.097***	-0.093***
	(0.014)	(0.014)	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)
Log other HH income	-0.006	-0.007	-0.005	-0.003	-0.004	-0.004	-0.004
	(0.005)	(0.005)	(0.004)	(0.003)	(0.004)	(0.004)	(0.004)
Constant	0.027	0.323	-0.369	-0.093	-0.003	-0.157	-0.096
	(0.695)	(0.662)	(0.853)	(0.680)	(0.927)	(0.689)	(0.736)
Observations	8,416	8,416	8,133	6,952	6,885	7,789	7,063
No. of Households	2,425	2,425	2,394	2,077	2,048	2,159	1,976
R^2	0.033	0.027	0.033	0.030	0.030	0.034	0.032
Household FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wave FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes		Yes	Yes	Yes	Yes	Yes
Age quadratic	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Education dummies	Yes		Yes	Yes	Yes	Yes	Yes
Local house prices			Yes				
Sample				Head in lab. force	Head in lab. force, no LTU	Females	Married

Note. The sample includes secondary earners from married and cohabiting couples aged 23 to 65 for the years 2001-2006.
*** 1 percent ** 5 percent * 10 percent significance level.
Robust standard errors in parenthesis.

solid blue line reports the distribution for households with a LTV in the top 20 percent. The two distributions do not show any particular difference, indicating that households with a high LTV are not more likely than the rest to have experienced negative or positive income changes. The right panel replicates the same exercise for the p-LTI. The difference in the income growth

Figure 13: Regression coefficients of female employment on LTV and p-LTI quintiles.



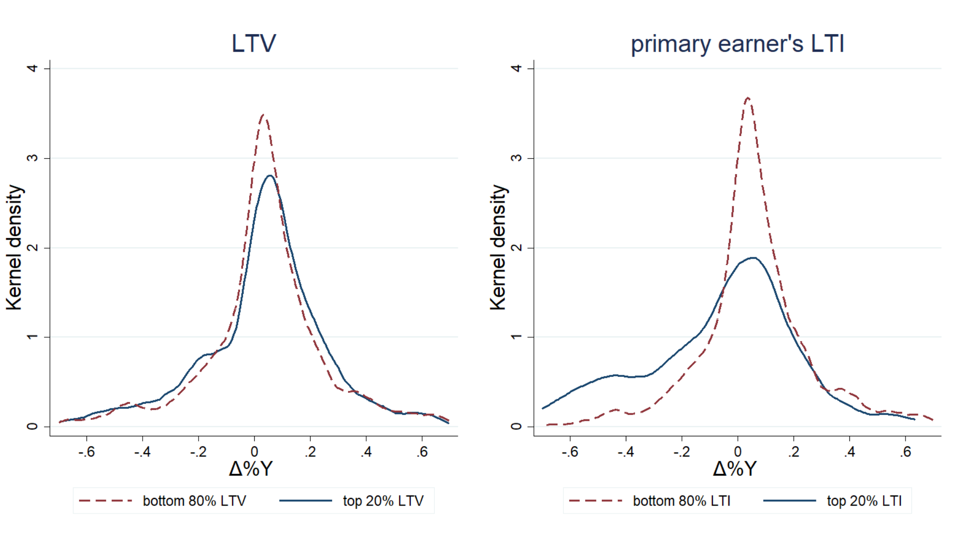
Note. The sample includes secondary earners from married and cohabiting couples aged 23 to 65 for the years 2001-2006. The bars represent the 90 percent confidence interval.

distribution of households in the bottom 80 and top 20 percent is very pronounced. The latter is negatively skewed, with a large mass below zero, implying that many households with high p-LTI's have experienced a fall in either main earnings or non-labor income in the current year. While only 31 percent of households in the first four quintiles had a negative income change, the fraction rises to 50 percent for those in the top quintile. When considering large falls of 15 percent or more, the comparison is 11 and 32. As income is the denominator of the p-LTI ratio, by construction a fall in income yields a rise in the p-LTI, which is the reason for many p-LTI's in the top quintile. This result suggests that the added worker effect is to a large extent the driver of high secondary worker employment for the top quintile.[38]

Overall, the above empirical analysis shows that stylized facts from the data are consistent with the model's main predictions on the relationship between leverage and the labor supply of secondary earners. In particular, the labor supply of secondary earners shows a negative association with LTV levels and a positive one with the p-LTI. The magnitude of this relationship, however, is more moderate for the former measure. Moreover, high p-LTI levels are partly accounted for by falls in the earnings of the primary earner.

[38]Interestingly, Figure A.3 in the appendix suggests that some of these falls are temporary, as the distribution of income growth for the following wave is positively skewed.

Figure 14: Nonparametric distribution of primary income growth by LTV and p-LTI.



Note. The sample includes secondary earners from married and cohabiting couples aged 23 to 65 for the years 2001-2006. The non-parametric densities are computed using the Epanechnikov kernel on 50 points between -0.7 and 0.7.

9 Conclusion

This paper analyzed the relationship between housing debt, leverage-based borrowing constraints, and labor supply. Through a life cycle model of a two-worker household, I showed how leverage limits on debt are important determinants of labor supply decisions at the extensive margin. The model implies that the labor supply of the secondary earner (which is assumed to be female) is negatively correlated with the household's LTV and positively correlated with the primary earner's LTI. The results originate from the interaction of the leverage limits with two competing motives within the household: the incentive to substitute away from costly female labor supply and the need to use female labor to repay debt when male earnings are low.

The interaction between labor choices and leverage constraints is important because the latter are used by policymakers for macro-prudential reasons or to influence homeownership rates. Using the model, I showed that changes in the LTV and LTI constraints alter the working decisions of households over the life cycle. Labor adjustments ultimately amplify the effect of loosening the constraints on homeownership for young households and mitigate the impact of a tightening.

The LTV- and LTI-based constraints entail large heterogeneity in the response of labor supply to income shocks depending on the household's leverage position. At all ages, high-LTV households have a more elastic extensive margin of labor supply compared to households with low leverage. High-LTV households decrease employment more pronouncedly after a fall in female wages and increase it the most after a fall in male earnings. Finally, unexpected house price drops also play an important role for those who are highly leveraged. The fall in prices tightens the LTV limit, forcing females in high-LTV households to supply more labor than desired.

