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Marginal Propensities to Consume Before and After the Great Recession

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Abstract

Using a quasi maximum likelihood approach for a semi-structural model, we find highly precise and distinct estimates of consumption responses to idiosyncratic income shocks for different groups of households. Homeowners stratified by liquid wealth exhibit the most dispersion in their marginal propensities to consume. Time-varying estimates support strong patterns of heterogeneity by homeownership status and balance sheet liquidity, with economically and statistically significant increases in the sensitivity of transitory consumption for homeowners, especially those with lower liquid wealth, following the collapse in house prices with the Great Recession. These findings support consumption theories that include housing as an illiquid asset.

Keywords: Marginal propensity to consume; Great Recession; household liquidity; housing wealth.

JEL codes: E21; C13; C33; D12; D14.

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1 Introduction

The boom and bust of the U.S. housing market in the 2000s had a huge 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 housing wealth and its impact on consumption during the Great Recession has been examined extensively; see, for example, [Dynan \(2012\)](#), [Mian, Rao, and Sufi \(2013\)](#), [Baker \(2018\)](#), and [Garriga and Hedlund \(2020\)](#). In terms of policy implications, [Ganong and Noel \(2020\)](#) consider the effects of mortgage modification programs following the Great Recession on consumption. They argue that the effectiveness of such policies depends crucially on which households respond the most to changes in income.

In this paper, we investigate the sources of heterogeneity in the sensitivity of household consumption to idiosyncratic income shocks before and after the Great Recession ("1998-2006" and "2007-2016"). Measuring the responsiveness of consumption to permanent and transitory shocks involves jointly estimating income and consumption processes. Specifically, we use data from the Panel Survey of Income Dynamics (PSID) and estimate a more flexible version of the semi-structural model from [Blundell, Pistaferri, and Preston \(2008\)](#) (BPP hereafter) via a quasi maximum likelihood approach. As discussed in [Chatterjee, Morley, and Singh \(2020\)](#), this approach to estimation addresses highly non-Normal shock distributions and efficiently handles missing observations using the Kalman filter, providing considerably more precise estimates of consumption responses to income shocks than GMM, especially in smaller samples such as we have for household groups. We consider how estimates vary both cross-sectionally and over time for households with different balance sheet characteristics 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 important for identifying what led to large changes in consumption with the Great Recession and informing fiscal initiatives that could be implemented during economic downturns involving large declines in house prices.

In terms of our econometric approach, we make what turns out to be an important extension to the BPP model by letting 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 the concern raised in [Commault \(2020\)](#) about the model specification in BPP. It also allows different short-run

and long-run consumption elasticities with respect to the transitory shocks, providing a measure of the 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 heterogeneity in all model parameters despite relatively small samples for different groups classified along key aspects of household balance sheets, as well as allowing for possible structural change in parameters over time. In particular, [Chatterjee et al. \(2020\)](#) show via Monte Carlo simulation that QMLE is substantially more accurate than GMM in small samples and when allowing for non-Normal shocks and structural change, with the better performance due, at least in part, to a more efficient treatment of missing observations by directly modeling idiosyncratic income and consumption in log levels rather than considering growth rates. The QMLE approach also provides formal Wald tests for the stability of consumption responses across time.

Our first key finding is in terms of heterogeneity in MPCs implied by short-run elasticities and median household consumption-income ratios. We find that MPCs are strongly negatively associated with total household wealth, as well as underlying measures corresponding to housing wealth and liquid wealth.² These results are qualitatively consistent with what would be predicted by either one or two-asset incomplete market models, e.g. [Carroll \(1997\)](#) and [Kaplan and Violante \(2014\)](#). We also show that MPCs are positively associated with household leverage, as defined in [Mian et al. \(2013\)](#). When looking across different groups stratified by homeownership status, hand-to-mouth status, liquid wealth, housing wealth, and leverage, we find that heterogeneity in MPCs almost entirely reflects differences in transitory responses of consumption, rather than permanent responses or median consumption-income ratios, and these differences 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 0.17 (compared to an estimate of 0.11 for all households),

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

²Preferences may also play a role in explaining MPC heterogeneity, see [Gelman \(2020\)](#) and [Aguilar, Bils, and Boar \(2020\)](#). This source of heterogeneity is implicitly allowed for given that our consumption elasticity estimates can be interpreted as average elasticities for each group under consideration; see [Commault \(2020\)](#).

with a majority of those with lower liquid wealth homeowners having high enough liquid wealth relative to income such that they would not be classified as "hand-to-mouth". Also, if we exclude hand-to-mouth households from the subgroup of homeowners with lower liquid wealth, the estimated transitory response is even higher at 0.25. These results are consistent with the theoretical prediction of [Boar, Gorea, and Midrigan \(2020\)](#), who consider a two-asset incomplete markets model, where the illiquid asset is carefully micro-founded as housing, as in [Kaplan, Mitman, and Violante \(2020a\)](#), but they examine the role of housing equity in smoothing idiosyncratic income shocks rather than aggregate shocks. In particular, [Boar et al. \(2020\)](#) argue that homeowners who are liquidity constrained are a much broader group than those who are "hand-to-mouth", which is related to what we find given that many of the lower liquid wealth homeowners are likely to be liquidity constrained in the face of income shocks.³

Our second key finding is in terms of changes in consumption responses over time. We find 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. Notably, the estimates increased from 0.08 during the 1998-2006 subsample period to 0.14 in the 2007-2016 subsample period. Among homeowners, those with lower liquid wealth experienced the largest increase in their estimated transitory response of consumption, doubling from 0.13 to 0.26. Homeowners with higher leverage before the Great Recession also experienced an increase in their estimated transitory response from 0.12 to 0.17, although the increase is not statistically significant. The time-varying estimates suggest that implied MPCs generally increased after the Great Recession, with the pattern of change appearing to reflect a negative housing wealth effect amplified by low liquidity. In particular, the MPC was higher for renters than homeowners before the Great Recession, but increased for homeowners by 40% to the same level as that of renters for the full sample period, while the MPC for lower liquid wealth homeowners increased the most by 85% compared to about 30% for higher leverage households. Meanwhile, reflecting a higher proportion of households with large transitory consumption responses after the Great Recession, the MPC for all households also increased by about

³[Boar et al. \(2020\)](#) define "hand-to-mouth" households as those for whom the borrowing constraint on liquid assets (i.e. the risk-free asset) binds. By contrast, homeowners for whom a constraint on the minimum mortgage payment binds are defined as "liquidity constrained". Their model, which is calibrated to the U.S. economy in 2001, suggests that 25% of homeowners are hand-to-mouth, while over 80% of homeowners are liquidity constrained.

33%. These changes imply similar changes in consumption elasticities with respect to house prices based on the rule-of-thumb formula in [Berger, Guerrieri, Lorenzoni, and Vavra \(2018\)](#), supporting the argument in [Kaplan, Mitman, and Violante \(2020b\)](#) that the fall in housing wealth was more important than deleveraging in driving down consumption during the Great Recession.

We also consider heterogeneity in consumption responses to idiosyncratic permanent income shocks. Consumption insurance against these shocks is 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 be more sensitive to permanent shocks, thus having less consumption insurance, than their counterparts. However, these responses are much more stable over time than the transitory consumption responses to transitory income shocks, with time-varying estimates suggesting no notable or statistically-significant changes in consumption insurance for any group of households despite large changes in housing wealth.

Our analysis relates to two strands of the literature on consumption behavior. First, we contribute to the literature that develops methods and estimates the impact of transitory income shocks on consumption. Broadly speaking, there are two approaches. The first approach exploits natural experiments such as fiscal tax rebates ([Parker, Souleles, Johnson, and McClelland, 2013](#)), lottery winnings ([Fagereng, Holm, and Natvik, 2020](#)), and mortgage modification programs ([Ganong and Noel, 2020](#)) to identify exogenous income changes and their impact on consumption.⁴ The second approach is semi-structural, popularized by BPP, where statistical methods are employed to infer responses to idiosyncratic permanent or transitory income shocks without the econometrician directly observing these shocks, but only assuming a structure for the underlying income and consumption processes. This approach has been used extensively, although usually based on GMM rather than the more precise QMLE approach taken in our analysis; see, for example, [Kaplan et al. \(2014\)](#) and [Auclert \(2019\)](#). We also follow the suggestion in [Commault \(2020\)](#) of extending the semi-structural approach to allow transitory consumption responses to income shocks.

Second, there is a large literature that examines why consumption fell during the Great Recession; see, for example, [Mian et al. \(2013\)](#), [Huo and Ríos-Rull \(2016\)](#), [Baker \(2018\)](#), [Garriga and Hedlund \(2020\)](#), [Jones, Midrigan, and Philippon \(2020\)](#) and [Kaplan et al. \(2020b\)](#).

⁴Some studies have also examined heterogeneity in MPCs using hypothetical surveys; see, for example, [Christelis, Georgarakos, Jappelli, Pistaferri, and Van Rooij \(2019\)](#) and [Fuster, Kaplan, and Zafar \(2020\)](#).

On the empirical side, [Mian et al. \(2013\)](#) argue that the decline was largely driven by exposure to household leverage. However, [Kaplan et al. \(2020b\)](#) argue that the decline was due to a negative housing wealth effect. Our results inform the debate in the literature by suggesting it was lower liquid wealth homeowners more than higher leverage homeowners who became more sensitive to income shocks following the collapse in house prices, thus providing at least indirect support for a larger role of a negative housing wealth effect than deleveraging.

The rest of this paper is organized as follows: Section 2 describes the data and 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 concludes with a discussion of the implications of our results for different theories of consumption.

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 began collecting information on household expenditure covering 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 correspond to observations for 1998-2016 due to the retrospective nature of the PSID.⁵

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 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 cate-

⁵In any wave, the PSID survey reports information for the previous year. For example, the data released in 1999 contains information collected for 1998. When reporting our results, we refer to the year to which the data corresponds rather than the year labelled in the PSID.

gories: 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. While we include the actual reported rent for households living in rental housing, we impute rent for homeowners. 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 the self-reported house value from the PSID. Given possible issues with this approach to measuring imputed rent, we also check that our results are robust to excluding housing from our measure of consumption. Each component of consumption is then deflated using the corresponding sub-index 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 household 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 (house value minus first and second mortgages), pensions, and non-primary real estate, where pensions and non-primary real estate are reported as net values in the data. Total wealth is defined as the sum of liquid wealth (minus non-credit card debt given the measure of liquid wealth after 2011) and illiquid wealth. A related aspect of the balance sheet that we consider is household leverage, which is measured as the ratio of house value to total wealth, as in [Mian et al. \(2013\)](#). All wealth variables are deflated using headline CPI.

Our initial dataset consists of an unbalanced panel of 83,831 observations. We closely follow [Kaplan et al. \(2014\)](#)'s sample-selection procedure. From the initial dataset, we drop households who are in the SEO (Survey of Economic Opportunity), which is a sample of low-income households. We focus on households for which there was no change of head-

⁶Before 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.

ship and the age of the head of the household is between 25 and 64. We drop households reporting zero expenditure or who had missing information on key demographics in terms of education or 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 appearing 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 online appendix A for more details).

To try to address issues with transitions between household groups discussed below, we follow [Cloyne, Ferreira, and Surico \(2019\)](#) by only considering households who have not changed their status for at least two consecutive waves in a particular group at a given point of time. For our time-varying estimation, we further only consider households meeting the criteria to be classified if they were classified in the group prior to the Great Recession. That is, to minimize compositional changes for groups due to new entrants into a particular classification after the Great Recession, we do not include these households when estimating consumption responses for a group after 2007. However, we also consider robustness of our results to alternative approaches to sample selection. See online appendix B for more details on different sample selections.

2.2 Household groups and their characteristics

We classify households based on homeownership status as being either renters or homeowners, noting that housing constitutes 66% of the value of illiquid assets for the households in our sample. As reported in Table 1, renters are relatively young, poor, and likely to be liquidity constrained. Homeowners are older and wealthier. Following [Kaplan et al. \(2014\)](#), we also classify households based on hand-to-mouth (HtM) status into poor hand-to-mouth (PHtM), wealthy hand-to-mouth (WHtM), and non-hand-to-mouth (NHtM) categories.⁷ Summary statistics for the HtM groups are also reported in Table 1 and suggest PHtM households have a similar profile to renters (only 7% of PHtM households own a house), while WHtM households have a similar profile to homeowners (93% of WHtM

⁷Specifically, households are classified as HtM if their liquid wealth is positive and less than half of their bi-weekly income or their liquid wealth is negative and less than the difference between half of their bi-weekly income and a credit limit that 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 groups based on homeownership and HtM status. Income, consumption, balance sheet variables, and age are median values for each group. The population 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 median values for each subgroup. The population 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.

households own a house).

In order to explore the role of household balance sheets further, we stratify the homeowner group into subgroups based on liquid wealth, housing wealth, and leverage. A household is in the "high" ("low") subgroup for a particular balance sheet characteristic if their balance sheet value is above (below or equal to) the median value across all homeowners in a given year. Table 2 reports the balance sheet and demographic characteristics for the different subgroups of homeowners. There are three features worth highlighting. First, the lower liquid wealth and lower housing wealth homeowners are relatively poor and are likely to be liquidity constrained given that they have very low or negative liquid wealth.

