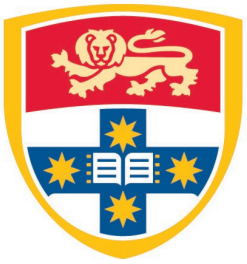

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# Marginal Propensities to Consume Before and After the Great Recession

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**Abstract**

How do marginal propensities to consume out of income differ across households and over time? Using a quasi maximum likelihood approach for a semi-structural model, we obtain precise estimates of consumption responses to idiosyncratic income shocks for households in the PSID grouped by homeownership status and various balance sheet characteristics. Rather than by hand-to-mouth status based on very low liquid wealth relative to income, we find it is homeowners more broadly stratified by higher and lower liquid wealth who exhibit the most heterogeneity in marginal propensities to consume out of transitory income shocks. Time-varying estimates before and after the Great Recession confirm the overall importance of balance sheet liquidity, with significant increases in transitory consumption responses associated with a deterioration in housing wealth, especially for homeowners with low liquid wealth. There appears to be far less heterogeneity in what are much smaller and more stable permanent consumption responses to transitory income shocks, while responses to permanent income shocks are most strongly related to homeownership status, with implied consumption insurance higher for homeowners than renters, but no significant changes in the time-varying estimates. These findings are broadly consistent with theories of consumption that include housing as the primary illiquid asset.

*Keywords*: Marginal propensity to consume; Great Recession; liquid assets; housing wealth; consumption insurance.
*JEL codes*: E21; C13; C33, D12; D14.

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# 1 Introduction

It is clear that the boom-bust in the U.S. housing market in the 2000s had a significant impact on household balance sheets given that housing is the largest component of household wealth and is typically financed by debt contracts. The deterioration in household balance sheets and its impact on consumption during the Great Recession has been examined extensively; see, for example, Dynan (2012), Mian, Rao and Sufi (2013), Baker (2018), Garriga and Hedlund (2020), and Kaplan, Mitman and Violante (2020b). Related, Ganong and Noel (2020) examine the effects on consumption of mortgage modification programs such as a reduction in principal payments and short-term payments, both programs that were part of 2009 Home Affordable Modification Program (HAMP). The effectiveness of such policies depends crucially on which households respond the most to changes in income, which is the focus of our analysis.

We consider heterogeneity in the sensitivity of household consumption to idiosyncratic income shocks before and after the Great Recession ("1998-2007" and "2008-2016"). Measuring the responsiveness of consumption to both permanent and transitory shocks requires estimation of the income process for households. We use income and consumption data from the Panel Survey of Income Dynamics (PSID) and estimate a modified version of the model by Blundell, Pistaferri and Preston (2008) (BPP hereafter) via the quasi maximum likelihood approach proposed in Chatterjee, Morley and Singh (2020). This approach efficiently handles missing observations in the levels of the data using the Kalman filter and provides precise estimates of consumption responses to income shocks. We investigate how these estimates vary both cross-sectionally and over time for households with different balance sheet positions based on homeownership status, hand-to-mouth status, liquid wealth, housing wealth, and leverage. Understanding variation in consumption responses to income along these dimensions is crucial for identifying the sources of consumption fluctuations and informing fiscal stimulus programs that could be implemented during an economic downturn.

In terms of our econometric approach, we consider semi-structural analysis along the lines of BPP, but we extend their model to let transitory income shocks impact the transitory component of consumption, not just the permanent component. This allows consumption growth to depend on both current and lagged transitory income shocks, addressing a concern raised in Commault (2020) regarding the empirical model of BPP. It also leads to different short-run and long-run consumption elasticities with respect to the transitory

shocks, which allows the calculation of a formal marginal propensity to consume (MPC) that is conceptually closer to what is captured in natural experiments, such as short-term consumption responses to tax rebates.[1] Meanwhile, our use of quasi maximum likelihood estimation (QMLE) following Chatterjee et al. (2020) addresses concerns in Altonji and Segal (1996) about small sample biases related to estimation of weighting matrices for GMM and lets us consider relatively small samples in terms of different groups classified along key aspects of household balance sheets, as well as possible structural change in parameters over time. In particular, Chatterjee et al. (2020) show via Monte Carlo simulation that QMLE is far more accurate than GMM in small samples and when allowing for structural change, with the better performance due, at least in part, to a more efficient treatment of missing observations by modeling idiosyncratic income and consumption in log levels rather than growth rates. The QMLE approach also allows us to easily employ Wald tests for restrictions on parameters, including to test the stability of consumption elasticities over time.

Our first key finding is in terms of heterogeneity in MPCs based on short-run elasticities with respect to idiosyncratic transitory income shocks. We find that MPCs are strongly negatively associated with total household wealth, as well as underlying measures corresponding both to housing wealth and liquid wealth. These results are qualitatively consistent with what would be predicted by either one or two-asset incomplete incomplete markets models, e.g. Carroll (1997) and Kaplan and Violante (2014). We also show that MPCs are positively associated with leverage, as defined in Mian et al. (2013). When looking across groups stratified by homeownership status, hand-to-mouth status, liquid wealth, housing wealth, and leverage, we find that heterogeneity is driven by different transitory responses of consumption that clearly exist beyond the hand-to-mouth status of households. In particular, the estimated transitory response of homeowners with liquid wealth below the median is 50% higher than the estimate for all households, with a majority of low liquid wealth homeowners having either high enough income or liquid wealth such that they would not be classified as hand-to-mouth. Also, even if we exclude hand-to-mouth households from the subgroup of homeowners with low liquid wealth, the estimated transitory response remains high. These results are consistent with the theoretical prediction of Boar, Gorea and Midri-

[1]Specifically, natural experiments could involve a transitory response of consumption, while the original BPP model assumes the response of consumption is permanent. One remaining distinction from some natural experiments, especially in terms of tax shocks, is that we are capturing the MPC out of idiosyncratic transitory income shocks, while tax shocks may have general-equilibrium effects if they have aggregate implications or different properties in terms of the ability of households to diversify the income risk.

gan (2020), who consider a two-asset incomplete markets model, where like Kaplan et al. (2020a) the illiquid asset is carefully micro-founded as housing, but they examine the role of housing equity in smoothing idiosyncratic income shocks rather than aggregate shocks. Notably, Boar et al. (2020) argue that homeowners who are liquidity constrained are distinct from hand-to-mouth homeowners, which is consistent with what we find.

Our second key finding is in terms of changes in MPCs over time. In particular, we show that, while the relatively small permanent responses to transitory income shocks do not appear to change, the transitory responses of homeowners increased significantly, both statistically and economically, with the Great Recession, going from an estimated 0.09 during the 1998-2007 subsample period to 0.14 in the 2008-2016 subsample period.[2] Among homeowners, we find that those with low liquid wealth experienced the largest increase in their estimated transitory response of consumption, surging from 0.13 to 0.26. Homeowners who were highly leveraged before the Great Recession also experienced an increase in their estimated transitory response, although the increase is not statistically significant. Our time-varying estimates suggest that MPCs are generally higher after the Great Recession, with the increases appearing to correspond to a negative housing wealth effect amplified by diminished liquidity. Furthermore, the changes in transitory responses of consumption have altered some key patterns in terms of MPC heterogeneity. In particular, before the Great Recession, the MPC was higher for renters than homeowners. However, after the Great Recession, the MPC for homeowners has increased to a similar level as that of renters, with the MPC for liquidity-constrained homeowners jumping to an even higher level. When house prices were booming, homeowners could presumably obtain additional liquidity using their housing wealth (see, for example, Hurst and Stafford, 2004). However, as house prices plummeted during the Great Recession and only sluggishly recovered since then, homeowners have found it more difficult to access such liquidity and, as a result, consumption of liquidity-constrained homeowners has become highly sensitive to transitory income shocks. Meanwhile, reflecting the increasing proportion of households with high transitory consumption responses, the MPC for all households has also increased after the Great Recession.

Our analysis also considers heterogeneity in consumption responses to idiosyncratic permanent income shocks. We find that heterogeneity in terms of consumption insurance

[2]The increase appears to be sustained well after the end of the Great Recession, as estimated changes are larger and more precise when allowing a permanent change in the 2008-2016 subsample period rather than a temporary one-time change corresponding just to the Great Recession in 2008.

against these shocks is more related to homeownership status, housing wealth, and hand-to-mouth status, with renters, homeowners below the median housing wealth, and hand-to-mouth households all appearing to respond more to permanent shocks than their counterparts. Time-varying estimates suggest no significant changes in consumption insurance for any group of households.

**Related literature.** Our analysis relates to three strands of the literature on consumption behavior. First, we contribute to the literature that develops methods that enable estimation of the impact of transitory income shocks on consumption.[3] Broadly speaking, there are two approaches. The first approach exploits natural experiments such as fiscal tax rebates (Parker et al., 2013), lottery winnings (Fagereng et al., 2020), or mortgage modification programs (Ganong and Noel, 2020) to identify exogenous income changes and their impact on consumption. The second approach is semi-structural, popularized by Blundell et al. (2008), where statistical methods are employed to infer responses to idiosyncratic permanent or transitory income shocks without directly observing these shocks, but assuming a structure for the underlying income and consumption processes. This approach has been used extensively, see for example Kaplan et al. (2014) and Auclert (2019), among others. Our paper follows Commault (2020) in extending the semi-structural approach to allow, but not require, estimates to be more in line with what is found in natural experiments by also considering transitory consumption responses.

Second, in terms of values of MPCs in particular, our analysis is closely related to the literature that estimates consumption responses to transitory income shocks; see for example Johnson et al. (2006), Parker et al. (2013), Bunn et al. (2018), Gelman (2020), and Fagereng et al. (2020). Most of these papers argue that aggregate MPCs implied by a two-asset incomplete asset markets model of Kaplan and Violante (2014) and/or a buffer stock model with discount factor heterogeneity as in Carroll et al. (2017) are best suited to reconcile the empirical estimates of MPCs out of transitory income shocks. Modeling the illiquid asset as housing, Boar et al. (2020) show that in the U.S. homeowners are liquidity constrained, despite not being classified as hand-to-mouth. As a result such homeowners are unable to smooth consumption in the event of transitory shocks to their income. Our estimates sup-

[3]While preferences may also play a role in explaining MPC heterogeneity, we do not focus on this mechanism. See Gelman (2020) and Aguiar et al. (2020) for the role of preferences in MPC heterogeneity. We note that this source of heterogeneity is implicitly allowed for as our consumption elasticity estimates can be interpreted as average elasticities for each group under consideration; see Commault (2020).

port the theoretical mechanisms emphasized in Boar et al. (2020).

Third, there is a large literature that examines why aggregate consumption fell during the Great Recession; see for example Midrigan and Philippon (2011), Mian et al. (2013), Huo and Ríos-Rull (2016), Garriga and Hedlund (2020), Baker (2018), Kaplan et al. (2020b). On the empirical side, Mian et al. (2013) argue that the decline in consumption is largely driven by exposure to household leverage. However, Kaplan et al. (2020b) show that the decline is purely due to a negative housing wealth effect. Our results complement the debate in the literature by showing that, relative to the housing boom period, the spending of U.S. households appears to have declined due to a negative housing wealth effect having a severe impact upon liquidity-constrained homeowners.

The rest of this paper is organized as follows: Section 2 discusses the data and the empirical methods used in our analysis. Sections 3 and 4 present our main results in terms of heterogeneous responses of consumption to income shocks and time-varying estimates. Section 5 relates our results to different theories of consumption and concludes.

# 2 Empirical Framework

In this section we describe the data, sample selection, and empirical methods employed in our analysis.

## 2.1 Data and sample selection

The PSID is a longitudinal survey with a representative sample of approximately 5,000 U.S. households. Between 1968-1996, the survey re-interviewed both the original families and their split-off annually, but then only biennially since 1997. Starting in 1999, the survey started collecting information on household expenditure which covers 70% of consumption categories in the Consumer Expenditure Survey. Therefore, to obtain measures of income and consumption for each household, we look at the ten waves of data from 1999 to 2017 which corresponds to the data from 1998-2016 due to the retrospective nature of the PSID.[4]

Our measure of income is the annual flow of disposable household income, where the household income tax is calculated using the NBER's TAXSIM program. Total household

[4]In any wave, the PSID survey reports information for the previous year. For example, the data released in 1999 contains information collected for 1998. Throughout the paper, we refer to the year to which the data corresponds to rather than the year labelled in the PSID.

income consists of labor income, transfers, social security, and head and wife's investment income such as income from housing leases, interest, dividend payments, trusts, and alimony. The measure of consumption is also an annual flow and includes three broad categories: food, nondurables (excluding food), and housing. Food consumption includes food at home, delivery, and eaten out. Nondurable consumption includes gasoline, health insurance, health services, public transport, utilities, education, and childcare. Although we include the actual reported rent for households who live in rental housing, we impute rent for homeowners.[5] Following related literature, e.g. Blundell, Pistaferri and Saporta-Eksten (2016), we consider the user-cost of owner-occupied housing which takes into account interest payments on mortgages, depreciation, and expectation of house price appreciation when imputing rent. Based on the user-cost estimates of Poterba and Sinai (2010), the annual imputed rent in our analysis is 6% of self-reported housing value from the PSID survey. We deflate each component of consumption using the corresponding component from the Consumer Price Index (CPI) obtained from the Bureau of Labor Statistics. Income is deflated using headline CPI.

The PSID also provides information on wealth in every wave. Following Kaplan et al. (2014), we classify wealth into two categories: liquid wealth and illiquid wealth. Liquid wealth is liquid assets less liquid debt, where liquid assets include cash, stocks, and bonds and liquid debt includes credit card debt, student loans, medical bills, legal bills, and other personal loans before 2011 and only credit card debt from 2011.[6] Illiquid wealth consists of housing wealth (housing value minus first and second mortgages), pensions, and non-primary real estate.[7] Then we define total wealth as the sum of illiquid wealth and liquid wealth (minus non-credit card debt given the measure of liquid wealth after 2011). The other aspects of the balance sheet that we consider in our analysis are housing wealth (housing value less mortgage balance) and leverage, defined as in Mian et al. (2013) as the share of housing value to total wealth. All nominal wealth variables are deflated using headline CPI with the base year of 1999.

Our initial dataset consists of an unbalanced panel of 83,831 observations. We closely

[5] In our robustness analysis, we also consider estimation what happens when housing consumption is not included and find our results are robust.

[6] Before 2011, the PSID did not report the individual components of liquid debt, but instead reported an aggregated measure of debt including credit card debt, student loans, medical bills, legal bills, and other personal loans. However, since 2011, each individual component of liquid debt is separately reported. We follow Kaplan et al. (2014) to account for changes in reporting norms in the PSID. Note that the average median real liquid wealth was $1,724 before 2011 and $2,137 from 2011.

[7] Pensions and non-primary real estate are reported as net values in the PSID.

follow Kaplan et al. (2014)'s sample-selection procedure. From the initial dataset, we drop households that are in the SEO (Survey of Economic Opportunity) sample, which is a sample of low-income households. We focus on households for which there was no change of headship and the age of the head of the household is between 25 and 64. We drop households who reported zero expenditure or had missing information on key demographics in terms of education and race. Households with annual gross income growth higher than 500% or lower than negative 80% and households with annual household gross income of less than $100 U.S. dollars were also dropped. Finally, we drop households who appeared in the survey for less than three waves and do not have two consecutive waves of data. Given these adjustments, our estimation sample consists of 5,047 households with 31,830 observations; see Table B–1 in the appendix for more details.

## 2.2 Household groups and their characteristics

While Kaplan et al. (2014) emphasize the role of liquid wealth, Hurst and Stafford (2004) and Boar et al. (2020) emphasize the role of home equity in providing insurance against income shocks and others such as Mian et al. (2013) and Dynan (2012) have highlighted the role of household leverage during the Great Recession. In this paper, we consider groups of households stratified by both homeownership status and hand-to-mouth (HtM) status. Among homeowners, we further stratify households into subgroups by liquid wealth, housing wealth, and leverage.

The grouping of households in such a manner leads to a few econometric issues. First, there is likely to be a selection bias as households are not randomly assigned into groups and they also endogenously transition between groups. Second, transitions across groups over time are also likely to impact the composition of the groups. To mitigate these issues, we follow Cloyne et al. (2019) and consider only those households who have not changed their status for at least two consecutive waves. In particular, for households to be considered in a particular group, they need to be in that status for two consecutive waves.[8]

Note that classifying households based on balance sheet characteristics naturally results in some overlaps between different groups. The overlaps between groups are reported in Table B–2 in the appendix. Although groups classified using a particular characteristic, e.g.

[8]This restriction excludes households who frequently transition (wave-to-wave) from one group to another. When we apply this restriction, the relative shares of mutually exclusive groups such as HtM groups do not add up to one, as can be seen in row 2 in Tables 1 and 2.

homeownership status, obviously will not overlap with each other, they will overlap with groups classified based on another characteristic, e.g. HtM status. This makes it challenging to compare estimates of consumption responses across groups classified based on different characteristics and isolate key aspects of the balance sheet that might be associated with these consumption responses. We consider this issue carefully in discussing our results in Sections 3 and 4.

We classify households based on homeownership status as being either renters and homeowners, noting that housing constitutes 66% of the value of illiquid assets for our sample of households. As reported in Table 1, renters are relatively young, poor, and likely to be credit constrained. Homeowners are older and wealthier. To explore the role of balance sheets further, we stratify homeowners into subgroups based on liquid wealth, housing wealth, and leverage. A household is in the "high" ("low") subgroup for that particular balance sheet variable if the balance sheet value is above (below and equal to) the median value across all households in a given year. For example if a homeowner is in the high liquid wealth group in 2002, then its liquid wealth is above the median liquid wealth of homeowners in 2002.