The analysis in this paper leaves scope for further research in several directions. In particular, future works should take into account the general equilibrium consequences for both house prices and wages. Computing the stationary distributions needed to obtain equilibrium prices is extremely challenging under the strong nonlinearity and multiple discontinuities of the policy functions. However, a general equilibrium framework would be essential to address important questions such as the role played by high housing debt in the sustained period of low wages and high employment experienced by the UK after the Great Recession. A further direction of investigation would be to incorporate bankruptcy and foreclosure decisions, which recent research has shown to be crucial for both macroeconomic fluctuations (Mitman, 2016) and for the relationship between the housing and labor markets (Hsu et al., 2017).

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A Data Appendix

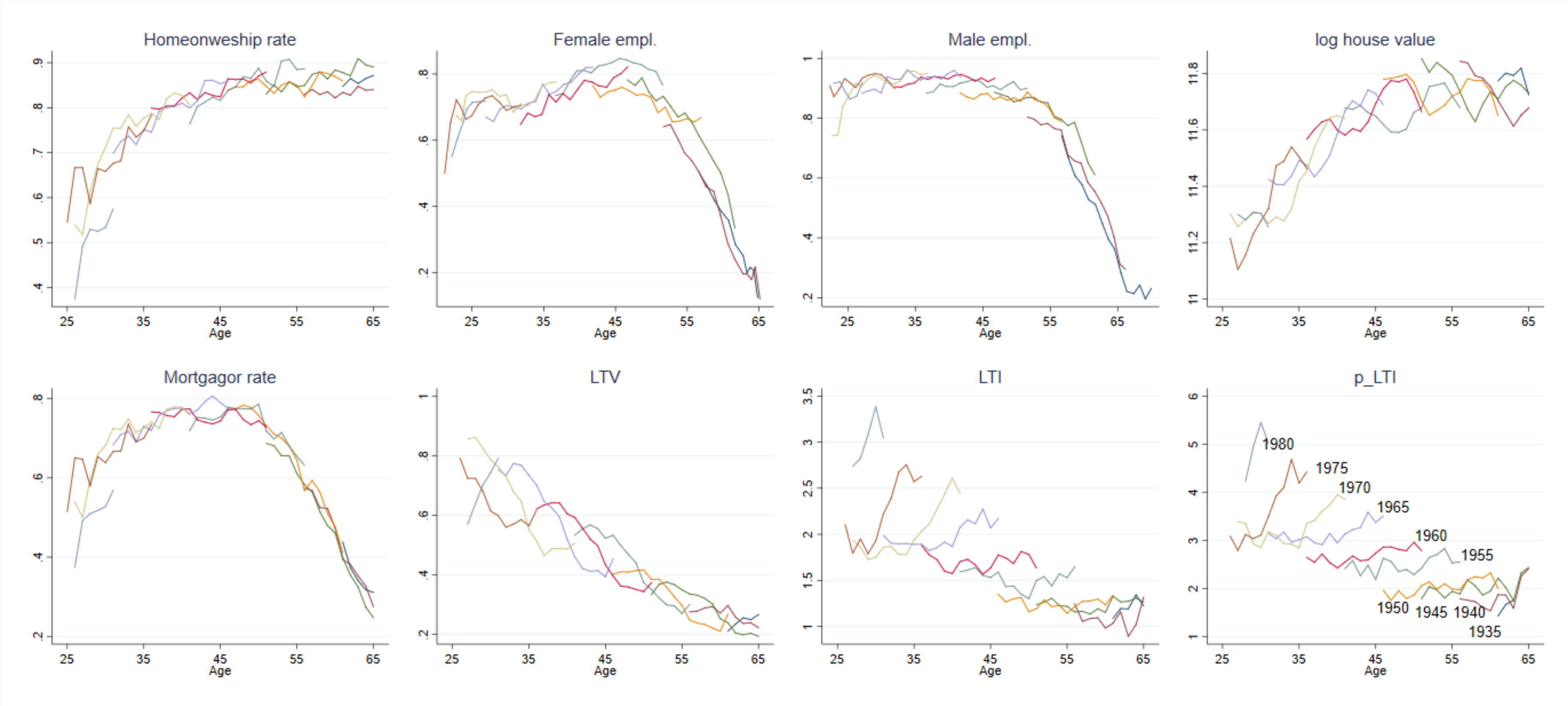
A.1 Additional descriptive empirical analysis

Table A.1: Descriptive statistics for household head and secondary earner in the 2001 wave of the BHPS for couples where the secondary earner is aged 23-40.

	Head of Household	**Not Head of Household**
Sex		
% Female	12.6	87.4
Labor Force Status		
% Employed	90.2	75.6
% Unemployed	2.1	2.3
% Maternity leave	0.1	2.4
% Family care	3	15.9
% Other LF status	4.6	3.7
Child Care*		
% Sole responsible for child care	8.3	58
% Sole carer for ill children	14.6	69

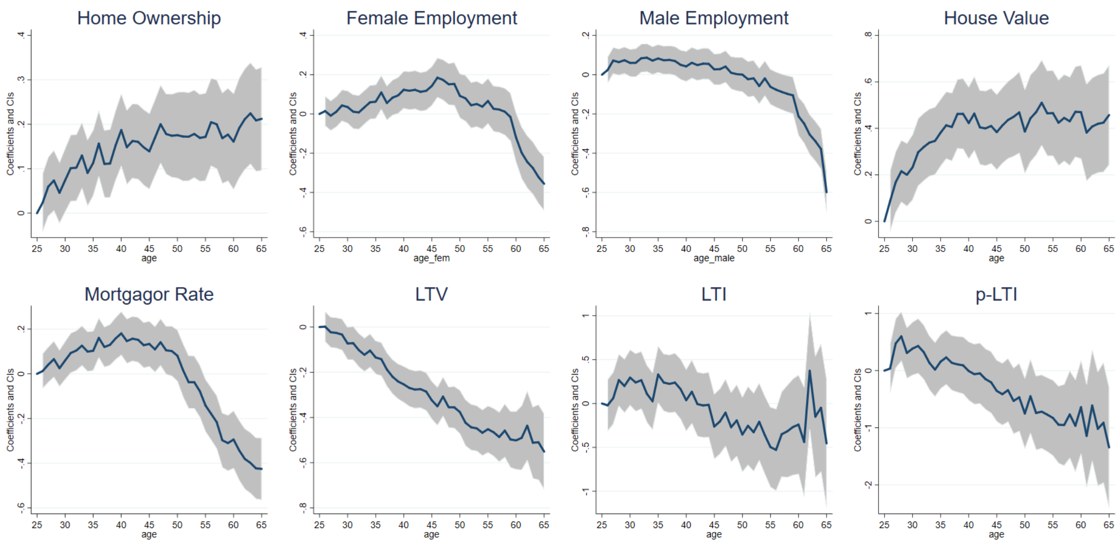
Note. Summary statistics produced using couples in the year-2001 wave of the BHPS where the secondary earner is between the ages of 23 and 40.
* Child care questions refer only to the subset of couples with one or more children under the age of 12.

