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TEMPTATION AND COMMITMENT:
UNDERSTANDING HAND-TO-MOUTH BEHAVIOR

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ABSTRACT

This paper presents a model of consumption behavior that explains the presence of 'wealthy hand-to-mouth' consumers using a mechanism that differs from those analyzed previously. We show that a two-asset model with temptation preferences generates a demand for commitment and thus illiquidity, leading to hand-to-mouth behavior even when liquid assets deliver higher returns than illiquid assets. This model fits other features of the data, such as the fact that the Marginal Propensity to Consume declines only slowly with shock size. Moreover, temptation and commitment have important policy implications: we show that housing subsidies and mandatory mortgage amortization increase household savings.

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1 Introduction

A large fraction of households in the US and other developed countries have almost zero liquid assets, despite holding substantial wealth in illiquid assets, primarily housing, but also retirement accounts. Data from the Panel Study of Income Dynamics indicate that roughly 20% of U.S. households own a house, but have liquid assets worth less than two weeks of income. The fact that wealthy consumers and in particular homeowners do not have liquid savings implies that they have a limited ability to absorb adverse income shocks and therefore, as documented in many studies, have a relatively large Marginal Propensity to Consume (MPC) out of temporary shocks. These consumers have been labeled as 'wealthy hand-to-mouth' households.

In an influential paper, Kaplan and Violante (2014) have proposed an interesting explanation of wealthy hand-to-mouth consumers. They consider a model with two assets: one which is liquid and delivers a meager return (such as bank deposits) and one which is illiquid and yields an attractive return. They then show that such a model is able to deliver a substantial fraction of wealthy hand-to-mouth consumers that are willing to withstand some fluctuations in consumption to exploit the returns on the illiquid asset.

This model, however, cannot explain an additional puzzling aspect of the large concentration of household wealth into housing. Many households concentrate their wealth in housing even though it delivers a lower risk-adjusted return than liquid assets such as equities, even when accounting for imputed rent and other benefits to homeownership, as documented in many studies.[1] Indeed, in this paper, we document that a two-asset model, of the type analysed by Kaplan and Violante (2014), cannot fit the large share of wealthy hand-to-mouth consumers when there exists a high-return liquid asset.

We make three contributions to the existing literature. First, we propose a different explanation for the presence of wealthy hand-to-mouth consumers. In particular, we study the role of self-control problems, which may generate a desire for illiquidity. We construct a model with temptation preferences and an endogenous demand for commitment and calibrate its parameters using data on consumption, assets, and housing from the Panel Study of Income Dynamics (PSID). Temptation preferences are attractive from a theoretical point of view, as choices emerging from this axiomatization are time consistent, and from an empirical point of view, as this type of behaviour is consistent with experimental evidence (Toussaert, 2018) and consumption behavior (Kovacs, Low, and Moran, 2020). We find that our model fits the data well, matching the large share of wealthy hand-to-mouth households despite the fact that housing does not deliver higher returns than equities.

[1] See for instance Flavin and Yamashita (2002), Goetzmann and Spiegel (2002), and Piazzesi, Schneider, and Tuzel (2007).

Second, in addition to the ability to explain the large share of wealthy hand-to-mouth households with a high Marginal Propensity to Consume (MPC), our model generates patterns of consumption, saving and portfolio behaviour that are in line with the available evidence. Our model is consistent with recent empirical evidence, which we review below, showing that the consumption response to income shocks declines only slowly with shock size. This evidence is difficult to rationalize using a traditional two-asset model, and yet, it has important implications for the design of targeted fiscal stimulus policies. In addition, our model is in line with a growing experimental literature which finds that households often save in low-return illiquid accounts despite the availability of liquid accounts with higher or equal returns (Thaler and Benartzi, 2004; Ashraf, Karlan, and Yin, 2006; Beshears et al., 2020). This type of saving behavior is difficult to explain with traditional models, but has important implications for our understanding of wealthy hand-to-mouth behavior, as well as policies designed to promote savings.

Finally, we use our model to analyse the impacts of three important policies: the targeting of stimulus measures, the tax deductability of mortgage interest payments, which effectively constitute a sizeable subsidy to home ownership, and mandatory ammortization of mortgages. On the first issue, we find that fiscal stimulus is more effective if targeted to the poorest consumer. Furthermore, our model's implications on savings imply that subsidies to home ownership, as well as mandatory amortization, stimulate total savings, as they increase the demand for commitment.

Why do so many homeowners hold very small amounts of liquid assets? To try to explain this behavior, we start with a two-asset life-cycle model of consumption and saving behavior, where one asset, such as stocks, is liquid and the other, such as housing, is not. In our model, liquid assets deliver higher risk-adjusted returns than illiquid ones consistent with the empirical evidence.[2] We find that such a model cannot match the large share of hand-to-mouth homeowners without failing to match other targeted moments, even when allowing for flexibility in time preferences, risk aversion, and taste for housing, as well as generous tax benefits to homeownership.

To explain the presence of wealthy consumers with a relatively high MPC, we need a mechanism that increases demand for illiquid assets but not liquid assets. Rather than introducing additional changes to the nature of assets households can access, following Kaplan and Violante (2014) and a large number of heterogeneous agent macro models, we consider a different class of preferences. In particular, we introduce a temptation element into preferences, using the approach proposed by Gul and Pesendorfer (2001, 2004). These preferences imply that households suffer from self-control problems, which

[2]The importance of return differences was also highlighted by Shiller (2014), who says, "It would be perhaps smarter, if wealth accumulation is your goal, to rent and put money in the stock market, which has historically shown much higher returns than the housing market."

introduces present bias behaviour. Temptation represents the idea that households may find it difficult to save in liquid assets, due to the possibility of instantaneous gratification that is hard to resist. Temptation, therefore, creates a demand for commitment devices that may allow households to mitigate self-control problems. Housing may act as such a savings commitment device, not only because it is illiquid and allows households to lock away their wealth, but also because amortizing mortgages force households to make regular mortgage payments and accumulate wealth in the form of home equity.

Temptation preferences are not the only ones that give rise to self control problems, present biases and, possibly, to a demand for commitment devices. Another strand of the literature that focuses on self-control problems, which may make it difficult for households to save in liquid assets, uses a model with hyperbolic discounting, as developed by Strotz (1956), Phelps and Pollak (1968), Laibson (1997), Harris and Laibson (2001) and Angeletos et al. (2001). Temptation preferences, however, unlike hyperbolic discounting, do not generate time inconsistent choices, making equilibria easier to define and allowing for straightforward welfare analysis.

In our model, we allow households to save in two instruments: liquid assets and illiquid housing, where housing provides direct utility, serves as collateral for mortgages, and provides realistic tax advantages. The return on liquid asset (shares) is higher than the return to housing. Households can borrow using fixed-rate, fully-amortizing mortgages. We calibrate and simulate our model to evaluate the ability of self-control problems and commitment generated by temptation preferences to explain the observed life-cycle profiles of consumption and wealth accumulation. Having established the consistency of the model with a variety of facts, as well as its ability to explain some of the puzzling evidence mentioned above, we use the model to assess the consequences of different policies, such as fiscal stimulus targeting, mandatory mortgage amortization, and housing subsidies.

The view of illiquidity that we highlight helps improve our understanding of observed consumption behavior. For instance, our model can explain recent empirical evidence showing that the marginal propensity to consume (MPC) declines relatively slowly with shock size. While historically it has been difficult to study how the MPC varies by shock size (as most stimulus payments are small), there exists a growing empirical literature that studies this question using new sources of variation and better quality data. The early empirical literature suggested that MPCs were small for large shocks (Hsieh, 2003). However, new empirical evidence has overturned this finding (Kueng, 2018), and shown that MPCs remain sizeable even in response to large income shocks (Kueng, 2018; Fuster, Kaplan, and Zafar, 2018; Aladangady et al., 2018; Bunn et al., 2018; Fagereng, Holm, and Natvik, 2019). This new empirical evidence is difficult to rationalize in traditional two-asset models, where the consumption response to large income shocks is negligible. We show that our model can accommodate it.

We also show that temptation preferences and the demand for commitment (and illiquidity) have important implications for saving behavior and wealth accumulation. We find that the opportunity to purchase a savings commitment device (in our case, housing) induces households to accumulate more wealth over the life-cycle. Furthermore, a subsidy to the commitment device may increase overall wealth because households are able to reduce temptation by locking their wealth in illiquid form, which, in turn, binds them to save by committing to regular mortgage payments that build up wealth in the form of home equity.

We briefly summarize the implications of temptation and commitment for the three different policies we consider. First, we use our model to asses the effects on consumption of fiscal stimulus payments targeted towards different segments of the income distribution. We find that the largest change in aggregate consumption is achieved when larger stimulus payments are targeted towards the bottom 20% of the income distribution, rather than smaller payments to the entire population. This result is driven by the fact that these households have a higher than average MPC, which declines only slowly with the size of the stimulus payment. In contrast, stimulus payments have historically been rather small and targeted to a large proportion of the population. In the US, for instance, stimulus checks were given to 80-85% of households in both 2008 and 2020.

In addition, there is a growing debate about the effect of mandatory amortization policies. While mandatory amortization requirements have recently been introduced by Sweden and the Netherlands, there exists concern that these policies may simply result in a re-balancing of household portfolios away from liquid assets and into illiquid housing, potentially reducing households' resilience to income shocks (Svensson, 2019, 2020). However, if mortgage payments serve as a commitment device, amortization might not result in simple portfolio re-balancing, but may also induce households to accumulate more wealth. Simulating our calibrated model, we find that while there is some portfolio re-balancing from liquid to illiquid assets, it is not one-to-one. In our simulations, mandatory amortization policies increase overall wealth accumulation by around 10% by the time of retirement. Every additional dollar of housing wealth only reduces liquid assets by roughly 60 cents. This finding is consistent with recent empirical evidence from the Netherlands, showing that mandatory amortization results in increased wealth accumulation, as households accumulate more housing wealth due to this policy, but do not reduce their non-housing assets (Bernstein and Koudijs, 2020).