The overlap between these two subgroups is close to 60% and, while both have low levels of income and liquid wealth, their median levels of liquid wealth are higher than that of WHtM in Table 1. Second, the overlap between higher liquid wealth and higher housing wealth homeowners is more than 60%, with both subgroups holding high levels of liquid wealth and total wealth. Third, higher leverage homeowners have sizeable liquid wealth, but are highly indebted overall. Other subgroups with high leverage are homeowners with lower liquid wealth and lower housing wealth. See online appendix A for more details on overlaps between different household groups and summary statistics for the subsample periods used in our time-varying estimation.

2.3 Empirical methods

Following BPP, we first isolate idiosyncratic income and consumption for each household i in our sample by controlling for cohort effects, time dummies, region, education, race, employment status, family size, number of dependent children, children that have moved out, and working family members other than head and partner. Specifically, we regress logs of household income and consumption on the various controls:

$$\ln Y_{it} = \beta' X_{it} + y_{it}, \quad (1)$$

$$\ln C_{it} = \alpha' X_{it} + c_{it}, \quad (2)$$

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

We then consider a semi-structural unobserved components model that decomposes idiosyncratic log income and consumption for each household in a group into permanent and transitory components over time. The model is specified as follows:

$$y_{it} = \tau_{it} + \epsilon_{it} \quad \epsilon_{it} \sim i.i.d.(0, \sigma_{\epsilon,t}^2) \quad (3)$$

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

where the permanent components are specified as random walks:

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

$$\kappa_{it} = \kappa_{it-1} + \tilde{\gamma}_{\epsilon} \epsilon_{it} + u_{it} \quad u_{it} \sim i.i.d.(0, \sigma_{u,t}^2) \quad (6)$$

For household i , the common stochastic trend for income and consumption (i.e. "permanent income"), τ_{it} , is driven by permanent income shocks, η_{it} , such as promotion or major health diagnoses that affect the ability to work. Households are also subject to transitory income shocks, ϵ_{it} . Consumption has an additional stochastic trend, κ_{it} , that could reflect wealth shocks, u_{it} , and we also allow for transitory consumption shocks, v_{it} , to capture fluctuations in reported consumption possibly due to measurement error in the survey or temporary changes in preferences. We assume that these idiosyncratic shocks are not correlated with each other, over time, or across households, but allow for changes in their variances over time. Parameters, including the variances, are assumed to be the same within a group, but not necessarily across groups. However, as discussed in [Commault \(2020\)](#), consumption response parameters can be interpreted as averages for each group, thus heterogeneity is implicitly allowed for within groups, in addition to being explicitly allowed for across groups by estimating different parameter values for each group.

The key parameters in the model are the γ 's, which capture the responses of consumption to income shocks. These are assumed to be constant across time, although we test for structural changes in their values for different groups of households in Section 4.⁸ Following BPP, the parameters $\bar{\gamma}_\epsilon$ and γ_η 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. Given idiosyncratic income and consumption data in logs, the sum of the consumption response parameters that load on ϵ_{it} , which we denote as $\gamma_\epsilon \equiv \bar{\gamma}_\epsilon + \tilde{\gamma}_\epsilon$, corresponds to the short-run elasticity of consumption with respect to transitory income shocks, i.e. $\gamma_\epsilon = \frac{\partial c_{it}}{\partial \epsilon_{it}}$, while $\bar{\gamma}_\epsilon = \lim_{h \rightarrow \infty} \frac{\partial c_{it+h}}{\partial \epsilon_{it}}$ corresponds to the long-run elasticity with respect to transitory income shocks and $\gamma_\eta = \frac{\partial c_{it}}{\partial \eta_{it}}$ corresponds to the (assumed constant) elasticity with respect to permanent income shocks. The short-run elasticity with respect to transitory shocks is sometimes directly referred to

⁸Constant γ 's also imply symmetric and proportional responses to different shocks, while it is possible that responses depend on the sign or size of shocks. [Arellano, Blundell, and Bonhomme \(2017\)](#) investigate nonlinearities in the relationship between income and consumption using a nonparametric approach and quantile regressions and they find some size and sign effects for the persistence of income shocks and asymmetries in consumption responses. Adapting our QMLE approach to capture such nonlinearities is technically feasible, but practically challenging given a general need to extend beyond the basic Kalman filter. Instead, we consider tests of our linear specification by checking if the consumption responses are different depending on the mean, variance, or skewness of residual income growth in a particular wave. We find no evidence of such effects, although this could be due to low power for the tests. We do find some evidence of differences for the transitory consumption response to transitory income shocks for some groups depending on the sign of residual income growth for each household, but the average effects across both cases are very close to what we find with our linear specification. We leave a deeper examination of asymmetries and other nonlinearities to future research.

as the "MPC", e.g. [Jappelli and Pistaferri \(2010\)](#) and [Kaplan et al. \(2014\)](#), but we reserve this descriptor for the short-run elasticity multiplied by the (unadjusted levels rather than residual logs) consumption-income ratio (i.e. $MPC \equiv \gamma_\epsilon \times \frac{C_{it}}{Y_{it}}$, where we use the median consumption-income ratio for a given group in our calculations of MPCs). This gives the MPC the dollar-for-dollar units often considered in natural experiments.⁹ Meanwhile, we follow [Kaplan and Violante \(2010\)](#) in referring to $1 - \gamma_\eta$ as "consumption insurance" against permanent income shocks.

To estimate parameters for the unobserved components model, we cast the model into state-space form and employ QMLE; see online appendix C and [Chatterjee et al. \(2020\)](#) for more details.¹⁰ 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 simulation that QMLE performs better than GMM in terms of root mean square error of parameter estimates for the BPP model, especially in small samples and when allowing for highly non-Normal shocks and 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 ignored when there is not another consecutive observation in levels to form a growth rate). The QMLE approach also allows us to consider Wald tests for restrictions on parameters based on the estimated variance-covariance matrix calculated using the Huber-White sandwich formula. We calculate Wald statistics to test the stability of the consumption response parameters across time. To protect against spurious findings of heterogeneity or time variation in consumption responses, we explicitly allow for different shock variances across groups and across time.

It is important to note that the time period t in our model denotes a year given that the income and consumption data correspond to annual flows. Because the waves of data are only available biennially, we treat the alternating years with no data as missing observations to be handled by the Kalman filter just like other missing observations from the unbalanced panel. It should be highlighted that this approach is potentially different than working with

⁹If consumption is under-reported in the PSID, the MPCs will be downward biased compared to natural experiments. However, assuming a similar under-reporting for different groups, heterogeneity in MPCs should still be evident even if consumption is under-reported in the survey.

¹⁰Our approach is also somewhat related to [Primiceri and van Rens \(2009\)](#), who employ likelihood-based Bayesian estimation for an unobserved components model of household income and consumption inequality.

wave growth rates implied by the model. In particular, the implied growth rates across waves are given as follows:

$$y_{it} - y_{it-2} = \eta_{it} + \eta_{it-1} + \epsilon_{it} - \epsilon_{it-2} \quad (7)$$

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

Then, following a GMM/IV approach to estimation, the short-run elasticity, γ_ϵ , could be identified for this model given what [Commault \(2020\)](#) refers to as the "biennial passthrough" coefficient, $\hat{\phi}_2^\epsilon = \frac{\text{cov}(c_{it}-c_{it-2}, y_{it}-y_{it+2})}{\text{cov}(y_{it}-y_{it-2}, y_{it}-y_{it+2})}$. However, [Commault \(2020\)](#) notes that $\hat{\phi}_2^\epsilon$ will not be equivalent to the short-run elasticity when there are first-order moving-average dynamics in transitory income at an annual frequency, as assumed in the original BPP model. Instead, it is the annual passthrough coefficient $\hat{\phi}^\epsilon = \frac{\text{cov}(c_{it}-c_{it-1}, y_{it+1}-y_{it+2})}{\text{cov}(y_{it}-y_{it-1}, y_{it+1}-y_{it+2})}$ in [Commault \(2020\)](#) that would identify γ_ϵ . However, $\hat{\phi}^\epsilon$ cannot be calculated given only biennial observations of the levels data. By contrast, our QMLE approach directly estimates γ_ϵ even when only biennial data are available, although estimation requires an assumption about the value of the moving-average parameter at an annual frequency, which is not identified given only biennial observations. We are implicitly setting the moving-average parameter to zero in our model specification, which places a lower-bound on the estimated consumption responses to transitory income shocks, although we find the estimates 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 that they considered in their analysis.¹¹ An additional source of difference with our approach 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 observation in levels, 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 we find they are similar, but our estimates are more precise, suggesting that the moving-average parameter is close to zero (since $\hat{\phi}_2^\epsilon$ would be equivalent to the short-run elasticity if the moving-average parameter were zero) and the additional observations incorporated in our estimation contain useful information about the model parameters.

¹¹Specifically, the biennial income growth data identifies only $(1 + \theta^2)\sigma_\epsilon^2$, where θ is the moving-average parameter, rather than σ_ϵ^2 . So for non-zero values of θ , the estimated σ_ϵ^2 would decrease as the absolute value of θ increases, implying correspondingly higher estimates of $\tilde{\gamma}_\epsilon$ and $\tilde{\gamma}_\epsilon$ to capture the same movements in biennial consumption growth. However, because BPP find estimates of θ around 0.1 (implying $\theta^2 \approx 0.01$), the changes in the estimates of σ_ϵ^2 , $\tilde{\gamma}_\epsilon$, and $\tilde{\gamma}_\epsilon$ for such a value instead of $\theta = 0$ would be negligible.

3 Heterogeneity in Consumption Responses

In this section, we present our baseline results for the unobserved components model discussed in the previous section under the assumption of constant consumption response parameters for each group over the full 1998-2016 sample period, but allowing the variances of income and consumption shocks to be different across groups and before and after the Great Recession in order to account for possible heteroskedasticity.

3.1 Responses to transitory income shocks

Figure 1 plots the implied MPC for each household group against key balance sheet measures of median total wealth, liquid wealth, housing wealth, and leverage. The MPCs for the different groups of households provide clear evidence of heterogeneity related to these household balance sheet characteristics. In particular, 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 \(2014\)](#).¹² There is also a positive relationship between the MPCs and household leverage (bottom right panel), implying that highly indebted homeowners tend to respond more to transitory income shocks.

To allow more precise comparisons, Table 3 reports estimates of the consumption response parameters (full sets of results for all model parameters, including time-varying variances of shocks for different groups, are given in online appendix D). Before looking at results across different household groups, we note that 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. In estimating the overall impact on consumption of transitory income shocks using the biennial PSID data from 1999-2017 via a GMM/IV approach based on growth rates across waves, [Commault \(2020\)](#) finds a biennial passthrough coefficient for a transitory income shock of 0.13 with standard error of 0.06 (see her Table 4), which is comparable to our implied estimate of the short-run elasticity with respect to transitory shocks, i.e. $\gamma_\epsilon \equiv \tilde{\gamma}_\epsilon + \tilde{\gamma}_{\epsilon'}$, of 0.14 with standard error of 0.02.¹³ Meanwhile, the estimate of the impact

¹²A number of other empirical studies, including [Zeldes \(1989\)](#), [Johnson, Parker, and Souleles \(2006\)](#), [Parker et al. \(2013\)](#), [Baker and Yannelis \(2017\)](#), and [Fagereng et al. \(2020\)](#), have documented a significant negative correlation between MPCs and liquid wealth.

¹³As noted in the previous section, the biennial passthrough coefficient will only be strictly equivalent to γ_ϵ 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

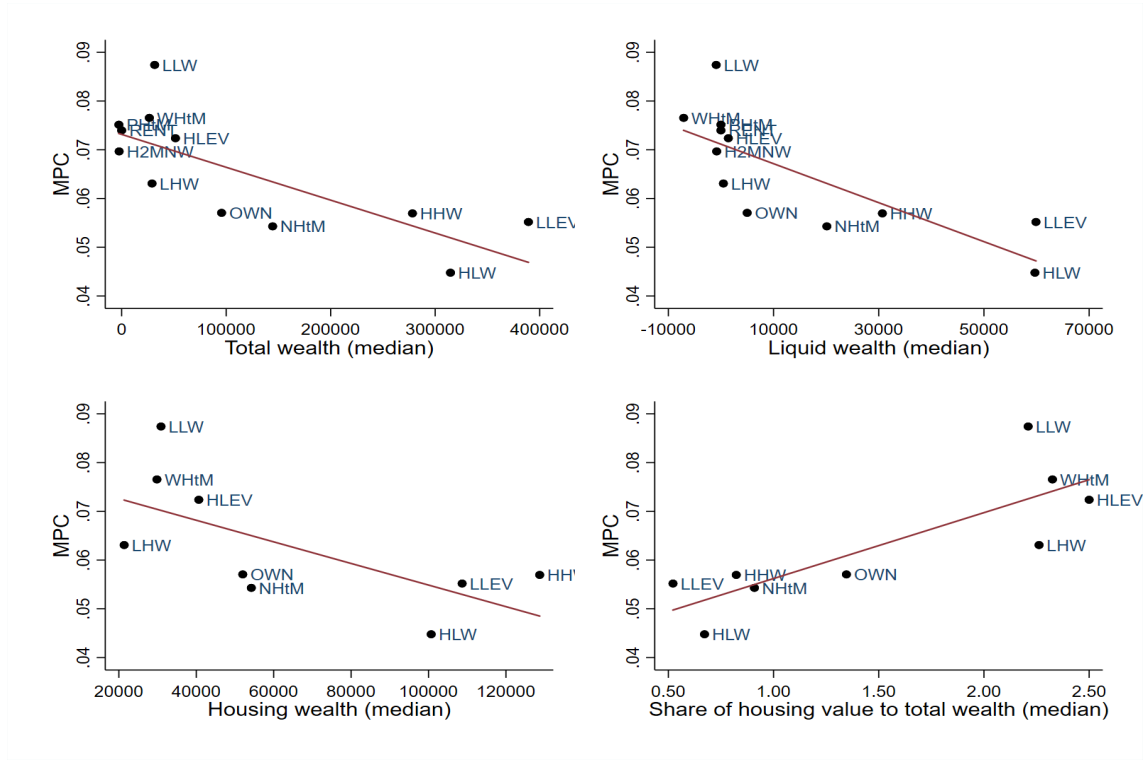


Figure 1: MPCs vs. household wealth and leverage

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 leverage measured as the ratio of house 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, γ_e , and the median consumption-income ratio on the y -axis and the corresponding median balance sheet value on the x -axis for 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 classification.

of transitory income shocks on the permanent component of consumption, $\tilde{\gamma}_\epsilon$, 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 permanent response of consumption is always small for different household groups and is often statistically insignificant. Thus, we focus on the transitory consumption responses to transitory income shocks, $\tilde{\gamma}_\epsilon$, when considering possible sources of MPC heterogeneity. 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 the transitory consumption responses.