Figure A.1: Life cycle profiles by 5-year cohorts for the years 1991-2008.



Note. Source: BHPS waves 1991-2008. The sample includes married couples and those in permanent partnerships aged 23 to 65. Households are divided into 5-year cohorts based on the secondary earner's year of birth. In the rightmost panel of the first row, house values are deflated to 2001 prices using the UKHPI series.

Figure A.2: Age effects for homeownership, employment, average house value, percentage of mortgagors, average LTV, LTI, and p-LTI using the regression approach by Deaton and Paxson (1993).



Note. Source: BHPS waves 2001-2006. Sample includes married couples and those in permanent partnerships where the secondary earner is aged 23 to 65. The age effects are obtained using a linear regression on age dummies, 10-year cohort dummies, and wave dummies. These last are constrained to sum to 0 as in Deaton and Paxson (1993).

A.2 Income profiles and idiosyncratic shocks

I follow Bottazzi et al. (2007) in using the estimation suggested by Blundell et al. (2008). The identification assumes that log wages for individual i at period j follow the process:

$$\log W_{i,j} = H_{i,j} + Z_{i,j} + u_{i,j},$$

where $H_{i,j}$ is a deterministic component based on observable characteristics, $Z_{i,j}$ is a persistent idiosyncratic component, and $u_{i,j}$ is a transitory one-period component. The idiosyncratic process is a martingale: $Z_{i,j} = Z_{i,j-1} + \epsilon_{i,j}$. Letting $w_{i,j} = \log W_{i,j} - H_{i,j}$ be the unexplained part of earnings, then the unexplained earnings growth is given by $\Delta w_{i,j} = \Delta u_{i,j} + \epsilon_{i,j}$. Hence:

$$cov(\Delta w_{i,j}, \Delta w_{i,j+s}) = \begin{cases} var(\epsilon_{i,j}) + var(\Delta u_{i,j}) & \text{if } s = 0 \\ cov(\Delta u_{i,j}, \Delta u_{i,j+s}) & \text{if } s \neq 0 \end{cases}$$

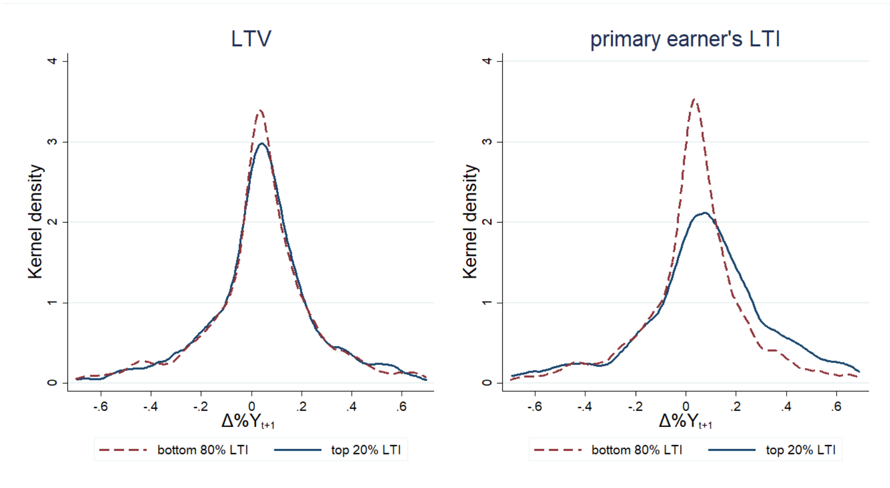
The assumptions of serially uncorrelated transitory shocks, in particular, means that the variance of the innovations to the idiosyncratic component can be identified by the single moment

$$var(\epsilon_{i,j}) = cov(\Delta w_{i,j}, \Delta w_{i,j-1} + \Delta w_{i,j} + \Delta w_{i,j+1}).$$

First, I obtain the deterministic component of wages by regressing the log hourly wage on a set of control variables. The chosen variables for males are an age quadratic, dummies for government administrative region, education level of the head of the household, five-year cohort dummies, household size, and number of children. For females, I account for selection in observing wages based on the decision to work. I therefore use a Heckman-correction 2-step estimation where the selection is based on "other household income", being married, and number of children. The age quadratic is used to calibrate the deterministic component of income and wages for each sex. The residuals from the regressions are used to estimate the parameters of the idiosyncratic income process.

Because the parameter is identified through three periods, at least three years of data are required. The sample of interest for the model is 2001-2006. However, to improve the estimation by having more data and by spanning a time period that includes at least one recession and one recovery, I use all the

Figure A.3: Nonparametric distribution of income growth in wave $t+1$ by LTV and p-LTI for wave t.



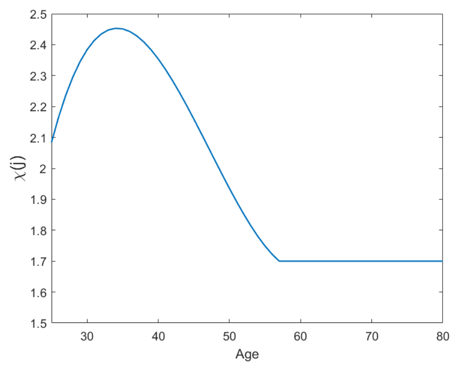
Note. The non-parametric densities are computed using the Epanechnikov kernel on 50 points between -0.7 and 0.7.