We also classify households into poor hand-to-mouth (PHtM), wealthy hand-to-mouth (WHtM), and non-hand-to-mouth (NHtM) categories.[9] As noted previously in the literature, and also evident from Table 1, PHtM households have low liquid wealth, illiquid wealth, and debt on average and are likely to have limited access to credit markets. WHtM households are also liquidity constrained, but they have sizable illiquid wealth, which makes them distinct from PHtM households. Lastly, NHtM households are comparatively wealthy on average and not liquidity constrained.

Table 2 reports the balance sheet and demographic characteristics for different subgroups of homeowners. There are three particularly notable characteristics to highlight in this table. First, homeowners who are relatively poor and liquidity constrained are the low liquid wealth and low housing wealth homeowners. The overlap between these two groups is close to 60% and both have low levels of income and liquid wealth, but the median liquid wealth is higher than that of WHtM. Second, the overlap between high liquid wealth and high housing wealth households is more than 60%. Both groups hold high levels of liquid

[9]Specifically, households are classified as HtM if their liquid wealth balance is positive but less than half of their bi-weekly income or their liquid wealth balance is negative and is less than the difference between half of their bi-weekly income and a credit limit which is equivalent to the monthly income. If a household has a positive (zero or negative) amount of illiquid wealth, then it is classified as wealthy (poor) HtM. As reported in the first row of Table 1, the share of HtM households sums to 37% of our sample, which is in line with the share reported in other studies that use the PSID; see, for example, Aguiar et al. (2020).

Table 1: Summary statistics for household groups by homeownership and HtM status

| | All (1) | Renters (2) | Homeowners (3) | PHtM (4) | WHtM (5) | NHtM (6) |
|---|---|---|---|---|---|---|
| Share (% of total population)* | – | 31.1 | 68.9 | 16.1 | 20.8 | 63.1 |
| Share (% of total population)** | – | 26.8 | 66.5 | 11.1 | 12.9 | 54.7 |
| Income | 48,870 | 29,470 | 61,266 | 24,689 | 46,616 | 59,642 |
| Consumption | 22,439 | 16,942 | 26,049 | 15,511 | 22,345 | 25,131 |
| **Balance sheet variables** | | | | | | |
| Liquid wealth | 2,000 | 0 | 4,987 | 0 | -7,086 | 20,138 |
| Illiquid wealth | 37,432 | 0 | 73,457 | 0 | 38,180 | 83,867 |
| Housing wealth | 25,000 | 0 | 52,005 | 0 | 29,833 | 54,224 |
| Total wealth | 49,979 | 0 | 95,614 | -2,685 | 26,472 | 144,493 |
| Debt | 41,483 | 1,119 | 94,000 | 3,729 | 76,128 | 52,046 |
| Leverage | 1.11 | – | 1.11 | – | 2.32 | 0.91 |
| **Demographics** | | | | | | |
| Age | 43 | 36 | 45 | 37 | 43 | 46 |
| Frac. of college | 0.65 | 0.59 | 0.70 | 0.47 | 0.60 | 0.73 |
| Frac. of married | 0.67 | 0.37 | 0.81 | 0.38 | 0.72 | 0.74 |
| **Other characteristics** | | | | | | |
| Frac. of homeowners | 0.69 | 0 | 1 | 0.07 | 0.93 | 0.79 |
| Frac. of employed | 0.87 | 0.83 | 0.91 | 0.77 | 0.86 | 0.89 |

Notes: The table reports key demographic and balance sheet characteristics for all households and each group based on homeownership and HtM status. Income, consumption balance sheet variables and age are the median values for that group. The shares reported in the first two rows are based on total number of observations (number of households $N$ times the number of times they appear $t$) in our pooled sample. *: calculated for the sample before applying the two consecutive period restriction. **: calculated for the sample after applying the two consecutive period restriction.

Table 2: Summary statistics for homeowner subgroups

| | High LW (1) | Low LW (2) | High HW (3) | Low HW (4) | High Lev. (5) | Low Lev. (6) |
|---|---|---|---|---|---|---|
| Share (% of total population)* | 34.8 | 34.2 | 34.8 | 34.1 | 31.4 | 31.5 |
| Share (% of total population)** | 28.5 | 28.6 | 30.1 | 30.0 | 24.9 | 25.5 |
| Income | 73,080 | 48,423 | 71,869 | 50,330 | 57,741 | 65,167 |
| Consumption | 29,607 | 22,142 | 32,088 | 20,770 | 25,103 | 26,885 |
| **Balance sheet variables** | | | | | | |
| Liquid wealth | 59,691 | -900 | 30,694 | 473 | 1,406 | 59,891 |
| Illiquid wealth | 172,123 | 37,816 | 198,458 | 27,455 | 48,404 | 215,458 |
| Housing wealth | 100,690 | 30,887 | 128,717 | 21,372 | 40,653 | 108,681 |
| Total wealth | 314,617 | 31,577 | 278,280 | 29,043 | 51,489 | 389,221 |
| Debt | 78,250 | 79,657 | 70,000 | 83,394 | 102,079 | 28,362 |
| Leverage | 0.67 | 2.21 | 0.82 | 2.26 | 2.50 | 0.52 |
| **Demographics** | | | | | | |
| Age | 49 | 43 | 51 | 41 | 42 | 52 |
| Frac. of college | 0.79 | 0.58 | 0.77 | 0.61 | 0.67 | 0.72 |
| Frac. of married | 0.84 | 0.76 | 0.84 | 0.76 | 0.79 | 0.81 |
| **Other characteristics** | | | | | | |
| Frac. of homeowners | 1 | 1 | 1 | 1 | 1 | 1 |
| Frac. of employed | 0.89 | 0.88 | 0.87 | 0.90 | 0.93 | 0.84 |

Notes: The table reports key demographic and balance sheet characteristics for each subgroup of homeowners based on balance sheet status, where LW is liquid wealth, HW is housing wealth, and Lev. is leverage. Income, consumption balance sheet variables and age are the median values for that group. The shares reported in the first two rows are based on total number of observations (number of households $N$ times the number of times they appear $t$) in our pooled sample. *: calculated for the sample before applying the two consecutive period restriction. **: calculated for the sample after applying the two consecutive period restriction.

wealth and total wealth. Finally, high leverage homeowners have sizeable liquid wealth, but are highly indebted overall. Other groups with high leverage are homeowners with low liquid wealth and low housing wealth.

## 2.3 Empirical methods

Following BPP, we first isolate idiosyncratic (residual) income and consumption by regressing the logs of household income and consumption on cohort effects and a vector of observable controls that include education, race, employment status, region, and time dummies. We also include other controls such as the number of dependent children, family size, working family members other than head and partner, and children that have moved out.

Specifically,

$$\ln Y_{it} = \beta' X_{it} + y_{it}, \tag{1}$$

$$\ln C_{it} = \alpha' X_{it} + c_{it}, \tag{2}$$

where $Y_{it}$ and $C_{it}$ denote income and consumption for household $i$ in year $t$, respectively. $X_{it}$ is a vector of the control variables. The last terms $y_{it}$ and $c_{it}$ are the residual measures of idiosyncratic log income and consumption from the regressions.

We then consider a panel unobserved components model that decomposes idiosyncratic log income and consumption for household $i$, $y_{it}$ and $c_{it}$, into permanent and transitory components. Note that $t$ denotes a time period of a year given the income and consumption measures correspond to annual flows, although the biennial data collection means there will be missing observations. We discuss how we handle missing observations in more detail below.

The equations of the semi-structural unobserved component income-consumption model are given below:

$$y_{it} = \tau_{it} + \epsilon_{it} \qquad \epsilon_{it} \sim i.i.d.(0, \sigma^2_{\epsilon,t}) \tag{3}$$

$$c_{it} = \gamma_\eta \tau_{it} + \tilde{\gamma}_\epsilon \epsilon_{it} + \kappa_{it} + v_{it} \qquad v_{it} \sim i.i.d.(0, \sigma^2_{v,t}) \tag{4}$$

where the permanent components are specified as random walks:

$$\tau_{it} = \tau_{it-1} + \eta_{it} \qquad \eta_{it} \sim i.i.d.(0, \sigma^2_{\eta,t}) \tag{5}$$

$$\kappa_{it} = \kappa_{it-1} + \gamma_\epsilon \epsilon_{it} + u_{it} \qquad u_{it} \sim i.i.d.(0, \sigma^2_{u,t}) \tag{6}$$

For household $i$, the common stochastic trend for income and consumption ("permanent income") is $\tau_{it}$, while $\kappa_{it}$ is an additional stochastic trend for consumption. Following BPP, the parameters $\gamma_\epsilon$ and $\gamma_\eta$ capture the impacts of transitory and permanent income shocks on permanent consumption, while we add $\tilde{\gamma}_\epsilon$ to the BPP model in order to capture the impact of transitory income shocks on transitory consumption. Note that we allow these impacts of income shocks on consumption to be time-varying in Section 4.

The permanent income shock, $\eta_{it}$, can be interpreted as reflecting shocks to health, promotion, or other idiosyncratic factors that result in a change in permanent income. Other permanent shocks to consumption, $u_{it}$, beyond the permanent shocks to income could reflect tastes and preferences or shocks to non-labor income, such as wealth shocks. The transitory income shock is $\epsilon_{it}$, while the transitory consumption shock is $v_{it}$, where the latter could

capture other sources of transitory fluctuations in reported consumption, including measurement error in the survey data. We assume that shocks are not correlated with each other and households within a group draw shocks independently from distributions where the variance is allowed to change over time.

Given idiosyncratic income and consumption data in logs, it is straightforward to see from the model that the sum of the consumption response parameters $\tilde{\gamma}_\epsilon + \gamma_\epsilon$ corresponds to the short-run elasticity of consumption with respect to transitory income shocks, $\gamma_\epsilon$ corresponds to the long-run elasticity with respect to transitory income shocks, and $\gamma_\eta$ corresponds to the (constant) elasticity with respect to permanent income shocks. The short-run elasticity with respect to transitory shocks is sometimes directly referred to as the "MPC" (e.g. Jappelli and Pistaferri (2010) and Kaplan et al. (2014)), but we reserve this description for the short-run elasticity multiplied by the (unadjusted) consumption-income ratio (i.e. MPC $\equiv (\tilde{\gamma}_\epsilon + \gamma_\epsilon) \times \frac{C_{it}}{Y_{it}}$, where we use the median consumption-income ratio for a given group in our calculations) in order to give it the dollar-for-dollar units often considered in natural experiments. Meanwhile, we follow Kaplan and Violante (2010) in referring to $1 - \gamma_\eta$ as consumption insurance against permanent income shocks.

In standard theoretical models, if markets were complete, households would have full insurance, which implies $\tilde{\gamma}_\epsilon = 0$, $\gamma_\epsilon = 0$, and $\gamma_\eta = 0$. Meanwhile, in the absence of complete markets, but under the permanent income hypothesis with random walk consumption, permanent income shocks would fully transmit, $\gamma_\eta = 1$, but households should not respond very much to transitory income shocks (given finite lives, permanent consumption would respond fractionally to a transitory income shock, but the effect would inversely related to remaining life expectancy and should be quite small for the household groups that we consider). See Jappelli and Pistaferri (2010) for more details about MPCs and consumption insurance.

To estimate the unobserved components model given by equations (1)-(6), we cast the model into state-space form and employ QMLE; see the appendix and Chatterjee et al. (2020) for more details. In our analysis, we encounter small sample sizes when grouping households by balance sheet characteristics. By using QMLE, we are able to address concerns raised in Altonji and Segal (1996) about small sample biases related to estimation of weighting matrices for GMM. In particular, Chatterjee et al. (2020) show via Monte Carlo experiments that QMLE performs better than GMM in terms of root mean square error for parameter estimates, especially in small samples and when allowing for structural change.

Part of the better performance is due to a more efficient treatment of missing observations by using the Kalman filter and modeling the data in log levels rather than growth rates (implying observations are not thrown out when there is not a consecutive observation in levels to form a growth rate). The QMLE approach also allows us to easily employ Wald tests based on the estimated variance-covariance matrix calculated using the Huber-White sandwich formula for restrictions on parameters, including to test the stability of consumption elasticities over time.

Because the waves of data are available only biennially, we treat the alternating years with no data as missing observations to also be handled by the Kalman filter like any other missing observations from the unbalanced panel. This approach is potentially different than working with wave growth rates implied by the model. In particular, note the implied growth rates across waves are given as follows:

$$y_{it} - y_{it-2} = \eta_{it} + \eta_{it-1} + \epsilon_{it} - \epsilon_{it-2} \tag{7}$$

$$c_{it} - c_{it-2} = \gamma_\eta(\eta_{it} + \eta_{it-1}) + (\tilde{\gamma}_\epsilon + \gamma_\epsilon)\epsilon_{it} + \gamma_\epsilon\epsilon_{it-1} + \tilde{\gamma}_\epsilon\epsilon_{it-2} + u_{it} + u_{it-1} + v_{it} - v_{it-2} \tag{8}$$

Then, following a GMM/IV approach to estimation, the short-run elasticity $\tilde{\gamma}_\epsilon + \gamma_\epsilon$ could be identified for this model given what Commault (2020) refers to as the biennial passthrough coefficient $\hat{\phi}_2^\epsilon = \frac{cov(c_{it}-c_{it-2}, y_{it}-y_{it+2})}{cov(y_{it}-y_{it-2}, y_{it}-y_{it+2}))}$. However, Commault (2020) notes that $\hat{\phi}_2^\epsilon$ will not be the same as (the equivalent of) $\tilde{\gamma}_\epsilon + \gamma_\epsilon$ if there are first-order moving-average dynamics in transitory income at an annual frequency, as assumed in the original BPP model. Instead, the it would be the annual passthrough coefficient $\hat{\phi}^\epsilon = \frac{cov(\Delta c_{it}, -\Delta y_{it+2})}{cov(\Delta y_{it}, -\Delta y_{it+2})}$ that would identify $\tilde{\gamma}_\epsilon + \gamma_\epsilon$. However, $\hat{\phi}^\epsilon$ cannot be calculated given only biennial observations of the levels data. By contrast, our QMLE approach directly estimates $\tilde{\gamma}_\epsilon + \gamma_\epsilon$, although it requires an assumption about the value of the moving-average parameter, which is not identified given only biennial observations. We have chosen to (implicitly) set the moving-average parameter to zero in our model specification as this places a lower-bound on the estimated consumption responses, which we find are the same to three decimals if instead we were to assume a moving-average parameter similar to what BPP found for the earlier annual data they considered in their analysis.[10] An additional source of difference with our approach

[10] In particular, the biennial income growth data identifies only $(1 + \theta^2)\sigma_\epsilon^2$, where $\theta$ is the moving-average parameter, rather than $\sigma_\epsilon^2$. So for non-zero values of $\theta$, the estimated $\sigma_\epsilon^2$ will decrease as the absolute value of $\theta$ increases, implying correspondingly higher estimates of $\tilde{\gamma}_\epsilon$ and $\gamma_\epsilon$ to imply the same movements in biennial consumption growth. However, because BPP find estimates of $\theta$ around 0.1 (implying $\theta^2 \approx 0.01$), the changes in the estimates of $\sigma_\epsilon^2$, $\tilde{\gamma}_\epsilon$, and $\gamma_\epsilon$ for such a value instead of $\theta = 0$ will be negligible.

from working with growth rates across waves is that QMLE based on the model in log levels retains more information, as it incorporates every available levels observation, while growth rates are only available for consecutive biennial observations in levels. As briefly discussed when reporting our results in the next section, we compare our estimates to the biennial passthrough estimate in Commault (2020) and an estimate based on QMLE for an unobserved components representation of biennial growth rates and find they are similar, but ours are more precise, suggesting that the moving-average parameter is close to zero (since $\hat{\phi}_2^{\epsilon}$ would identify $\tilde{\gamma}_\epsilon + \gamma_\epsilon$ if the moving-average parameter were zero) and the additional observations incorporated in our estimation contain useful information about the model parameters.

# 3 Heterogeneity in Consumption Responses

In this section, we present our baseline results for the empirical model discussed in the previous section assuming fixed responses of consumption, in particular constant parameters $\tilde{\gamma}_\epsilon$, $\gamma_\epsilon$, and $\gamma_\eta$, but allowing the variances of income and consumption shocks to be different before and after the Great Recession to account for possible heteroskedasticity. The full set of parameter estimates are given in Tables C–1 to C–3 in the appendix.

## 3.1 Responses to transitory income shocks

The MPCs for different groups of households provide clear evidence of heterogeneity related to household balance sheet characteristics. Figure 1 plots the MPC for each household group against key balance sheet measures of median total wealth, liquid wealth, housing wealth, and leverage. The negative relationships between the MPCs and total wealth, liquid wealth, and housing wealth (top panels and bottom left panel) are consistent with what would be predicted by either one or two-asset incomplete markets models, e.g. Carroll (1997) and Kaplan and Violante (2014). There is also a positive relationship between the MPCs and leverage (bottom right panel), implying that more indebted homeowners tend to respond more to transitory income shocks.