Finally, we show that our model generates similar effects by providing an incentive to purchase housing, through the mortgage interest tax deduction. The debate around this program is similar to the arguments around the provision of tax incentives to save in illiquid retirement accounts, such as IRAs or 401(k) accounts. Some studies argued that such subsidies may not increase savings and result only in household portfolio re-allocation, while others thought that such tax incentives would result in an increase in savings.[3] Yet none of these papers consider the effect of making commitment more affordable, which could stimulate savings. Using our calibrated model, we find evidence of some substitution from liquid to illiquid assets as a result of housing subsidies: every additional dollar of housing wealth reduces liquid assets by roughly 33 cents. However, the increase in housing wealth is not perfectly offset by a reduction in liquid assets, thus overall wealth accumulation is increased by around 7% by the time of retirement.

The rest of the paper proceeds as follows. First we develop a life-cycle model of hand-to-mouth behaviour driven by temptation preferences (Section 2). We demonstrate that temptation generates a desire for illiquidity and a demand for commitment devices (Section 3). We calibrate the model using U.S. data (Section 4) and evaluate the implications for consumption behavior and the marginal propensity to consume (Section 5). Finally, we use our calibrated model to study the effect of policies designed to incentive saving behavior (Section 6).

2 A Model with Temptation Preferences

We develop a life-cycle model of consumption and housing with temptation preferences, building upon a model of consumption behavior with uninsurable income risk. In this model, households save for two reasons: to maintain consumption following adverse income shocks (the precautionary motive) and following retirement (the life-cycle motive). We extend this model by allowing households to save in either liquid assets or illiquid housing, where housing gives flow utility, serves as collateral, and provides tax advantages. This generates a third incentive for households to accumulate wealth (the housing motive). Housing transactions incur significant costs, thus making housing illiquid.

Households live for T years and work during the initial W years. Households maximize their present discounted lifetime utility, which depends on both nondurable consumption and housing services. Households have access to two investment assets: liquid assets and illiquid housing. While all households are born as renters, they have the possibility to purchase housing which comes in discrete sizes, offers a utility benefit, and serves as collateral for mortgages.

Temptation Preferences. Households with standard preferences have no demand for commitment, as more choice and more flexibility are always weakly beneficial. To allow for the possibility that households desire commitment, we incorporate temptation preferences

[3] In the case of retirement accounts, see Venti and Wise (1986, 1987), Gale and Scholz (1994), Attanasio and DeLeire (2002). In the case of housing, see Rosen (1985); Poterba (1992), Gervais (2002), Chambers, Garriga, and Schlagenhauf (2009), Floetotto, Kirker, and Stroebel (2016), and Nakajima (2020).

by Gul and Pesendorfer (2001, 2004). According to these preferences, it may be difficult to save due to the temptation to spend for short term gratification. This generates a desire for commitment, as households would like to reduce temptation by locking away their wealth in illiquid form. More specifically, households want to maximize the sum of their expected discounted lifetime utility, subject to a budget constraint we define later:

$$\max \mathbb{E}_t \sum_{t=0}^{T} \beta^t U(c_t, h_t, \tilde{c}_t, \tilde{h}_t) \tag{1}$$

where c_t and h_t are the chosen level of nondurable consumption and housing, while $\tilde{c}_t$ and $\tilde{h}_t$ are the most tempting consumption and housing alternatives each period. The key feature of temptation preferences is that utility $U()$ depends not only on actual consumption and housing decisions, but also the most tempting consumption and housing alternatives available in the choice set each period. We define the utility function as:

$$U(c_t, h_t, \tilde{c}_t, \tilde{h}_t) = u(c_t, h_t) - \lambda \Big[u(\tilde{c}_t, \tilde{h}_t) - u(c_t, h_t) \Big] \tag{2}$$

where the felicity function $u()$ is concave and increasing in both c_t and h_t. We define the most tempting feasible alternative as that which maximizes current period felicity:

$$\big[\tilde{c}_t, \tilde{h}_t \big] = \arg \max_{c_t, h_t \in \mathscr{A}_t} u(c_t, h_t), \tag{3}$$

where $\mathscr{A}_t$ represents the current period choice set, which will be defined later. The term in square brackets in equation (2) represents the utility cost of temptation. The cost of temptation is proportional to the felicity you could enjoy if you only cared about the present $u(\tilde{c}_t, \tilde{h}_t)$ minus the felicity you actually enjoy given your current consumption and housing decisions $u(c_t, h_t)$. The parameter λ captures the degree of temptation. This model nests standard preferences, as temptation disappears when $\lambda = 0$.

Temptation preferences have been applied in a number of macroeconomic models (Amador, Werning, and Angeletos, 2006; Krusell, Kuruscu, and Smith, 2010; Nakajima, 2012; Schlafmann, 2020). That said, temptation is not the only way to generate present-biased households and therefore to create demand for commitment devices. The main alternative is to use dynamically inconsistent preferences in the form of hyperbolic discounting (Strotz, 1956; Laibson, 1997; Harris and Laibson, 2001). There are two main advantages of the temptation model over the model with hyperbolic-discounting. First, temptation preferences are dynamically consistent, which makes welfare analysis straightforward.[4] Second, the importance of temptation preferences can be measured directly

[4]For more information on the difficulty of welfare analysis under hyperbolic discounting, see Fang and Silverman (2009).

from observed consumption decisions using a linearized Euler equation, as in Kovacs, Low, and Moran (2020).

Assets. Households who wish to save can invest in two types of assets: a fully liquid financial asset, a_t, or less-liquid housing, h_t. The financial asset, a_t, yields a certain return r in each period. We abstract away from the idea of return risk in our model, therefore we calibrate our model using risk-adjusted returns.

Households can adjust housing in any period. We assume that housing exists on a discrete grid with k different sizes: $h^k \in \{h^1, h^2, ..., h^k\}$. The price of each house $p_t(h^k)$ depends on its size and is determined relative to the index price $\bar{p}_t$:

$$p_t(h^k) = g(h^k)\bar{p}_t$$

where $0 < g(h^k) \leq 1$, $g'(h^k) > 0$ and $g''(h^k) < 0$. House prices grow at a constant rate, $1 + r^H$, over time, representing a fixed gross return on the housing asset, therefore the initial index price determines all other house prices for each time period:

$$\bar{p}_t = (1 + r^H)\bar{p}_{t-1}. \qquad \forall t \quad \text{given} \quad \bar{p}_1 \tag{4}$$

Buying or selling a home incurs a fixed cost, which is a fraction F of the price of the home:

$$Fp_t(h^k).$$

We assume that housing markets are segmented, therefore renters are only permitted to live in the smallest available house (h^1).[5] We assume that the cost of renting is proportional to the price of this unit:

$$rent_t = \eta p_t(h^1).$$

where η represents rental scale.

Note that we abstract from the option to save in retirement accounts, as we want to focus our attention on the choice between liquid assets and housing. This seems like a reasonable simplification, as most households hold very little in retirement assets. As Kaplan and Violante (2014) note, the median household keeps only \$950 in their retirement account, according to the Survey of Consumer Finances. In Section A.7.2, we consider sensitivity to this assumption.

Mortgages. The most widely used mortgage contract in the U.S. is the fully-amortizing

[5] For evidence of segmentation in housing markets, see Greenwald and Guren (2019).

fixed-rate mortgage.[6] Therefore we assume that mortgages are of this kind with regular required mortgage payments that force households to gradually build up wealth in the form of home equity. As a result, housing may act as a commitment device not only because of its illiquidity, but also because of the regular mortgage payments mp_t every period.

The mortgage balance for households who buy a house at time t is

$$m_{t+1} = (1 - \psi)p_t(h_t)(1 + r^M) \tag{5}$$

where ψ is the down-payment households choose to pay, but at least 10 % of the home's actual value, $\psi^{\min} = 0.1$. The law-of-motion for existing mortgages on the other hand is

$$m_{t+1} = (m_t - mp_t)(1 + r^M) \tag{6}$$

where mp_t represents the required mortgage payment at time t. We assume that mortgages are fully-amortizing with constant-level payment plans, as is the case for the vast majority of mortgages in the United States, therefore households must make equal mortgage payments mp_t every year that they own the house until they pay off the mortgage. We assume that all mortgage debt must be paid off by age W when households retire. Thus households make fixed repayments each year based on the following formula:

$$mp_t = \frac{(1 + r^M)^s}{\sum_{j=1}^{s}(1 + r^M)^j} m_t \tag{7}$$

where the required payment depends on $s = W - t + 1$ which is the number of periods until retirement. If there exists a positive mortgage balance $m_t > 0$ at the time a house is sold, the value of the house is used to repay the mortgage and the remaining home equity goes to the household. As households are required to pay off their mortgages by the time of retirement, the terminal condition, $m_{W+1} = 0$, is satisfied.

If households receive large negative income shocks such that they cannot make their mortgage payment, they are forced to default on their mortgage. In this situation, households are forced to sell their home and repay their remaining mortgage debt.[7]

[6]These mortgages accounted for approximately two-thirds of mortgage origination in the U.S. during the 2000's (Amromin et al., 2018). The prevalence of these mortgage features began with the passage of the National Housing Act in 1934 which created the Federal Housing Administration (FHA). By offering to insure mortgages, the FHA was able to insist on fixed-rate mortgages with constant-level fully-amortizing payment plans (Wiedemer and Baker, 2012). The Dodd-Frank Financial Reform Bill of 2010 reaffirmed these standards by introducing the concept of a "qualified" mortgage that requires fixed rate mortgages to have fully amortizing payments.

[7]In the case where mortgage debt is larger than the house value plus transaction costs, then the remaining debt is written off and the government provides a minimum consumption floor. This modeling choice ensures that households never experience infinite negative utility.