BHPS years from 1991 to 2008.

A.3 Number of children and equivalization coefficient

Figure A.4 shows the paths for number the equivalization coefficient $\chi(j)$. The equivalization coefficient is based on the OECD scale, where the first adult is given a weight of 1, the second of .7 and each child a weight of 0.5. Hence, $\chi(j)$ is equal to 1.7 plus 0.5 times the average number of children at each age from the BHPS (where age is taken to be the male's age). The function for the average number of children is estimated as a cubic polynomial of age.

Figure A.4: Housing equivalization coefficient based on avergae household size from the BHPS.



A.4 Initial distribution of assets

In the years 1995, 2000, and 2005 the BHPS included questions regarding savings and investments. I use the 2000 wave to obtain the empirical distribution of net worth for couples within the ages of 23 and 27.

The sample includes all individuals who report being married or living as a couple. Those for which the spouse is present in the survey are matched with their partner to compute all combined measures of savings and investments. Net worth is computed as (joint) savings and investments plus the value of their house minus the outstanding mortgage balance for homeowners and outstanding unsecured debt. As discussed by Banks et al. (2002), the savings and investment variables in the BHPS present some important limitations at the household level. In many cases the two members of a couple report having joint holdings that are inconsistent with each other, or report that only part of their savings are jointly held but do not specify the precise amount. Furthermore, many households report no savings, or reply that they do not know their savings level. Given that these cases account for a relatively small fraction of my sample, I do not implement the kind of "hot-deck" imputation and case-by-case assumptions that are discussed by Banks et al. (2002).

It is important to note that about half of the couples in the sample report no savings. However, a significant portion of these still own a house or have a mortgage. It is therefore important to use these variables, and not just liquid savings to calibrate the initial distribution of assets. I assume that all households start with no housing. However, given that initial assets are calibrated to include housing assets, several households purchase a house within the first period of the model. A large portion of households report negative values of total net worth, although of very small size in the majority of cases. Since in the model households cannot have negative net worth, I censor the initial distribution of assets in the simulation at 0, assigning this value to the empirical fraction of households that have zero or negative net worth.

B Computational Solution

The nature of the borrowing constraint function and the discontinuity of the labor policy decision create several points of non-differentiability in the value function. Computationally fast algorithms such as the Endogenous Gridpoint Method adapted for discrete-continuous choices are therefore unfeasible. I hence opt for the slower but more robust method of computing the value function over a fixed discretized grid within the state space. The computation starts by solving the problem for the last period and then moving backwards one period at the time. In order to solve the model over a square space I follow Bajari et al. (2013) in transforming the state space for financial assets a_t. Specifically, I define $m_j(h_{j-1}) = a_j + \lambda_h p h_{j-1}$, $m_{j+1}(h_j) = a_{j+1} + \lambda_h p h_j$, so that the state spaces for the variables m_t and m_{t+1} always have 0 as a lower bound. Hence, for every combination of the finite values of h_{j-1} and h_j, the maximization over $m_{j+1}|m_j$ can be solved on a fixed two-dimensional grid. The corresponding values of a_j and a_{j+1} can then be recovered. In each period, for a given h_{j-1} I first solve the optimal level of consumption, savings, and work conditional on each level of h_j. I then maximize over the possible choices for h_j. The optimal choice of labor, conditional on h_{j-1} and h_j is found through two-state budgeting. Conditional on $[a_t, a_{t+1}, h_{t-1}, h_t, y_t, w_t^f]$, n_t^f and c_t need to be solved simultaneously through the budget constraint and the intra-temporal first-order condition that equalizes the Marginal Rate of Substitution of leisure and consumption to the wage:

$$c_j + n_j^f w_j^f = (1+r)a_j - a_{j+1} + p(h_{j-1} - h_j) - \xi(n_j^f, j) - \Phi(h_{j-1}, h_j) + y_j \tag{5}$$

$$\frac{\partial U(c_j, h_j, n_j^f, j)}{\partial n_j^f} = w_j^f \frac{\partial U(c_j, h_j, n_j^f, j)}{\partial c_j} \tag{6}$$

In order to do this in a computationally efficient manner, for a given w_j^f I first numerically approximate c and n^f as functions of the non-labor resources through a tenth-order Chebyshev polynomial. Then, during the value function computation, I use the linear approximation to compute the the values of c and n^f for a given value of the right-hand-side of (5). In this way, I obtain the optimal solution conditional on the female being in the labor force. I then also compute the case in which the female does not work and take the maximum of the two options for each point in the state space.

For the computation, I use 200 grid points to discretize the grid of financial assets. I use the method described inTauchen (1986) for the discretization of the earnings process for men and women. Since the earnings processes are age-dependent, the discretization needs to be done separately for each age. I use 10 points for the male's permanent earnings and 15 for female wages. For the male, the grid space is then doubled to include the possibility of unemployment.

The simulations to compute the life cycle averages are done by simulating the joint Markov process for male and female earnings 10,000 times and then computing the resulting paths for the choice variables. The starting distribution for financial assets is based on the empirical distribution of net worth in the 2000 wave of the BHPS for households aged 23-27.

The labor supply responses with respect to shocks to female wage and male income for a given age are computed by solving the policy function once more imposing an unexpected permanent one-standard deviation fall in all earnings at the respective age.