To allow exact comparisons, Table 3 reports the point estimates for the consumption response parameters, along with their standard errors. The estimated transitory response of consumption to a transitory income shock, $\tilde{\gamma}_\epsilon$, for all households is 0.11 with a standard error of 0.01. Note that, in estimating the overall impact on consumption of transitory in-

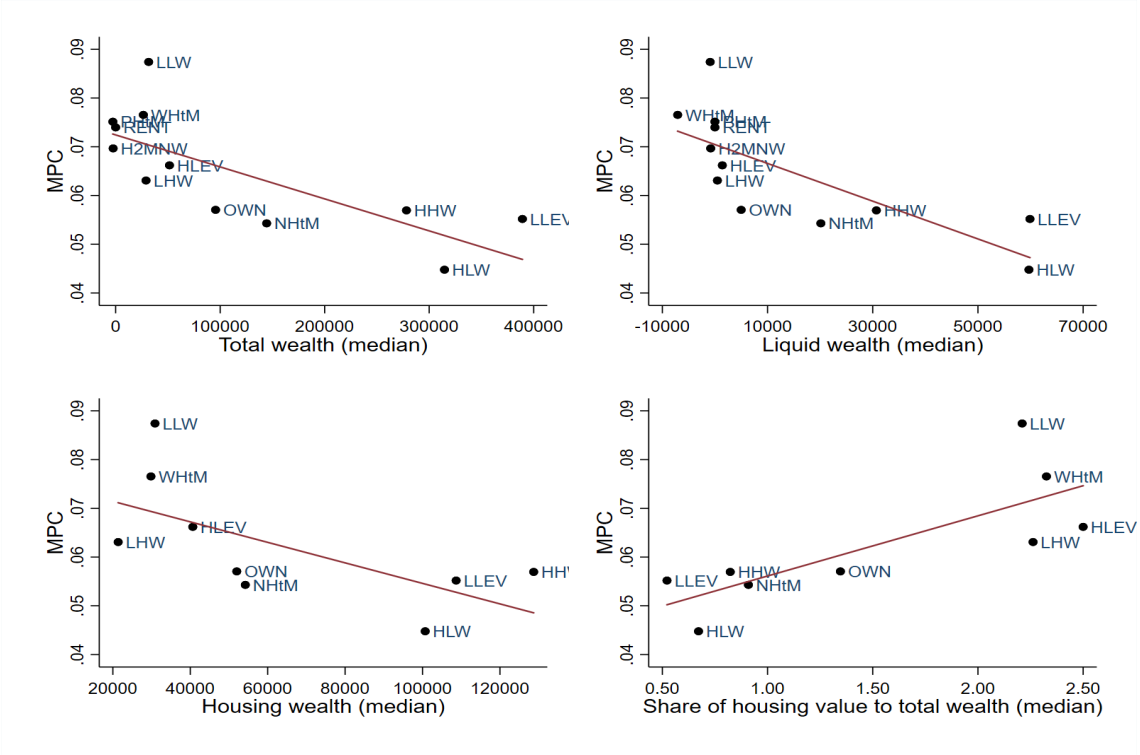



Figure 1: Marginal propensities to consume and household characteristics

Notes: The figure plots MPCs out of idiosyncratic transitory income shocks for different groups against their median total wealth (top left), liquid wealth (top right), housing wealth (bottom left), and share of housing value to total wealth (bottom right). Note that each point in these scatter plots corresponds to the MPC based on the estimated short-run elasticity and the median consumption-income ratio on the $y$-axis and the corresponding median balance sheet value on the $x$-axis for different household groups based on homeownership status (RENT/OWN), HtM status (PHtM/WHtM/NHtM), and homeowners further stratified into subgroups based on liquid wealth (LLW/HLW), housing wealth (LHW/HHW), and leverage (LLEV/HLEV), where the first L or H refers to households below or above median for a particular balance sheet characteristic.

come shocks using the biennial PSID data from 1999-2017 via a GMM/IV approach based on growth rates across waves, Commault (2020) finds that a biennial passthrough coefficient for a transitory income shock of 0.13 with standard error of 0.06 (see her Table 4) compared to our implied estimate of the short-run elasticity with respect to transitory shocks of 0.14 with standard error of 0.02.[11] Meanwhile, the estimate of the impact of transitory income shock on the permanent component of consumption, $\gamma_\epsilon$, for all households is 0.03 with a standard error of 0.01. As might be expected given the age distributions of the various household groups (in particular, substantial remaining life expectancies when receiving a transitory income shock), the estimated response of permanent consumption is always small for different household groups and is often insignificant. Thus, we focus on the transitory consumption responses to transitory income shocks, $\tilde{\gamma}_\epsilon$, in considering possible sources of MPC heterogeneity.[12]

Examining the cross-sectional pattern of heterogeneity in transitory consumption responses more closely, we first note that, based on homeownership status, renters have a higher transitory response than homeowners in our baseline results, although the difference does not appear to be statistically significant given the standard errors for the estimates. Among homeowners, there are large differences in balance sheet positions compared to renters, so we further stratify homeowners into subgroups based on liquid wealth, housing wealth, and leverage. Not surprisingly, and consistent with Figure 1, we find that homeowners with low liquid wealth, low housing wealth, and those who are highly leveraged have higher transitory responses relative to their respective counterparts. Among all of these subgroups, it is the estimated transitory response of homeowners with low liquid wealth that is highest at 0.17 with a standard error of 0.03 (this subgroup also had the highest MPC in Figure 1). Of these households, only 42% are WHtM. Although they are similar to the WHtM in many respects, the median value of their liquid assets is $-\$900$ vs. $-\$7086$ for WHtM households, see Tables 1 and 2. Removing HtM households from this subgroup further in-

[11] As noted in the previous section, the biennial passthrough coefficient will only be strictly equivalent to $\tilde{\gamma}_\epsilon + \gamma_\epsilon$ if there are no moving-average dynamics in transitory income at an annual frequency. Meanwhile, some of the difference in precision for the estimate is due to more missing observations for biennial growth rates when a household drops out and re-enters the survey. Notably, the estimated transitory response for all households based on QMLE for an unobserved components representation of biennial growth rates is 0.10 with a standard error of 0.02, which is slightly different and a bit less precise than the estimate reported in Table 3 based on estimation in levels.

[12] In principle, different median consumption-income ratios for different household groups could also play a role in MPC heterogeneity. However, we find that, in practice, most of the heterogeneity is accounted for by differences in transitory consumption responses.

Table 3: Estimates of consumption response parameters

| | **All** | **Renter** | **Homeowner** | **PHtM** | **WHtM** | **NHtM** |
|---|---|---|---|---|---|---|
| $\tilde{\gamma}_\epsilon$ | 0.11 (0.01) | 0.12 (0.02) | 0.11 (0.02) | 0.12 (0.03) | 0.13 (0.03) | 0.10 (0.02) |
| $\gamma_\epsilon$ | 0.03 (0.01) | 0.01 (0.01) | 0.03 (0.03) | 0.00 (0.00) | 0.03 (0.01) | 0.03 (0.01) |
| $\gamma_\eta$ | 0.38 (0.03) | 0.49 (0.00) | 0.34 (0.04) | 0.46 (0.03) | 0.47 (0.12) | 0.34 (0.04) |
| No. of households | 5047 | 2047 | 3633 | 1060 | 1285 | 3659 |
| | **Low LW** | **High LW** | **Low HW** | **High HW** | **High Lev.** | **Low Lev.** |
| $\tilde{\gamma}_\epsilon$ | 0.17 (0.03) | 0.08 (0.02) | 0.13 (0.03) | 0.10 (0.02) | 0.15 (0.03) | 0.12 (0.03) |
| $\gamma_\epsilon$ | 0.02 (0.01) | 0.03 (0.01) | 0.02 (0.01) | 0.02 (0.01) | 0.00 (0.02) | 0.01 (0.01) |
| $\gamma_\eta$ | 0.30 (0.08) | 0.27 (0.05) | 0.39 (0.05) | 0.27 (0.05) | 0.34 (0.08) | 0.22 (0.05) |
| No. of households | 2198 | 1949 | 2266 | 1910 | 2011 | 1793 |

Notes: The table reports point estimates of permanent and transitory consumption responses to permanent and transitory income shocks with standard errors in parentheses.

creases the estimated transitory response to 0.25 with a standard error of 0.05. This suggests that, despite not being HtM households, these homeowners are still liquidity constrained. Therefore, liquidity constraints for some homeowners extend beyond the HtM dimension, as also argued by Boar et al. (2020). Removing HtM households from low housing wealth and high leverage subgroups, however, has either no impact or leads to a small decrease in estimated transitory responses.[13] Meanwhile, consistent with related literature that distinguishes households based on their HtM status, for example Kaplan et al. (2014) and Aguiar et al. (2020), we also find that HtM households, both PHtM and WHtM, have somewhat higher estimated transitory responses compared to NHtM households, although the differences are not striking.[14]

## 3.2 Consumption insurance

In Figure 2 we plot the consumption insurance for each household group against median total wealth and housing wealth for that group. What is clear is that, while households do not have full consumption insurance against permanent income shocks, wealthier households

[13] See Table C–4 in the appendix for the full set of estimates.

[14] We find stronger heterogeneity in transitory responses along the HtM dimension when we consider a sample selection that does not exclude transient households, i.e. households with the same status for less than two consecutive periods. The results suggest that WHtM households have the highest transitory responses followed by PHtM and NHtM households, with the estimates of 0.18 (0.04), 0.13 (0.03), and 0.10 (0.03), respectively.

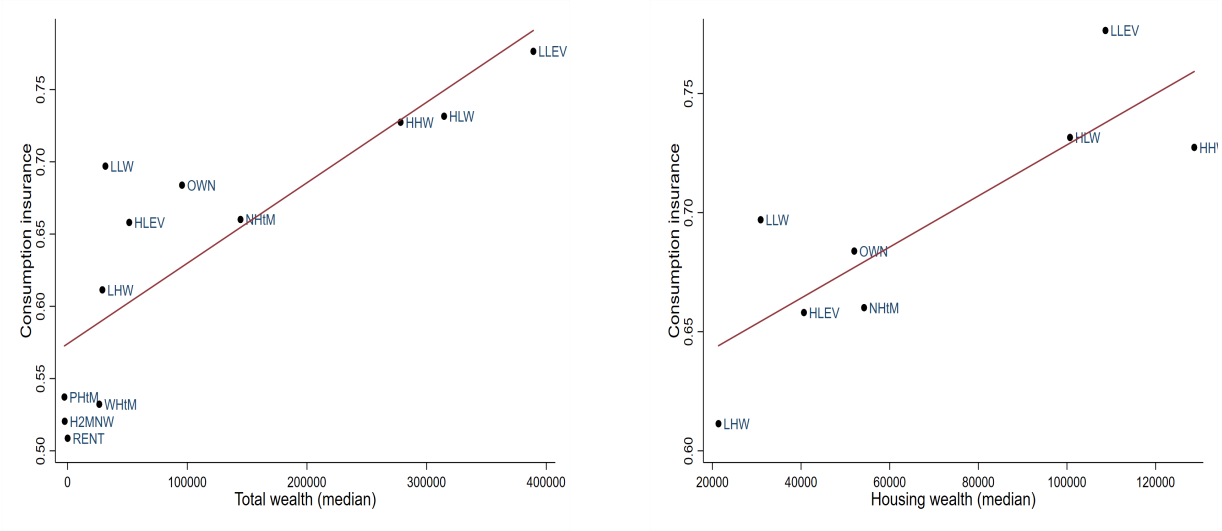



Figure 2: Consumption insurance

Notes: The figure plots consumption insurance for different groups against total wealth (left panel) and housing wealth (right panel). Note that each point in these scatter plots corresponds to consumption insurance on the $y$-axis and the corresponding median balance sheet value on the $x$-axis for different household groups based on homeownership status (RENT/OWN), HtM status (PHtM/WHtM/NHtM), and homeowners further stratified into subgroups based on liquid wealth (LLW/HLW), housing wealth (LHW/HHW), and leverage (LLEV/HLEV), where the first L or H refers to households below or above median for a particular balance sheet characteristic.

have a greater ability to absorb the shocks than poorer households. Meanwhile, in the face of a permanent shock, households may be more likely to incur transaction costs in accessing illiquid assets to smooth their consumption than in the case of a transitory shock. The estimates of the response of consumption to permanent income shocks, $\gamma_\eta$, are also reported in Table 3. For all households, the estimate is 0.38 with a standard error of 0.03, which implies that, on average, U.S. households have consumption insurance of 62%.[15]

# 4 Time-Varying Estimates

The rise in household debt and subsequent deleveraging, along with the boom and bust in housing wealth (see, for example, Mian et al., 2013 and Kaplan et al., 2020b), are often cited as important aspects of a household balance sheets that are crucial for understanding the effects of the Great Recession on consumption and the aggregate economy at large. Here we examine how the response of household consumption to idiosyncratic income shocks varied

[15] Chatterjee et al. (2020) find that consumption insurance was 55% in the BPP sample of data, which was a panel of annual observations for disposable income from PSID and imputed nondurable consumption over an earlier sample period of 1978-1992.

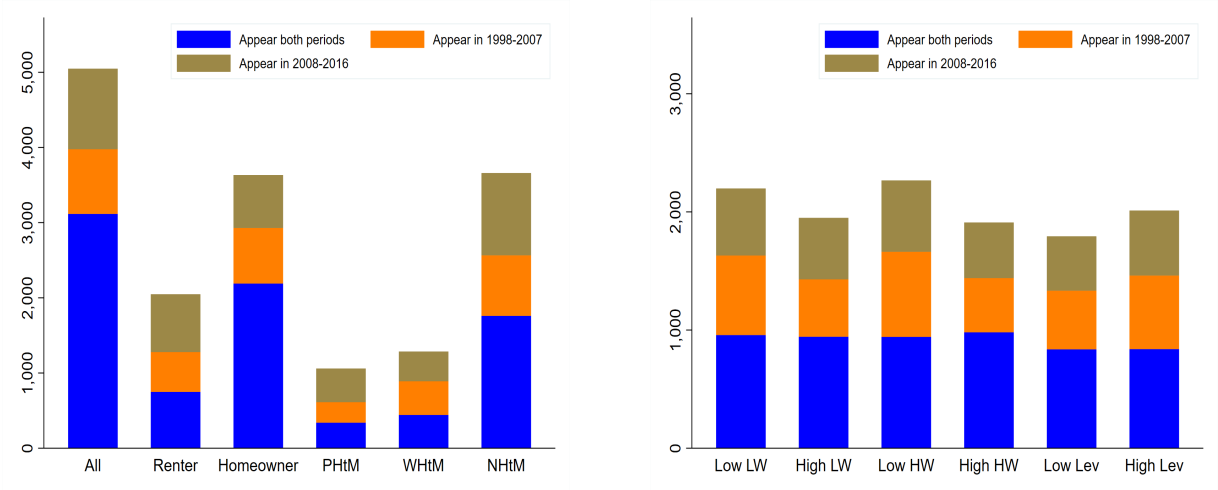



Figure 3: Number of households in one or both subsample periods

Notes: The blue bars represent the number of households who were in a subgroup in both periods, while the orange and brown bars show the number of households who were in a subgroup only in one subsample period.

from before to after the Great Recession.

As noted above, an important econometric concern regarding the time-varying analysis would be that the changes in the estimates of consumption responses might be partly due to compositional changes of the different household groups. That is, households classified in a particular group in subsample periods before and after 2007 might be different along both demographic and other balance sheet characteristics not used in classifying the groups. Moreover, households might endogenously transition out of a particular group over time. For example, low housing wealth homeowners become high housing wealth homeowners over time as they build equity or high leverage homeowners lower their debt after the Great Recession and transition to the low leverage homeowner subgroup.

Figure 3 reports the number of households who were in a particular group in both subsample periods (blue bars) or only one subsample period (orange or brown bars). The sum of all 3 bars gives the total number of households who appear at some point in particular group in the analysis presented in the previous section. The first bar of the left panel shows that 78% of all households in the first subsample period also appear in the second subsample period. Homeowners, as expected, are also relatively less transient and 75% of homeowners appear in both periods. However, renters, PHtM, and WHtM households transition out of their group more often. In particular, less than the half of households who were WHtM

before 2007 remained as WHtM in the period after 2007.[16] Similarly, subgroups based on homeowner balance sheets, the right panel of Figure 3, transition more often with more that than the half of homeowners in each balance sheet subgroup transitioning out of their subgroup classification from before to after the Great Recession.

To mitigate the impact of these transitions on our time-varying analysis, we consider two cases. In Sections 4.1 and 4.2, we first classify households into groups based on their status in the first subsample period. That is, we consider households who are classified in a particular group before 2007, but not those households who only appeared in that subgroup after 2007, corresponding to the households in the blue and orange bars in Figure 3.[17] For example, suppose a household was a renter before 2000 and became a homeowner from 2002 onward, this household is in the renter subgroup in 1998 and 2000, but in the homeowner subgroup from 2002 onward. In this case, the household's residual income and consumption data for the period 1998-2000 will be used in the renter group estimation, while the household's data from 2002 onward will be used in estimating the parameters for the homeowner group. In terms of Figure 3, this household is in the orange bar for the renter group and the blue bar for the homeowner group.[18] This strategy is designed to reduce the effect of possible endogenous transitions from one subgroup to another between the two sample periods considered in our analysis. Later in this section, we also consider an alternative and arguably more conservative classification to deal with possible endogenous transitions. In particular, we exclude households that were in a particular classification for only one of the two subsample periods. Specifically, we consider households in each group in the period before 2007 who also remained in that group in the period after 2007. Therefore, only the households in the blue bars in Figure 3 are included in this robustness analysis.