In our baseline model, we assume that households are not allowed to increase the size of their mortgage using cash-out refinancing or home equity loans. While this makes housing more illiquid than in reality, it is consistent with evidence that homeowners are often not allowed to extract home equity when they need it most (i.e. when their income falls). DeFusco and Mondragon (2018) highlight that employment documentation requirements prevent many homeowners from refinancing when they lose their job. Moreover, Boar, Gorea, and Midrigan (2020) find that there are substantial frictions that prevent homeowners from extracting home equity. They highlight that payment-to-income ratios often bind on households that have experienced negative income shocks. For these reasons, we believe it is worthwhile to assume that when household income falls, households will have to rely on their liquid asset buffer, rather than extract home equity.[8]

Income. Each household i receives idiosyncratic labor income, $y_{i,t}$, in every period before retirement, $t \leq W$, which is assumed to evolve according to the following:

$$\ln y_{i,t} = g_t + z_{i,t} \tag{8}$$

where g_t is a deterministic age profile approximated by a third-order age-polynomial, while $z_{i,t}$ is an idiosyncratic shock to log income that is described by an AR(1) Markov process:

$$\begin{aligned} z_{i,t} &= \rho z_{i,t-1} + \varepsilon_{i,t} \\ \varepsilon_{i,t} &\sim N(0, \sigma_\varepsilon^2) \\ \varepsilon_{i,0} &\sim N(0, \sigma_0^2). \end{aligned} \tag{9}$$

Note that we let the initial variance of the income innovations, $\varepsilon_{i,0}$, to be different from the subsequent periods' in order to account for initial heterogeneity in income at age 22 in the data.

Taxes and Pensions. We incorporate a number of realistic features into our model, which are important if the model is going to have a chance to fit observed life-cycle profiles of consumption and wealth accumulation. More specifically, we include progressive income taxation, large and realistic tax benefits to homeownership, and social-security based retirement. We build progressive income taxation into the model following Keane and Wasi (2016), who assume a nonlinear tax function:

$$\tau(y_{i,t}, a_{i,t}) = e^{\tau_1 + \tau_2 \log(y_{i,t} + r a_{i,t} - \tau_d)} \tag{10}$$

[8] In addition, we have experimented with allowing home equity withdrawal in our model and find that the standard model still has difficulty matching the large share of homeowners holding zero liquid assets.

where the parameters τ_1 and τ_2 determine the progressivity of the aggregate tax schedule. These parameters are estimated based on income and tax data from the Current Population Survey, therefore $\tau(y_{i,t}, a_{i,t})$ represents the sum of federal, state, and municipal taxes, plus mandatory social security contributions. Taxes are levied on both labor income $y_{i,t}$ and capital gains $ra_{i,t}$, although it is important to note that capital gains to owner-occupied housing are not taxed in our model, thus providing a tax benefit to homeownership.

In addition, τ_d represents the deduction which is subtracted from income before the tax is applied. We define τ_d to be the greater of either the standard deduction τ_d^{standard} or mortgage interest payments. This allows our tax schedule to incorporate the mortgage interest tax deduction, a second large subsidy to homeownership in the United States. This results in an after-tax income for households given by the following equation:

$$\widetilde{y}_{i,t} = y_{i,t} - \tau(y_{i,t}, a_{i,t})$$

Following retirement at age W, households get a progressive social security-style pension determined by the following rule:

$$\widetilde{y}_{i,t} = \max \Big\{ \text{SS Income Floor, Annual PIA}(y_W) \Big\} \tag{11}$$

where Annual PIA(y_W) is the annual social security benefit (the primary insurance amount) received upon retirement, based on average indexed monthly earnings (AIME), which we approximate based on the last working period income, y_W.[9] We calibrate the social security income floor and primary insurance amount based on U.S. legislation from 2015.[10]

Functional Form. Turning to the choice of functional form for the felicity function, u, we follow Attanasio et al. (2012) and let home ownership affect the felicity function flexibly. This is important as we do not have a strong prior on whether housing utility is additive or multiplicative, therefore we want a very flexible functional form that includes both options.

$$u(c_t, h_t) = n_t \left(\frac{\left(\frac{c_t}{n_t}\right)^{1-\gamma}}{1-\gamma} \exp\Big[\theta\phi(h_t, n_t)\Big] + \mu\phi(h_t, n_t) - \chi I_{h_t \neq h_{t-1}} \right) \tag{12}$$

[9]In reality, to calculate AIME, the worker's wage during the years of employment is first expressed in today's dollars, then the wages of the highest 35 years are summed up. This sum is then divided by 420 (12*35) in order to get the real average monthly earnings.

[10]The PIA is a piecewise linear function with two break points. Currently, the PIA is computed as 90% of AIME up to breakpoint 1, 32% of AIME up to breakpoint 2, and 15% of AIME up to the social security wage base.

where n_t is the exogenously given equivalence scale capturing the evolution of household composition over the life-cycle, γ is the risk aversion parameter, θ and μ are housing preference parameters, and $\phi(h_t, k_t)$ represents the benefit of owning house h_t with family size n_t. Housing affects immediate utility both directly and via the marginal utility of consumption. The direct effect represented by $\mu\phi(h_t, n_t)$ makes the utility function non-homothetic in consumption and housing. We will later calibrate the importance of μ and θ in explaining observed demand for housing.

The utility benefit of housing depends on the size of the house, h, which exists on a discrete grid with k values: $h^k \in \{h^1, h^2, ..., h^k\}$. We assume a segmented housing market by only allowing the smallest house, h^1, to be rented, which also provides lower utility than owning the same unit. In addition, the utility benefit of housing $\phi(h_t, k_t)$ increases with the size of the house h_t and decreases with the size of the family.

$$\phi(h_t, k_t) = \ln\left(\frac{h_t}{n_t}\right) \tag{13}$$

Whenever a household adjusts housing (i.e. when $I_{h_t \neq h_{t-1}}$ equals one in equation (12)), it suffers a utility cost, χ.[11] The utility cost, besides the financial transaction cost, plays an important role in our model, as it increases the illiquidity of housing, thus making housing more useful as a commitment device.

Budget Set. We define the budget set, $\mathscr{A}_t$, as follows:

$$\mathscr{A}_t = \begin{cases} x_t \in R^+ : x_t \leq a_t + \widetilde{y}_t - \mathbb{I}_t^{own} mp_t - (1 - \mathbb{I}_t^{own}) rent_t \\ \quad \text{if no housing adjustment} \\ \\ x_t \in R^+ : x_t \leq a_t + \widetilde{y}_t - \left[(1+F)p_t(h_t) - \dfrac{m_{t+1}}{(1+r^M)}\right] \\ \qquad\qquad + \left[(1-F)p_t(h_{t-1}) - m_t\right] \\ \quad \text{if housing adjustment} \end{cases} \tag{14}$$

This determines the choice set for households each period, which in turn pins down the most tempting alternative each period. Households will always be tempted to spend all of their available resources on either consumption or housing.

Recursive Formulation. We define the recursive formulation as follows:

$$V_t(\Omega_t) = \max\left\{V_t^0(\Omega_t), V_t^1(\Omega_t)\right\} \tag{15}$$

[11] Here we think of the non-monetary cost of changing homes, like finding new schools, setting up new utility providers, facing stress etc.

where $V_t^0(\Omega_t)$, and $V_t^1(\Omega_t)$ are the value functions conditional on not adjusting and adjusting housing. We define the vector of state variables $\Omega_t = \{a_t, z_t, m_t, h_{t-1}\}$. Those who choose not to adjust in period t solve the following dynamic problem:

$$V_t^0(\Omega_t) = \max_{\{c_t, a_{t+1}\}} U(c_t, h_t, \tilde{c}_t, \tilde{h}_t) + \beta \mathbb{E}_t V_{t+1}(\Omega_{t+1}), \tag{16}$$

subject to:

$$\begin{aligned}
a_{t+1} &= (1+r)\Big[a_t + \widetilde{y}_t - c_t - \mathbb{I}_t^{own} mp_t - (1-\mathbb{I}_t^{own}) rent_t\Big] \\
\widetilde{y}_t &= \begin{cases} exp(g_t + z_t), & \text{if } t \leq W \\ \text{SS Benefit}(y_W), & \text{if } t > W \end{cases} \\
z_t &= \rho z_{t-1} + \varepsilon_t \quad \text{and} \quad c_t > 0
\end{aligned} \tag{17}$$

Those who choose to adjust housing in period t solve the following dynamic problem:

$$V_t^1(\Omega_t) = \max_{\{c_t, h_t, m_{t+1}, a_{t+1}\}} U(c_t, h_t, \tilde{c}_t, \tilde{h}_t) + \beta \mathbb{E}_t V_{t+1}(\Omega_{t+1}), \tag{18}$$

subject to:

$$\begin{aligned}
a_{t+1} &= (1+r)\Big[a_t + \widetilde{y}_t - c_t - (1+F)p_t(h_t) + \frac{m_{t+1}}{(1+r^M)} + (1-F)p_t(h_{t-1}) - m_t\Big] \\
m_{t+1} &\leq (1-\psi^{\min})p_t(h_t)(1+r^M) \\
y_t &= \begin{cases} exp(g_t + z_t), & \text{if } t \leq W \\ \text{SS Benefit}(y_W), & \text{if } t > W \end{cases} \\
z_t &= \rho z_{t-1} + \varepsilon_t \quad \text{and} \quad c_t > 0
\end{aligned} \tag{19}$$

3 Key Model Insights

In this section, we demonstrate two implications of our model that differ from those of the standard model. First, our model generates a demand for illiquidity that is absent in a standard model. Second, the availability of housing helps households save for retirement. To better highlight the implications of temptation and commitment, we focus on a simplified version of our model in this section.

More specifically, we simplify our model by assuming that there is only one size of housing to rent and buy; that housing does not enter the utility function; that labor income is deterministic; and that the returns on liquid assets and housing are the same. Table 1 presents the parameter restrictions imposed in the simplified model.