C Further tables and figures from model

Figure C.1: Calibrated labor supply cost

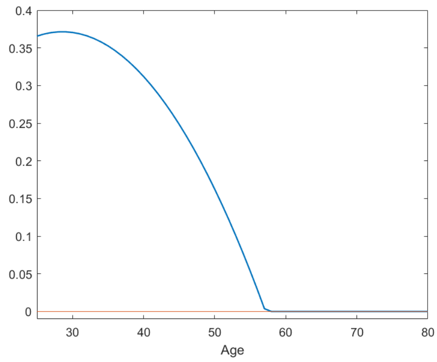
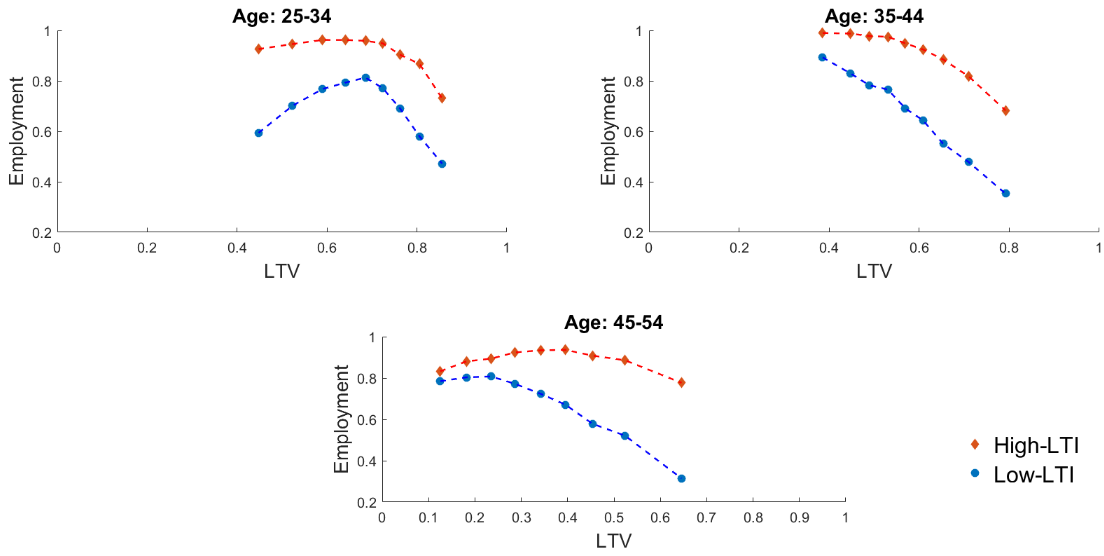


Table C.1: Empirical targets and simulated moments.

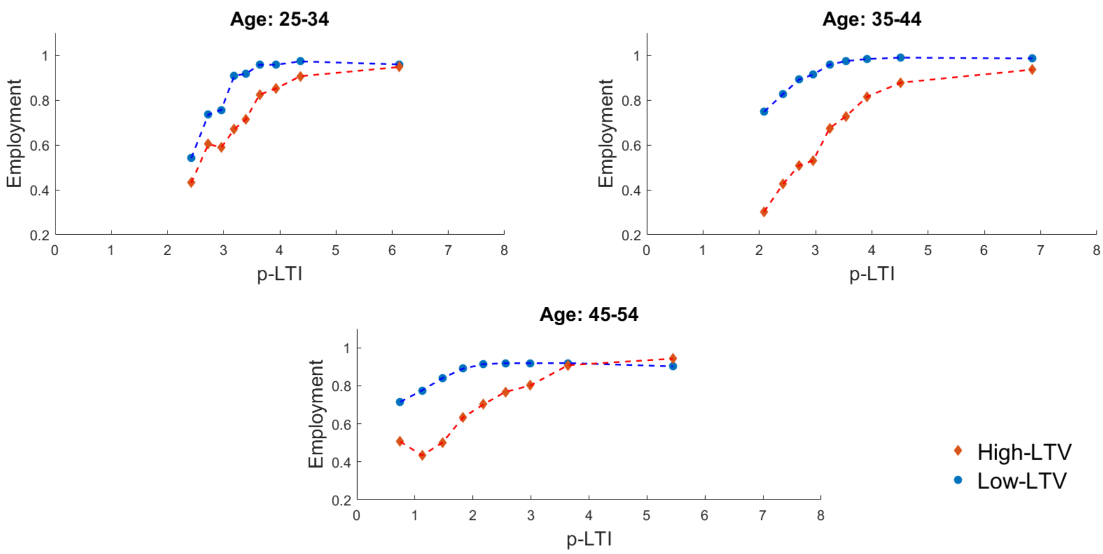
Moment	**Target**	**Model**
Average homeownership rate, age 30-55	.82	.82
Average home value, age 30-55	5.4	5.4
Female employment rate, age 25-29	.71	.70
Female employment rate, age 30-34	.71	.71
Female employment rate, age 35-39	.75	.72
Female employment rate, age 40-44	.78	.76
Female employment rate, age 45-49	.82	.82
Female average hours 30-54	35	35

Figure C.2: Employment rate by LTV ratio across age groups and p-LTI above or below median.



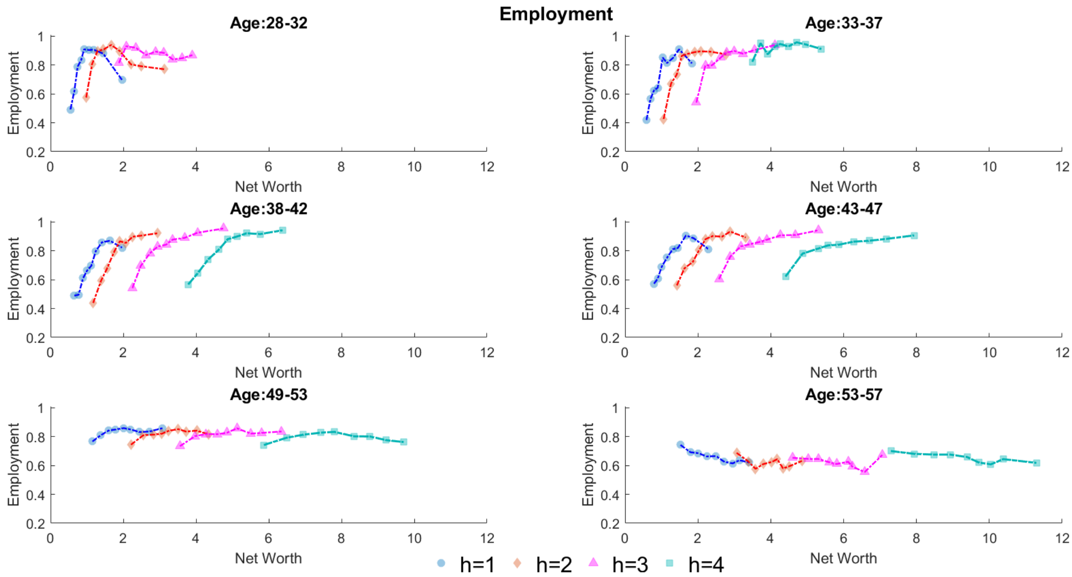
Note. Each plot is produced by grouping households into 10-year age groups. For each group, each point represents the employment rate (y-axis) for a given decile of the LTV (x-axis). In this way, the plot shows how a variable tends to change across the simulated distribution of the x-variable. The threshold for the high p-LTI group is the median value of p-LTI for mortgagors in the respective age group. The plots are produced using 10,000 simulations of individual income shocks starting from the calibrated initial distribution of net worth.