Examining the cross-sectional pattern of heterogeneity in transitory consumption responses, we find that, based on homeownership status, renters have a higher transitory response than homeowners in our baseline results, but the difference does not appear to be statistically significant given the standard errors for the estimates. Among homeowners, there are larger differences in balance sheet characteristics 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 lower liquid wealth, lower housing wealth, and higher leverage have more sensitive transitory responses relative to their respective counterparts. Among all of these subgroups, homeowners with lower liquid wealth, which was the subgroup with the highest MPC in Figure 1, have the largest estimated transitory response at 0.17 with a standard error of 0.03. 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. $-\$7,086$ for WHtM households; see Tables 1 and 2. We also note that removing HtM households from this subgroup further increases the estimated transitory response to 0.25 with a standard error of 0.05 (see online appendix D). This suggests that, despite not being HtM households, these homeowners are still likely to be liquidity constrained. Meanwhile, removing HtM households from low housing wealth and high leverage subgroups has either no impact or leads to a small decrease in estimated transitory responses (again, see online appendix D). Consistent with related literature that distinguishes households based on their HtM status, for example [Kaplan et al. \(2014\)](#) and

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 of 0.11 with a standard error of 0.01 reported in Table 3 based on estimation in levels.

Table 3: Estimates of consumption response parameters

	All	Renter	Homeowner	PHtM	WHtM	NHtM
γ_η	0.38 (0.03)	0.49 (0.00)	0.34 (0.04)	0.46 (0.03)	0.47 (0.12)	0.34 (0.04)
$\bar{\gamma}_\epsilon$	0.03 (0.01)	0.01 (0.01)	0.03 (0.03)	0.00 (0.00)	0.03 (0.01)	0.03 (0.01)
$\tilde{\gamma}_\epsilon$	0.11 (0.01)	0.12 (0.02)	0.11 (0.02)	0.12 (0.03)	0.13 (0.03)	0.10 (0.02)
γ_ϵ	0.14 (0.02)	0.13 (0.03)	0.14 (0.02)	0.12 (0.03)	0.16 (0.03)	0.13 (0.02)
MPC	0.06 (0.01)	0.07 (0.02)	0.06 (0.01)	0.08 (0.02)	0.08 (0.02)	0.05 (0.01)
No. of households	5,047	2,047	3,633	1,060	1,285	3,659
	Low LW	High LW	Low HW	High HW	High Lev.	Low Lev.
γ_η	0.30 (0.08)	0.27 (0.05)	0.39 (0.05)	0.27 (0.05)	0.34 (0.07)	0.22 (0.05)
$\bar{\gamma}_\epsilon$	0.02 (0.01)	0.03 (0.01)	0.02 (0.01)	0.02 (0.01)	0.03 (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)	0.14 (0.03)	0.12 (0.03)
γ_ϵ	0.19 (0.03)	0.11 (0.02)	0.15 (0.03)	0.12 (0.02)	0.16 (0.03)	0.14 (0.03)
MPC	0.09 (0.01)	0.04 (0.01)	0.06 (0.01)	0.06 (0.01)	0.07 (0.01)	0.06 (0.01)
No. of households	2,198	1,949	2,266	1,910	2,011	1,793

Notes: The table reports point estimates of permanent and transitory consumption responses to permanent and transitory income shocks with standard errors in parentheses. γ_η is the permanent response to a permanent income shock, $\bar{\gamma}_\epsilon$ is the permanent response to a transitory income shock, $\tilde{\gamma}_\epsilon$ is the transitory response to a transitory income shock, γ_ϵ is the short-run elasticity with respect to a transitory income shocks, and MPC is the short-run elasticity times the median consumption-income ratio. The upper panel reports estimates for all households and groups based on homeownership and HtM status, while the lower panel reports estimates for subgroups of homeowners based on liquid wealth (LW), housing wealth (HW), and leverage (Lev.), where low or high refer to households below or above median for a particular balance sheet classification.

[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

Figure 2 plots consumption insurance for each household group against median total wealth and housing wealth for that group. What is clear from this plot is that, while households generally do not have full consumption insurance against permanent income shocks, wealthier households do have a greater ability to absorb permanent income risk than poorer households. Furthermore, given a stronger link between consumption insurance and housing wealth than in the case of MPCs, households appear more willing to incur transaction costs in accessing illiquid funds to smooth their consumption in the face of a permanent shock than a transitory shock.

The underlying estimates for the response of consumption to permanent income shocks, γ_η , are also reported in Table 3. For all households, the estimate for γ_η of 0.38 with a standard error of 0.03 implies that, on average, U.S. households have consumption insurance of 62%. This is comparable to the estimate for γ_η of 0.45 with a standard error of 0.04 and corresponding consumption insurance of 55% in [Chatterjee et al. \(2020\)](#) for the BPP sample of data, which is a panel of annual observations for disposable income from the PSID and imputed nondurable consumption over an earlier sample period of 1978-1992. Meanwhile, as might be expected, homeowners, NHtM, higher liquid wealth, higher housing wealth, and lower leverage households all appear to be better able to absorb permanent income risk than their counterparts. [Chatterjee et al. \(2020\)](#) do not consider the same household groups as we do here, but they do find that older (ages 48-65) and college-educated households are better able to absorb permanent income risk than their counterparts, with similar point estimates (standard errors) for γ_η of 0.25 (0.06) and 0.29 (0.04), respectively, to what we find for higher liquid wealth, higher housing wealth, and lower leverage households in Table 3, all of which subgroups are older and more likely to be college-educated than their counterparts

¹⁴While we find liquid wealth is the key characteristic behind MPC heterogeneity, we should not downplay the potential role of HtM status. In particular, we find more 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 for this alternative sample selection suggest that WHtM households have notably higher transitory responses compared PHtM and NHtM households, with estimates (standard errors) of 0.18 (0.04), 0.13 (0.03), and 0.10 (0.03), respectively. Meanwhile, the baseline estimates for HtM households are robust to considering the classification based on real net wealth in [Zeldes \(1989\)](#) (see online appendix C).

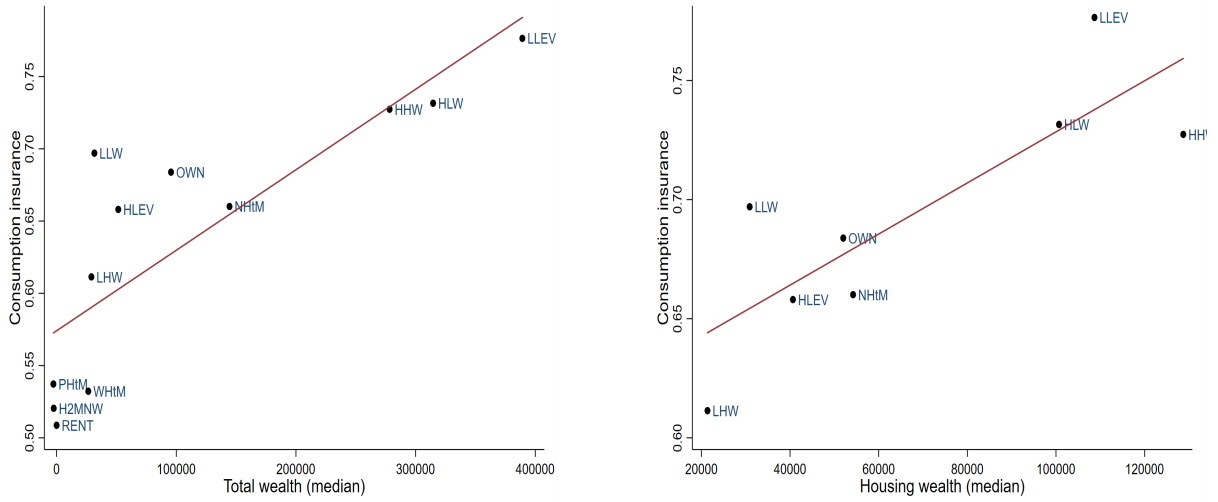


Figure 2: Consumption insurance vs. household wealth

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 based on estimated $1 - \gamma_\eta$ 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 classification.

according to Table 2.

4 Time-Varying Estimates

The boom and bust in housing wealth along with the rise in household debt and subsequent deleveraging are often cited as important aspects of household balance sheets for understanding the behavior of consumption around the Great Recession. In this section, we examine how estimated consumption responses varied from before to after the Great Recession by allowing different parameter values in the 1998-2006 and 2007-2016 subsample periods. We then document trends in wealth and leverage for different household groups over the full sample period and relate these to changes in MPCs. Finally, we consider what changes in MPCs imply for consumption elasticities with respect to house prices in order to investigate whether the fall in housing wealth or deleveraging was more likely to have driven down consumption during the Great Recession.

4.1 Transitory responses before and after the Great Recession

Table 4 reports estimates of the time-varying transitory consumption responses to idiosyncratic transitory income shocks before and after the Great Recession, along with Wald statistics for a test of parameter stability across the full 1998-2016 sample period (full sets of results for all parameters are given in online appendix E). The estimated transitory response, $\tilde{\gamma}_\epsilon$, for all households increased from 0.09 to 0.14, and the increase is statistically significant given the Wald test. Furthermore, the estimated transitory response in the 2007-2016 subsample period is higher than in the 1998-2006 subsample period for every group, although the change is not always statistically significant. Households who were homeowners before the Great Recession experienced a statistically-significant increase in their transitory consumption response from 0.08 to 0.14. By contrast, the estimated transitory response of renters only increased from 0.10 to 0.13 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 (in our sample 93% of WHtM and 79% of NHtM are homeowners), had increases in their estimated transitory responses, although the increases are not statistically significant, possibly due to a relatively small sample size, at least in the case of WHtM households.

The result that the transitory consumption response increased significantly for homeowners, but not for renters, directly suggests that the increase is associated with the negative wealth effects experienced by homeowners during the housing bust, as discussed more in the next subsection. Meanwhile, examining the time-varying transitory responses for homeowner subgroups, homeowners with lower liquid wealth and homeowners with higher leverage experienced particularly large increases in their estimated transitory responses, although the increase is only statistically significant for lower liquid wealth homeowners, with the estimated transitory response doubling from 0.13 to 0.26.¹⁵ For higher leverage homeowners, the statistically-insignificant increase was closer to 50% from 0.12 to 0.17.¹⁶

In terms of key robustness checks, first recall that there are substantial overlaps between lower liquid wealth homeowners, higher leverage homeowners, and HtM households (see

¹⁵Because house prices rebounded somewhat from 2012, we also considered estimation where we restricted the second sample period to 2007-2012 for robustness. Our main finding, which is that the transitory responses significantly increased for lower liquid wealth homeowners, still holds. The full estimation results for this robustness check are reported in online appendix F.

¹⁶Demyanyk, Loutskina, and Murphy (2019) argue that fiscal stimulus during the Great Recession could have been more effective in geographical areas with higher debt because households in those areas tend to have higher MPCs.