Table 1: Parameters in the Simplified Model

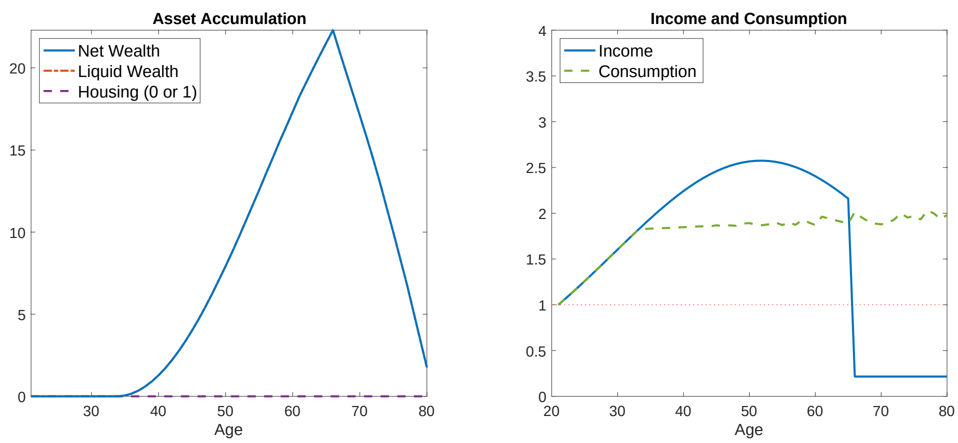
Parameter		**Value**
k	Housing options	1
θ	Housing preference (MU of consumption)	0
μ	Housing preference (non-homotheticity)	0
z	Idiosyncratic shock to log income	0
r	Net return on liquid asset	0.021
r^H	Net return on housing	0.021

Note: This table presents the parameter assumptions that we use to simplify our model in Section 3, relative to the full model that we calibrate in Section 4.

3.1 Demand for Illiquidity

In this simplified model, households with standard preferences ($\lambda = 0$) have no demand for housing. Homeownership comes with sizeable transaction costs, yet delivers no benefits in terms of either utility or returns. This is demonstrated in Figure 1, which presents the life-cycle profiles of assets and consumption in the model without temptation. The left panel presents asset accumulation, which reaches a peak at age 65 when the household retires. The household saves only in liquid assets and never purchases a home. The right panel presents income and consumption over the life-cycle. We see that income rises in a hump shape, before dropping drastically at the time of retirement. Despite this hump-shaped income process, the household is able to perfectly smooth consumption between the early 30s and the end of life.

Figure 1: Life-Cycle Asset and Consumption Profiles without Temptation

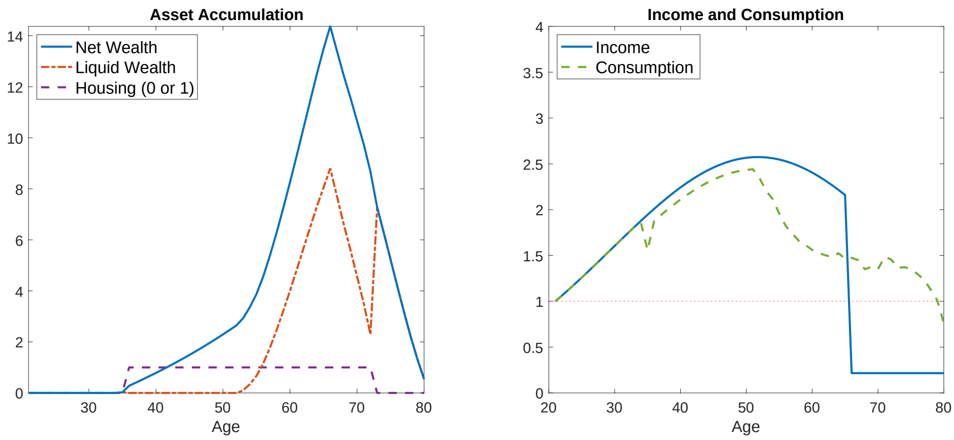


Note: This figure shows the life-cycle profiles of assets, income, and consumption in a model without temptation, where housing delivers equal return to liquid assets and provides no direct utility benefit.

In contrast, households with temptation demand housing, despite the fact that housing delivers no direct financial or utility benefits. In the left panel of Figure 2, we see that households with temptation preferences begin to accumulate liquid assets relatively late in life. This is because liquid wealth accumulation is difficult in the presence of temptation, owing to the disutility cost of deviating from your most tempting consumption alternative each period. As a result, households purchase housing despite the presence of sizeable transaction costs. This is driven by the fact that housing provides commitment, which helps households accumulating wealth for two reasons. First, households are able to reduce temptation by locking their wealth in illiquid housing; second, households are able to bind themselves to save in the future by committing to regular mortgage payments that build up wealth in the form of home equity.[12]

Households are able to decrease the utility cost of temptation by locking away their wealth in housing. In other words, temptation and commitment generate a preference for illiquidity. As a result, households spend a significant fraction of their lives holding no liquid wealth despite owning housing.

Figure 2: Life-Cycle Asset and Consumption Profiles with Temptation



Note: This figure shows the life-cycle profiles of assets, income, and consumption in a model with temptation, where housing delivers equal return to liquid assets and provides no direct utility benefit.

The right panel of Figure 2 shows the implications of household portfolio decisions for consumption. Since tempted households do not accumulate liquid wealth early in life, consumption closely tracks income until shortly before home purchase.[13] After buying a house, consumption continues to follow income closely: the difference between the two is

[12]This has been highlighted by Shiller (2014), who says, "One nice thing about investing in a house is that you're committed to a mortgage payment. So if you don't take out a home equity line of credit or do something like that, you will accumulate wealth."

[13]Temptation causes households to accumulate their downpayment quickly prior to home purchase. Consistent with this finding, Haurin, Hendershott, and Wachter (1997) find that households save the majority of their downpayment in the year prior to homeownership. Similarly, Charles and Hurst (2002) find that the vast majority of mortgage applicants have liquid wealth less than 10% of their predicted house value at the time of mortgage application.

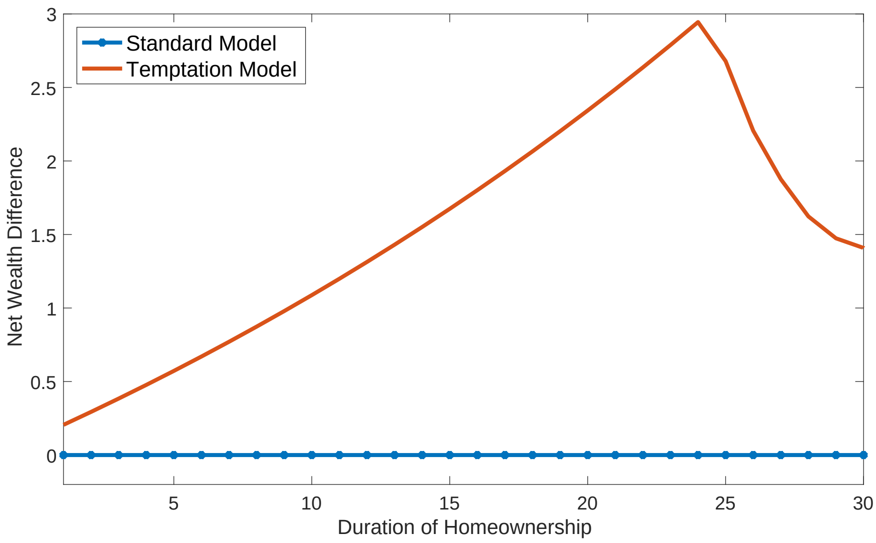
equal to the mandatory mortgage repayment each period. After age 55, when households start accumulating liquid wealth, consumption drops steadily. This is the consequence of temptation: households do not accumulate much wealth for retirement early in life, therefore consumption declines when nearing retirement.

3.2 Access to Commitment Increases Wealth Accumulation

In this section, we study how the availability of housing impacts the wealth accumulation of households. We demonstrate that in a standard model, the presence of housing has no impact on wealth accumulation, as housing delivers identical returns to liquid assets in our simplified model. In contrast, in a temptation model, the presence of housing enables households to accumulate greater wealth for retirement, as illiquid housing enables households to "lock away" their wealth and therefore mitigate the effects of temptation.

To see this, we look at patterns of wealth accumulation, imposing different assumptions on the availability of housing and household preferences. We therefore simulate households under four scenarios: with and without housing and with and without temptation. This allows us to observe the difference in wealth accumulation when housing is not available (i.e. when a savings commitment device is not available).

Figure 3: The Change in Wealth when Housing is Available



Note: This figure shows the difference in net wealth when housing is available versus when housing is unavailable. The red line shows the difference for a tempted household, while the blue line with round markers shows the difference for a standard household. The duration of homeownership is measured for a household that owns housing and all other simulations are compared based on age.

Figure 3 presents our results from these simulations using our simplified model. The solid red line shows the difference in net wealth for a tempted household that has access to housing, relative to an identical household that does not have access to housing. The line is increasing over the duration of home ownership, indicating that the presence of housing changes the savings behavior of the tempted households. After buying a home, households are required to repay the mortgage in each period, which acts as a self-imposed commitment device that forces them to accumulate home equity. When housing is not available, households have no way to mitigate their temptation, therefore they accumulate less wealth by the time of retirement.

It is interesting to note that the red line begins to decline towards the end of the 30 year window that we consider, as households near retirement. This is because tempted households without access to housing decide to accumulate liquid assets rapidly immediately prior to retirement. When the tempted household does not have access to a commitment device, they suffer a temptation cost for every period that they hold liquid assets, therefore they try to accumulate wealth for retirement as late and as quickly as possible. They catch up with the tempted household with housing, although this effect is only partial.

In contrast, the blue line with round markers in Figure 3 shows the difference in wealth accumulation for a standard household that has access to housing, relative to an identical household that does not have access to housing. The line is horizontal, indicating that the presence of housing does not change the savings behavior of the standard household. In this model, the type of asset choice does not impact the amount of asset accumulation.

4 Calibration and Model Fit

We divide our model parameters into two sets. The first set ($\mathbb{P}$) contains parameters that we assign based on external evidence. The second set (Γ) contains parameters that we internally calibrate using the Method of Simulated Moments (MSM), which minimizes the distance between key moments in the model and the data.

4.1 External Parameter Values

In this section we discuss the parameters that are assigned based on external evidence. The complete list of parameter values can be found in Table A.1

Asset Returns. Traditional models rationalize the behavior of the wealthy hand-to-mouth by assuming that illiquid assets deliver excess returns relative to all available liquid assets. However, this assumption does not hold when we look at specific assets such as housing and equities. There exists a wide body of empirical literature showing that housing delivers lower risk-adjusted returns than publicly traded equities. This poses a challenge for traditional models of hand-to-mouth behavior. If a liquid asset such as equities were added to the model of Kaplan and Violante (2014), the wealthy hand-to-mouth would disappear.