Figure C.3: Employment rate by p-LTI ratio across age groups and LTV above or below median.



Note. Each plot is produced by grouping households into 10-year age groups. For each group, each point represents the employment rate (y-axis) for a given decile of the p-LTI (x-axis). In this way, the plot shows how a variable tends to change across the simulated distribution of the x-variable. The threshold for the high LTV group is the median value of LTV for mortgagors in the respective age group. The plots are produced using 10,000 simulations of individual income processes starting from the calibrated initial distribution of net worth.

Figure C.4: Employment rate by net worth across age groups and house size.



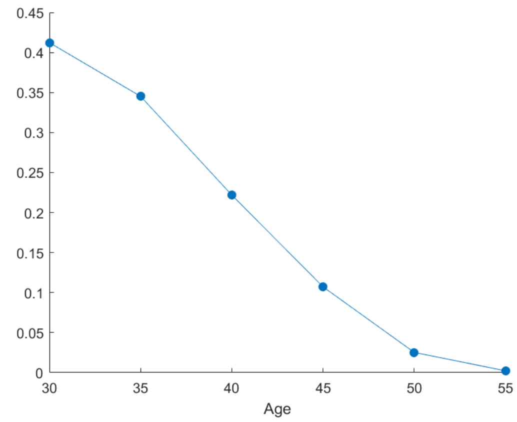
Note. Each plot is produced by grouping together households in five-year group and divide them into owners of each house size. For each group, each point represents the employment rate on the y-axis for a given decile of the variable on the x-axis. In this way, the plot shows how a variable tends to change across the simulated distribution of the x-variable. The plots are produced using 10,000 simulations of individual income processes starting from the calibrated initial distribution of net worth.

Table C.2: Correlation of male earnings and female wages with the LTV and p-LTI at different ages in the baseline model.

Age	**LTV**		**p-LTI**	
	Corr(y^m, LTV)	**Corr(w^f,LTV)**	**Corr(y^m,p-LTI)**	**Corr(w^f,p-LTI)**
30	0.240	-0.207	-0.565	0.111
35	0.146	-0.503	-0.541	0.046
40	0.108	-0.544	-0.498	0.026
45	-0.009	-0.530	-0.504	-0.036
50	-0.026	-0.422	-0.415	-0.052
55	-0.010	-0.294	-0.367	0.004

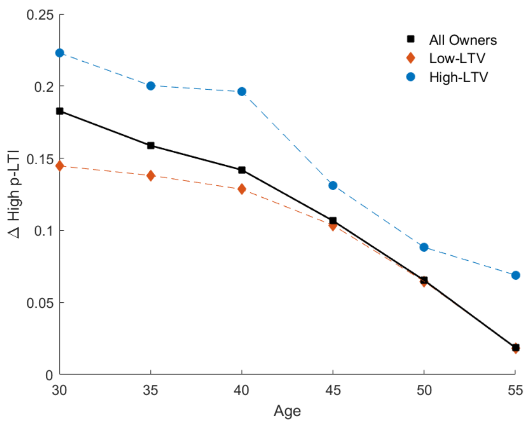
Note. The correlations are produced using 10,000 simulations of individual income processes starting from the calibrated initial distribution of net worth.

Figure C.5: Fraction of high-LTV homeowners at different ages in the baseline model.



Note. The points correspond to the ages at which the initial female employment response is computed in Figure 11. The series is computed using 10,000 simulations of individual income processes and draws from the calibrated initial distribution of net worth.

Figure C.6: Change in the fraction of high p-LTI homeowners at different ages and by low- and high-LTV group after a one-standard deviation permanent fall in male earnings.

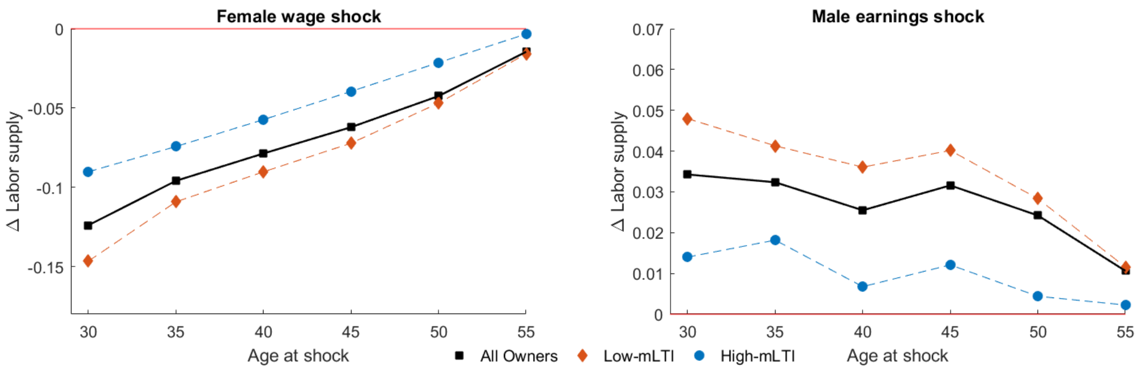


Note. The points correspond to the ages at which the initial female employment response is computed in Figure 11. The series is computed using 10,000 simulations of individual income processes and draws from the calibrated initial distribution of net worth.

D Decomposition of labor supply response to income shocks by the male's LTI.

Figure D.1 reports the initial response of female employment to a one-standard deviation fall in either female potential wages or male earnings, broken down by p-LTI level. I choose the value of 3.5 as the threshold for high-p-LTI households, which is close ot the 80^{th} percentile of the unconditional distribution for all mortgagors. At this value the household is borrowing-constrained unless the female is employed. The fall in employment after a negative shock to female earnings is slightly lower for high-p-LTI households, as they rely more heavily on female labor for debt repayment. The added worker effect is larger for the low-p-LTI group, as it includes “marginal” households who become constrained as a result of the fall in male earnings. Meanwhile, the high-p-LTI includes households who already rely on female labor and therefore their decisions are not strongly affected.