Table 4: Estimates of time-varying consumption responses

	All	Renter	Homeowner	PHtM	WHtM	NHtM
$\tilde{\gamma}_\epsilon$ 1998-2006	0.09 (0.02)	0.10 (0.03)	0.08 (0.02)	0.07 (0.06)	0.09 (0.04)	0.09 (0.02)
$\tilde{\gamma}_\epsilon$ 2007-2016	0.14 (0.02)	0.13 (0.04)	0.14 (0.02)	0.08 (0.07)	0.13 (0.05)	0.12 (0.03)
MPC 1998-2006	0.06 (0.01)	0.06 (0.02)	0.05 (0.01)	0.05 (0.05)	0.06 (0.02)	0.05 (0.01)
MPC 2007-2016	0.08 (0.01)	0.08 (0.02)	0.07 (0.01)	0.06 (0.06)	0.08 (0.02)	0.06 (0.01)
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.
$\tilde{\gamma}_\epsilon$ 1998-2006	0.13 (0.03)	0.08 (0.03)	0.12 (0.03)	0.08 (0.03)	0.12 (0.03)	0.10 (0.03)
$\tilde{\gamma}_\epsilon$ 2007-2016	0.26 (0.04)	0.12 (0.04)	0.13 (0.05)	0.12 (0.04)	0.17 (0.04)	0.12 (0.04)
MPC 1998-2006	0.07 (0.02)	0.04 (0.01)	0.06 (0.01)	0.04 (0.01)	0.07 (0.01)	0.05 (0.01)
MPC 2007-2016	0.13 (0.02)	0.06 (0.01)	0.06 (0.01)	0.06 (0.01)	0.09 (0.01)	0.06 (0.01)
Wald statistic	12.45	1.14	0.06	1.01	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. $\tilde{\gamma}_\epsilon$ is the transitory response to a transitory income shock and MPC is the short-run elasticity times the median consumption-income ratio. Estimates are reported for two subsample periods of 1998-2006 and 2007-2016. A Wald statistic for a test of parameter stability with a 5% critical value of 3.84 based on a $\chi^2(1)$ distribution under the null hypothesis $H_0 : \tilde{\gamma}_\epsilon$ 1998-2006 = $\tilde{\gamma}_\epsilon$ 2007-2016 is also reported.

online appendix G). Thus, to further isolate the roles of particular aspects of homeowner balance sheets, we also consider estimation excluding overlapping households from the subgroups (see online appendix E). Given this adjustment, sample sizes become smaller and standard errors larger, which in turn impacts the Wald statistics for testing the stability of the transitory responses. However, what we are interested in is whether the change in the transitory response in the second subsample period is in the same direction after removing the overlapping households. We find that excluding higher leverage homeowners from the low liquid wealth subgroup yields a higher estimated transitory response of 0.25 in the second subsample period, while excluding lower liquid wealth homeowners from high leverage subgroup lowers the estimated transitory response to 0.07 in the second subsample period. This suggests that liquid wealth is more relevant than leverage when considering changes in the response of consumption to transitory income shocks after the Great Recession.¹⁷ When we exclude HtM households from the low liquid wealth subgroup, we find that an even higher estimated transitory response of 0.39 in the second subsample period and the change is still statistically significant despite a smaller sample size. Second, to further corroborate our results, we also consider estimation using only households who appear in a particular group in both subsample periods (see online appendix E). For most of the household groups, the main conclusions drawn based on the estimates in Table 4 remain unchanged. Again, lower liquid wealth homeowners stand out and their transitory response is significantly higher, statistically and economically, after the Great Recession. Third, we also consider the possibility of more frequent changes in model parameters for all households by allowing a structural break after every two waves. We find the same pattern of change in the consumption response parameters as in Table 4, although the parameter estimates are not as precise given the shorter subsample periods (see online appendix F).

4.2 Trends in household wealth and leverage

To provide some context for interpreting the time-varying estimates, Figure 3 plots U.S. house price indices and the household-debt-to-GDP ratio over similar sample periods to our PSID data. The boom, bust, and sluggish recovery of house prices around the Great Recession is evident in both the FHFA and Case-Shiller house price indices, while a rapid

¹⁷We also estimate our model for subgroups based on debt-to-asset ratios for homeowners. The estimated transitory responses for homeowners with above-median debt-to-asset ratios are 0.14 (0.03) and 0.13 (0.05) in the first and second subsample periods, respectively.

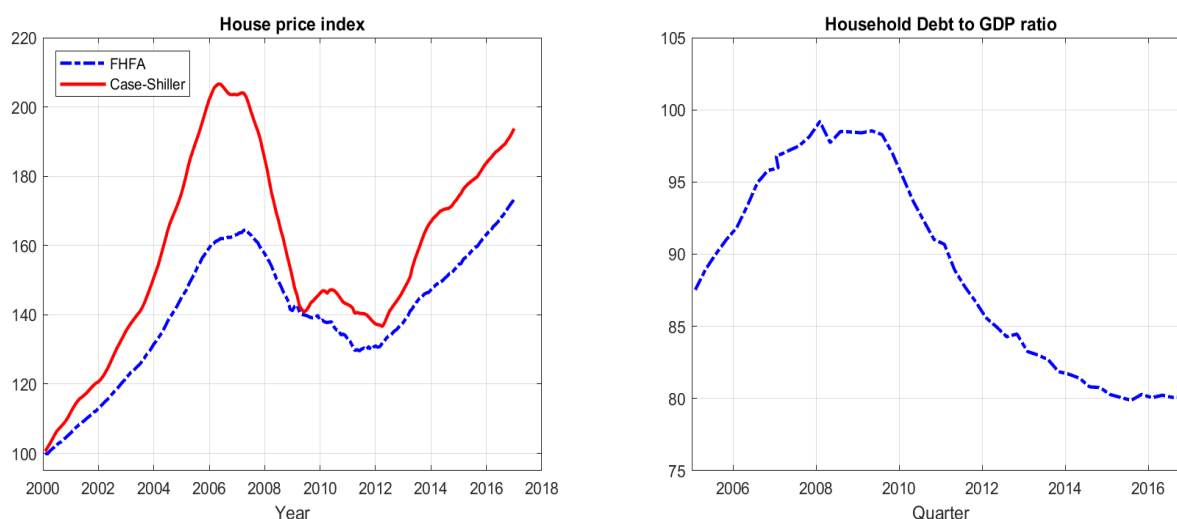
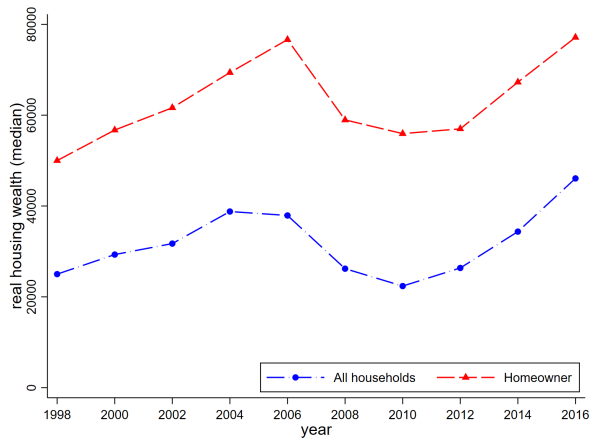


Figure 3: U.S. house price indices and household-debt-to-GDP ratio (%)

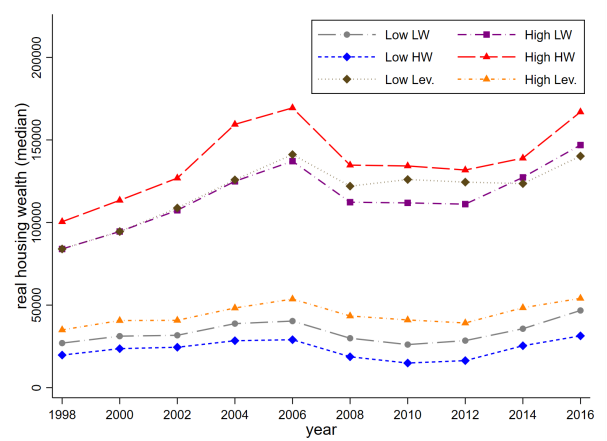
Sources: Federal Housing Finance Association; FRED, Federal Reserve Bank of St. Louis

increase in leverage followed by a gradual deleveraging is evident in the household-debt-to-GDP ratio. These patterns are mirrored in the PSID data. In particular, Figure 4 plots household wealth and leverage characteristics for all households, homeowners, and homeowner subgroups in the PSID over the full sample period. Panels (a) and (b) show that housing wealth increased for all groups before the Great Recession, fell during the Great Recession, and recovered sluggishly afterwards, closely following the boom and bust in house prices on display in Figure 3. Panel (c) shows that household leverage, i.e. the ratio of house value to total wealth, increased gradually for homeowners from 1.0 to 1.2 during the housing boom and decreased after the Great Recession back to 1.0, similar in pattern to the rise and fall in the household-debt-to-GDP ratio seen in Figure 3. As reported in Table 2, and also seen in panel (f), leverage is much higher, generally above 2, for homeowners with low liquid wealth, low housing wealth, or high leverage, but the levels gradually fell after the Great Recession. Finally, panels (e) and (f) show that, while liquid wealth decreased for homeowners from 2002 to 2010, renters have low liquid wealth throughout the full sample period and, among homeowners, liquid wealth varies considerably. It is particularly low, close to that of renters, for homeowners with lower liquid wealth, lower housing wealth, or higher leverage.

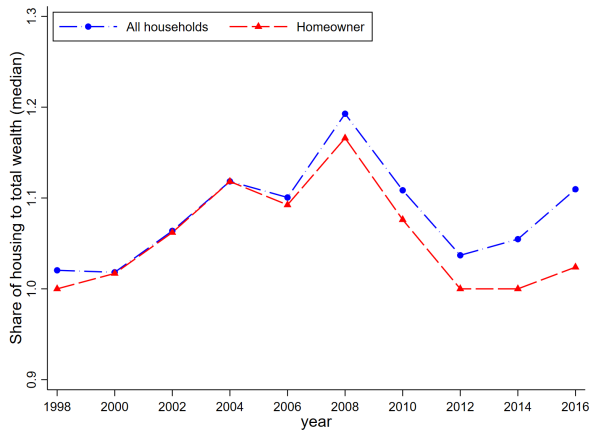
Figure 5 plots the time-varying MPCs (also reported in Table 4) based on time-varying consumption response estimates and median consumption-income ratios for each group in



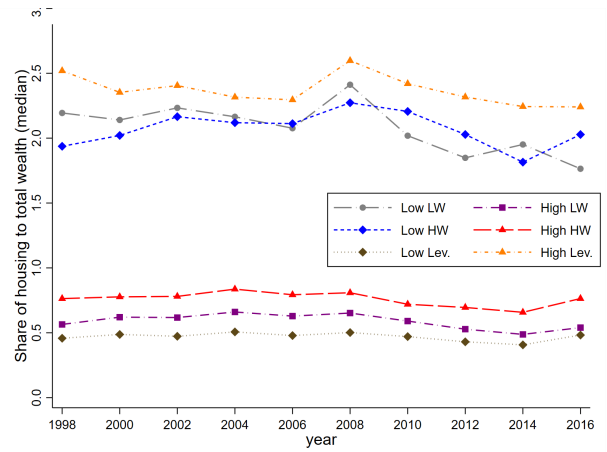
(a) Housing wealth: all and homeowners



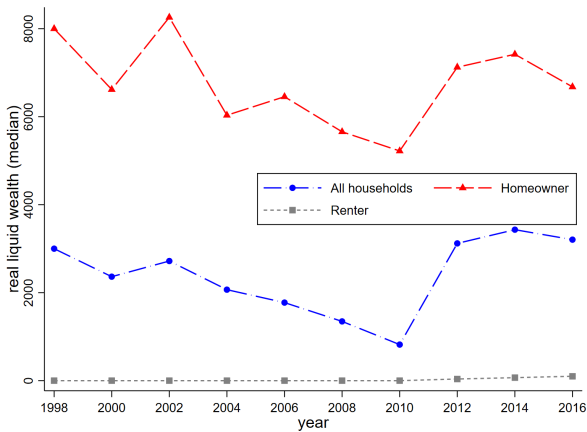
(b) Housing wealth: homeowner subgroups



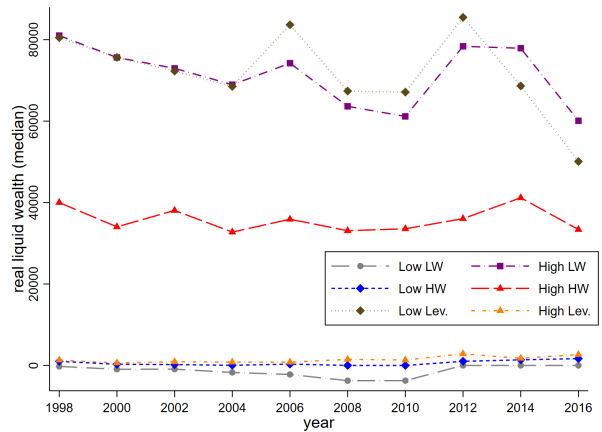
(c) Leverage: all and homeowners



(d) Leverage: homeowner subgroups



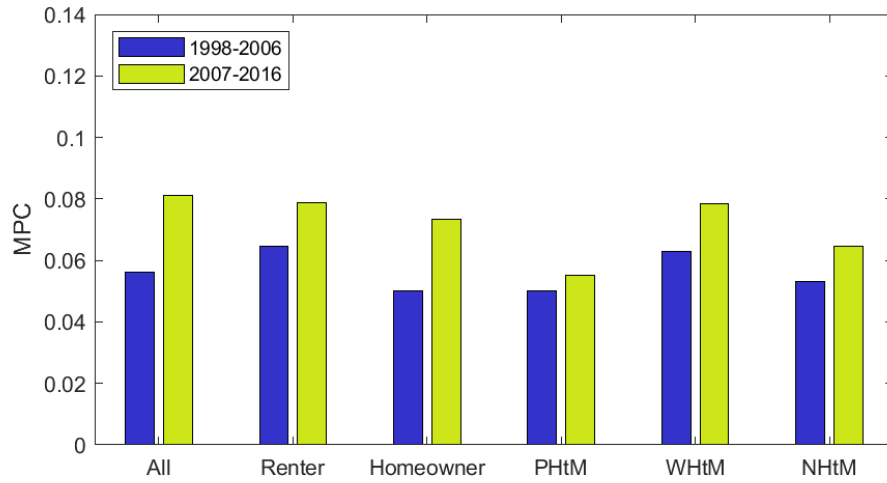
(e) Liquid wealth: all, homeowners, and renters



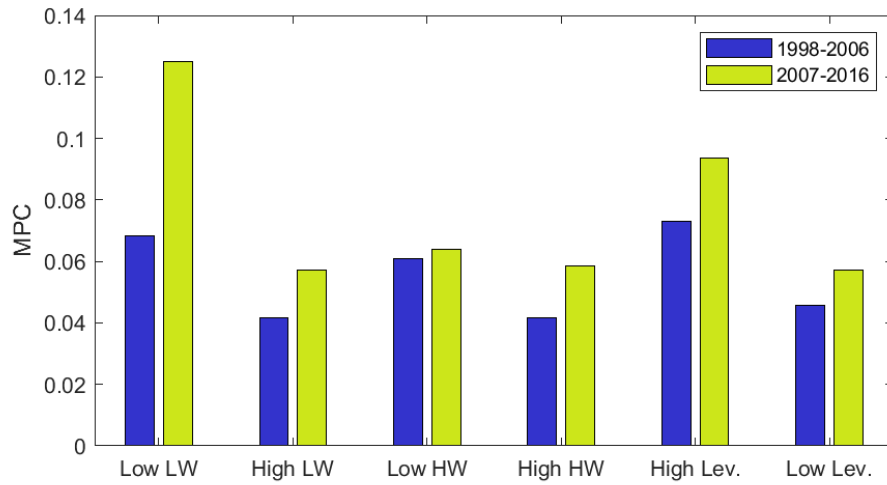
(f) Liquid wealth: homeowner subgroups

Figure 4: Housing wealth, leverage, and liquid wealth for different groups in the PSID

Note: The plots report wave-by-wave values for median real housing wealth (top panel), leverage (middle panel), and real liquid wealth (bottom panel) for all households, homeowners, renters (only in the case of liquid wealth), and homeowner subgroups in the PSID.