We set ourselves the challenge of rationalizing the large share of the wealthy hand-to-mouth, despite the presence of a high-return liquid asset. We calculate average real risk-adjusted returns between 1950 and 2016 using data from the Federal Reserve Bank of St. Louis. Details of the computation can be found in Appendix A.2, while the results are reported in Table 2. The average real risk-adjusted return is 5.40% for stocks and 2.10% for housing.

Table 2: Real Asset Returns

	Mean	St.Dev.	Risk-adj. Mean
Stock	8.24	16.82	5.40
Housing	2.34	5.06	2.10

Note: Stock: S&P 500, Housing: Case-Shiller index augmented by average housing service flow, maintenance cost and home insurance.

Our calculated returns show that there exists a liquid asset (stock) that delivers substantially higher risk-adjusted returns than housing. Based on the above findings, we set a real risk-adjusted return of 2.1% for housing ($r^H = 0.021$) and 5.4% for liquid assets ($r = 0.054$) in our baseline model. This calibration is consistent with a wide body of literature including Flavin and Yamashita (2002), Goetzmann and Spiegel (2002), and Piazzesi, Schneider, and Tuzel (2007) who show that housing delivers worse risk-adjusted returns than stock, even when accounting for imputed rents and other benefits to homeownership.[14]

Temptation Parameter. We set $\lambda = 0.28$ following the parameter estimate obtained by Kovacs, Low, and Moran (2020). These authors develop two complementary strategies to estimate the strength of temptation: first, a semi-structural Euler equation approach using observed consumption data, and second, a simulation based approach targeting the life-cycle profiles of consumption and wealth accumulation. The authors apply these two estimation strategies to the U.S. using data from the Consumer Expenditure Survey (CEX) and find similar estimates of λ in both cases. We opt to use the point estimate from the Euler equation method, as this semi-structural approach requires fewer assumptions about the economic environment faced by households.

By assuming that households suffer from temptation, our model implies a desire for illiquidity which is consistent with a growing experimental literature. For instance,

[14] We compute imputed rents using the balance sheet approach, following Piazzesi, Schneider, and Tuzel (2007) among others, which we describe in Appendix A.2. That said, Jordà et al. (2019) develop an alternative method to compute imputed rents. Based on their imputation, housing and equities in the U.S. have delivered roughly equivalent returns since the 1950s. For this reason, in Appendix A.7.1 we evaluate the sensitivity of our results to $r = r^H$. We find that it has little effect on our core results.

Ashraf, Karlan, and Yin (2006) conduct a field experiment where households are offered a savings account that does not permit withdrawals before a certain date or before a certain savings goal is achieved. The authors find that this savings account is taken up by a large share of households and leads to increased savings. Similarly, Beshears et al. (2020) conduct a lab experiment to study how individuals divide money between liquid and illiquid accounts. They find that illiquid accounts with higher early-withdrawal penalties attract more deposits.

House Sizes and House Prices. Determining the set of available house sizes in the data is difficult because we only observe house prices for those that have chosen to purchase a house. Nonetheless, we calculate the distribution of house prices for households between age 20 and 30. We use this distribution of house prices to define the different house sizes, and these sizes are then kept constant over time. However, the price of each house will evolve over time following equation (4). In our model, we set the maximum house price (size) at 8 times average income at age 22, corresponding to the 90th percentile of observed house prices for the age group 20-30 in the data, and we set the minimum price to be equal to average income. We allocate the remaining points on the house size grid to a logarithmic scale, following Nakajima and Telyukova (2020). We assume that there are $k = 7$ different house sizes available. We impose the same house size structure on the models with and without temptation. Following Attanasio et al. (2012), we impose a 5% fixed cost of moving, F, representing the cost of real estate agents, lawyers, surveyors, and moving companies. This is consistent with empirical evidence showing that transaction costs for housing are usually at least 5% of the asset value (OECD, 2011). Finally, we assume that capital gains to owner-occupied housing are not taxable.

Mortgages. We calculate the average mortgage rate over the period between 1950 and 2016 based on the 30-year fixed rate mortgage. The average mortgage rate is 4.1%, therefore we calibrate the net mortgage rate, $r^M = 0.041$, which is two percentage points higher than the risk-adjusted return on housing. We assume that each household can borrow up to 90% of the value of its home, hence the minimum downpayment requirement, ψ is set to be 10%. Following the U.S. tax code, we assume that mortgage interest payments are fully deductible from taxable income.

Income and Taxes. We calibrate income over the life-cycle in two steps. First, we use the estimated parameters for the stochastic component of income from Choukhmane (2019). We then estimate a third-order age polynomial on income in order to approximate the deterministic part of labor income. For the parameters of the non-linear tax function we use the estimation results by Keane and Wasi (2016) and convert them to 2015 units. We parametrize the progressive social security-style pension based on U.S. legislation from 2015. All income parameters are listed in Table A.1 in the Appendix.

Demographics. In the model, we account for changes in household composition over the life-cycle by assuming an exogenous and deterministic life-cycle profile for household composition. This is performed using the equivalence scale n_t which enters into the utility function. To calculate the equivalence scale n_t, we follow the OECD methodology using PSID data. This methodology assigns weight 1 to the first adult in the household, weight 0.7 to the second adult and each subsequent person aged 14 and over, and weight 0.5 to each child aged under 14. We then average by age in order to construct n_t.

Initial wealth. We assume zero initial housing wealth. We set the initial liquid wealth distribution to match the distribution for 22-25-year-old households in the PSID.

Prices. All variables in the model are expressed in 2015 prices. Where necessary, exogenous parameters from the existing literature are adjusted to represent 2015 prices.

4.2 Calibrated Parameters

The remaining parameters in the model, $\Gamma = \{\beta, \gamma, \mu, \theta\, \chi\}$, the the impatience parameter, the risk aversion parameter, the housing preference (taste) parameters respectively, and the utility cost of changing home, are internally calibrated by the Method of Simulated Moments such that the model matches aggregate statistics of consumption and wealth accumulation. This second stage takes the first stage calibrated parameters fixed, $\hat{\mathbb{P}}$, while choosing Γ to minimizes some measure of the distance, f, between the empirical moments, m^e, and the simulated moments, $m^s(\hat{\mathbb{P}}, \Gamma)$.

$$f(\hat{\mathbb{P}}, \Gamma) \equiv [m^s(\hat{\mathbb{P}}, \Gamma) - m^e] \tag{20}$$

We choose to target the mean life-cycle profiles of four variables: consumption, liquid assets, net housing wealth, and the share of homeowners with zero liquid assets. To focus on the working life, we target the mean of each variable between ages 25 and 65, giving 164 moment conditions. We also target the average homeownership rate and the average share of homeowners who move in a given year, giving two additional moments. Altogether we target $N_m = 166$ moment conditions to calibrate the five parameters in Γ.

In order to capture the fact that these targeted moments vary substantially in both scale and volatility, we use a weighting matrix, W, to create our scalar-valued final distance function, f^{W}, equal to the weighted sum of squared deviations of simulated moments from their corresponding empirical counterparts:

$$f^{\mathrm{W}}(\hat{\mathbb{P}}, \Gamma) \equiv f(\hat{\mathbb{P}}, \Gamma) \cdot W^{-1} \cdot f(\hat{\mathbb{P}}, \Gamma)' \tag{21}$$

where W is a diagonal N_m x N_m matrix that includes the variance of the targeted moments along the main diagonal. In effect, this means that our MSM approach places more weight on moments that are more precisely estimated in the data.[15]

Pinning down the structural parameters requires that each structural parameter in Γ has an independent effect on at least one targeted moment in $m^s(\hat{\mathbb{P}}, \Gamma)$. More formally, our model is identified if the mapping from structural parameters Γ to targeted moments $m^s(\hat{\mathbb{P}}, \Gamma)$ is full rank near the true Γ. In Section 5 we discuss the way in which structural parameters impact targeted moments.

Our MSM results are based on simulations for 1,000 households for two scenarios each. In the first scenario, we set λ to be 0.28 following Kovacs, Low, and Moran (2020) and we call this the model with temptation. In the second scenario, we set parameter λ to be zero and we call this the model without temptation. As a result, we can compare the ability of these two models to match the empirical patterns of household consumption and portfolio allocation together with their calibrated parameters.

We target the mean life-cycle profiles of consumption, liquid assets, net housing wealth, and the share of homeowners with no liquid wealth between ages 25 and 65. We also target the average homeownership rate and the average share of homeowners who move in a given year. All data comes from the Panel Study of Income Dynamics (PSID) waves 1999 to 2015. Detailed information on the sample is contained in Appendix A.3. In this section, we describe each targeted moment in turn.

Consumption. We compute real nondurable consumption following the classification in Blundell, Pistaferri, and Saporta-Eksten (2016). With this classification our consumption measure covers approximately 70 percent of consumption expenditure on nondurable goods and services.

Liquid assets. We compute liquid assets as the sum of bank account deposits and publicly traded stock. We believe that publicly traded stock are essentially liquid because there are very low transaction costs on these assets, thus it would be easy for households to sell their stock position for consumption smoothing purposes.

Net housing wealth. We measure net housing wealth as the reported value of the household's main residence minus all mortgage debt on this home. We exclude net wealth from other real estate.

Wealthy Hand-to-Mouth. We target the share of homeowners with liquid assets less than two weeks of income, which we refer to as the wealthy hand-to-mouth. This is an appealing description: these households are wealthy as they own a house, yet live hand-to-mouth with essentially zero liquid wealth that can be used for consumption smoothing (Kaplan, Violante, and Weidner, 2014).

[15] We choose to use the diagonal weighting matrix rather than the full variance-covariance matrix as many authors have found that the full variance-covariance matrix leads to biased estimates in small samples. See Altonji and Segal (1996) for example.

Homeownership. We target the average homeownership rate between ages 25 - 65.

Movers. We target the average share of homeowners that move for non-work reasons each year. We exclude moves for work since that is outside the scope of our model.

4.2.1 Calibrated Parameter Values

Table 3 presents the results for the calibrated preference parameters: time preference (β), risk aversion (γ), taste for housing (μ, θ), and the disutility of moving (χ). The first column shows the calibrated parameters for the temptation model. The second column shows the calibrated parameters for the model without temptation, where we turn off temptation.