Figure D.1: Contemporaneous labor supply response to female and male earnings shocks between low-p-LTI and high-p-LTI homeowners and ages.



Note. Each point reports the response of the extensive margin female labor supply in percentage point (i.e. employment rate) to an unexpected one-standard deviation permanent fall in female wages or male earnings occurring a given age. Households are divided into low-p-LTI homeowners (p-LTI<3), and high-p-LTI homeowners (p-LTI≥3). The black squares report the response for all homeowners. All plots are produced using 10,000 individual simulations.

E Empirical analysis: robustness checks

Table E.1: Regression of employment of the secondary earner on quintiles of LTV and primary earner's LTI, controlling for household characteristics and using an alternative sample in which secondary earners are selected in the year 2001 only.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
LTV							
LTV < 20th pctile	-0.014	-0.013	-0.016	-0.004	-0.003	-0.010	-0.021
	(0.023)	(0.023)	(0.023)	(0.027)	(0.027)	(0.024)	(0.023)
20th < LTV < 40th pctile	-0.030	-0.029	-0.033	-0.028	-0.029	-0.026	-0.031
	(0.025)	(0.025)	(0.026)	(0.029)	(0.030)	(0.027)	(0.026)
40th < LTV < 60th pctile	-0.037	-0.035	-0.033	-0.035	-0.035	-0.032	-0.037
	(0.026)	(0.026)	(0.027)	(0.031)	(0.031)	(0.029)	(0.027)
60th < LTV < 80th pctile	-0.061**	-0.057**	-0.057*	-0.059*	-0.059*	-0.061*	-0.062**
	(0.029)	(0.028)	(0.029)	(0.033)	(0.033)	(0.031)	(0.030)
80th < LTV	-0.073**	-0.070**	-0.070**	-0.072**	-0.072**	-0.076**	-0.078**
	(0.030)	(0.030)	(0.032)	(0.035)	(0.035)	(0.034)	(0.033)
p-LTI							
p-LTI < 20th pctile	0.030	0.031	0.026	0.020	0.021	0.028	0.028
	(0.024)	(0.023)	(0.024)	(0.026)	(0.026)	(0.025)	(0.024)
20th < p-LTI < 40th pctile	0.060**	0.060**	0.056**	0.051*	0.051*	0.060**	0.055**
	(0.024)	(0.024)	(0.024)	(0.027)	(0.028)	(0.026)	(0.025)
40th < p-LTI < 60th pctile	0.051*	0.047*	0.051*	0.041	0.041	0.048*	0.036
	(0.027)	(0.027)	(0.027)	(0.030)	(0.031)	(0.029)	(0.028)
60th < p-LTI < 80th pctile	0.072**	0.070**	0.067**	0.072**	0.073**	0.076**	0.071**
	(0.030)	(0.030)	(0.030)	(0.033)	(0.033)	(0.032)	(0.032)
80th < p-LTI	0.082**	0.078**	0.084**	0.076**	0.076**	0.083**	0.078**
	(0.031)	(0.031)	(0.031)	(0.035)	(0.035)	(0.034)	(0.033)
Renter	0.054*	0.056*	0.064**	0.043	0.048	0.052	0.078*
	(0.029)	(0.030)	(0.030)	(0.033)	(0.034)	(0.036)	(0.040)
No. children in the HH	-0.065***	-0.065***	-0.063***	-0.072***	-0.074***	-0.082***	-0.071***
	(0.013)	(0.013)	(0.013)	(0.014)	(0.014)	(0.015)	(0.014)
Log other HH income	-0.005	-0.005	-0.004	-0.002	-0.002	-0.004	-0.003
	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.003)
Constant	0.295	0.276	0.173	0.269	0.439	0.306	0.230
	(0.697)	(0.679)	(0.829)	(0.674)	(0.938)	(0.733)	(0.753)
Observations	8,069	8,069	7,775	6,567	6,510	7,194	6,969
No. of Households	2,050	2,050	2,028	1,754	1,734	1,817	1,783
R^2	0.029	0.025	0.029	0.023	0.024	0.031	0.030
Household FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wave FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes		Yes	Yes	Yes	Yes	Yes
Age quadratic	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Education dummies	Yes		Yes	Yes	Yes	Yes	Yes
Local house prices			Yes				
Sample				Head in lab. force	Head in lab. force, no LTU	Females	Married

Sample includes secondary earners from married and cohabiting couples aged 23 to 65 selected in the year 2001.
*** 1 percent ** 5 percent * 10 percent significance level.
Robust standard errors in parenthesis.

Table E.2: Regression of employment of females on quintiles of LTV and male earner's LTI, controlling for household characteristics.