(a) Broad categories



(b) Homeowner subgroups

Figure 5: Time-varying MPCs

Note: The figure plots MPCs out of idiosyncratic transitory income shocks for subsample period 1998-2006 (blue bars) and 2007-2016 (green bars) for different groups.

the subsample periods. The results closely reflect the changes in transitory consumption responses rather than changes in permanent consumption responses or consumption-income ratios.¹⁸ Recall that the changes in transitory consumption responses to transitory income shocks were statistically significant in the cases of all households, homeowners, and lower liquid wealth homeowners. These cases stand out in Figure 5 in terms of the changes in MPCs, although the estimated increase in the MPC for WHtM households also appears large and may only be statistically insignificant because of a relatively small sample size.

Taken together with the trends in Figure 4, the time-varying estimates in Table 4 and Figure 5 suggest that a negative housing wealth effect amplified by low liquidity is closely related to a rise in transitory consumption responses and MPCs since the Great Recession.¹⁹ Before the Great Recession, the households with high MPCs were mainly renters and WHtM households, while homeowners' balance sheets did not appear to matter quite as much beyond HtM status; see the 1998-2006 MPCs in the lower panel of Figure 5. However, since the Great Recession when household balance sheets changed substantially, the estimates suggest that, in addition to renters and WHtM households, homeowners, particularly those with lower liquid wealth, also have high MPCs. Intuitively, homeowners could easily access additional liquidity from their housing wealth through cash-out refinancing or 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; see [Hurst and Stafford \(2004\)](#) for empirical evidence that households use their housing wealth to insure against bad income realizations. As house prices fell and housing wealth declined, credit constraints likely became 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; see also [Gross, Notowidigdo, and Wang \(2019\)](#), who find an increase of about 30%

¹⁸Changes in permanent consumption responses to either permanent or transitory income shocks are not statistically significant for any group. In terms of consumption insurance, [Guvenen, Ozkan, and Song \(2014\)](#) 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 transitory 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 again be more willing to incur transaction costs in accessing illiquid funds when facing permanent shocks and, therefore, not alter their response to such shocks as much as for transitory shocks.

¹⁹As another robustness check that was also noted in Section 2.1, we consider estimation removing housing (rent and imputed rent) from the measure of consumption (see online appendix F). 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 lower liquid wealth homeowners.

in the MPC out of liquidity between 2007 and 2009 using U.S. credit card transaction data, a similar magnitude to the increase we find for all households in Figure 4.

4.3 Implied consumption elasticities with respect to house prices

Beyond direct effects of changes in the sensitivity of consumption to income shocks, increased MPCs may also correspond to changes in the effect of house prices on consumption, which could further help in understanding the fall in consumption during the Great Recession. To examine this possible channel, we compute the consumption elasticity with respect to house prices for each group in each of the two subsample periods based on the rule-of-thumb formula proposed by [Berger et al. \(2018\)](#):

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

where δ is the depreciation rate for housing, set to 2% per annum, and PH is the reported house *value* (distinct from housing *wealth*, which is net of mortgage debt) 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 period, while the MPC values are based on the time-varying estimates and the median consumption-income ratio for each group in each subsample period. This rule-of-thumb formula implies that the consumption elasticity with respect to house prices will be larger if either the MPC or the house-value-to-consumption ratio is higher, all else equal.

The consumption elasticity with respect to house prices has often been employed to understand the mechanism behind the fall in consumption during the Great Recession. Consistent with higher MPCs in the second subsample period, Figure 6 shows that consumption elasticities with respect to house prices increased after 2007, despite concomitant falls in house-value-to-consumption ratios. For all households, the elasticity is 0.28 for the subsample period before the Great Recession and 0.43 for the subsample period afterwards, with 95% confidence intervals in each period of [0.20, 0.36] and [0.32, 0.55], respectively. These estimates are high, but in line with the estimates in [Berger et al. \(2018\)](#).²⁰ As with the MPCs,

²⁰Using 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 comparatively imprecise 95% confidence interval of [0.15, 0.52]. They also find estimates above 0.5 for households with high house values. Estimates in the literature vary considerably based on data and methods; see, for example, [Mian et al. \(2013\)](#), [Aladangady \(2017\)](#), [Paiella and Pistaferri \(2017\)](#), [Kaplan et al. \(2020b\)](#), [Guren, McKay, Nakamura, and Steinsson \(2020\)](#), and [Graham and Makridis \(2020\)](#). We note that the scale of our consumption elasticities may be high if the self-reported house-value-to-consumption ratios are overly optimistic in the PSID or the assumed 2% depreciation rate is too low.

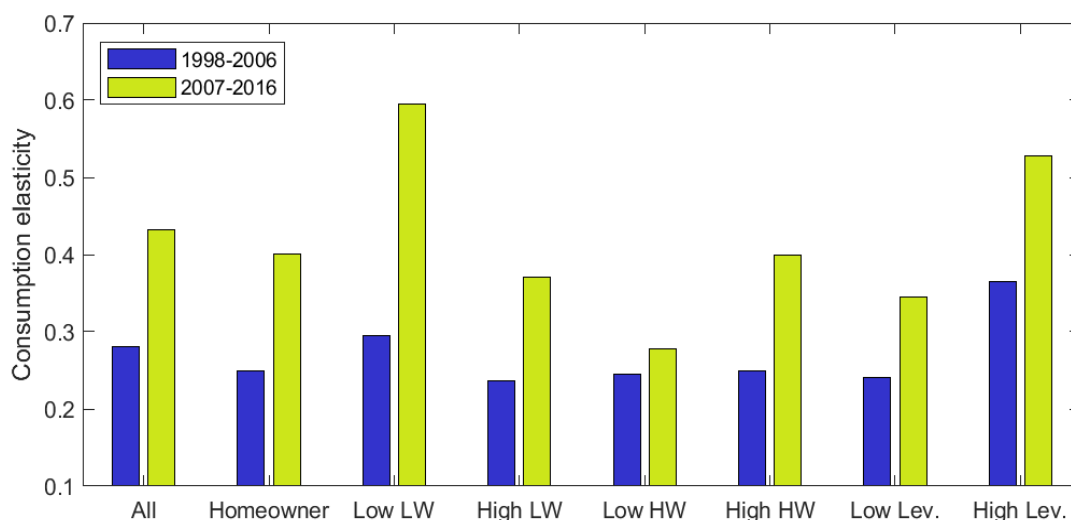


Figure 6: Consumption elasticities with respect to house prices

Note: The figure plots elasticities of consumption with respect to house prices for subsample period 1998-2006 (blue bars) and 2007-2016 (green bars) for a subset of groups.

the increase in the elasticity is largest for lower liquid wealth homeowners. 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 main role, then we would have expected higher leverage households to have had a larger increase in their MPC and, therefore, a larger increase in their implied consumption elasticity with respect to house prices. However, the change in the transitory consumption response was not statistically significant for the high leverage subgroup (although the point estimate did increase, just not nearly as much as for lower liquid wealth homeowners). Instead our result suggests that increases in elasticities are most closely related to a rise in MPCs due to a housing wealth effect, especially for lower liquid wealth homeowners. This supports the argument in [Kaplan et al. \(2020a\)](#) that a negative housing wealth shock more than deleveraging drove down consumption during the Great Recession.

However, the qualitative differences that we find across different household groups should be informative as long as any reporting biases are similar across groups. [Berger et al. \(2018\)](#) also discuss a variety of theoretical reasons why their rule-of-thumb formula may not be accurate, including the presence of adjustment costs, although they show that it works well as an approximation in many settings.

5 Conclusion

We conclude by discussing how our results align with different theories of consumption behavior. Starting with a standard one-asset model that features a precautionary savings motive due to the presence of either occasionally-binding borrowing constraints or concave marginal utility in the presence of income uncertainty and incomplete markets, poor households with low levels of wealth should have higher marginal propensities to consume; see, for example, [Carroll and Kimball \(1996\)](#), [Carroll \(1997\)](#), and [Carroll \(2019\)](#). 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 finding that estimated marginal propensities to consume out of idiosyncratic transitory income shocks are decreasing in different measures of household wealth is, therefore, qualitatively consistent with the predictions of theoretical models featuring a precautionary savings motive. However, as argued in [Kaplan and Violante \(2014\)](#), one-asset models fail to generate large consumption responses in the aggregate because there are too few households with close to zero wealth and hence with high enough implied marginal propensities to consume.²¹ In the two-asset (liquid and illiquid) model of [Kaplan and Violante \(2014\)](#), a higher return on the illiquid asset induces a tradeoff between consumption smoothing and higher lifetime consumption. In this setting, some households will find it optimal to hold relatively few liquid assets while holding a large amount of illiquid assets. Consumption for such households will be sensitive to transitory changes in income, consistent with our finding of a higher marginal propensity to consume for homeowners with lower liquid wealth.

In a two-asset setting, then, what would generate a rise in the transitory consumption response for all households, such as we find with our time-varying estimation? An increase in the aggregate is possible if either the fraction of households who are liquidity constrained increases or the sensitivity of consumption to idiosyncratic transitory income shocks increases due to a fall in wealth. Our results suggest that both forces are likely to be at play. In particular, we find that the negative housing wealth shock and low liquidity for some homeowners is associated with a large increase in the sensitivity of consumption to transitory income shocks. Specifically, half of all homeowners (i.e., those with below median liquid wealth) saw a large increase in their estimated marginal propensity to consume, with many of those

²¹[Carroll, Slacalek, Tokuoka, and White \(2017\)](#) show that heterogeneity in discount factors can also generate the fraction of households with a low level of wealth found in the data, while simultaneously matching the mean level of wealth in the data.

households not technically classified as "hand-to-mouth". Therefore, our time-varying estimates support the theoretical result of Boar et al. (2020), who model the illiquid asset as housing in a two-asset incomplete markets model and suggest that liquidity constraints bind for most homeowners, even though these homeowners are not necessarily hand-to-mouth.

In summary, our quasi maximum likelihood approach provides highly precise estimates of consumption responses that shed new light on the relationship between marginal propensities to consume and household balance sheet characteristics, including how they have changed from before the Great Recession to afterwards. In terms of policy implications, our finding of a closer association of household balance sheet liquidity than leverage with increased marginal propensities to consume supports the view that stabilization policies designed to improve liquidity of homeowners would be more effective than debt relief programs during and in the aftermath of recessions associated with large declines in house prices.

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Online Appendix for “Marginal Propensities to Consume Before and After the Great Recession”

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A Information on Sample Selection and Group Overlaps

This appendix reports on the number of observations dropped during sample selection and the overlap between different household groups for our analysis in Section 3.

Table A–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 A–2: Overlaps between household groups

	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	0.07	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	0.79	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 categories. These overlaps are based on the sample that was used in the analysis of constant consumption responses in Section 3. The reader should interpret the numbers from the rows. For example, 0.43 in the second row and the third column implies that 43% of the total observations in the homeowner subgroup are also in the low liquid wealth homeowner subgroup. Similarly, 0.67 in the third row and the fifth row suggests that 67% of the total observations in the low liquid wealth homeowner subgroups are also in the low housing wealth homeowner subgroup.

B Compositional Changes and Group Classification

Figure B–1 reports the number of households 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 appearing in a particular group at some point in the analysis presented in Section 3. 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 2007.¹ Similarly, subgroups of homeowners based on balance sheet characteristics, the right panel of Figure B–1, transition more often with more than half of homeowners in each balance sheet subgroup transitioning out of their subgroup classification from before to after the Great Recession.