The model with temptation yields an annual discount factor (β) of 0.96 and a risk aversion parameter (γ) of 2.41, consistent with most of the macroeconomic literature. The additive utility benefit of housing (μ) is roughly 0.3, while the non-separable utility benefit of housing (θ) is 0.16. It is worth noting that the calibrated positive value of θ implies that consumption and housing are complements. This is in line with the results from Attanasio et al. (2012) who calibrate a similar utility function for housing, albeit with two types of homes, and find that consumption and housing are complements.[16] We find that the utility cost of moving (χ) is 0.43 in the temptation model. For an easier interpretation, we calculate the consumption equivalence of parameter, χ, by expressing it as the amount of additional consumption that households require to be indifferent between moving and not moving homes. An average homeowner aged 25, for example, has to face a utility cost that is equivalent to an additional $\$6,000$ of consumption if it decides to buy a bigger house.[17]

The model without temptation yields both a lower impatience parameter of ($\beta = 0.91$) and a lower risk aversion parameter ($\gamma = 1.88$). Moreover, without temptation the model features significantly higher housing taste parameters ($\mu = 0.59$ and $\theta = 0.28$). This is because the model without temptation requires strong discounting of future utility and greater tolerance to risk to try to explain the large share of the wealthy hand-to-mouth, while matching the substantial housing wealth accumulation over the life-cycle. Compared to the model with temptation, the model without temptation delivers a higher

[16] Since μ is positive, an increase in housing has a direct positive effect on utility. In addition, it is worth noting that a positive θ implies Edgeworth complementarity of consumption and home ownership, as the cross derivative of utility with respect to consumption and housing is positive

$$\frac{\partial u(c_t, h_t)/\partial c_t}{\partial h_t} = \theta\phi'(h_t, n_t)c_t^{-\gamma}\exp(\theta\phi(h_t, n_t)) > 0$$

Thus in the model with temptation, housing and consumption are complements, whereas in the model without temptation housing and consumption are (weak) complements.

[17] Naturally, the consumption equivalence is different depending on the age of households, their current housing status, and their next period housing status.

Table 3: Internally calibrated parameters

PARAMETER		Temptation Model	No Temptation Model
Time preference	β	0.959 (0.000)	0.914 (0.000)
Risk aversion	γ	2.415 (0.052)	1.884 (0.019)
Housing utility (separable)	μ	0.291 (0.000)	0.591 (0.004)
Housing utility (non-separable)	θ	0.160 (0.007)	0.282 (0.003)
Utility cost of housing adjustment	χ	0.437 (0.037)	0.887 (0.039)
Goodness of Fit	$f^{\mathrm{W}}(\hat{\mathbb{P}}, \hat{\Gamma})$	5.667	10.059

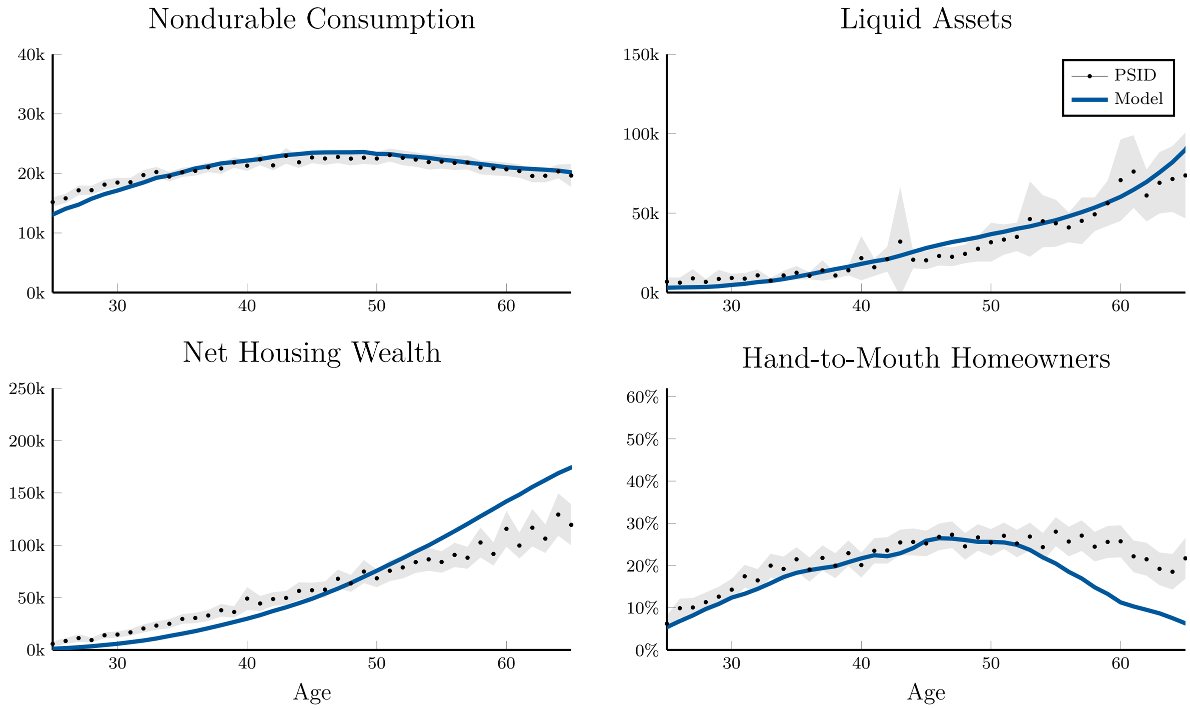
Note: In the temptation model we set $\lambda = 0.28$. In the model without temptation we set $\lambda = 0$. Goodness of fit is defined by equation (21).

value of utility cost of moving ($\chi = 0.88$).

4.3 Model Fit

Baseline Model with Temptation. We first analyze the performance of their calibrated model with temptation. Figure 4 shows the simulated life-cycle moments from the temptation model (the solid blue line) and the targeted moments from the PSID (the black dotted line). In general, the temptation model obtains a good fit of the life-cycle profile of consumption and liquid asset accumulation. The model obtains a good fit of net housing wealth up until age 50, although after this point, net housing wealth starts diverging a bit as households approach retirement. The divergence of net housing wealth arises from the simplifying assumption in our model that all mortgages must be paid off by age 65, when households are forced to retire. In reality, some households continue to work and/or maintain positive mortgage balances after age 65, which helps explain this difference. Notice that, apart from very young ages, household's wealth is concentrated in illiquid housing: by the age of 40, housing wealth accounts for about 70% of the average U.S. household's wealth. This overwhelming dominance of housing wealth only starts declining later in life, close to retirement, reaching roughly 60% by age 65.

Figure 4: Fit of the Temptation Model



Note: This figure shows the life-cycle moments from the temptation model (solid blue line) and the PSID (black dotted line). The moments from the PSID are shown with bands of 1.96 standard deviations around the mean. Table A.4 in the Appendix shows the fit of the other moments that we target: the average homeownership rate and the average share of homeowners moving each period.

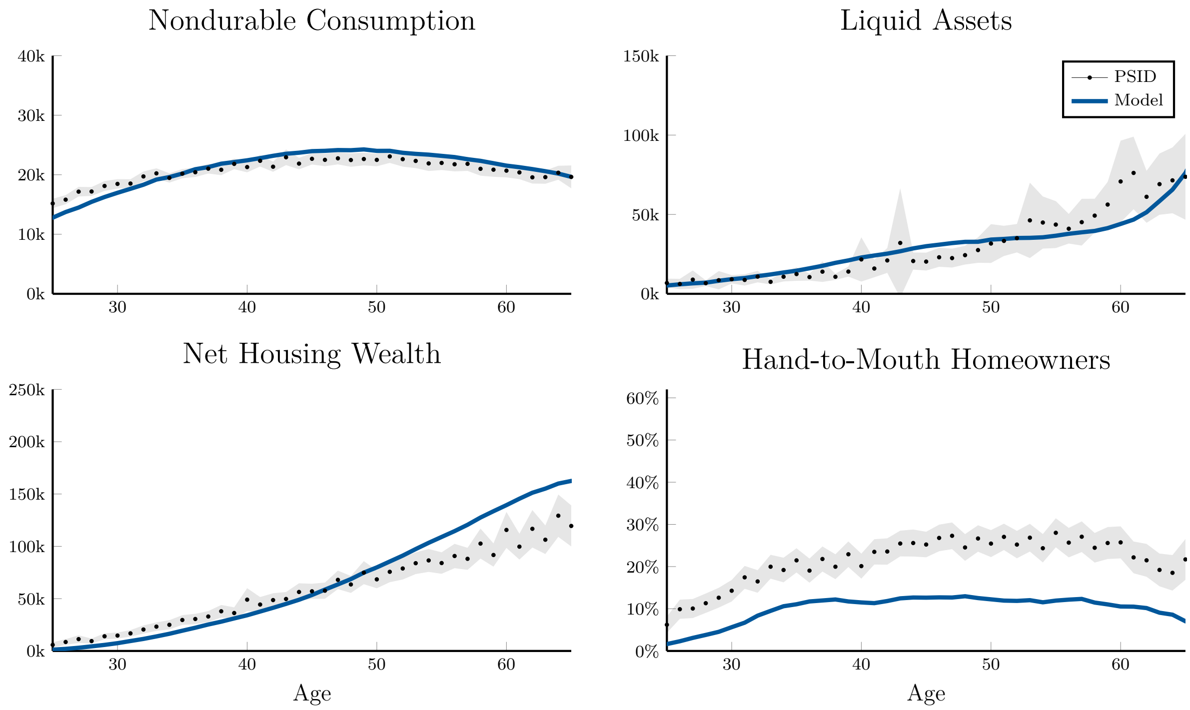
Most importantly, the temptation model obtains a good fit of the wealthy hand-to-mouth. In the temptation model, wealthy hand-to-mouth behaviour is mainly driven by the fact that households are willing to withstand fluctuations in consumption in order to obtain the commitment benefit of illiquid assets. The age profile for the wealthy hand-to-mouth is hump-shaped with a peak around age 45, when roughly 25% of households own a home but hold essentially zero liquid wealth. These findings are very similar to what Kaplan, Violante, and Weidner (2014) document using the U.S. Survey of Consumer Finances: they find a hump-shaped life-cycle profile of the wealthy hand-to-mouth with a peak of around 22% at age 40.