	(1)	(2)	(3)	(4)	(5)	(6)
LTV						
LTV < 20th pctile	-0.007	-0.007	-0.008	0.002	0.002	-0.022
	(0.023)	(0.022)	(0.023)	(0.026)	(0.027)	(0.024)
20th < LTV < 40th pctile	-0.009	-0.009	-0.009	-0.007	-0.007	-0.013
	(0.025)	(0.025)	(0.025)	(0.029)	(0.029)	(0.027)
40th < LTV < 60th pctile	-0.020	-0.019	-0.015	-0.016	-0.016	-0.022
	(0.027)	(0.027)	(0.027)	(0.031)	(0.031)	(0.029)
60th < LTV < 80th pctile	-0.031	-0.029	-0.026	-0.026	-0.027	-0.039
	(0.029)	(0.028)	(0.030)	(0.032)	(0.033)	(0.031)
80th < LTV	-0.048	-0.046	-0.040	-0.044	-0.045	-0.049
	(0.031)	(0.031)	(0.032)	(0.035)	(0.035)	(0.034)
p-LTI						
p-LTI < 20th pctile	0.036	0.038	0.032	0.031	0.032	0.039
	(0.024)	(0.023)	(0.024)	(0.027)	(0.027)	(0.025)
20th < p-LTI < 40th pctile	0.066**	0.067**	0.062**	0.060**	0.061**	0.058**
	(0.024)	(0.025)	(0.025)	(0.028)	(0.028)	(0.025)
40th < p-LTI < 60th pctile	0.061**	0.061**	0.061**	0.056*	0.057*	0.048*
	(0.027)	(0.027)	(0.028)	(0.031)	(0.031)	(0.029)
60th < p-LTI < 80th pctile	0.095**	0.093**	0.089**	0.091**	0.092**	0.077**
	(0.030)	(0.029)	(0.030)	(0.034)	(0.034)	(0.032)
80th < p-LTI	0.100**	0.100**	0.101**	0.091**	0.092**	0.091**
	(0.031)	(0.031)	(0.032)	(0.036)	(0.036)	(0.035)
Renter	0.000	-0.002	0.004	-0.010	-0.007	0.016
	(0.037)	(0.039)	(0.039)	(0.040)	(0.040)	(0.045)
No. children in the HH	-0.085***	-0.086***	-0.084***	-0.089***	-0.093***	-0.086***
	(0.014)	(0.014)	(0.015)	(0.015)	(0.015)	(0.015)
Log other HH income	-0.007	-0.006	-0.006	-0.004	-0.005	-0.004
	(0.005)	(0.005)	(0.005)	(0.004)	(0.005)	(0.004)
Constant	0.169	0.344	-0.557	0.067	0.136	-0.150
	(0.668)	(0.651)	(0.830)	(0.663)	(0.888)	(0.741)
Observations	8,879	8,879	8,569	7,479	7,389	7,421
No. of Households	2,382	2,382	2,356	2,095	2,063	1,966
R^2	0.033	0.027	0.033	0.028	0.030	0.032
Household FE	Yes	Yes	Yes	Yes	Yes	Yes
Wave FE	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes		Yes	Yes	Yes	Yes
Age quadratic	Yes	Yes	Yes	Yes	Yes	Yes
Education dummies	Yes		Yes	Yes	Yes	Yes
Local house prices			Yes			
Sample				Head in lab. force	Head in lab. force, no LTU	Married

Sample includes females from married and cohabiting couples aged 23 to 65 for the years 2001-2006.

*** 1 percent ** 5 percent * 10 percent significance level.

Robust standard errors in parenthesis.

Table E.3: Regression of employment of the secondary earner on quintiles of LTV and primary earner's LTI, controlling for household characteristics, and using the extended time sample 1998-2008.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
LTV							
LTV < 20th pctile	-0.002	-0.003	-0.007	-0.006	0.002	-0.002	-0.008
	(0.019)	(0.018)	(0.019)	(0.020)	(0.029)	(0.019)	(0.020)
20th < LTV < 40th pctile	-0.013	-0.014	-0.016	-0.015	-0.020	-0.014	-0.017
	(0.020)	(0.020)	(0.020)	(0.021)	(0.033)	(0.020)	(0.022)
40th < LTV < 60th pctile	-0.047**	-0.049**	-0.045**	-0.041*	-0.066*	-0.046**	-0.045**
	(0.021)	(0.021)	(0.021)	(0.022)	(0.035)	(0.021)	(0.022)
60th < LTV < 80th pctile	-0.074***	-0.076***	-0.072**	-0.066**	-0.076*	-0.073**	-0.075**
	(0.022)	(0.023)	(0.023)	(0.024)	(0.040)	(0.023)	(0.025)
80th < LTV	-0.049**	-0.053**	-0.050**	-0.034	-0.065	-0.047*	-0.042
	(0.024)	(0.024)	(0.024)	(0.025)	(0.041)	(0.024)	(0.026)
LTI							
p-LTI < 20th pctile	0.032*	0.035*	0.041**	0.037*	0.032	0.033*	0.034*
	(0.019)	(0.019)	(0.019)	(0.021)	(0.032)	(0.019)	(0.020)
20th < p-LTI < 40th pctile	0.057**	0.059**	0.064**	0.057**	0.048	0.061**	0.059**
	(0.020)	(0.020)	(0.021)	(0.022)	(0.035)	(0.021)	(0.022)
40th < p-LTI < 60th pctile	0.056**	0.058**	0.064**	0.048**	0.055	0.059**	0.054**
	(0.021)	(0.021)	(0.021)	(0.022)	(0.038)	(0.021)	(0.023)
60th < p-LTI < 80th pctile	0.080***	0.083***	0.083***	0.077***	0.087**	0.083***	0.077***
	(0.021)	(0.021)	(0.021)	(0.022)	(0.037)	(0.021)	(0.023)
80th < p-LTI	0.105***	0.111***	0.111***	0.092***	0.078*	0.108***	0.117***
	(0.023)	(0.023)	(0.023)	(0.024)	(0.042)	(0.024)	(0.025)
Renter	0.014	0.017	0.015	0.008	0.041	0.022	0.023
	(0.023)	(0.024)	(0.024)	(0.022)	(0.039)	(0.024)	(0.028)
No. children in the HH	-0.083***	-0.084***	-0.083***	-0.080***	-0.087***	-0.089***	-0.081***
	(0.008)	(0.009)	(0.009)	(0.009)	(0.015)	(0.009)	(0.009)
Log other HH income	-0.010**	-0.011**	-0.010*	-0.012**	-0.009	-0.010*	-0.011*
	(0.005)	(0.005)	(0.005)	(0.006)	(0.008)	(0.006)	(0.006)
Constant	-0.502	-0.423	-0.569	-0.056	-1.183	-0.627	-0.824
	(0.479)	(0.472)	(0.678)	(0.568)	(1.215)	(0.465)	(0.504)
Observations	16,748	16,748	16,034	13,710	6,071	15,557	14,180
No. of Households	3,085	3,085	3,022	2,625	650	2,683	2,485
R^2	0.058	0.049	0.058	0.042	0.072	0.059	0.060
Household FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wave FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes		Yes	Yes	Yes	Yes	Yes
Age quadratic	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Education dummies	Yes		Yes	Yes	Yes	Yes	Yes
Local house prices			Yes				
Sample				Male in lab. force no male LTU	Balanced	Females	Married

Sample includes secondary earners from married and cohabiting couples aged 23 to 65 for the years 1998-2008.
*** 1 percent ** 5 percent * 10 percent significance level.
Robust standard errors in parenthesis.