For the analysis in Section 4, we classify households into groups based on their status in the first subsample period. That is, we consider households classified in a particular group before 2007, but not those who only appear in a group after 2007. For example, suppose a household was a renter before 2000 and became a homeowner from 2002 onward, this household is in the renter classification in 1998 and 2000, but the homeowner classification 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.² In terms of Figure B–1, this household is in the orange bar for the renter group and the blue bar for the homeowner group. 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.³ We also consider an alternative and arguably more conservative classification to deal with possible endogenous transitions. In particular, we exclude households who were in a particular classification for only one of the two subsample periods. Specifically,

¹This is consistent with [Kaplan et al. \(2014\)](#) who show that the expected duration of HtM status is 3.5 to 4.5 years.

²To consider another example, suppose a household was a homeowner until 2006 and transitioned to being a renter by 2008. In this case, the household’s data from 1998–2006 will be used in the estimation of the homeowner group and the observations from 2007–2016 will be discarded.

³The summary statistics and overlaps between different household groups for this sample (reported in Tables G–1 to G–3 in online appendix G) are similar to those reported in Tables 1 and 2, and Table A–2 in online appendix A.

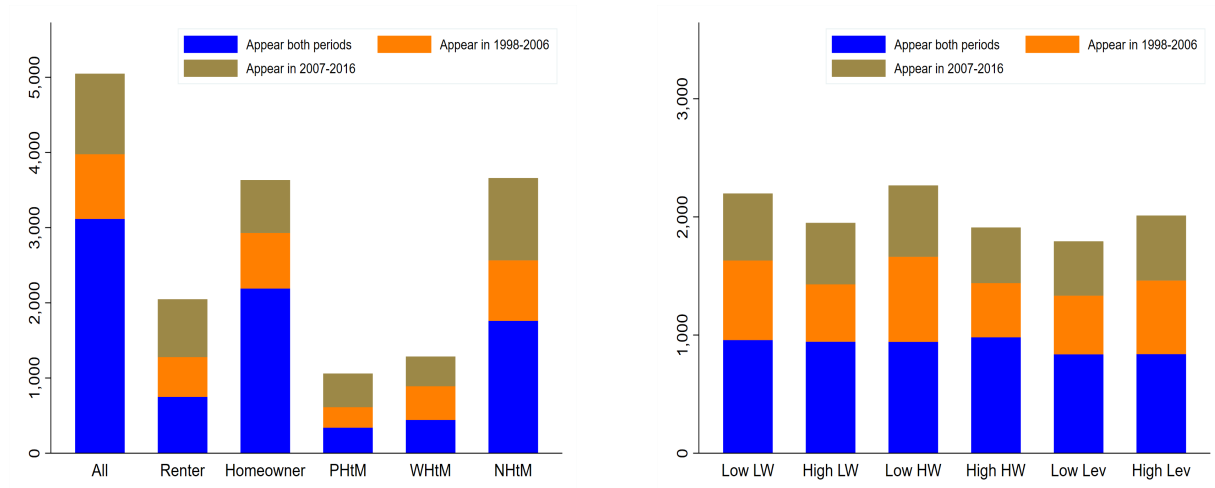


Figure B-1: Number of households in one or both subsample periods

Note: The blue bars represent the number of households in a particular group in both periods, while the orange and brown bars show the number of households in a particular group only in one subsample period.

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 B-1 are included in this robustness analysis.

C State-Space Form

In this appendix, we present the state-space form for the unobserved components representation of the modified BPP model presented 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

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

The state equation is

$$\mathbf{X}_t = \mathbf{F}\mathbf{X}_{t-1} + \mathbf{v}_t,$$

where

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

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

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

Given the 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 $z_{u 0|0} = c_1 - \gamma_\eta y_1$ (or first available values given missing observations) with variances of 100 along with $\epsilon_{0|0} = \epsilon_{-1|0} = v_{0|0} = 0$ and variances of these shocks to initialize the Kalman filter.⁴

⁴See Chatterjee et al. (2020) for details on estimation of the BPP model via QMLE and the Kalman filter.

D 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 for each household group are held constant over the full sample period, but variances are allowed to vary across groups and over time.

Table D–1: Estimates for all households and groups by homeownership status

		All	Renters	Homeowners
		INCOME		
σ_η	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)
σ_ϵ	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		
σ_u	1998-06	0.08 (0.01)	0.08 (0.04)	0.08 (0.01)
	2007-16	0.10 (0.00)	0.11 (0.01)	0.09 (0.00)
σ_v	1998-06	0.26 (0.01)	0.34 (0.02)	0.21 (0.01)
	2007-16	0.30 (0.00)	0.36 (0.01)	0.24 (0.00)
$\bar{\gamma}_\epsilon$		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)
γ_η		0.38 (0.03)	0.49 (0.00)	0.32 (0.03)
N		5,047	2,047	3,633

Notes: The table reports estimates for all model parameters, with standard errors in parentheses. The results are for the constant consumption response analysis also reported in Table 3.

Table D–2: Estimates for groups by HtM status

		PHtM	WHtM	NHtM	HtM _{nw}
INCOME					
σ_η	1998-06	0.12 (0.02)	0.11 (0.01)	0.11 (0.01)	0.12 (0.01)
	2007-16	0.15 (0.02)	0.09 (0.01)	0.11 (0.01)	0.13 (0.01)
σ_ϵ	1998-06	0.34 (0.01)	0.26 (0.01)	0.24 (0.01)	0.29 (0.01)
	2007-16	0.33 (0.01)	0.26 (0.01)	0.24 (0.01)	0.30 (0.01)
CONSUMPTION					
σ_u	1998-06	0.16 (0.06)	0.07 (0.04)	0.08 (0.01)	0.06 (0.04)
	2007-16	0.13 (0.02)	0.10 (0.02)	0.10 (0.01)	0.10 (0.01)
σ_v	1998-06	0.35 (0.04)	0.27 (0.02)	0.22 (0.01)	0.33 (0.02)
	2007-16	0.34 (0.01)	0.26 (0.01)	0.27 (0.01)	0.34 (0.01)
$\tilde{\gamma}_\epsilon$		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)
γ_η		0.46 (0.03)	0.47 (0.12)	0.34 (0.04)	0.48 (0.01)
N		1,060	1,285	3,659	1,886

Notes: The table reports estimates for all model parameters, with standard errors in parentheses. The results are for the constant consumption response analysis also reported in Table 3. Following [Zeldes \(1989\)](#), a household is classified as HtM_{nw} (hand-to-mouth based on net wealth) if their real net wealth is less than the head of household's two-month labor earnings.

Table D-3: Estimates for subgroups of homeowners

		Low LW	High LW	Low HW	High HW	High Lev.	Low Lev.
INCOME							
σ_η	1998-06	0.12 (0.01)	0.11 (0.01)	0.11 (0.01)	0.12 (0.01)	0.10 (0.01)	0.13 (0.01)
	2007-16	0.10 (0.01)	0.11 (0.01)	0.11 (0.01)	0.11 (0.01)	0.09 (0.01)	0.12 (0.01)
σ_ϵ	1998-06	0.24 (0.01)	0.24 (0.01)	0.22 (0.01)	0.25 (0.01)	0.22 (0.01)	0.25 (0.01)
	2007-16	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							
σ_u	1998-06	0.08 (0.01)	0.08 (0.01)	0.07 (0.01)	0.07 (0.01)	0.08 (0.01)	0.08 (0.01)
	2007-16	0.10 (0.01)	0.09 (0.01)	0.08 (0.01)	0.09 (0.01)	0.08 (0.01)	0.10 (0.01)
σ_v	1998-06	0.23 (0.01)	0.18 (0.01)	0.21 (0.01)	0.20 (0.01)	0.18 (0.01)	0.20 (0.01)
	2007-16	0.25 (0.01)	0.23 (0.01)	0.26 (0.01)	0.23 (0.01)	0.22 (0.01)	0.25 (0.01)
$\tilde{\gamma}_\epsilon$		0.02 (0.01)	0.03 (0.01)	0.02 (0.01)	0.02 (0.01)	0.03 (0.01)	0.01 (0.01)
$\tilde{\gamma}_\epsilon$		0.17 (0.03)	0.08 (0.02)	0.13 (0.03)	0.10 (0.02)	0.14 (0.03)	0.12 (0.03)
γ_η		0.30 (0.08)	0.27 (0.05)	0.39 (0.05)	0.27 (0.05)	0.34 (0.07)	0.22 (0.05)
N		2,198	1,949	2,266	1,910	2,011	1,793

Notes: The table reports estimates for all model parameters, with standard errors in parentheses. The results are for the constant consumption response analysis also reported in Table 3.

Table D–4: Estimates for homeowners excluding HtM

		Low LW	Low HW	High Lev
		INCOME		
σ_η	1998-06	0.12 (0.01)	0.10 (0.01)	0.09 (0.01)
	2007-16	0.08 (0.01)	0.11 (0.01)	0.09 (0.01)
σ_ϵ	1998-06	0.22 (0.01)	0.23 (0.01)	0.21 (0.01)
	2007-16	0.21 (0.01)	0.18 (0.01)	0.19 (0.01)
		CONSUMPTION		
σ_u	1998-06	0.08 (0.01)	0.07 (0.01)	0.08 (0.01)
	2007-16	0.10 (0.01)	0.08 (0.01)	0.07 (0.01)
σ_v	1998-06	0.21 (0.01)	0.21 (0.01)	0.17 (0.01)
	2007-16	0.25 (0.01)	0.26 (0.01)	0.23 (0.01)
$\tilde{\gamma}_\epsilon$		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)
γ_η		0.13 (0.09)	0.41 (0.06)	0.38 (0.07)
N		1,726	1,998	1,316

Notes: The table reports estimates for all model parameters, with standard errors in parentheses. The results are for constant consumption responses of homeowners excluding hand-to-mouth households.

E 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 E-1: Time-varying estimates for all households and groups by homeownership status

		All	Renters	Homeowners
		INCOME		
σ_η	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)
σ_ϵ	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		
σ_u	1998-06	0.08 (0.01)	0.08 (0.04)	0.08 (0.01)
	2007-16	0.10 (0.00)	0.10 (0.01)	0.09 (0.00)
σ_v	1998-06	0.26 (0.01)	0.34 (0.02)	0.21 (0.01)
	2007-16	0.28 (0.00)	0.33 (0.01)	0.24 (0.01)
$\tilde{\gamma}_\epsilon$	1998-06	0.03 (0.01)	0.02 (0.02)	0.03 (0.01)
	2007-16	0.03 (0.01)	0.02 (0.02)	0.03 (0.01)
$\tilde{\gamma}_\epsilon$	1998-06	0.09 (0.02)	0.10 (0.03)	0.08 (0.02)
	2007-16	0.14 (0.02)	0.13 (0.04)	0.14 (0.02)
γ_η	1998-06	0.36 (0.00)	0.49 (0.14)	0.31 (0.03)
	2007-16	0.39 (0.02)	0.51 (0.00)	0.32 (0.03)
N		3,977	1,278	2,930

Notes: The table reports estimates for all model parameters, with standard errors in parentheses. The results are for the time-varying analysis also reported in Table 4.

Table E-2: Time-varying estimates for groups by HtM status

		PHtM	WHtM	NHtM
		INCOME		
σ_η	1998-06	0.12 (0.02)	0.11 (0.01)	0.11 (0.01)
	2007-16	0.14 (0.02)	0.07 (0.01)	0.11 (0.00)
σ_ϵ	1998-06	0.34 (0.01)	0.26 (0.01)	0.24 (0.01)
	2007-16	0.31 (0.02)	0.27 (0.01)	0.23 (0.01)
		CONSUMPTION		
σ_u	1998-06	0.16 (0.06)	0.07 (0.04)	0.08 (0.01)
	2007-16	0.12 (0.02)	0.10 (0.02)	0.10 (0.00)
σ_v	1998-06	0.35 (0.04)	0.27 (0.02)	0.22 (0.01)
	2007-16	0.31 (0.02)	0.24 (0.02)	0.24 (0.01)
$\tilde{\gamma}_\epsilon$	1998-06	0.01 (0.03)	0.04 (0.02)	0.04 (0.01)
	2007-16	0.01 (0.03)	0.03 (0.03)	0.04 (0.01)
$\tilde{\gamma}_\epsilon$	1998-06	0.07 (0.06)	0.09 (0.04)	0.09 (0.02)
	2007-16	0.08 (0.07)	0.13 (0.05)	0.12 (0.03)
γ_η	1998-06	0.66 (0.14)	0.47 (0.04)	0.30 (0.04)
	2007-16	0.59 (0.12)	0.50 (0.00)	0.33 (0.04)
N		612	890	2,566

Notes: The table reports estimates for all model parameters, with standard errors in parentheses. The results are for the time-varying analysis also reported in Table 4.