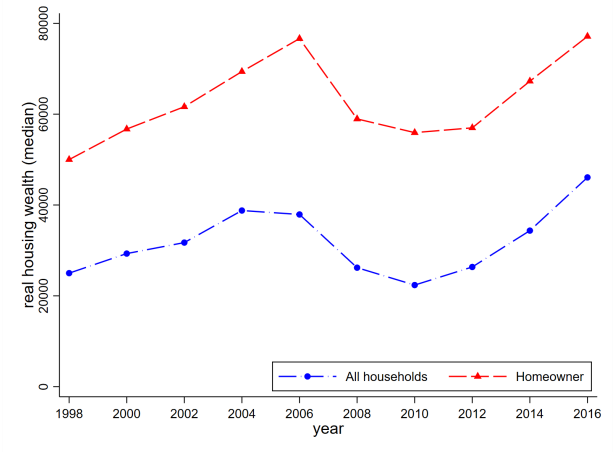
## 4.1 Trends in household wealth and leverage

**Housing wealth.** House prices increased before the Great Recession, plummeted during the Great Recession, and sluggishly recovered afterwards (see the left panel in Figure B–1

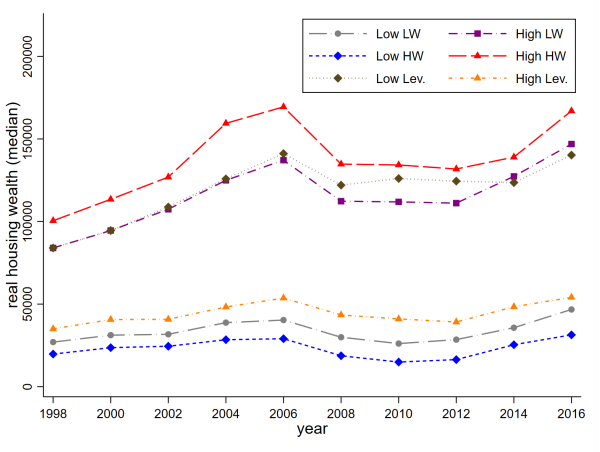
[16] This is consistent with Kaplan et al. (2014) who show that the expected duration of HtM status is 3.5 to 4.5 years.

[17] The summary statistics and overlaps between different household groups for this sample (reported in Tables F–1 to F–3 in the appendix) are similar to those reported in Tables 1, 2, and B–2.

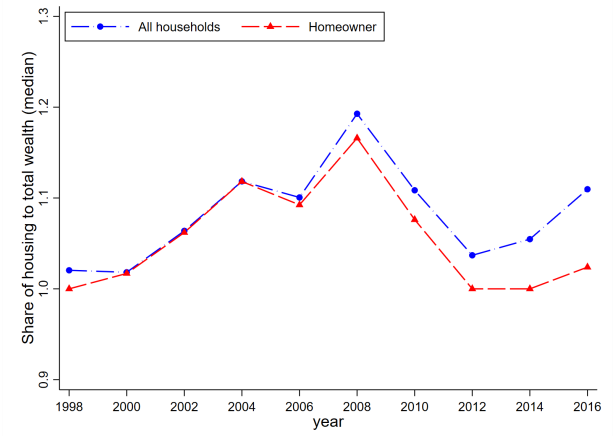
[18] To consider another example, suppose a household was a homeowner until 2006 and transitioned to being a renter from 2008. In this case, the household's data from 1998-2006 will be used in the estimation of the homeowner group. In terms of Figure 3, this household is in the orange bar for the renter group and the brown bar for the homeowner group.



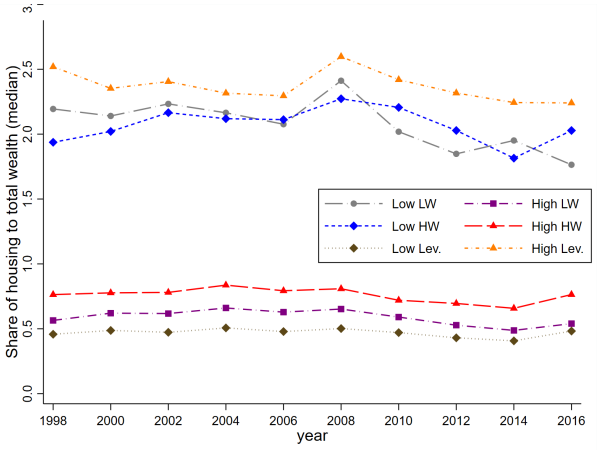

(a) Housing wealth: all and homeowners



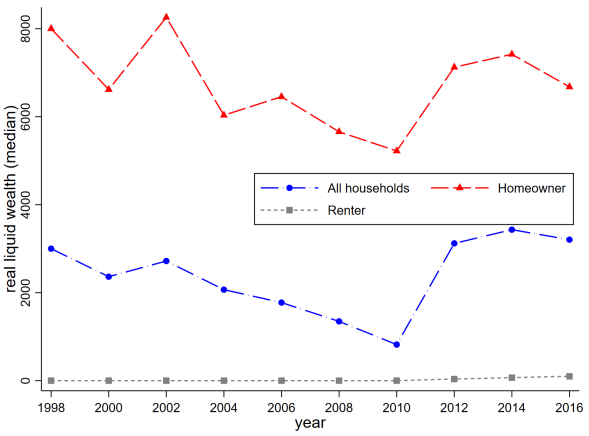

(b) Housing wealth: homeowner subgroups



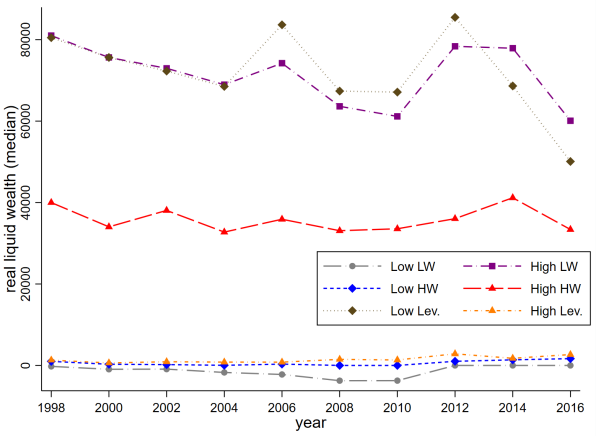

(c) Leverage: all and homeowners




(d) Leverage: homeowner subgroups




(e) Liquid wealth: all, homeowners and renters




(f) Liquid wealth: homeowner subgroups

Figure 4: Changes in the housing wealth, leverage, and liquid wealth

Notes: The plots depict the changes in median housing wealth (top panel), leverage (middle panel), and liquid wealth (bottom panel) for different subgroups.

in the appendix). Panel (a) in Figure 4 shows that the median real housing wealth for the all households and homeowners in the PSID data closely follows the pattern of house prices observed in the aggregate data. In Panel (b), we plot the same information for subgroups of homeowners and a similar pattern is also observed. Housing wealth reached its peak in 2006, declined until 2012, and rebounded since 2014. It is also worth noting that households fall into two broader categories – housing wealthy and housing poor. The former category includes high housing wealth, low leverage, and high liquid wealth homeowners. Although these homeowners are wealthier in terms of housing asset holdings, they also experienced relatively larger absolute declines in their housing wealth during the Great Recession. For instance, the median real housing wealth for homeowners in the high housing wealth groups was $137,000 in 2006, but it decreased to $111,000 in 2012, a decline of $26,000 (i.e. a 19% decrease). The housing poor category includes low liquid wealth, low housing wealth, and high leverage homeowners. Homeowners in these groups also had significant declines in their housing wealth and, because they had lower levels of housing wealth to begin with, the percentage declines are larger. For low liquid wealth homeowners, for example, housing wealth decreased from $40,300 in 2006 to $26,100 in 2010, which represents a decline of 35%.

**Leverage.** The household-debt-to-GDP ratio increased up to the Great Recession and only started to decline after 2010; see the right panel of Figure B–1. In Panels (c) and (d) of Figure 4, we plot household leverage, i.e., the share of housing value to total wealth, over our sample period. Panel (c) shows that household leverage in the PSID data increased gradually from 1.0 to 1.2 over the period of housing boom and decreased after the Great Recession to 1.0. This is in line with the widely-held notion that U.S. households were highly leveraged before the Great Recession and they deleveraged thereafter. As noted in Table 2, and also seen in Panel (d), the level of leverage is higher, close to 2.5, for homeowners in the housing poor group, that is low liquid wealth, low housing wealth, and high leverage homeowner subgroups, while it dropped to 1.8 after the Great Recession.

**Liquid wealth.** Panels (e) and (f) in Figure 4 plots liquid wealth of each household group. From Panel (e), we can see that liquid wealth decreased gradually from 2002 to 2010 for homeowners. Renters, in general, have low liquid wealth throughout the full sample period. Liquid wealth also varies quite significantly across the subgroups of homeowners. As

shown in Panel (f), housing poor homeowners, have low liquid wealth, while homeowners in high liquid wealth and low leverage subgroups have much higher levels of liquid wealth. It is also worth noting that the median liquid wealth of low liquid wealth homeowners is similar to that of renters.

## 4.2 Time-varying transitory responses and MPCs

Table 4 reports the estimated time-varying transitory consumption responses to idiosyncratic transitory income shocks, pre and post 2007. This table considers household groups based on status in the first subsample period, as described in the previous subsection. The estimated transitory response for all households increased from 0.09 to 0.14, and the increase is statistically significant given the Wald test.[19] In addition, for most groups, the estimated transitory response in the 2008-2016 subsample period is higher than in the 1998-2007 subsample period.[20]

Households who were homeowners before the Great Recession experienced a large and statistically-significant increase in their transitory consumption response in the latter period. The estimated response for homeowners was 0.08 before the Great Recession and 0.14 since then. By contrast, the estimated transitory response of renters with zero housing wealth increased only marginally and the increase is not statistically significant. A similar finding is also observed along the HtM dimension. WHtM and NHtM households, who typically have a large amount of their wealth in housing, saw an increase in their estimated transitory responses, although the change is not statistically significant, possibly due to a relatively small sample size, at least in the case of WHtM households. Note that in our sample 93% of WHtM and 79% of NHtM are homeowners. The result that the transitory consumption response increased for homeowners but not for renters suggests that such an increase could be associated with the negative wealth effects experienced by the homeowners during the

[19] Perhaps related, we note that Gross et al. (2019) find that the MPC out of liquidity increased by 30% between 2007 and 2009 using U.S. credit card transaction data.

[20] The full time-varying estimation results are reported in Tables D–1 to D–3 in the appendix. Estimates for consumption insurance with respect to permanent income shocks decreased or remained unchanged for most of subgroups after the Great Recession, but none of the changes is statistically significant. Guvenen et al. (2014) document that permanent income shocks occur much less frequently than transitory income shocks and that income risk is higher in recessions due to increased negative skewness of income shocks. Thus, consumption insurance may not have changed as much as responses to transitory shocks with the Great Recession because there are fewer permanent shocks and they may not have changed their distribution as much. Also, given less frequency, households would be more likely to pay fixed costs of accessing illiquid assets when facing permanent shocks and, therefore, not alter their response to such shocks as much as for transitory shocks.

Table 4: Time-varying transitory responses

| | All | Renter | Homeowner | PHtM | WHtM | NHtM |
|---|---|---|---|---|---|---|
| $\tilde{\gamma}_\epsilon$ 1998-2007 | 0.09 (0.02) | 0.10 (0.03) | 0.08 (0.02) | 0.07 (0.06) | 0.09 (0.04) | 0.09 (0.02) |
| $\tilde{\gamma}_\epsilon$ 2008-2016 | 0.14 (0.02) | 0.12 (0.04) | 0.14 (0.02) | 0.08 (0.07) | 0.13 (0.05) | 0.12 (0.03) |
| Wald statistic | 5.88 | 0.42 | 5.82 | 0.01 | 0.58 | 1.13 |
| No. of households | 3,977 | 1,278 | 2,930 | 612 | 890 | 2,566 |
| | **Low LW** | **High LW** | **Low HW** | **High HW** | **High Lev.** | **Low Lev.** |
| $\tilde{\gamma}_\epsilon$ 1998-2007 | 0.13 (0.03) | 0.09 (0.02) | 0.12 (0.03) | 0.09 (0.04) | 0.12 (0.03) | 0.10 (0.03) |
| $\tilde{\gamma}_\epsilon$ 2008-2016 | 0.26 (0.04) | 0.13 (0.03) | 0.13 (0.05) | 0.13 (0.04) | 0.17 (0.04) | 0.12 (0.04) |
| Wald statistic | 12.45 | 1.41 | 0.06 | 0.93 | 1.70 | 0.50 |
| No. of households | 1,631 | 1,429 | 1,663 | 1,440 | 1,462 | 1,334 |

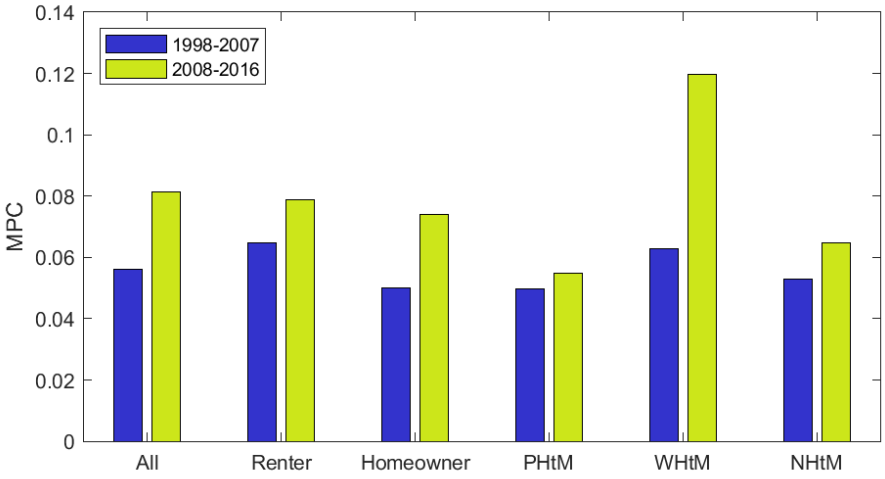
Notes: This table reports point estimates of transitory consumption responses to idiosyncratic transitory income shocks with standard errors in parentheses. It also reports Wald tests for parameter stability with a 5% critical value of 3.84 based on a $\chi^2(1)$ distribution.

housing bust.

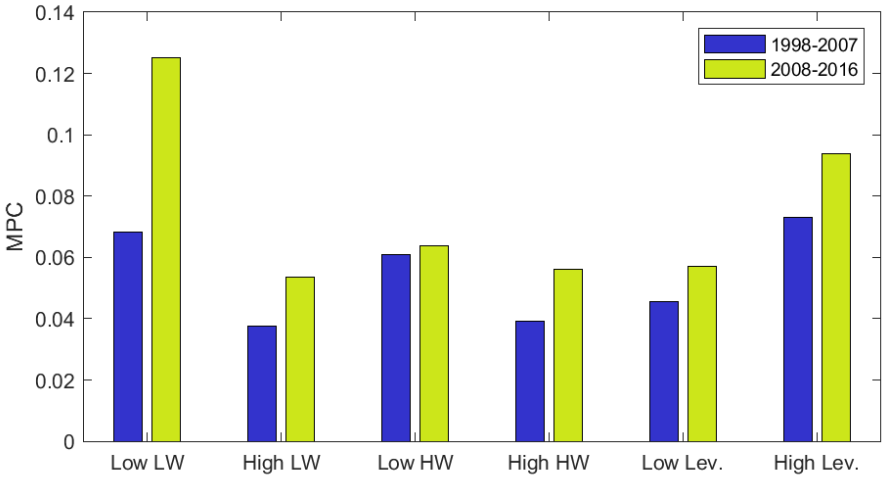
Examining the time-varying transitory responses for homeowner subgroups, it should also be noted that, while the increases are not always statistically significant, the transitory responses of homeowners in all subgroups increased in the second subsample period. Homeowners with low liquid wealth and high leverage experienced particularly large increases in their transitory responses, although the increase was only statistically significant for the low liquid wealth homeowners, with the estimated transitory response effectively doubling from 0.13 to 0.26. For high leverage homeowners, the increase was close to 50% from 0.12 to 0.17.[21]

Recall that, as noted above (and also seen in Table B–2), the overlaps between low liquid wealth homeowners and high leverage or HtM homeowners is substantial. To isolate the roles of particular aspects of homeowner balance sheets further, we exclude overlapping subgroups and re-estimate the model. As a result of this adjustment, the sample sizes become smaller and standard errors larger, which in turn impacts the Wald statistics for time-varying transitory responses. However, what we are interested in is whether the change in the transitory response in the second period is in the same direction after removing the over-

[21] Because house prices rebounded from 2012, we also considered estimation restricting the second sample to 2008-2012 for robustness. Our main conclusion, which is that the transitory responses significantly increased for liquidity-constrained homeowners, still holds. The full estimation results for this robustness check are reported in Tables from E–1 to E–3 in the appendix.




(a) Broad categories




(b) Homeowner subgroups

Figure 5: Time-varying MPCs

Notes: The figure plots MPCs out of idiosyncratic transitory income shocks for subsample period 1998-2007 (blue bar) and 2008-2016 (green bar) for different groups.