As noted by Parker (2017), hand-to-mouth status may be either situational (i.e. a result of poor income shocks or temporary illiquidity, as in Kaplan and Violante (2014)) or reflective of persistent household traits (i.e. preferences or behavioral characteristics). Our model of temptation and commitment implies a relatively high persistence of hand-to-mouth status. In our calibrated model, there is a roughly 60% probability that a household who is wealthy hand-to-mouth in one year remains wealthy hand-to-mouth two years later. This is consistent with empirical evidence from the PSID showing that hand-to-mouth status is highly persistent in the data (Aguiar, Bils, and Boar, 2020).

Model without Temptation. We next analyze the performance of the model where we turn off temptation ($\lambda = 0$) and re-calibrate the remaining preference parameters. We document that our two-asset model without temptation, of the type analysed by Kaplan and Violante (2014), cannot fit the large share of the wealthy hand-to-mouth when housing does not deliver higher risk-adjusted returns than liquid assets.

Figure 5 shows the simulated life-cycle moments from the model without temptation (the solid blue line) and the targeted moments from the PSID (the black dotted line).

Figure 5: Fit of the No Temptation Model



Note: This figure shows the life-cycle moments from our no temptation model (solid blue line) and the PSID (black dotted line), where we impose $\lambda = 0$. The moments from the PSID are shown with bands of 1.96 standard deviations around the mean.

We observe that the model without temptation obtains a good match of the life-cycle profile of consumption. After age 50, the model over predicts (similarly to the model with temptation) housing wealth accumulation. However, in contrast to the temptation model, in the model without temptation there is no combination of the preference parameters that can match the large share of wealthy hand-to-mouth households without failing to match other targeted moments. This is despite the fact that the model is relatively flexible and allows for impatience, different types of housing taste, and varying degrees of risk aversion.

High impatience is unable to explain the large share of wealthy hand-to-mouth households without compromising model fit elsewhere. For instance, if β were lowered below our calibrated value in the model without temptation ($\hat{\beta} = 0.91$), we would obtain a better fit of the wealthy hand-to-mouth, but a worse fit of the life-cycle profile of wealth accumulation.

Greater tolerance towards risk (i.e. lower γ) reduces the degree to which households are worried about consumption fluctuations. However, it also reduces the degree to which households accumulate wealth for a down-payment in order to purchase housing, thus reducing the homeownership rate. As a result, a lower value of γ slightly decreases the share of the wealthy hand-to-mouth, while simultaneously increasing the share of poor hand-to-mouth households.

Higher housing taste (μ or θ) is unable to explain the large share of the wealthy hand-to-mouth. This is because higher housing taste makes homeowners more averse to losing their homes, thus generating a stronger precautionary savings motive for homeowners. This "housing smoothing" motive results in a smaller share of homeowners holding zero liquid assets.

5 Implications for Consumption Behavior

Understanding households' preference for illiquidity is interesting not only from a theoretical point of view, but also for understanding the consumption response to income shocks and fiscal stimulus payments. A growing macro literature argues that households with low liquid assets are important in explaining aggregate consumption behavior.[18] In this section, we study the implications of the alternative view of illiquidity that we have developed.

First, we evaluate the ability of our model to match empirical evidence on heterogeneity in the marginal propensity to consume (MPC). Our most important finding is that the average MPC in our model declines relatively slowly with shock size. In other words, large income shocks still induce a sizeable increase in consumption. This result is consistent with a growing empirical literature, but inconsistent with previous models of hand-to-mouth behavior. To the best of our knowledge, our model is the first that is able to replicate this empirical finding. In addition, our model fits well-known evidence that MPCs decline slowly with wealth, but quickly with liquid assets.

Next, we assess the implications for the design of targeted fiscal stimulus payments, which depends crucially on MPC heterogeneity. We use our calibrated model to evaluate the trade-off associated with targeting stimulus payments. We find that fiscal stimulus is the most effective when the government targets households in the bottom 20% of the income distribution.

[18] See for instance Kaplan and Violante (2014), Carroll et al. (2017), Kaplan, Moll, and Violante (2018), Auclert, Rognlie, and Straub (2018), Luetticke (2018), and Bayer et al. (2019).

5.1 MPC Heterogeneity: Model versus Data

We use our calibrated model to study the consumption response to unanticipated and transitory income shocks. The details of this procedure can be found in Appendix A.5. We find that our model generates an average annual MPC of 0.43 in response to a $1,000 income shock. This lies well within the standard range of annual MPCs estimated by the empirical literature. For instance, Carroll, Slacalek, Tokuoka, and White (2017) give a comprehensive summary of the empirical literature and report that average annual MPC estimates for the U.S. range between 0.2 and 0.6.

5.1.1 Heterogeneity by Shock Size

To study the effect of shock size on consumption behavior, we experiment with changing the magnitude of the income shock. The results are contained in Table 4. We observe that the average MPC declines only slowly with the size of the income shock. For instance, changing the shock size from $1,000 to $10,000 only causes the average MPC to decline from 0.43 to 0.29.

Table 4: MPC Heterogeneity by Shock Size

	SHOCK SIZE		
	$1,000	$5,000	$10,000
MPC	0.43	0.37	0.29
	(0.002)	(0.002)	(0.001)

Note: Each coefficient represents the average annual MPC in our calibrated model. The procedure used to compute MPCs is described in Appendix A.5.

This result is consistent with a growing empirical literature that finds that the average MPC remains large in response to large income shocks. Most similar to our analysis, Fagereng, Holm, and Natvik (2019) study the consumption response to large and unanticipated lottery winnings using administrative tax data from Norway. They find that the average MPC only gradually declines as the size of the shock increases: households that receive large payments still consume most of their payment shortly after receipt.

In addition, Kueng (2018) studies the consumption response to large and anticipated payments of the Alaska Permanent Fund and also finds a large MPC. In response to an average payment of $4,600, Kueng (2018) finds a quarterly MPC of just under 0.3.[19]

[19] While the early empirical literature suggested that MPCs were small for large shocks (Hsieh, 2003), new empirical evidence has overturned this finding. More specifically, Kueng (2018) replicates the analysis in Hsieh (2003) and shows that (i) the small and insignificant consumption response was a result of nonclassical measurement error in income data attenuating the estimates, and (ii) the estimates in Hsieh (2003) are of consumption elasticities rather than MPCs.

Finally, Aladangady et al. (2018) study the consumption response to the Earned Income Tax Credit and also find a large MPC in response to this large and anticipated income shock. This quasi-experimental evidence has been corroborated by survey evidence that finds similar results. For instance, Bunn et al. (2018) and Fuster, Kaplan, and Zafar (2018) both find a large MPC in response to large income shocks.

Large MPCs in response to large income shocks cannot be explained by traditional two-asset models. For instance, while the model of Kaplan and Violante (2014) obtains a good fit of the average MPC out of small income shocks, it predates these recent empirical findings and cannot rationalize large MPCs in response to large income shocks.[20] Section 5.2 explores the reasons for these differences.

5.1.2 Heterogeneity by Asset Holdings

There exists a large literature showing that liquidity is an important determinant of MPC heterogeneity, most importantly Kaplan and Violante (2014). We assess the predictive power of our model relative to existing literature. We find that the average MPC in our model declines slowly with net wealth, but quickly with cash-on-hand. This is consistent with empirical evidence by Jappelli and Pistaferri (2014) and Fagereng, Holm, and Natvik (2019), as well as the model of hand-to-mouth households by Kaplan and Violante (2014). The results are contained in Appendix A.6.

5.2 MPC Decomposition

In our model, households exhibit high MPCs for two reasons. First, there is the effect of illiquidity: households keep the vast majority of their wealth in illiquid form, thus restricting their ability to smooth consumption over transitory income shocks. Second, there is the mechanical effect of temptation: households experience increased temptation ($\tilde{c}$) in response to a positive income shock, therefore they consume more today. In this section, we decompose the relative importance of these two mechanisms.

We decompose the mechanical effect of temptation using the following procedure. For each household $i \in [1, 2, ..., N]$ and each period of working life $t \in [1, 2, ...W]$, we simulate two versions of household i starting at time t, where one receives an unanticipated and transitory income shock of x dollars, while the other does not. This is performed using our baseline parameter estimates for the temptation model with $\lambda = 0$, thus turning off the mechanical effect of temptation. We assume that the state variables at the time of

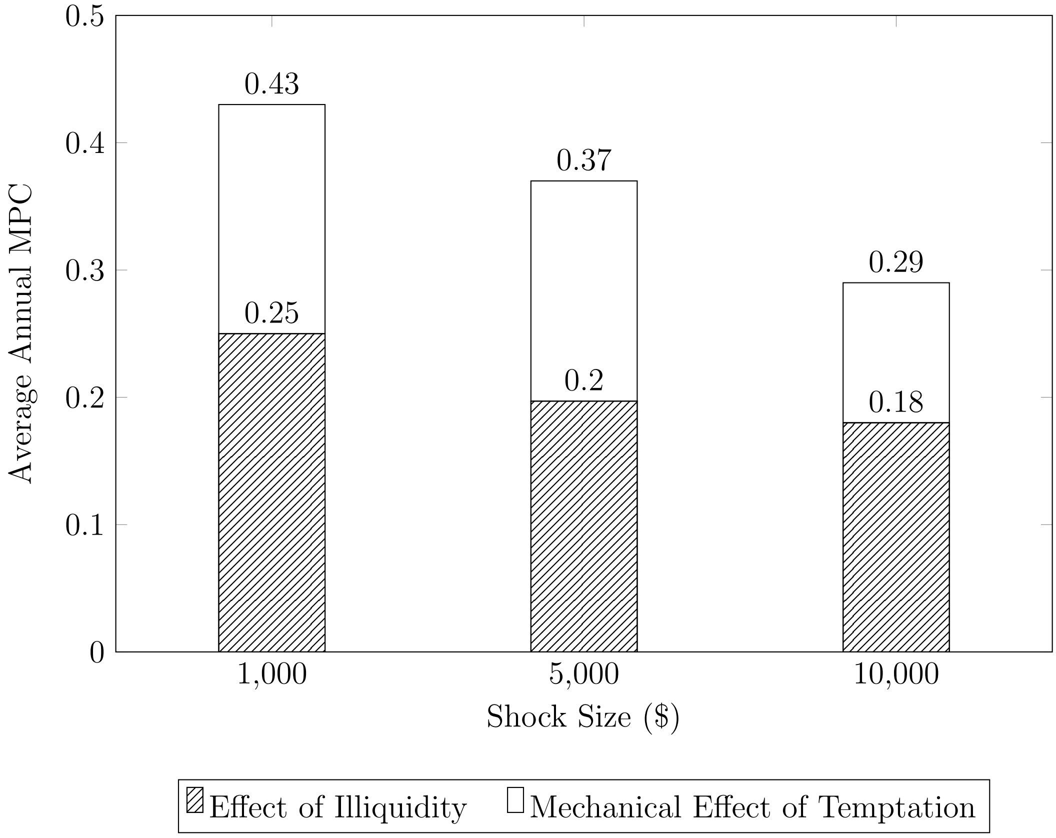
[20] Note that historically it has been difficult to measure consumption response for large shocks, as most governmental stimulus payments are small. As a result, most of the empirical work on MPCs focuses on the consumption response to small income shocks. See for instance Shapiro and Slemrod (2003), Johnson, Parker, and Souleles (2006), Shapiro and Slemrod (2009), Parker et al. (2013) or Misra and Surico (2014) all analyze the consumption response of households to the 2001 and the 2008 fiscal stimulus, with average payments of \$600 and \$1,200.