Table E-3: Time-varying estimates for subgroups of homeowners

		Low LW	High LW	Low HW	High HW	High Lev.	Low Lev.
INCOME							
σ_η	1998-06	0.12 (0.01)	0.12 (0.01)	0.11 (0.01)	0.12 (0.01)	0.10 (0.01)	0.13 (0.01)
	2007-16	0.09 (0.01)	0.10 (0.01)	0.10 (0.01)	0.11 (0.01)	0.08 (0.01)	0.11 (0.01)
σ_ϵ	1998-06	0.24 (0.01)	0.23 (0.01)	0.22 (0.01)	0.24 (0.01)	0.22 (0.01)	0.25 (0.01)
	2007-16	0.23 (0.01)	0.22 (0.01)	0.21 (0.01)	0.23 (0.01)	0.20 (0.01)	0.25 (0.01)
CONSUMPTION							
σ_u	1998-06	0.08 (0.01)	0.08 (0.01)	0.07 (0.01)	0.07 (0.01)	0.08 (0.01)	0.08 (0.01)
	2007-16	0.09 (0.01)	0.10 (0.01)	0.08 (0.01)	0.09 (0.01)	0.08 (0.01)	0.10 (0.01)
σ_v	1998-06	0.23 (0.01)	0.18 (0.01)	0.21 (0.01)	0.20 (0.01)	0.18 (0.01)	0.20 (0.01)
	2007-16	0.25 (0.01)	0.21 (0.01)	0.26 (0.01)	0.22 (0.01)	0.20 (0.01)	0.23 (0.01)
$\tilde{\gamma}_\epsilon$	1998-06	0.02 (0.02)	0.02 (0.02)	0.03 (0.02)	0.01 (0.03)	0.04 (0.02)	0.01 (0.02)
	2007-16	0.02 (0.02)	0.02 (0.02)	0.03 (0.02)	0.01 (0.03)	0.04 (0.02)	0.01 (0.02)
$\tilde{\gamma}_\epsilon$	1998-06	0.13 (0.03)	0.08 (0.03)	0.12 (0.03)	0.08 (0.03)	0.12 (0.03)	0.10 (0.03)
	2007-16	0.26 (0.04)	0.12 (0.04)	0.13 (0.05)	0.12 (0.04)	0.17 (0.04)	0.12 (0.04)
γ_η	1998-06	0.29 (0.05)	0.25 (0.05)	0.41 (0.08)	0.26 (0.04)	0.28 (0.07)	0.23 (0.05)
	2007-16	0.33 (0.05)	0.25 (0.05)	0.40 (0.07)	0.28 (0.04)	0.31 (0.07)	0.23 (0.05)
N		1,631	1,429	1,663	1,440	1,462	1,334

Notes: The table reports estimates for all model parameters, with standard errors in parentheses. The results are for the time-varying analysis also reported in Table 4.

Table E-4: Time-varying estimates for miscellaneous 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						
σ_η	1998-06	0.15 (0.02)	0.12 (0.01)	0.10 (0.02)	0.11 (0.01)	0.12 (0.01)
	2007-16	0.11 (0.02)	0.09 (0.01)	0.08 (0.02)	0.11 (0.01)	0.11 (0.01)
σ_ϵ	1998-06	0.26 (0.01)	0.23 (0.01)	0.19 (0.02)	0.21 (0.01)	0.25 (0.01)
	2007-16	0.23 (0.02)	0.19 (0.02)	0.20 (0.03)	0.19 (0.01)	0.25 (0.01)
CONSUMPTION						
σ_u	1998-06	0.10 (0.02)	0.09 (0.01)	0.09 (0.02)	0.08 (0.01)	0.08 (0.01)
	2007-16	0.11 (0.02)	0.08 (0.02)	0.06 (0.01)	0.09 (0.01)	0.10 (0.01)
σ_v	1998-06	0.26 (0.02)	0.21 (0.01)	0.14 (0.01)	0.19 (0.01)	0.20 (0.01)
	2007-16	0.29 (0.02)	0.24 (0.02)	0.20 (0.01)	0.22 (0.01)	0.24 (0.01)
$\tilde{\gamma}_\epsilon$	1998-06	0.02 (0.02)	0.00 (0.07)	0.01 (0.04)	0.03 (0.02)	0.00 (0.00)
	2007-16	0.02 (0.02)	0.00 (0.07)	0.01 (0.04)	0.03 (0.02)	0.00 (0.00)
$\tilde{\gamma}_\epsilon$	1998-06	0.14 (0.07)	0.14 (0.07)	0.13 (0.06)	0.14 (0.03)	0.11 (0.02)
	2007-16	0.25 (0.10)	0.39 (0.10)	0.07 (0.08)	0.13 (0.05)	0.15 (0.03)
γ_η	1998-06	0.22 (0.12)	0.22 (0.10)	0.39 (0.10)	0.29 (0.07)	0.23 (0.05)
	2007-16	0.23 (0.12)	0.30 (0.11)	0.37 (0.10)	0.31 (0.07)	0.25 (0.05)
N		560	753	391	1,658	1,454

Notes: The table reports estimates for all model parameters, with standard errors in parentheses. Columns 3-4 report estimates for low liquid wealth (LW) homeowners (homeowners whose liquid wealth is below the median liquid wealth value across all homeowners in a given year) removing overlapping homeowners with high leverage and HtM households, respectively. Column 5 reports the estimates for high leverage homeowners removing overlapping low liquid wealth homeowners. The last two columns report estimates for high and low debt-to-asset (D2A) subgroups where the D2A ratio is defined as total debt (mortgages + credit card debt + non-credit card debt) divided by total asset (checks and savings + house + pension).

Table E–5: Time-varying estimates for all household and groups by homeownership status using an alternative sample selection

		All	Renters	Homeowners
		INCOME		
σ_η	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)
σ_ϵ	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		
σ_u	1998-06	0.08 (0.01)	0.06 (0.04)	0.08 (0.01)
	2007-16	0.10 (0.00)	0.11 (0.01)	0.09 (0.00)
σ_v	1998-06	0.25 (0.01)	0.33 (0.02)	0.20 (0.01)
	2007-16	0.28 (0.00)	0.33 (0.01)	0.24 (0.00)
$\bar{\gamma}_\epsilon$	1998-06	0.03 (0.01)	0.04 (0.02)	0.03 (0.01)
	2007-16	0.03 (0.01)	0.03 (0.02)	0.03 (0.01)
$\tilde{\gamma}_\epsilon$	1998-06	0.10 (0.02)	0.12 (0.04)	0.09 (0.02)
	2007-16	0.14 (0.02)	0.13 (0.04)	0.14 (0.02)
γ_η	1998-06	0.35 (0.03)	0.45 (0.04)	0.30 (0.03)
	2007-16	0.38 (0.02)	0.47 (0.03)	0.32 (0.03)
N		3,117	749	2,190

Notes: The table reports full estimates, with standard errors in parentheses. The results are for the time-varying analysis using an alternative sample selection described in online appendix B.

Table E–6: Time-varying estimates for groups by HtM status using an alternative sample selection

		PHtM	WHtM	NHtM
		INCOME		
σ_η	1998-06	0.12 (0.02)	0.11 (0.01)	0.11 (0.01)
	2007-16	0.14 (0.02)	0.08 (0.02)	0.11 (0.00)
σ_ϵ	1998-06	0.35 (0.02)	0.25 (0.01)	0.24 (0.01)
	2007-16	0.31 (0.02)	0.27 (0.02)	0.22 (0.02)
		CONSUMPTION		
σ_u	1998-06	0.03 (0.09)	0.06 (0.05)	0.08 (0.01)
	2007-16	0.13 (0.02)	0.10 (0.02)	0.10 (0.00)
σ_v	1998-06	0.37 (0.03)	0.29 (0.04)	0.21 (0.01)
	2007-16	0.31 (0.02)	0.24 (0.02)	0.24 (0.01)
$\tilde{\gamma}_\epsilon$	1998-06	0.01 (0.03)	0.04 (0.03)	0.04 (0.02)
	2007-16	0.02 (0.03)	0.04 (0.03)	0.04 (0.02)
$\tilde{\gamma}_\epsilon$	1998-06	0.11 (0.07)	0.08 (0.06)	0.08 (0.03)
	2007-16	0.09 (0.07)	0.12 (0.05)	0.12 (0.03)
γ_η	1998-06	0.61 (0.15)	0.46 (0.03)	0.30 (0.04)
	2007-16	0.55 (0.04)	0.49 (0.01)	0.33 (0.04)
N		340	442	1,761

Notes: The table reports full estimates, with standard errors in parentheses. The results are for the time-varying analysis using an alternative sample selection described in online appendix B.

Table E-7: Time-varying estimates for subgroups of homeowners using an alternative sample selection

		Low LW	High LW	Low HW	High HW	High Lev.	Low Lev.
		INCOME					
σ_η	1998-06	0.11 (0.01)	0.12 (0.01)	0.10 (0.01)	0.12 (0.01)	0.09 (0.01)	0.13 (0.01)
	2007-16	0.09 (0.01)	0.10 (0.01)	0.10 (0.01)	0.11 (0.01)	0.08 (0.01)	0.11 (0.01)
σ_ϵ	1998-06	0.23 (0.01)	0.23 (0.01)	0.22 (0.01)	0.23 (0.01)	0.20 (0.01)	0.25 (0.01)
	2007-16	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					
σ_u	1998-06	0.07 (0.01)	0.08 (0.01)	0.07 (0.02)	0.07 (0.01)	0.07 (0.01)	0.08 (0.01)
	2007-16	0.09 (0.01)	0.10 (0.01)	0.08 (0.01)	0.09 (0.01)	0.08 (0.01)	0.10 (0.01)
σ_v	1998-06	0.23 (0.02)	0.18 (0.01)	0.21 (0.01)	0.19 (0.02)	0.17 (0.01)	0.20 (0.01)
	2007-16	0.25 (0.01)	0.221 (0.01)	0.26 (0.01)	0.22 (0.01)	0.20 (0.01)	0.23 (0.01)
$\tilde{\gamma}_\epsilon$	1998-06	0.02 (0.03)	0.01 (0.02)	0.03 (0.02)	0.01 (0.02)	0.06 (0.02)	0.01 (0.02)
	2007-16	0.02 (0.03)	0.01 (0.02)	0.03 (0.02)	0.01 (0.02)	0.06 (0.02)	0.01 (0.02)
$\tilde{\gamma}_\eta$	1998-06	0.12 (0.04)	0.10 (0.03)	0.10 (0.03)	0.10 (0.03)	0.13 (0.04)	0.12 (0.03)
	2007-16	0.25 (0.04)	0.12 (0.03)	0.12 (0.03)	0.12 (0.03)	0.16 (0.05)	0.13 (0.04)
γ_η	1998-06	0.32 (0.06)	0.22 (0.06)	0.41 (0.08)	0.25 (0.05)	0.29 (0.08)	0.22 (0.05)
	2007-16	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

Notes: The table reports full estimates, with standard errors in parentheses. The results are for the time-varying analysis using an alternative sample selection described in online appendix B.

F Robustness Checks

In this appendix, we report the results of three robustness checks. First, we restrict the second subsample period to end in 2012. Second, we exclude housing from the measure of consumption. Third, we allow for a structural break after every two waves.

F.1 Sample period from 1998 to 2012

Table F–1: Time-varying estimates (1998-2006) and (2007-2012) for all households and groups by homeownership status

		All	Renters	Homeowners
		INCOME		
σ_η	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)
σ_ϵ	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		
σ_u	1998-06	0.08 (0.01)	0.09 (0.04)	0.08 (0.01)
	2007-12	0.10 (0.01)	0.10 (0.02)	0.09 (0.00)
σ_v	1998-06	0.26 (0.01)	0.34 (0.02)	0.21 (0.01)
	2007-12	0.25 (0.01)	0.31 (0.02)	0.21 (0.01)
$\bar{\gamma}_\epsilon$	1998-06	0.04 (0.01)	0.03 (0.02)	0.04 (0.01)
	2007-12	0.04 (0.01)	0.03 (0.02)	0.04 (0.01)
$\tilde{\gamma}_\epsilon$	1998-06	0.09 (0.02)	0.09 (0.04)	0.08 (0.02)
	2007-12	0.15 (0.02)	0.12 (0.05)	0.14 (0.03)
γ_η	1998-06	0.34 (0.03)	0.48 (0.10)	0.28 (0.03)
	2007-12	0.36 (0.03)	0.49 (0.03)	0.29 (0.03)
Wald statistic		5.88	0.32	4.15
N		3,977	1,278	2,930

Notes: The table reports point estimates with standard errors in parentheses. It uses the same group classification as in Table 4, however the second subsample period ends in 2012 instead of 2016. A Wald statistic for a test of parameter stability with a 5% critical value of 3.84 based on a $\chi^2(1)$ distribution under the null hypothesis $H_0 : \tilde{\gamma}_\epsilon \text{ 1998-2006} = \tilde{\gamma}_\epsilon \text{ 2007-2012}$ is also reported.

Table F–2: Time-varying estimates (1998-2006) and (2007-2012) for groups by HtM status

		PHtM	WHtM	NHtM
		INCOME		
σ_η	1998-06	0.13 (0.02)	0.11 (0.01)	0.11 (0.01)
	2007-12	0.15 (0.02)	0.10 (0.02)	0.10 (0.01)
σ_ϵ	1998-06	0.34 (0.02)	0.26 (0.01)	0.24 (0.01)
	2007-12	0.32 (0.02)	0.27 (0.02)	0.23 (0.01)
		CONSUMPTION		
σ_u	1998-06	0.16 (0.07)	0.07 (0.04)	0.08 (0.01)
	2007-12	0.11 (0.04)	0.09 (0.02)	0.10 (0.01)
σ_v	1998-06	0.35 (0.02)	0.27 (0.02)	0.22 (0.01)
	2007-12	0.30 (0.02)	0.23 (0.02)	0.21 (0.01)
$\tilde{\gamma}_\epsilon$	1998-06	0.00 (0.08)	0.04 (0.05)	0.04 (0.02)
	2007-12	0.01 (0.09)	0.04 (0.05)	0.04 (0.02)
$\tilde{\gamma}_\epsilon$	1998-06	0.09 (0.05)	0.09 (0.05)	0.10 (0.02)
	2007-12	0.17 (0.07)	0.09 (0.07)	0.13 (0.03)
γ_η	1998-06	0.55 (0.11)	0.47 (0.08)	0.24 (0.05)
	2007-12	0.48 (0.111)	0.49 (0.03)	0.27 (0.05)
Wald statistic		1.31	0.00	0.53
N		612	890	2,566

Notes: The table reports point estimates with standard errors in parentheses. It uses the same group classification as in Table 4, however the second subsample period ends in 2012 instead of 2016. A Wald statistic for a test of parameter stability with a 5% critical value of 3.84 based on a $\chi^2(1)$ distribution under the null hypothesis $H_0 : \tilde{\gamma}_\epsilon \text{ 1998-2006} = \tilde{\gamma}_\epsilon \text{ 2007-2012}$ is also reported.