Table 5: Time-varying transitory responses after removing overlapping subgroups

| | **Low LW** | | **High Lev** |
|---|---|---|---|
| | w/o High Lev | w/o HtM | w/o Low LW |
| $\tilde{\gamma}_c$ 1998-2007 | 0.14 (0.07) | 0.14 (0.07) | 0.13 (0.06) |
| $\tilde{\gamma}_c$ 2008-2016 | 0.25 (0.10) | 0.39 (0.10) | 0.07 (0.08) |
| Wald statistic | 1.26 | 7.00 | 0.55 |
| No. of households | 560 | 753 | 319 |

Notes: This table reports point estimates of transitory consumption responses to idiosyncratic transitory income shocks with standard errors in parentheses for subgroups after removing overlaps. It also reports Wald tests for parameter stability with a 5% critical value of 3.84 based on a $\chi^2(1)$ distribution.

lapping households from the different groups. As seen from Table 5, excluding high leverage homeowners from the low liquid wealth homeowner subgroup yields a higher estimated transitory response in the second period, while excluding low liquid wealth homeowners from high leverage homeowners lowers the estimated transitory response in the second period. This implies that low liquid wealth is more relevant than leverage when considering changes in the response of consumption to transitory income shocks after 2007.[22] When we exclude HtM homeowners from low liquid wealth homeowners, we also find that the estimated transitory response increases in the second period and the increase is even larger than before and remains statistically significant. We also note that renters, who hold low levels of liquid wealth similar to low liquid wealth homeowners, do not appear to exhibit a higher transitory response in the second subsample period.

Figure 5 plots the time-varying MPCs based on time-varying consumption response estimates and median consumption-income ratios for each group in the subsample periods. The results closely reflect the changes in transitory consumption responses reported in Table 4. Recall that the the changes in consumption responses were significant for all households, homeowners, and low liquid wealth households. These cases stand out for the changes in the MPCs, although the MPC for WHtM households also appears large and may only be insignificant because of a relatively small sample size. Taken together, these results suggest that a negative housing wealth effect amplified by diminished liquidity is closely related to a rise in transitory consumption responses and MPCs since the Great Recession. Intuitively, homeowners could easily access additional liquidity through their housing wealth such as

[22]We also estimate our model for subgroups based on debt-to-asset ratios for homeowners. The estimated transitory responses for high debt-to-asset ratio homeowners are 0.14 (0.03) and 0.13 (0.05) in the first and second subsample periods, respectively.

Table 6: Time-varying transitory responses based on group status in both subsample periods

| | **All** | **Renter** | **Homeowner** | **PHtM** | **WHtM** | **NHtM** |
|---|---|---|---|---|---|---|
| $\tilde{\gamma}_\epsilon$ 1998-2007 | 0.10 (0.02) | 0.12 (0.04) | 0.09 (0.02) | 0.11 (0.07) | 0.08 (0.06) | 0.08 (0.03) |
| $\tilde{\gamma}_\epsilon$ 2008-2016 | 0.14 (0.02) | 0.13 (0.04) | 0.14 (0.02) | 0.09 (0.07) | 0.12 (0.03) | 0.12 (0.03) |
| Wald statistic | 3.67 | 0.08 | 3.72 | 0.13 | 0.45 | 1.31 |
| No. of households | 3,117 | 749 | 2,190 | 340 | 442 | 1,761 |
| | **Low LW** | **High LW** | **Low HW** | **High HW** | **High Lev.** | **Low Lev.** |
| $\tilde{\gamma}_\epsilon$ 1998-2007 | 0.12 (0.04) | 0.10 (0.04) | 0.10 (0.04) | 0.10 (0.03) | 0.13 (0.04) | 0.12 (0.03) |
| $\tilde{\gamma}_\epsilon$ 2008-2016 | 0.25 (0.04) | 0.12 (0.04) | 0.12 (0.05) | 0.12 (0.03) | 0.16 (0.05) | 0.13 (0.04) |
| Wald statistic | 9.60 | 0.36 | 0.13 | 0.38 | 0.36 | 0.06 |
| No. of households | 958 | 944 | 942 | 981 | 839 | 837 |

Notes: This table reports point estimates of transitory consumption responses to idiosyncratic transitory income shocks with standard errors in parentheses for groups based on status in both subsample periods. It also reports Wald tests for parameter stability with a 5% critical value of 3.84 based on a $\chi^2(1)$ distribution.

Home Equity Lines of Credit (HELOC) during the housing boom period, but it became more costly for them to do so during the housing bust.[23] As house prices fell and housing wealth declined, credit constraints become tighter for many homeowners due to a fall in the value of their collateral. This made it more difficult for them to borrow to smooth consumption in the event of transitory shocks to their income.[24]

**Time-varying transitory responses based on an alternative classification**. To further corroborate our conclusions drawn from Table 4, we also consider only households that appear in a particular group in both subsample periods. The households considered in this case correspond to the blue bars in Figure 3 and, as a result of the smaller sample size, the standard errors for the estimates are generally larger. For most of the household groups, the main conclusion drawn based on the estimates in Table 4 hold up. Again, low liquid wealth homeowners stand out and their transitory response is significantly higher, statistically and economically, after the Great Recession. This alternative classification of subgroups reinforces our conclusion that liquidity-constrained homeowners are highly sensitive to transi-

[23] Hurst and Stafford (2004) provide empirical evidence that households do use their housing wealth to insure against bad income realizations.

[24] In Tables from E–4 to E–6 in the appendix, we report time-varying estimation results that remove housing (rent and imputed rent) from the measure of consumption. Although the estimates of transitory responses become slightly larger, the qualitative conclusions remain unchanged, with transitory responses increasing since the Great Recession and the increases being larger for liquidity-constrained homeowners.

tory income shocks and the increase in sensitivity corresponds to a negative housing wealth effect.

Apart from time variation in transitory consumption responses, the results in this section also point towards changed cross-sectional patterns in MPCs. Before the Great Recession, households with high MPCs were mainly renters and WHtM. Homeowners' balance sheets did not appear to matter quite as much; see the 1998-2007 MPCs in the lower panel of Figure 5. However, since the Great Recession when household balance sheet changed substantially, our results suggest that, in addition to renters and WHtM households, homeowners, particularly liquidity-constrained homeowners, also have high MPCs. Notably, the collapse in housing wealth had a severe impact on liquidity-constrained homeowners even though many of them are not classified as HtM. Around 48% (in terms of $N$) of low liquid wealth homeowners are NHtM and they constitute 20% of the whole sample of households, suggesting that the decline in housing wealth during the Great Recession resulted in a substantial rise in the proportion of households who behave like HtM.[25] In particular, the Great Recession has increased the proportion of households who respond sensitively to transitory income shocks and raised the MPC for all households.

### 4.3 Consumption elasticities with respect to house prices

Using the estimates of MPCs before and after the Great Recession, we compute the consumption elasticity with respect to house prices, $\omega$, for each group over the two subsample periods. We use the rule-of-thumb formula proposed by Berger et al. (2018):

$$\omega = \text{MPC} \times (1-\delta)\frac{P_{t-1}H_{it-1}}{C_{it}} \tag{9}$$

where $\delta$ is the depreciation rate for housing, set to 2% per annum, and $PH$ is the reported housing value in the PSID expressed in real terms using the housing component of the CPI. The $PH/C$ term is set to the median value for each group in each subsample, while the MPC values are based on the time-varying estimates and the median consumption-income ratio for each group in each subsample period. Equation (9) implies that the consumption elasticity with respect to house price shocks will be larger if the MPC and the ratio of housing value to income are larger.

[25] After excluding HtM households from low liquid wealth homeowners, the estimated transitory responses in the first and second subsample periods are 0.14 (0.07) and 0.39 (0.10), respectively, and the change is statistically significant.

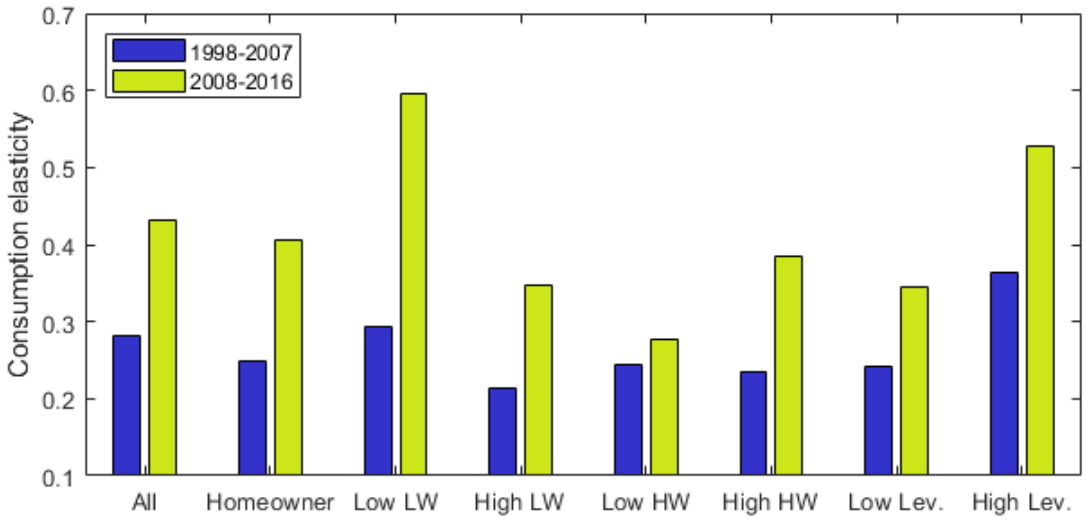



Figure 6: Consumption elasticity with respect to house prices

Notes: The figure plots elasticities of consumption with respect to house prices for subsample period 1998-2007 (blue bar) and 2008-2016 (green bar) for a subset of groups.

The consumption elasticity with respect to house prices has often been employed (see, for example, Mian et al., 2013, Kaplan et al., 2020b and Berger et al., 2018) to understand the mechanism behind consumption declines during the Great Recession. Consistent with higher MPCs in the second subsample period, Figure 6 also shows that consumption elasticities with respect to house prices increased since the Great Recession, despite a fall in the house-value-to-consumption ratio. For all households, the calculated elasticity is 0.28 for the subsample period before the Great Recession and 0.43 for the subsample period afterwards. The 95% confidence intervals in each period are [0.20, 0.36] and [0.32, 0.55], respectively. Our estimates of the consumption elasticity for all households are in line with the estimates in Berger et al. (2018).[26] As with MPCs, the increase in the elasticity is largest for low liquid wealth homeowners.[27] This finding somewhat contradicts a widely-held view that household indebtedness is detrimental to consumption during economic downturns (see, for example, Guerrieri and Lorenzoni, 2017 and Garriga and Hedlund, 2020). If leverage had played the most significant role, then we would expect that households who were

[26]Using a sample period from 1998 to 2010 and the BPP approach to estimate the MPC, Berger et al. (2018) compute an aggregate elasticity of 0.33 with a 95% confidence interval of [0.15, 0.52].

[27]The consumption elasticity with respect to house prices also increased for households in the HtM subgroups. For WHtM households, it increased from 0.18 to 0.27. Similarly, the elasticity of NHtM households increased from 0.19 to 0.29.

more leveraged to have had a large and significant increase in MPCs and, therefore, the larger increase in their consumption elasticity with respect to house prices. Instead our result suggests that increases in elasticities are primarily due to a housing wealth effect, as argued by Kaplan et al. (2020a). The negative housing wealth effect on consumption is then further amplified by liquidity constraints faced by homeowners.

# 5 Discussion and Conclusion

How do our results align with theories of consumption behavior? Starting with a standard one-asset consumption model that features a precautionary savings motive in the presence of income uncertainty and incomplete markets, poor households with low levels of wealth should have high MPCs; see, for example, Carroll and Kimball (1996), Carroll (1997), and Kaplan and Violante (2010).[28] The consumption policy function in these models is strictly concave with respect to wealth, steep at low levels of wealth, and almost flat at higher levels of wealth. Our baseline results in which estimated MPCs are decreasing in total wealth and housing wealth in Figure 1 are, therefore, qualitatively consistent with the predictions of models with a precautionary savings motive. In Table 3, a higher estimated transitory consumption response for PHtM households relative to the estimated transitory response for NHtM households is also consistent with one-asset models, although the difference is not large. However, as argued in Kaplan and Violante (2014), this class of models fails to generate large consumption responses in the aggregate partly because there are too few households with close to zero wealth, and hence with a high enough implied MPC in a one-asset setting. Note that PHtM only constitute 11% of the sample of households. Moreover, this class of models cannot explain high estimated consumption responses for WHtM households or homeowners with low liquid wealth, high leverage, or high housing wealth relative to their respective counterparts in Table 3.

In the two-asset (liquid and illiquid) model of Kaplan and Violante (2014), a higher return on the illiquid asset induces a trade-off between consumption smoothing and higher life-time consumption. In this setting, some households will find it optimal to hold relatively few liquid assets while holding a large amount of illiquid assets. Such a model can, therefore, generate a larger fraction of households who are HtM and have a high MPC in order to bring the quantitative predictions of the model closer to the estimates of large sensitivities

[28] In this class of models, a precautionary savings motive arises due to the presence of either occasionally-binding borrowing constraints or concave marginal utility.

of consumption to transitory changes in income seen in the data.[29] In the sample of households considered in Table 3, 24% of the households are HtM. The prediction of this two-asset model is thus consistent with our finding that WHtM exhibit high transitory consumption responses, as seen in Table 3.

In these two-asset models then, what mechanism would generate a rise in the transitory consumption response for all households, as seen our time-varying analysis in Table 4? This increase in the aggregate is possible if either the fraction of people who are liquidity constrained increases or the sensitivity of consumption to idiosyncratic transitory income shock increases. Our empirical results suggest that both mechanisms are at play. A negative housing wealth effect and diminished liquidity of homeowners is associated with an increase in the sensitivity of consumption to transitory income shocks. Our results also suggest that, because close to 50% of homeowners with low levels of liquid wealth are not classified as HtM, there is also an increase in the proportion of households who behave like HtM households in a two-asset setting. The time-varying results are consistent with the theoretical result of Boar et al. (2020), who carefully model the illiquid asset as housing in a two-asset incomplete markets model that features detailed institutional aspects of the U.S. housing market, including loan-to-value and payment-to-income ratios, as well as long-term mortgages. They show that liquidity constraints bind for most homeowners, even though these homeowners might not be technically classified as HtM. Put differently, in their model, the fraction of liquidity-constrained homeowners is larger than the fraction of homeowners who are HtM. This is consistent with our findings that MPC heterogeneity extends well beyond the HtM status of households and that liquidity-constrained homeowners experienced a large increase in their MPCs after the Great Recession.

**Conclusion.** Which households respond the most to changes in income over time? In this paper, we have uncovered heterogeneity in marginal propensities to consume out of income before and after the Great Recession by estimating consumption responses using a panel unobserved components model. We show that homeowners with low levels of liquid wealth in particular have a high transitory response to idiosyncratic transitory income shocks. Despite the high transitory response, we note that many these low liquid wealth homeowners either have high enough income or enough holdings of liquid wealth such that they would

[29] Carroll et al. (2017) show that introducing heterogeneity in discount factors can generate the fraction of households with a low level of wealth as in the data, while simultaneously matching the mean level of wealth in the data.

not be classified hand-to-mouth. Next, we find that the transitory responses for homeowners who experienced a large decline in their housing wealth increased significantly after the Great Recession. Among subgroups of homeowners, homeowners with low liquid wealth saw the largest increase. The rise in transitory responses after the Great Recession appears to be driven by a negative housing wealth effect that is amplified by liquidity constraints faced by homeowners. Our results also shed light on the mechanism behind the decline in consumption during the Great Recession. Relative to during the housing boom, the consumption elasticity with respect to house prices during and after the housing bust increased primarily due to a negative housing wealth effect. Again, the negative housing wealth effect had a more severe impact on liquidity-constrained homeowners.

In terms of policy implications, our findings support the view that stabilization policies designed to improve liquidity of homeowners would be more effective than that debt relief programs (see e.g., Ganong and Noel (2020) and Boar et al. (2020)) during and in the aftermath of a recession associated with a collapse in house prices. We also highlight that our QMLE approach to estimation allows us to obtain more precise estimates of consumption elasticities in small samples, which are crucial for understanding heterogeneity across subgroups and different time periods. This approach also lets us formally test the stability of consumption responses over time.

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# A State-Space Form

In this appendix, we present the state-space form for the unobserved components representation of the model in levels discussed in Section 2.3.

Suppressing household-specific subscripts for simplicity and letting $z$ denote the accumulation of a shock, the observation equation for our model in levels is

$$\mathbf{y_t} = \mathbf{H}\mathbf{X_t},$$

where

$$\mathbf{y_t} = \begin{bmatrix} y_t \\ c_t \end{bmatrix}, \ \mathbf{H} = \begin{bmatrix} 1 & 0 & 1 & 0 & 0 \\ \tilde{\gamma}_\epsilon & 1 & \gamma_\eta & \gamma_\epsilon & 1 \end{bmatrix}, \text{ and } \mathbf{X_t} = \begin{bmatrix} \epsilon_t \\ \upsilon_t \\ \tau_t \\ z_{\epsilon t} \\ z_{ut} \end{bmatrix}.$$

The state equation is

$$\mathbf{X_t} = \mathbf{F}\mathbf{X_{t-1}} + \mathbf{v_t},$$

where

$$\mathbf{F} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix}, \ \mathbf{v_t} = \begin{bmatrix} \epsilon_t \\ \upsilon_t \\ \eta_t \\ \epsilon_t \\ u_t \end{bmatrix},$$

and the covariance matrix of $\mathbf{v}_t$, $\mathbf{Q}$, is given by

$$\mathbf{Q} = \begin{pmatrix} \sigma^2_{\epsilon,t} & 0 & 0 & \sigma^2_{\epsilon,t} & 0 \\ 0 & \sigma^2_{\upsilon,t} & 0 & 0 & 0 \\ 0 & 0 & \sigma^2_{\eta,t} & 0 & 0 \\ \sigma^2_{\epsilon,t} & 0 & 0 & \sigma^2_{\epsilon,t} & 0 \\ 0 & 0 & 0 & 0 & \sigma^2_{u,t} \end{pmatrix}.$$

Given a state-space form and an assumption of Normality, the Kalman filter can then be used to calculate the quasi likelihood based on the prediction error decomposition and an assumption of independence of idiosyncratic income and consumption across households. We adapt the Kalman filter equations to handle missing observations, which are prevalent in the PSID.

We evaluate the quasi likelihood from the second time period of the data in levels using highly diffuse priors on initial values of unobserved stochastic trends centered at $\tau_{0|0} = y_1$, $z_{\epsilon 0|0} = 0$, and $z_{u0|0} = c_1 - \gamma_\eta y_1$ (or first available values given missing observations) with variances of 100 along with $\epsilon_{0|0} = \epsilon_{-1|0} = \upsilon_{0|0} = 0$ and variances of these shocks to initialize the Kalman filter.[30]

[30] See Chatterjee et al. (2020) for more details on estimation via QMLE and the Kalman filter.

# B Additional Figure and Tables for Sample Selection

In this appendix, the figure plots the aggregate time series of the house price index and household debt-to-GDP ratio in the United States. The two tables present the observations dropped during sample selection and the overlap between household groups for our analysis in Section 3.


Figure B–1: House price index and Household debt to GDP ratio in the United States

Source: Federal Housing Finance Association; FRED, Federal Reserve Bank of St. Louis

Table B–1: Sample selection

| Description | Dropped | Remaining |
|---|---|---|
| Initial unbalanced sample | | 83,831 |
| Intermittent headship | 13,266 | 70,565 |
| Income outliers | 10,314 | 60,251 |
| Missing observations on race, education, or state of residence | 1,479 | 58,772 |
| Less than 3 years of appearance | 3,289 | 55,483 |
| Age restriction and SEO households | 23,466 | 32,017 |
| At least two consecutive years of appearance | 187 | 31,830 |

Table B–2: Overlaps between the subgroups

| | Renter | Homeowner | Low LW | High LW | Low HW | High HW | High Lev | Low Lev | PHtM | WHtM | NHtM |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Renter | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.41 | 0.04 | 0.34 |
| Homeowner | 0.00 | 1.00 | 0.43 | 0.43 | 0.45 | 0.45 | 0.43 | 0.43 | 0.01 | 0.18 | 0.64 |
| Low LW | 0.00 | 1.00 | 1.00 | 0.00 | 0.67 | 0.24 | 0.53 | 0.15 | 0.02 | 0.42 | 0.29 |
| High LW | 0.00 | 1.00 | 0.00 | 1.00 | 0.24 | 0.69 | 0.23 | 0.64 | 0.00 | 0.00 | 1.00 |
| Low HW | 0.00 | 1.00 | 0.63 | 0.23 | 1.00 | 0.00 | 0.49 | 0.18 | 0.02 | 0.27 | 0.48 |
| High HW | 0.00 | 1.00 | 0.22 | 0.65 | 0.00 | 1.00 | 0.26 | 0.61 | 0.00 | 0.09 | 0.81 |
| High Lev. | 0.00 | 1.00 | 0.61 | 0.27 | 0.59 | 0.31 | 1.00 | 0.00 | 0.00 | 0.26 | 0.56 |
| Low Lev. | 0.00 | 1.00 | 0.17 | 0.72 | 0.21 | 0.73 | 0.00 | 1.00 | 0.00 | 0.07 | 0.85 |
| PHtM | 0.90 | 0.06 | 0.06 | 0.00 | 0.06 | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 |
| WHtM | 0.06 | 0.93 | 0.92 | 0.00 | 0.62 | 0.21 | 0.49 | 0.14 | 0.00 | 1.00 | 0.00 |
| NHtM | 0.13 | 0.78 | 0.15 | 0.52 | 0.26 | 0.45 | 0.25 | 0.40 | 0.00 | 0.00 | 1.00 |

Notes: The table reports the fraction of $N \times t$ observations that overlap with other classifications. These overlaps are based on the sample that was used in the analysis of constant MPC in Section 3.

# C Full Set of Estimates for Baseline Consumption Responses

This appendix reports the full set of estimates for our empirical model in the baseline case considered in Section 3 where consumption responses are held constant over the full sample period.

Table C–1: Full Estimates for subgroups by homeownership status

| | | All | Renters | Homeowners |
|---|---|---|---|---|
| | | | INCOME | |
| $\sigma_\eta$ | 1998-06 | 0.12 (0.00) | 0.12 (0.01) | 0.12 (0.01) |
| | 2007-16 | 0.13 (0.00) | 0.14 (0.01) | 0.11 (0.00) |
| $\sigma_\epsilon$ | 1998-06 | 0.26 (0.00) | 0.31 (0.01) | 0.24 (0.00) |
| | 2007-16 | 0.26 (0.00) | 0.32 (0.01) | 0.22 (0.01) |
| | | | CONSUMPTION | |
| $\sigma_u$ | 1998-07 | 0.08 (0.01) | 0.08 (0.04) | 0.08 (0.01) |
| | 2008-16 | 0.10 (0.00) | 0.11 (0.01) | 0.09 (0.00) |
| $\sigma_v$ | 1998-07 | 0.26 (0.01) | 0.34 (0.02) | 0.21 (0.01) |
| | 2008-16 | 0.30 (0.00) | 0.36 (0.01) | 0.24 (0.00) |
| $\gamma_\epsilon$ | | 0.03 (0.01) | 0.01 (0.01) | 0.03 (0.03) |
| $\tilde{\gamma}_\epsilon$ | | 0.11 (0.01) | 0.12 (0.02) | 0.11 (0.02) |
| $\gamma_\eta$ | | 0.38 (0.03) | 0.49 (0.00) | 0.32 (0.03) |
| $N$ | | 5047 | 2047 | 3633 |

Notes: The table reports full estimates with standard errors in parentheses for Table 3 in the main text.

Table C–2: Full Estimates for subgroups by HtM status

| | | PHtM | WHtM | NHtM | $HtM_{nw}$ |
|---|---|---|---|---|---|
| | | | INCOME | | |
| $\sigma_\eta$ | 1998-07 | 0.12 (0.02) | 0.11 (0.01) | 0.11 (0.01) | 0.12 (0.01) |
| | 2008-16 | 0.15 (0.02) | 0.09 (0.01) | 0.11 (0.01) | 0.13 (0.01) |
| $\sigma_\epsilon$ | 1998-07 | 0.34 (0.01) | 0.26 (0.01) | 0.24 (0.01) | 0.29 (0.01) |
| | 2008-16 | 0.33 (0.01) | 0.26 (0.01) | 0.24 (0.01) | 0.30 (0.01) |
| | | | CONSUMPTION | | |
| $\sigma_u$ | 1998-07 | 0.16 (0.06) | 0.07 (0.04) | 0.08 (0.01) | 0.06 (0.04) |
| | 2008-16 | 0.13 (0.02) | 0.10 (0.02) | 0.10 (0.01) | 0.10 (0.01) |
| $\sigma_v$ | 1998-07 | 0.35 (0.04) | 0.27 (0.02) | 0.22 (0.01) | 0.33 (0.02) |
| | 2008-16 | 0.34 (0.01) | 0.26 (0.01) | 0.27 (0.01) | 0.34 (0.01) |
| $\gamma_\epsilon$ | | 0.00 (0.00) | 0.03 (0.01) | 0.03 (0.01) | 0.00 (0.00) |
| $\tilde{\gamma}_\epsilon$ | | 0.12 (0.03) | 0.13 (0.03) | 0.10 (0.02) | 0.13 (0.03) |
| $\gamma_\eta$ | | 0.46 (0.03) | 0.47 (0.12) | 0.34 (0.04) | 0.48 (0.01) |
| $N$ | | 1060 | 1285 | 3659 | 1886 |

The table reports full estimates with standard errors in parentheses for Table 3 in the main text.

Table C–3: Full Estimates for subgroups of homeowners

| | | Low LW | High LW | Low HW | High HW | High Lev. | Low Lev. |
|---|---|---|---|---|---|---|---|
| | | | | INCOME | | | |
| $\sigma_\eta$ | 1998-07 | 0.12 (0.01) | 0.11 (0.01) | 0.11 (0.01) | 0.12 (0.01) | 0.10 (0.01) | 0.13 (0.01) |
| | 2008-16 | 0.10 (0.01) | 0.11 (0.01) | 0.11 (0.01) | 0.11 (0.01) | 0.09 (0.01) | 0.12 (0.01) |
| $\sigma_\epsilon$ | 1998-07 | 0.24 (0.01) | 0.24 (0.01) | 0.22 (0.01) | 0.25 (0.01) | 0.22 (0.01) | 0.25 (0.01) |
| | 2008-16 | 0.23 (0.01) | 0.22 (0.01) | 0.20 (0.01) | 0.23 (0.01) | 0.20 (0.01) | 0.24 (0.01) |
| | | | | CONSUMPTION | | | |
| $\sigma_u$ | 1998-07 | 0.08 (0.01) | 0.08 (0.01) | 0.07 (0.01) | 0.07 (0.01) | 0.08 (0.01) | 0.08 (0.01) |
| | 2008-16 | 0.10 (0.01) | 0.09 (0.01) | 0.08 (0.01) | 0.09 (0.01) | 0.08 (0.01) | 0.10 (0.01) |
| $\sigma_v$ | 1998-07 | 0.23 (0.01) | 0.18 (0.01) | 0.21 (0.01) | 0.20 (0.01) | 0.18 (0.01) | 0.20 (0.01) |
| | 2008-16 | 0.25 (0.01) | 0.23 (0.01) | 0.26 (0.01) | 0.23 (0.01) | 0.22 (0.01) | 0.25 (0.01) |
| $\gamma_\epsilon$ | | 0.02 (0.01) | 0.03 (0.01) | 0.02 (0.01) | 0.02 (0.01) | 0.00 (0.02) | 0.01 (0.01) |
| $\tilde{\gamma}_\epsilon$ | | 0.17 (0.03) | 0.08 (0.02) | 0.13 (0.03) | 0.10 (0.02) | 0.15 (0.03) | 0.12 (0.03) |
| $\gamma_\eta$ | | 0.30 (0.08) | 0.27 (0.05) | 0.39 (0.05) | 0.27 (0.05) | 0.34 (0.08) | 0.22 (0.05) |
| $N$ | | 2198 | 1949 | 2266 | 1910 | 2011 | 1793 |

The table reports full estimates with standard errors in parentheses for Table 3 in the main text.

Table C–4: Full Estimates for homeowners without HtM

| | | Low LW | Low HW | High Lev |
|---|---|---|---|---|
| | | | INCOME | |
| $\sigma_\eta$ | 1998-07 | 0.12 (0.01) | 0.10 (0.01) | 0.09 (0.01) |
| | 2008-16 | 0.08 (0.01) | 0.11 (0.01) | 0.09 (0.01) |
| $\sigma_\epsilon$ | 1998-07 | 0.22 (0.01) | 0.23 (0.01) | 0.21 (0.01) |
| | 2008-16 | 0.21 (0.01) | 0.18 (0.01) | 0.19 (0.01) |
| | | | CONSUMPTION | |
| $\sigma_u$ | 1998-07 | 0.08 (0.01) | 0.07 (0.01) | 0.08 (0.01) |
| | 2008-16 | 0.10 (0.01) | 0.08 (0.01) | 0.07 (0.01) |
| $\sigma_v$ | 1998-07 | 0.21 (0.01) | 0.21 (0.01) | 0.17 (0.01) |
| | 2008-16 | 0.25 (0.01) | 0.26 (0.01) | 0.23 (0.01) |
| $\gamma_\epsilon$ | | 0.00 (0.03) | 0.01 (0.02) | 0.02 (0.01) |
| $\tilde{\gamma}_\epsilon$ | | 0.25 (0.05) | 0.13 (0.03) | 0.12 (0.03) |
| $\gamma_\eta$ | | 0.13 (0.09) | 0.41 (0.06) | 0.38 (0.07) |
| $N$ | | 1726 | 1998 | 1316 |

Notes: The table reports point estimates with standard errors in parentheses.

# D Full Set of Estimates for Time-Varying Consumption Responses

This appendix reports the full set of estimates for our empirical model considered in Section 4 allowing for the time-varying consumption responses.

Table D–1: Full time-varying estimates for subgroups by homeownership status

| | | All | Renters | Homeowners |
|---|---|---|---|---|
| | | | INCOME | |
| $\sigma_\eta$ | 1998-06 | 0.12 (0.00) | 0.12 (0.01) | 0.12 (0.00) |
| | 2007-16 | 0.12 (0.00) | 0.13 (0.01) | 0.10 (0.00) |
| $\sigma_\epsilon$ | 1998-06 | 0.26 (0.00) | 0.31 (0.01) | 0.24 (0.00) |
| | 2007-16 | 0.24 (0.00) | 0.28 (0.01) | 0.22 (0.00) |
| | | | CONSUMPTION | |
| $\sigma_u$ | 1998-07 | 0.08 (0.01) | 0.08 (0.04) | 0.08 (0.01) |
| | 2008-16 | 0.10 (0.00) | 0.10 (0.01) | 0.09 (0.00) |
| $\sigma_v$ | 1998-07 | 0.26 (0.01) | 0.34 (0.02) | 0.21 (0.01) |
| | 2008-16 | 0.28 (0.00) | 0.33 (0.01) | 0.24 (0.01) |
| $\gamma_\epsilon$ | 1998-07 | 0.03 (0.01) | 0.02 (0.02) | 0.03 (0.01) |
| | 2008-16 | 0.03 (0.01) | 0.02 (0.02) | 0.03 (0.01) |
| $\tilde{\gamma}_\epsilon$ | 1998-07 | 0.09 (0.02) | 0.10 (0.03) | 0.08 (0.02) |
| | 2008-16 | 0.14 (0.02) | 0.12 (0.04) | 0.14 (0.02) |
| $\gamma_\eta$ | 1998-07 | 0.36 (0.00) | 0.49 (0.14) | 0.31 (0.03) |
| | 2008-16 | 0.39 (0.02) | 0.51 (0.00) | 0.32 (0.03) |
| $N$ | | 3977 | 1278 | 2930 |

The table reports full estimates with standard errors in parentheses for Table 4 in the main text.

Table D–2: Full time-varying estimates for subgroups by HtM status

| | | PHtM | WHtM | NHtM |
|---|---|---|---|---|
| | | | INCOME | |
| $\sigma_\eta$ | 1998-07 | 0.12 (0.02) | 0.11 (0.01) | 0.11 (0.01) |
| | 2008-16 | 0.14 (0.02) | 0.07 (0.01) | 0.11 (0.00) |
| $\sigma_\epsilon$ | 1998-07 | 0.34 (0.01) | 0.26 (0.01) | 0.24 (0.01) |
| | 2008-16 | 0.31 (0.02) | 0.27 (0.01) | 0.23 (0.01) |
| | | | CONSUMPTION | |
| $\sigma_u$ | 1998-07 | 0.16 (0.06) | 0.07 (0.04) | 0.08 (0.01) |
| | 2008-16 | 0.12 (0.02) | 0.10 (0.02) | 0.10 (0.00) |
| $\sigma_v$ | 1998-07 | 0.35 (0.04) | 0.27 (0.02) | 0.22 (0.01) |
| | 2008-16 | 0.31 (0.02) | 0.24 (0.02) | 0.24 (0.01) |
| $\gamma_\epsilon$ | 1998-07 | 0.01 (0.03) | 0.04 (0.02) | 0.04 (0.01) |
| | 2008-16 | 0.01 (0.03) | 0.03 (0.03) | 0.04 (0.01) |
| $\tilde{\gamma}_\epsilon$ | 1998-07 | 0.07 (0.06) | 0.09 (0.04) | 0.09 (0.02) |
| | 2008-16 | 0.08 (0.07) | 0.13 (0.05) | 0.12 (0.03) |
| $\gamma_\eta$ | 1998-07 | 0.66 (0.14) | 0.47 (0.04) | 0.30 (0.04) |
| | 2008-16 | 0.59 (0.12) | 0.50 (0.00) | 0.33 (0.04) |
| $N$ | | 612 | 890 | 2566 |

The table reports full estimates with standard errors in parentheses for Table 4 in the main text.