Table F–3: Time-varying estimates (1998-2006) and (2007-2012) for subgroups of homeowners

		Low LW	High LW	Low HW	High HW	High Lev.	Low Lev.
		INCOME					
σ_η	1998-06	0.12 (0.01)	0.12 (0.01)	0.11 (0.01)	0.12 (0.01)	0.10 (0.01)	0.13 (0.01)
	2007-12	0.11 (0.01)	0.10 (0.01)	0.12 (0.01)	0.11 (0.01)	0.09 (0.01)	0.10 (0.01)
σ_ϵ	1998-06	0.23 (0.01)	0.24 (0.01)	0.22 (0.01)	0.24(0.01)	0.22 (0.01)	0.25 (0.01)
	2007-12	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					
σ_u	1998-06	0.08 (0.01)	0.08 (0.01)	0.07 (0.01)	0.07(0.01)	0.08 (0.01)	0.08 (0.01)
	2007-12	0.09 (0.01)	0.10 (0.01)	0.07 (0.01)	0.10 (0.01)	0.06 (0.01)	0.10 (0.01)
σ_v	1998-06	0.23 (0.01)	0.18 (0.01)	0.21 (0.01)	0.20 (0.01)	0.18 (0.01)	0.20 (0.01)
	2007-12	0.23 (0.01)	0.17 (0.01)	0.23 (0.01)	0.19 (0.01)	0.19 (0.01)	0.20 (0.01)
$\tilde{\gamma}_\epsilon$	1998-06	0.03 (0.02)	0.02 (0.02)	0.04 (0.02)	0.02 (0.02)	0.04 (0.02)	0.03 (0.02)
	2007-12	0.03 (0.02)	0.02 (0.02)	0.04 (0.02)	0.02 (0.02)	0.04 (0.02)	0.03 (0.02)
$\tilde{\gamma}_\epsilon$	1998-06	0.12 (0.03)	0.10 (0.03)	0.12 (0.03)	0.08 (0.02)	0.11 (0.03)	0.11 (0.03)
	2007-12	0.22 (0.05)	0.13 (0.04)	0.09 (0.06)	0.11 (0.04)	0.13 (0.05)	0.12 (0.04)
γ_η	1998-06	0.30 (0.06)	0.19 (0.06)	0.38 (0.07)	0.23 (0.05)	0.33 (0.05)	0.15 (0.05)
	2007-12	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		1,631	1,429	1,663	1,440	1,462	1,334

Notes: The table reports point estimates with standard errors in parentheses. It uses the same group classification as in Table 4, however the second subsample period ends in 2012 instead of 2016. A Wald statistic for a test of parameter stability with a 5% critical value of 3.84 based on a $\chi^2(1)$ distribution under the null hypothesis $H_0 : \tilde{\gamma}_\epsilon^{1998-2006} = \tilde{\gamma}_\epsilon^{2007-2012}$ is also reported.

F.2 Excluding housing consumption

Table F–4: Time-varying estimates excluding housing consumption for all households and groups by homeownership status

		All	Renters	Homeowners
		INCOME		
σ_η	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)
σ_ϵ	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		
σ_u	1998-06	0.09 (0.01)	0.10 (0.05)	0.09 (0.01)
	2007-16	0.12 (0.00)	0.14 (0.01)	0.12 (0.01)
σ_v	1998-06	0.33 (0.01)	0.42 (0.02)	0.29 (0.01)
	2007-16	0.36 (0.01)	0.41 (0.01)	0.32 (0.01)
$\tilde{\gamma}_\epsilon$	1998-06	0.02 (0.01)	0.02 (0.02)	0.00 (0.07)
	2007-16	0.02 (0.01)	0.02 (0.02)	0.00 (0.07)
$\tilde{\gamma}_\epsilon$	1998-06	0.13 (0.02)	0.16 (0.03)	0.11 (0.04)
	2007-16	0.17 (0.03)	0.13 (0.04)	0.18 (0.04)
γ_η	1998-06	0.30 (0.03)	0.45 (0.03)	0.24 (0.04)
	2007-16	0.34 (0.03)	0.51 (0.01)	0.27 (0.04)
Wald statistic		3.13	0.34	2.46
N		3,977	1,278	2,930

Notes: The table reports point estimates with standard errors in parentheses. It uses the same group classification as in Table 4, however consumption for each household does not include rent or imputed rent. A Wald statistic for a test of parameter stability with a 5% critical value of 3.84 based on a $\chi^2(1)$ distribution under the null hypothesis $H_0 : \tilde{\gamma}_\epsilon \text{ 1998-2006} = \tilde{\gamma}_\epsilon \text{ 2007-2016}$ is also reported.

Table F–5: Time-varying estimates excluding housing consumption for groups by HtM status

		PHtM	WHtM	NHtM
		INCOME		
σ_η	1998-06	0.12 (0.02)	0.11 (0.01)	0.11 (0.01)
	2007-16	0.14 (0.02)	0.08 (0.02)	0.11 (0.00)
σ_ϵ	1998-06	0.34 (0.01)	0.26 (0.01)	0.24 (0.01)
	2007-16	0.31 (0.02)	0.27 (0.02)	0.23 (0.01)
		CONSUMPTION		
σ_u	1998-06	0.22 (0.07)	0.08 (0.04)	0.09 (0.01)
	2007-16	0.14 (0.03)	0.11 (0.02)	0.12 (0.01)
σ_v	1998-06	0.40 (0.04)	0.37 (0.04)	0.28 (0.01)
	2007-16	0.41 (0.02)	0.32 (0.02)	0.32 (0.01)
$\tilde{\gamma}_\epsilon$	1998-06	0.01 (0.03)	0.03 (0.02)	0.02 (0.02)
	2007-16	0.01 (0.03)	0.03 (0.02)	0.02 (0.02)
$\tilde{\gamma}_\epsilon$	1998-06	0.14 (0.05)	0.12 (0.05)	0.12 (0.02)
	2007-16	0.02 (0.09)	0.15 (0.07)	0.16 (0.04)
γ_η	1998-06	0.64 (0.08)	0.41 (0.07)	0.24 (0.04)
	2007-16	0.65 (0.09)	0.41 (0.07)	0.27 (0.04)
Wald statistic		1.86	0.17	1.26
N		612	890	2,566

Notes: The table reports point estimates with standard errors in parentheses. It uses the same group classification as in Table 4, however consumption for each household does not include rent or imputed rent. A Wald statistic for a test of parameter stability with a 5% critical value of 3.84 based on a $\chi^2(1)$ distribution under the null hypothesis $H_0 : \tilde{\gamma}_\epsilon \text{ 1998-2006} = \tilde{\gamma}_\epsilon \text{ 2007-2016}$ is also reported.

Table F–6: Time-varying estimates excluding housing consumption for subgroups of homeowners

		Low LW	High LW	Low HW	High HW	High Lev.	Low Lev.
		INCOME					
σ_η	1998-06	0.12 (0.01)	0.12 (0.01)	0.11 (0.01)	0.12 (0.01)	0.10 (0.01)	0.13 (0.01)
	2007-12	0.09 (0.01)	0.10 (0.01)	0.10 (0.01)	0.11 (0.01)	0.08 (0.01)	0.11 (0.01)
σ_ϵ	1998-06	0.24 (0.01)	0.24 (0.01)	0.22 (0.01)	0.24 (0.01)	0.22 (0.01)	0.25 (0.01)
	2007-12	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					
σ_u	1998-06	0.08 (0.02)	0.09 (0.01)	0.08 (0.02)	0.09 (0.01)	0.09 (0.01)	0.10 (0.01)
	2007-12	0.11 (0.01)	0.12 (0.01)	0.10 (0.01)	0.12 (0.01)	0.09 (0.01)	0.13 (0.01)
σ_v	1998-06	0.32 (0.02)	0.26 (0.01)	0.27 (0.01)	0.30 (0.02)	0.26 (0.01)	0.29 (0.02)
	2007-12	0.32 (0.01)	0.30 (0.01)	0.32 (0.01)	0.33 (0.01)	0.29 (0.01)	0.32 (0.01)
$\tilde{\gamma}_\epsilon$	1998-06	0.01 (0.01)	0.00 (0.01)	0.02 (0.04)	0.00 (0.00)	0.03 (0.02)	0.00 (0.05)
	2007-12	0.01 (0.01)	0.00 (0.01)	0.02 (0.04)	0.00 (0.00)	0.03 (0.02)	0.00 (0.05)
$\tilde{\gamma}_\epsilon$	1998-06	0.16 (0.03)	0.10 (0.03)	0.14 (0.05)	0.10 (0.03)	0.15 (0.04)	0.11 (0.04)
	2007-12	0.30 (0.05)	0.17 (0.05)	0.17 (0.07)	0.14 (0.04)	0.21 (0.05)	0.16 (0.05)
γ_η	1998-06	0.27 (0.06)	0.13 (0.06)	0.35 (0.08)	0.18 (0.06)	0.18 (0.09)	0.17 (0.05)
	2007-12	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		1,631	1,429	1,663	1,440	1,462	1,334

Notes: The table reports point estimates with standard errors in parentheses. It uses the same group classification as in Table 4, however consumption for each household does not include rent or imputed rent. A Wald statistic for a test of parameter stability with a 5% critical value of 3.84 based on a $\chi^2(1)$ distribution under the null hypothesis $H_0 : \tilde{\gamma}_\epsilon \text{ 1998-2006} = \tilde{\gamma}_\epsilon \text{ 2007-2016}$ is also reported.

F.3 Structural break after every two waves

Table F-7: Time-varying estimates with structural break after every two waves

		All
σ_η	1998-00	0.13 (0.01)
	2001-04	0.13 (0.01)
	2005-08	0.12 (0.01)
	2009-12	0.11 (0.01)
	2012-16	0.13 (0.01)
σ_ϵ	1998-00	0.25 (0.01)
	2001-04	0.26 (0.01)
	2005-08	0.26 (0.01)
	2009-12	0.25 (0.01)
	2012-16	0.22 (0.01)
σ_u	1998-00	0.10 (0.02)
	2001-04	0.09 (0.01)
	2005-08	0.06 (0.02)
	2009-12	0.10 (0.01)
	2013-16	0.13 (0.01)
σ_v	1998-00	0.24 (0.01)
	2001-04	0.25 (0.01)
	2005-08	0.26 (0.01)
	2009-12	0.26 (0.01)
	2013-16	0.32 (0.01)
$\tilde{\gamma}_\epsilon$	1998-00	0.03 (0.01)
	2001-04	0.04 (0.01)
	2005-08	0.03 (0.01)
	2009-12	0.03 (0.01)
	2013-16	0.03 (0.01)
$\tilde{\gamma}_\epsilon$	1998-00	0.09 (0.03)
	2001-04	0.09 (0.02)
	2005-08	0.13 (0.02)
	2009-12	0.13 (0.03)
	2013-16	0.15 (0.05)
γ_η	1998-00	0.28 (0.02)
	2001-04	0.36 (0.02)
	2005-08	0.39 (0.02)
	2009-12	0.39 (0.02)
	2013-16	0.39 (0.03)
N		3,977

Notes: The table reports point estimates with standard errors in parentheses. It uses the same group classification as in Table 4, however we allow for a structural break after every two waves.

G Summary Statistics and Group Overlaps for 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.

G.1 Summary statistics

Table G–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	50,873	29,623	60,317	23,770	47,107	61,778
Consumption	27,372	16,759	25,762	15,007	22,422	25,736
Balance sheet variables						
Liquid wealth	2,266	0	6,864	0	-8,013	26,1304
Illiquid wealth	46,305	0	89,502	0	39,000	105,072
Housing wealth	31,326	0	61,452	0	30,000	66,628
Total wealth	61,547	0	119,032	-2,434	26,951	184,765
Debt	45,322	1,048	77,109	3,227	76,578	52,755
Leverage	1.08	–	1.05	–	2.32	0.84
Demographics						
Age	45	39	47	39	43	48
Frac. of college	0.65	0.57	0.68	0.46	0.60	0.72
Frac. of married	0.69	0.38	0.81	0.37	0.73	0.77
Other characteristics						
Frac. of homeowners	0.73	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 all households 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 G–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.

G.2 Overlaps

Table G–3: Overlaps between household groups

	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 categories. These overlaps are based on the sample that was used in the analysis of time-varying consumption responses in Section 4. The reader should interpret the numbers from the rows. For example, 0.40 in the second row and the third column implies that 40% of the total observations in the homeowner subgroup are also in the low liquid wealth homeowner subgroup. Similarly, 0.64 in the third row and the fifth row suggests that 64% of the total observations in the low liquid wealth homeowner subgroups are also in the low housing wealth homeowner subgroup.

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