Table D–3: Full time-varying estimates for subgroups of homeowners

| | | Low LW | High LW | Low HW | High HW | High Lev. | Low Lev. |
|---|---|---|---|---|---|---|---|
| | | | | INCOME | | | |
| $\sigma_\eta$ | 1998-07 | 0.12 (0.01) | 0.12 (0.01) | 0.11 (0.01) | 0.12 (0.01) | 0.10 (0.01) | 0.13 (0.01) |
| | 2008-16 | 0.09 (0.01) | 0.10 (0.01) | 0.10 (0.01) | 0.11 (0.01) | 0.08 (0.01) | 0.11 (0.01) |
| $\sigma_\epsilon$ | 1998-07 | 0.24 (0.01) | 0.24 (0.01) | 0.22 (0.01) | 0.24 (0.01) | 0.22 (0.01) | 0.25 (0.01) |
| | 2008-16 | 0.23 (0.01) | 0.22 (0.01) | 0.21 (0.01) | 0.24 (0.01) | 0.20 (0.01) | 0.25 (0.01) |
| | | | | CONSUMPTION | | | |
| $\sigma_u$ | 1998-07 | 0.08 (0.01) | 0.08 (0.01) | 0.07 (0.01) | 0.07 (0.01) | 0.08 (0.01) | 0.08 (0.01) |
| | 2008-16 | 0.09 (0.01) | 0.10 (0.01) | 0.08 (0.01) | 0.09 (0.01) | 0.08 (0.01) | 0.10 (0.01) |
| $\sigma_v$ | 1998-07 | 0.23 (0.01) | 0.18 (0.01) | 0.21 (0.01) | 0.20 (0.01) | 0.18 (0.01) | 0.20 (0.01) |
| | 2008-16 | 0.25 (0.01) | 0.21 (0.01) | 0.26 (0.01) | 0.22 (0.01) | 0.20 (0.01) | 0.23 (0.01) |
| $\gamma_\epsilon$ | 1998-07 | 0.02 (0.02) | 0.00 (0.00) | 0.03 (0.02) | 0.00 (0.01) | 0.04 (0.02) | 0.01 (0.02) |
| | 2008-16 | 0.02 (0.02) | 0.00 (0.00) | 0.03 (0.02) | 0.00 (0.00) | 0.04 (0.02) | 0.01 (0.02) |
| $\tilde{\gamma_\epsilon}$ | 1998-07 | 0.13 (0.03) | 0.09 (0.02) | 0.12 (0.03) | 0.09 (0.04) | 0.12 (0.03) | 0.10 (0.03) |
| | 2008-16 | 0.26 (0.04) | 0.13 (0.03) | 0.13 (0.05) | 0.13 (0.04) | 0.17 (0.04) | 0.12 (0.04) |
| $\gamma_\eta$ | 1998-07 | 0.29 (0.05) | 0.24 (0.05) | 0.41 (0.08) | 0.26 (0.10) | 0.28 (0.07) | 0.23 (0.05) |
| | 2008-16 | 0.33 (0.05) | 0.25 (0.05) | 0.40 (0.07) | 0.27 (0.09) | 0.31 (0.07) | 0.23 (0.05) |
| $N$ | | 1631 | 1429 | 1663 | 1440 | 1462 | 1334 |

The table reports full estimates with standard errors in parentheses for Table 4 in the main text.

Table D–4: Miscellaneous tables for subgroups of homeowners

| | | Low LW w/o High Lev | Low LW w/o HtM | High Lev. w/o Low LW | High D2A | Low D2A |
|---|---|---|---|---|---|---|
| | | | | INCOME | | |
| $\sigma_\eta$ | 1998-07 | 0.15 (0.02) | 0.12 (0.01) | 0.10 (0.02) | 0.11 (0.01) | 0.12 (0.01) |
| | 2008-16 | 0.11 (0.02) | 0.09 (0.01) | 0.08 (0.02) | 0.11 (0.01) | 0.11 (0.01) |
| $\sigma_\epsilon$ | 1998-07 | 0.26 (0.01) | 0.23 (0.01) | 0.19 (0.02) | 0.21 (0.01) | 0.25 (0.01) |
| | 2008-16 | 0.23 (0.02) | 0.19 (0.02) | 0.20 (0.03) | 0.19 (0.01) | 0.25 (0.01) |
| | | | | CONSUMPTION | | |
| $\sigma_u$ | 1998-07 | 0.10 (0.02) | 0.09 (0.01) | 0.09 (0.02) | 0.08 (0.01) | 0.08 (0.01) |
| | 2008-16 | 0.11 (0.02) | 0.08 (0.02) | 0.06 (0.01) | 0.09 (0.01) | 0.10 (0.01) |
| $\sigma_v$ | 1998-07 | 0.26 (0.02) | 0.21 (0.01) | 0.14 (0.01) | 0.19 (0.01) | 0.20 (0.01) |
| | 2008-16 | 0.29 (0.02) | 0.24 (0.02) | 0.20 (0.01) | 0.22 (0.01) | 024 (0.01) |
| $\gamma_\epsilon$ | 1998-07 | 0.02 (0.02) | 0.00 (0.07) | 0.01 (0.04) | 0.03 (0.02) | 0.00 (0.00) |
| | 2008-16 | 0.02 (0.02) | 0.00 (0.07) | 0.01 (0.04) | 0.03 (0.02) | 0.00 (0.00) |
| $\tilde{\gamma}_\epsilon$ | 1998-07 | 0.14 (0.07) | 0.14 (0.07) | 0.13 (0.06) | 0.14 (0.03) | 0.11 (0.02) |
| | 2008-16 | 0.25 (0.10) | 0.39 (0.10) | 0.07 (0.08) | 0.13 (0.05) | 0.15 (0.03) |
| $\gamma_\eta$ | 1998-07 | 0.22 (0.12) | 0.22 (0.10) | 0.39 (0.10) | 0.29 (0.07) | 0.23 (0.05) |
| | 2008-16 | 0.23 (0.12) | 0.30 (0.11) | 0.37 (0.10) | 0.31 (0.07) | 0.25 (0.05) |
| $N$ | | 560 | 753 | 391 | 1658 | 1454 |

Columns 3-5 in the table report full estimates with standard errors in parentheses for Table 5 in the main text.

Table D–5: Full time-varying estimates for subgroups by homeownership status using alternative classification

| | | All | Renters | Homeowners |
|---|---|---|---|---|
| | | | INCOME | |
| $\sigma_\eta$ | 1998-06 | 0.12 (0.00) | 0.12 (0.01) | 0.12 (0.01) |
| | 2007-16 | 0.12 (0.00) | 0.13 (0.01) | 0.11 (0.00) |
| $\sigma_\epsilon$ | 1998-06 | 0.26 (0.00) | 0.33 (0.01) | 0.23 (0.00) |
| | 2007-16 | 0.24 (0.00) | 0.28 (0.01) | 0.22 (0.00) |
| | | | CONSUMPTION | |
| $\sigma_u$ | 1998-07 | 0.08 (0.01) | 0.06 (0.04) | 0.08 (0.01) |
| | 2008-16 | 0.10 (0.00) | 0.11 (0.01) | 0.09 (0.00) |
| $\sigma_v$ | 1998-07 | 0.25 (0.01) | 0.33 (0.02) | 0.20 (0.01) |
| | 2008-16 | 0.28 (0.00) | 0.33 (0.01) | 0.24 (0.00) |
| $\gamma_\epsilon$ | 1998-07 | 0.03 (0.01) | 0.04 (0.02) | 0.03 (0.01) |
| | 2008-16 | 0.03 (0.01) | 0.03 (0.02) | 0.03 (0.01) |
| $\tilde{\gamma}_\epsilon$ | 1998-07 | 0.10 (0.02) | 0.12 (0.04) | 0.09 (0.02) |
| | 2008-16 | 0.14 (0.02) | 0.13 (0.04) | 0.14 (0.02) |
| $\gamma_\eta$ | 1998-07 | 0.35 (0.03) | 0.45 (0.04) | 0.30 (0.03) |
| | 2008-16 | 0.38 (0.02) | 0.47 (0.03) | 0.32 (0.03) |
| $N$ | | 3117 | 749 | 2190 |

The table reports full estimates with standard errors in parentheses for Table 6 in the main text.

Table D–6: Full time-varying estimates for subgroups by HtM status using alternative classification

| | | PHtM | WHtM | NHtM |
|---|---|---|---|---|
| | | | INCOME | |
| $\sigma_\eta$ | 1998-07 | 0.12 (0.02) | 0.11 (0.01) | 0.11 (0.01) |
| | 2008-16 | 0.14 (0.02) | 0.08 (0.02) | 0.11 (0.00) |
| $\sigma_\epsilon$ | 1998-07 | 0.35 (0.02) | 0.25 (0.01) | 0.24 (0.01) |
| | 2008-16 | 0.31 (0.02) | 0.27 (0.02) | 0.22 (0.02) |
| | | | CONSUMPTION | |
| $\sigma_u$ | 1998-07 | 0.03 (0.09) | 0.06 (0.05) | 0.08 (0.01) |
| | 2008-16 | 0.13 (0.02) | 0.10 (0.02) | 0.10 (0.00) |
| $\sigma_v$ | 1998-07 | 0.37 (0.03) | 0.29 (0.04) | 0.21 (0.01) |
| | 2008-16 | 0.31 (0.02) | 0.24 (0.02) | 0.24 (0.01) |
| $\gamma_\epsilon$ | 1998-07 | 0.01 (0.03) | 0.04 (0.03) | 0.04 (0.02) |
| | 2008-16 | 0.02 (0.03) | 0.04 (0.03) | 0.04 (0.02) |
| $\tilde{\gamma}_\epsilon$ | 1998-07 | 0.11 (0.07) | 0.08 (0.06) | 0.08 (0.03) |
| | 2008-16 | 0.09 (0.07) | 0.12 (0.05) | 0.12 (0.03) |
| $\gamma_\eta$ | 1998-07 | 0.61 (0.15) | 0.46 (0.03) | 0.30 (0.04) |
| | 2008-16 | 0.55 (0.04) | 0.49 (0.01) | 0.33 (0.04) |
| $N$ | | 340 | 442 | 1761 |

The table reports full estimates with standard errors in parentheses for Table 6 in the main text.

Table D–7: Full time-varying estimates for subgroups of homeowners using alternative classification

| | | Low LW | High LW | Low HW | High HW | High Lev. | Low Lev. |
|---|---|---|---|---|---|---|---|
| | | | | INCOME | | | |
| $\sigma_\eta$ | 1998-07 | 0.11 (0.01) | 0.12 (0.01) | 0.10 (0.01) | 0.12 (0.01) | 0.09 (0.01) | 0.13 (0.01) |
| | 2008-16 | 0.09 (0.01) | 0.10 (0.01) | 0.10 (0.01) | 0.11 (0.01) | 0.08 (0.01) | 0.11 (0.01) |
| $\sigma_\epsilon$ | 1998-07 | 0.23 (0.01) | 0.23 (0.01) | 0.22 (0.01) | 0.23 (0.01) | 0.20 (0.01) | 0.25 (0.01) |
| | 2008-16 | 0.23 (0.01) | 0.22 (0.01) | 0.21 (0.01) | 0.24 (0.01) | 0.20 (0.01) | 0.25 (0.01) |
| | | | | CONSUMPTION | | | |
| $\sigma_u$ | 1998-07 | 0.07 (0.01) | 0.08 (0.01) | 0.07 (0.02) | 0.07 (0.01) | 0.07 (0.01) | 0.08 (0.01) |
| | 2008-16 | 0.09 (0.01) | 0.10 (0.01) | 0.08 (0.01) | 0.09 (0.01) | 0.08 (0.01) | 0.10 (0.01) |
| $\sigma_v$ | 1998-07 | 0.23 (0.02) | 0.18 (0.01) | 0.21 (0.01) | 0.19 (0.02) | 0.17 (0.01) | 0.20 (0.01) |
| | 2008-16 | 0.25 (0.01) | 0.221 (0.01) | 0.26 (0.01) | 0.22 (0.01) | 0.20 (0.01) | 0.23 (0.01) |
| $\gamma_\epsilon$ | 1998-07 | 0.02 (0.03) | 0.01 (0.02) | 0.03 (0.02) | 0.01 (0.02) | 0.06 (0.02) | 0.01 (0.02) |
| | 2008-16 | 0.02 (0.03) | 0.01 (0.02) | 0.03 (0.02) | 0.01 (0.02) | 0.06 (0.02) | 0.01 (0.02) |
| $\tilde{\gamma}_\epsilon$ | 1998-07 | 0.12 (0.04) | 0.10 (0.03) | 0.10 (0.03) | 0.10 (0.03) | 0.13 (0.04) | 0.12 (0.03) |
| | 2008-16 | 0.25 (0.04) | 0.12 (0.03) | 0.12 (0.03) | 0.12 (0.03) | 0.16 (0.05) | 0.13 (0.04) |
| $\gamma_\eta$ | 1998-07 | 0.32 (0.06) | 0.22 (0.06) | 0.41 (0.08) | 0.25 (0.05) | 0.29 (0.08) | 0.22 (0.05) |
| | 2008-16 | 0.36 (0.06) | 0.23 (0.06) | 0.40 (0.07) | 0.26 (0.05) | 0.31 (0.08) | 0.23 (0.05) |
| $N$ | | 958 | 944 | 942 | 981 | 839 | 837 |

The table reports full estimates with standard errors in parentheses for Table 6 in the main text.

# E Robustness Checks

In this appendix, we report the results of two robustness checks. First, we restrict the second period to end in 2012. Second, we exclude housing from total consumption.

## E.1 Sample period from 1998 to 2012

Table E–1: Time-varying estimates (1998-2007) and (2008-*2012*) subgroups by homeownership status

| | | All | Renters | Homeowners |
|---|---|---|---|---|
| | | | INCOME | |
| $\sigma_\eta$ | 1998-06 | 0.12 (0.00) | 0.12 (0.01) | 0.12 (0.01) |
| | 2007-12 | 0.13 (0.01) | 0.15 (0.01) | 0.11 (0.01) |
| $\sigma_\epsilon$ | 1998-06 | 0.26 (0.00) | 0.31 (0.01) | 0.24 (0.00) |
| | 2007-12 | 0.25 (0.01) | 0.28 (0.01) | 0.22 (0.01) |
| | | | CONSUMPTION | |
| $\sigma_u$ | 1998-07 | 0.08 (0.01) | 0.09 (0.04) | 0.08 (0.01) |
| | 2008-12 | 0.10 (0.01) | 0.10 (0.02) | 0.09 (0.00) |
| $\sigma_v$ | 1998-07 | 0.26 (0.01) | 0.34 (0.02) | 0.21 (0.01) |
| | 2008-12 | 0.25 (0.01) | 0.31 (0.02) | 0.21 (0.01) |
| $\gamma_\epsilon$ | 1998-07 | 0.04 (0.01) | 0.03 (0.02) | 0.04 (0.01) |
| | 2008-16 | 0.04 (0.01) | 0.03 (0.02) | 0.04 (0.01) |
| $\tilde{\gamma}_\epsilon$ | 1998-07 | 0.09 (0.02) | 0.09 (0.04) | 0.08 (0.02) |
| | 2008-16 | 0.15 (0.02) | 0.12 (0.05) | 0.14 (0.03) |
| $\gamma_\eta$ | 1998-07 | 0.34 (0.03) | 0.48 (0.10) | 0.28 (0.03) |
| | 2008-16 | 0.36 (0.03) | 0.49 (0.03) | 0.29 (0.03) |
| Wald statistic | | 5.88 | 0.32 | 4.15 |
| $N$ | | 3977 | 1278 | 2930 |

Notes: The table reports point estimates with standard errors in parentheses. It uses the same subgroup classification as in Table 4 however the second subsample period ends in 2012, 2008-2012.

Table E–2: Time-varying estimates (1998-2007) and (2008-*2012*) for subgroups by HtM status

| | | PHtM | WHtM | NHtM |
|---|---|---|---|---|
| | | | INCOME | |
| $\sigma_\eta$ | 1998-07 | 0.13 (0.02) | 0.11 (0.01) | 0.11 (0.01) |
| | 2008-12 | 0.15 (0.02) | 0.10 (0.02) | 0.10 (0.01) |
| $\sigma_\epsilon$ | 1998-07 | 0.34 (0.02) | 0.26 (0.01) | 0.24 (0.01) |
| | 2008-12 | 0.32 (0.02) | 0.27 (0.02) | 0.23 (0.01) |
| | | | CONSUMPTION | |
| $\sigma_u$ | 1998-07 | 0.16 (0.07) | 0.07 (0.04) | 0.08 (0.01) |
| | 2008-12 | 0.11 (0.04) | 0.09 (0.02) | 0.10 (0.01) |
| $\sigma_v$ | 1998-07 | 0.35 (0.02) | 0.27 (0.02) | 0.22 (0.01) |
| | 2008-12 | 0.30 (0.02) | 0.23 (0.02) | 0.21 (0.01) |
| $\gamma_\epsilon$ | 1998-07 | 0.00 (0.08) | 0.04 (0.05) | 0.04 (0.02) |
| | 2008-12 | 0.01 (0.09) | 0.04 (0.05) | 0.04 (0.02) |
| $\tilde{\gamma}_\epsilon$ | 1998-07 | 0.09 (0.05) | 0.09 (0.05) | 0.10 (0.02) |
| | 2008-12 | 0.17 (0.07) | 0.09 (0.07) | 0.13 (0.03) |
| $\gamma_\eta$ | 1998-07 | 0.55 (0.11) | 0.47 (0.08) | 0.24 (0.05) |
| | 2008-12 | 0.48 (0.111) | 0.49 (0.03) | 0.27 (0.05) |
| Wald statistic | | 1.31 | 0.00 | 0.53 |
| $N$ | | 612 | 890 | 2566 |

Notes: The table reports point estimates with standard errors in parentheses. It uses the same subgroup classification as in Table 4 however the second subsample period ends in 2012, 2008-2012.

Table E–3: Time-varying estimates (1998-2007) and (2008-*2012*)
for subgroups of homeowners

| | | Low LW | High LW | Low HW | High HW | High Lev. | Low Lev. |
|---|---|---|---|---|---|---|---|
| | | | | INCOME | | | |
| $\sigma_\eta$ | 1998-07 | 0.12 (0.01) | 0.12 (0.01) | 0.11 (0.01) | 0.12 (0.01) | 0.10 (0.01) | 0.13 (0.01) |
| | 2008-12 | 0.11 (0.01) | 0.10 (0.01) | 0.12 (0.01) | 0.11 (0.01) | 0.09 (0.01) | 0.10 (0.01) |
| $\sigma_\epsilon$ | 1998-07 | 0.23 (0.01) | 0.24 (0.01) | 0.22 (0.01) | 0.24(0.01) | 0.22 (0.01) | 0.25 (0.01) |
| | 2008-12 | 0.22 (0.01) | 0.23 (0.01) | 0.20 (0.01) | 0.25 (0.01) | 0.20 (0.01) | 0.26 (0.01) |
| | | | | CONSUMPTION | | | |
| $\sigma_u$ | 1998-07 | 0.08 (0.01) | 0.08 (0.01) | 0.07 (0.01) | 0.07(0.01) | 0.08 (0.01) | 0.08 (0.01) |
| | 2008-12 | 0.09 (0.01) | 0.10 (0.01) | 0.07 (0.01) | 0.10 (0.01) | 0.06 (0.01) | 0.10 (0.01) |
| $\sigma_v$ | 1998-07 | 0.23 (0.01) | 0.18 (0.01) | 0.21 (0.01) | 0.20 (0.01) | 0.18 (0.01) | 0.20 (0.01) |
| | 2008-12 | 0.23 (0.01) | 0.17 (0.01) | 0.23 (0.01) | 0.19 (0.01) | 0.19 (0.01) | 0.20 (0.01) |
| $\gamma_\epsilon$ | 1998-07 | 0.03 (0.02) | 0.02 (0.02) | 0.04 (0.02) | 0.02 (0.02) | 0.04 (0.02) | 0.03 (0.02) |
| | 2008-12 | 0.03 (0.02) | 0.02 (0.02) | 0.04 (0.02) | 0.02 (0.02) | 0.04 (0.02) | 0.03 (0.02) |
| $\tilde{\gamma}_\epsilon$ | 1998-07 | 0.12 (0.03) | 0.10 (0.03) | 0.12 (0.03) | 0.07 (0.01) | 0.11 (0.03) | 0.11 (0.03) |
| | 2008-12 | 0.22 (0.05) | 0.13 (0.04) | 0.09 (0.06) | 0.10 (0.01) | 0.13 (0.05) | 0.12 (0.04) |
| $\gamma_\eta$ | 1998-07 | 0.30 (0.06) | 0.19 (0.06) | 0.38 (0.07) | 0.23 (0.05) | 0.33 (0.05) | 0.15 (0.05) |
| | 2008-12 | 0.33 (0.06) | 0.19 (0.06) | 0.37 (0.07) | 0.24 (0.05) | 0.36 (0.05) | 0.16 (0.06) |
| Wald statistic | | 4.10 | 0.17 | 0.17 | 0.60 | 0.17 | 0.01 |
| $N$ | | 1631 | 1429 | 1663 | 1440 | 1462 | 1334 |

Notes: The table reports point estimates with standard errors in parentheses. It uses the same subgroup classification as in Table 4 however the second subsample period ends in 2012, 2008-2012.

## E.2 Excluding housing consumption

Table E–4: Time-varying estimates *without housing consumption* for subgroups by homeownership status

| | | All | Renters | Homeowners |
|---|---|---|---|---|
| | | | INCOME | |
| $\sigma_\eta$ | 1998-06 | 0.12 (0.00) | 0.12 (0.01) | 0.12 (0.01) |
| | 2007-16 | 0.12 (0.00) | 0.13 (0.01) | 0.10 (0.00) |
| $\sigma_\epsilon$ | 1998-06 | 0.26 (0.00) | 0.31 (0.01) | 0.24 (0.00) |
| | 2007-16 | 0.24 (0.00) | 0.28 (0.01) | 0.22 (0.00) |
| | | | CONSUMPTION | |
| $\sigma_u$ | 1998-07 | 0.09 (0.01) | 0.10 (0.05) | 0.09 (0.01) |
| | 2008-16 | 0.12 (0.00) | 0.14 (0.01) | 0.12 (0.01) |
| $\sigma_v$ | 1998-07 | 0.33 (0.01) | 0.42 (0.02) | 0.29 (0.01) |
| | 2008-16 | 0.36 (0.01) | 0.41 (0.01) | 0.32 (0.01) |
| $\gamma_\epsilon$ | 1998-07 | 0.02 (0.01) | 0.02 (0.02) | 0.00 (0.07) |
| | 2008-16 | 0.02 (0.01) | 0.02 (0.02) | 0.00 (0.07) |
| $\tilde{\gamma}_\epsilon$ | 1998-07 | 0.13 (0.02) | 0.16 (0.03) | 0.11 (0.04) |
| | 2008-16 | 0.17 (0.03) | 0.13 (0.04) | 0.18 (0.04) |
| $\gamma_\eta$ | 1998-07 | 0.30 (0.03) | 0.45 (0.03) | 0.24 (0.04) |
| | 2008-16 | 0.34 (0.03) | 0.51 (0.01) | 0.27 (0.04) |
| Wald statistic | | 3.13 | 0.34 | 2.46 |
| $N$ | | 3977 | 1278 | 2930 |

Notes: The table reports point estimates with standard errors in parentheses. It uses the same subgroup classification as in Table 4 however consumption for each household no longer includes housing.

Table E–5: Time-varying estimates *without housing consumption* for subgroups by HtM status

| | | PHtM | WHtM | NHtM |
|---|---|---|---|---|
| | | | INCOME | |
| $\sigma_\eta$ | 1998-07 | 0.12 (0.02) | 0.11 (0.01) | 0.11 (0.01) |
| | 2008-16 | 0.14 (0.02) | 0.08 (0.02) | 0.11 (0.00) |
| $\sigma_\epsilon$ | 1998-07 | 0.34 (0.01) | 0.26 (0.01) | 0.24 (0.01) |
| | 2008-16 | 0.31 (0.02) | 0.27 (0.02) | 0.23 (0.01) |
| | | | CONSUMPTION | |
| $\sigma_u$ | 1998-07 | 0.22 (0.07) | 0.08 (0.04) | 0.09 (0.01) |
| | 2008-16 | 0.14 (0.03) | 0.11 (0.02) | 0.12 (0.01) |
| $\sigma_v$ | 1998-07 | 0.40 (0.04) | 0.37 (0.04) | 0.28 (0.01) |
| | 2008-16 | 0.41 (0.02) | 0.32 (0.02) | 0.32 (0.01) |
| $\gamma_\epsilon$ | 1998-07 | 0.01 (0.03) | 0.03 (0.02) | 0.02 (0.02) |
| | 2008-16 | 0.01 (0.03) | 0.03 (0.02) | 0.02 (0.02) |
| $\tilde{\gamma}_\epsilon$ | 1998-07 | 0.14 (0.05) | 0.12 (0.05) | 0.12 (0.02) |
| | 2008-16 | 0.02 (0.09) | 0.15 (0.07) | 0.16 (0.04) |
| $\gamma_\eta$ | 1998-07 | 0.64 (0.08) | 0.41 (0.07) | 0.24 (0.04) |
| | 2008-16 | 0.65 (0.09) | 0.41 (0.07) | 0.27 (0.04) |
| Wald statistic | | 1.86 | 0.17 | 1.26 |
| $N$ | | 612 | 890 | 2566 |

Notes: Notes: The table reports point estimates with standard errors in parentheses. It uses the same subgroup classification as in Table 4 however consumption for each household no longer includes housing.

Table E–6: Time-varying estimates *without housing consumption* for subgroups of homeowners

| | | Low LW | High LW | Low HW | High HW | High Lev. | Low Lev. |
|---|---|---|---|---|---|---|---|
| | | | | INCOME | | | |
| $\sigma_\eta$ | 1998-07 | 0.12 (0.01) | 0.12 (0.01) | 0.11 (0.01) | 0.12 (0.01) | 0.10 (0.01) | 0.13 (0.01) |
| | 2008-12 | 0.09 (0.01) | 0.10 (0.01) | 0.10 (0.01) | 0.11 (0.01) | 0.08 (0.01) | 0.11 (0.01) |
| $\sigma_\epsilon$ | 1998-07 | 0.24 (0.01) | 0.24 (0.01) | 0.22 (0.01) | 0.24 (0.01) | 0.22 (0.01) | 0.25 (0.01) |
| | 2008-12 | 0.23 (0.01) | 0.22 (0.01) | 0.21 (0.01) | 0.24 (0.01) | 0.20 (0.01) | 0.25 (0.01) |
| | | | | CONSUMPTION | | | |
| $\sigma_u$ | 1998-07 | 0.08 (0.02) | 0.09 (0.01) | 0.08 (0.02) | 0.09 (0.01) | 0.09 (0.01) | 0.10 (0.01) |
| | 2008-12 | 0.11 (0.01) | 0.12 (0.01) | 0.10 (0.01) | 0.12 (0.01) | 0.09 (0.01) | 0.13 (0.01) |
| $\sigma_v$ | 1998-07 | 0.32 (0.02) | 0.26 (0.01) | 0.27 (0.01) | 0.30 (0.02) | 0.26 (0.01) | 0.29 (0.02) |
| | 2008-12 | 0.32 (0.01) | 0.30 (0.01) | 0.32 (0.01) | 0.33 (0.01) | 0.29 (0.01) | 0.32 (0.01) |
| $\gamma_\epsilon$ | 1998-07 | 0.01 (0.01) | 0.00 (0.01) | 0.02 (0.04) | 0.00 (0.00) | 0.03 (0.02) | 0.00 (0.05) |
| | 2008-12 | 0.01 (0.01) | 0.00 (0.01) | 0.02 (0.04) | 0.00 (0.00) | 0.03 (0.02) | 0.00 (0.05) |
| $\tilde{\gamma}_\epsilon$ | 1998-07 | 0.16 (0.03) | 0.10 (0.03) | 0.10 (0.04) | 0.15 (0.04) | 0.10 (0.03) | 0.11 (0.04) |
| | 2008-12 | 0.20 (0.05) | 0.17 (0.05) | 0.14 (0.04) | 0.21 (0.05) | 0.14 (0.04) | 0.16 (0.05) |
| $\gamma_\eta$ | 1998-07 | 0.27 (0.06) | 0.13 (0.06) | 0.35 (0.08) | 0.18 (0.06) | 0.18 (0.09) | 0.17 (0.05) |
| | 2008-12 | 0.31 (0.06) | 0.16 (0.06) | 0.34 (0.08) | 0.22 (0.06) | 0.24 (0.09) | 0.18 (0.05) |
| Wald statistic | | 8.59 | 2.34 | 0.23 | 0.85 | 0.95 | 1.38 |
| $N$ | | 1631 | 1429 | 1663 | 1440 | 1462 | 1334 |

Notes: Notes: The table reports point estimates with standard errors in parentheses. It uses the same subgroup classification as in Table 4 however consumption for each household no longer includes housing.

# F Summary Statistics and Overlaps for the Time-Varying Estimation Sample Selection

In this appendix, we report the summary statistics and overlaps between household groups for the time-varying estimation sample selection in Section 4.

## F.1 Summary statistics

Table F–1: Summary statistics for household groups by homeownership and HtM status

| | All (1) | Renters (2) | Homeowners (3) | PHtM (4) | WHtM (5) | NHtM (6) |
|---|---|---|---|---|---|---|
| Share (% of total population)* | – | 19.3 | 59.3 | 9.80 | 7.40 | 44.8 |
| Income | 48,870 | 29,623 | 60,317 | 23,770 | 47,107 | 61,778 |
| Consumption | 22,439 | 16,759 | 25,762 | 15,007 | 22,422 | 25,736 |
| **Balance sheet variables** | | | | | | |
| Liquid wealth | 2,000 | 0 | 6,864 | 0 | -8,013 | 26,1304 |
| Illiquid wealth | 37,432 | 0 | 89,502 | 0 | 39,000 | 105,072 |
| Housing wealth | 25,000 | 0 | 61,452 | 0 | 30,000 | 66,628 |
| Total wealth | 49,979 | 0 | 119,032 | -2,434 | 26,951 | 184,765 |
| Debt | 41,483 | 1,048 | 77,109 | 3,227 | 76,578 | 52,755 |
| Leverage | 1.11 | – | 1.05 | – | 2.32 | 0.84 |
| **Demographics** | | | | | | |
| Age | 43 | 39 | 47 | 39 | 43 | 48 |
| Frac. of college | 0.65 | 0.57 | 0.68 | 0.46 | 0.60 | 0.72 |
| Frac. of married | 0.67 | 0.38 | 0.81 | 0.37 | 0.73 | 0.77 |
| **Other characteristics** | | | | | | |
| Frac. of homeowners | 0.69 | 0 | 1 | 0.03 | 0.94 | 0.84 |
| Frac. of employed | 0.87 | 0.83 | 0.88 | 0.76 | 0.86 | 0.89 |

Notes: The table reports key demographic and balance sheet characteristics for the whole sample and each group based on homeownership and HtM status. Income, consumption balance sheet variables and age are the median values for that subgroup. The shares reported in the first two rows are based on total number of observations (number of households $N$ times the number of times they appear $t$) in our pooled sample. *: calculated for the sample after applying the two consecutive period restriction.

Table F–2: Summary statistics for homeowner subgroups

| | High LW (1) | Low LW (2) | High HW (3) | Low HW (4) | High Lev. (5) | Low Lev. (6) |
|---|---|---|---|---|---|---|
| Share (% of total population)* | 23.5 | 20.1 | 24.3 | 25.6 | 20.1 | 21.4 |
| Income | 74,156 | 48,911 | 73,260 | 50,460 | 58,607 | 65,827 |
| Consumption | 30,168 | 22,234 | 32,836 | 20,782 | 25,531 | 27,173 |
| **Balance sheet variables** | | | | | | |
| Liquid wealth | 71,532 | -1,123 | 35,620 | 403 | 1,293 | 72,269 |
| Illiquid wealth | 194,644 | 40,652 | 216,251 | 29,834 | 51,998 | 232,694 |
| Housing wealth | 112,038 | 33,389 | 137,275 | 22,661 | 44,416 | 115,408 |
| Total wealth | 365,735 | 34,445 | 310,353 | 31,326 | 56,019 | 437,769 |
| Debt | 71,240 | 77,049 | 70,000 | 68,094 | 102,429 | 25,490 |
| Leverage | 0.60 | 2.13 | 0.77 | 2.09 | 2.37 | 0.47 |
| **Demographics** | | | | | | |
| Age | 51 | 44 | 51 | 43 | 43 | 53 |
| Frac. of college | 0.79 | 0.56 | 0.77 | 0.59 | 0.66 | 0.72 |
| Frac. of married | 0.86 | 0.77 | 0.85 | 0.77 | 0.80 | 0.82 |
| **Other characteristics** | | | | | | |
| Frac. of homeowners | 1 | 1 | 1 | 1 | 1 | 1 |
| Frac. of employed | 0.88 | 0.88 | 0.87 | 0.89 | 0.93 | 0.84 |

Notes: The table reports key demographic and balance sheet characteristics for each subgroup of homeowners based on balance sheet status, where LW is liquid wealth, HW is housing wealth, and Lev. is leverage. Income, consumption balance sheet variables and age are the median values for that subgroup. The shares reported in the first two rows are based on total number of observations (number of households $N$ times the number of times they appear $t$) in our pooled sample. *: calculated for the sample after applying the two consecutive period restriction.

## F.2 Overlaps

Table F–3: Overlaps between the subgroups

| | Renter | Homeowner | Low LW | High LW | Low HW | High HW | High Lev | Low Lev | PHtM | WHtM | NHtM |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Renter | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.41 | 0.04 | 0.34 |
| Homeowner | 0.00 | 1.00 | 0.40 | 0.40 | 0.41 | 0.43 | 0.34 | 0.36 | 0.00 | 0.15 | 0.61 |
| Low LW | 0.00 | 1.00 | 1.00 | 0.00 | 0.64 | 0.21 | 0.52 | 0.13 | 0.01 | 0.38 | 0.25 |
| High LW | 0.00 | 1.00 | 0.00 | 1.00 | 0.19 | 0.70 | 0.19 | 0.65 | 0.00 | 0.00 | 1.00 |
| Low HW | 0.00 | 1.00 | 0.62 | 0.18 | 1.00 | 0.00 | 0.45 | 0.17 | 0.01 | 0.25 | 0.43 |
| High HW | 0.00 | 1.00 | 0.19 | 0.65 | 0.00 | 1.00 | 0.23 | 0.60 | 0.00 | 0.07 | 0.81 |
| High Lev. | 0.00 | 1.00 | 0.60 | 0.22 | 0.59 | 0.30 | 1.00 | 0.00 | 0.00 | 0.23 | 0.51 |
| Low Lev. | 0.00 | 1.00 | 0.17 | 0.72 | 0.19 | 0.52 | 0.00 | 1.00 | 0.00 | 0.05 | 0.85 |
| PHtM | 0.93 | 0.02 | 0.02 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 |
| WHtM | 0.05 | 0.93 | 0.92 | 0.00 | 0.62 | 0.17 | 0.48 | 0.10 | 0.00 | 1.00 | 0.00 |
| NHtM | 0.12 | 0.81 | 0.13 | 0.53 | 0.23 | 0.46 | 0.23 | 0.41 | 0.00 | 0.00 | 1.00 |

Notes: The table reports the fraction of $N \times t$ observations that overlap with other classifications. These overlaps are based on the sample that was used in the analysis of time-varying MPCs in Section 4.