the shock ($\Omega_{i,t}$) are identical for the two versions of the same household and are based on our baseline parameter estimates for the temptation model.[21]

$$\widetilde{\text{MPC}}(x) = \frac{1}{N}\frac{1}{W}\sum_{i=1}^{N}\sum_{t=1}^{W}\frac{c_{i,t}(\text{shock} = x, \lambda = 0, \Omega_{i,t}) - c_{i,t}(\text{shock} = 0, \lambda = 0, \Omega_{i,t})}{x} \tag{22}$$

Figure 6 presents the results from our model decomposition. The striped black bar shows the effect of illiquidity on consumption behavior when we turn off temptation, while the white bar shows the mechanical effect of temptation. We find that both mechanisms are important in generating large MPCs. The effect of illiquidity explains roughly 55-60% of the overall consumption response to an unanticipated and transitory income shock, while the mechanical effect of temptation explains the remainder. Even when households receive an income shock of $10,000, the effect of illiquidity remains substantial.

Figure 6: MPC Decomposition



Note: This figure shows the mechanisms driving consumption behavior in response to an unanticipated and transitory income shock. The striped black bar shows the effect of illiquidity, e.g. the MPC absent temptation ($\widetilde{\text{MPC}}(x)$). The white bar shows the mechanical effect of temptation ($\text{MPC}(x) - \widetilde{\text{MPC}}(x)$).

[21] In other words, we assume that households suffer from temptation prior to the realization of the unanticipated and transitory income shock. This ensures that turning off temptation does not alter the distribution of liquid assets, housing, and hand-to-mouth households prior to the shock.

Why does illiquidity have a large effect even when households receive an income shock of \$10,000? This is because a shock of \$10,000 is insufficient to induce many households to pay the housing transaction cost and adjust their housing stock. In our model, there are substantial adjustment costs to housing, both financial and nonfinancial. As a result of these adjustment costs, many households are liquidity constrained in the short-term, even if they have significant housing wealth, therefore they respond strongly to unexpected and transitory income shocks.

In contrast, Kaplan and Violante (2014) find a very small MPC (almost zero) in response to large income shocks. This is because their model has a small, additive adjustment cost of \$1,000. Moreover, if they were to include a larger adjustment cost, the wealthy hand-to-mouth would disappear. An important benefit of temptation is that it is able to accommodate a large and realistic adjustment cost,[22] yet still explain the presence of wealthy hand-to-mouth households. In a model with temptation, larger adjustment costs may actually increase demand for housing, whereas in a traditional model, larger adjustment costs always reduce demand for housing.

5.3 Targeted Fiscal Stimulus

As noted in the previous section, households with low cash-on-hand have the largest consumption response to transitory income shocks. In addition, the average consumption response declines relatively slowly with shock size. These two findings may have important implications for the design of fiscal stimulus policies, as they suggest that large and targeted fiscal stimulus payments could be very effective in boosting aggregate consumption. In contrast, most governments have historically relied upon small fiscal stimulus payments given to a large proportion of the population. In this section, we use our estimated model to study the efficiency of targeted stimulus.

We study the consumption response to alternative stimulus targeting policies by varying the fraction of households that receive a one time unanticipated stimulus payment from the government, where the government uses an income based targeting approach.[23] We focus on budget equivalent policies, for instance, giving \$500 to all households or \$1,000 to the bottom half of the income distribution. We simulate N households using our model and then compare their baseline consumption to a counterfactual simulation where the same households (with the same income shocks) are given a one time unanticipated stimulus payment at age t. We assume that all households between the ages of 22 and 65 are eligible for stimulus payments, therefore we repeat this exercise for all

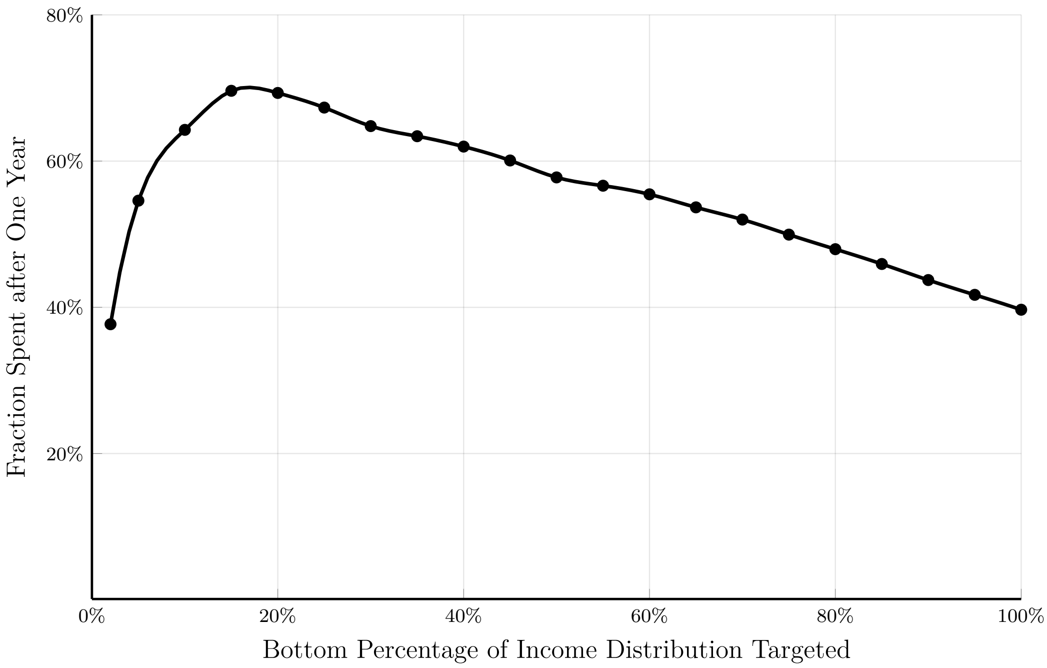
[22] In our case, 5% of the value of the home (OECD, 2011), as well as the utility cost of moving.

[23] We study the response to income targeting as most governments have comprehensive information on residents' income, but not liquid assets. Of course, Fagereng, Holm, and Natvik (2019) might be able to help Norway perform targeted stimulus based on liquid assets, which may be even more effective.

t within this age range and then aggregate our results.[24] We then report the fraction of aggregate stimulus that is consumed within one year after disbursal.

Figure 7 shows the aggregate one year consumption response to budget equivalent fiscal stimulus policies that target different fractions of the income distribution. At one extreme, all households are given a stimulus payment of $500, while at the other extreme the bottom 2% of households in the income distribution are given a stimulus payment of $25,000. At either extreme, just under 40% of stimulus payments are consumed within the year of disbursal. We observe that the consumption response gradually rises as the government moves from a policy that distributes stimulus to all households to a policy that targets the bottom 20% of the income distribution. At the optimum, when $2,500 is given to each household in the bottom 20% of the distribution, we observe that 68% of aggregate stimulus is consumed within one year.

Figure 7: Income Targeted Stimulus Payments



These results imply that fiscal stimulus can produce a much larger consumption response when it is heavily targeted towards households in the lowest quintile of the income distribution. In contrast, during the Great Recession, most governments that provided stimulus payments decided to give payments to a large fraction of the population, with very little targeting. For instance, under the Economic Stimulus Act of 2008, the U.S. government gave tax rebates to approximately 80-85% of households, with an average stimulus payment of $600-$1,200.

Targeted fiscal stimulus allows the government to reach households with higher MPCs,

[24] We choose $N = 1,000$ for each time period, therefore there are 44,000 households in our simulation.

but there exists a trade-off, as larger stimulus payments induce households to save a larger fraction of their income in either housing or liquid assets. As a result, the consumption response observed in Figure 4 declines when the government targets households in the very bottom of the income distribution. For instance, in response to a stimulus payment of $25,000, approximately 29% is saved in housing wealth. Nevertheless, a very large stimulus payment is needed to convince households to increase their investment in housing, due to the presence of sizable housing transaction costs.

We find a more important role for stimulus targeting than the existing theoretical literature. For instance, while the model of Kaplan and Violante (2014) implies a similar consumption response when stimulus payments are given to the entire population, they find smaller gains to targeted stimulus payments, and their optimal policy is to target the bottom half of the income distribution.[25] This difference is driven by the above trade-off between targeting households with high MPCs and giving larger payments. Their model requires very small transaction costs ($1,000 in their preferred calibration) in order to explain the presence of wealthy hand-to-mouth households, therefore there is a rapid decline in the MPC based on size of stimulus payment, as larger stimulus payments induce more households to pay this cost and put their wealth in the illiquid asset. In contrast, in our model we have a realistic housing transaction cost of 5% of the value of the home, as well as a utility cost χ that we estimate, therefore fewer households are willing to adjust housing due to a stimulus payment, unless that payment is very large. As a result, our model is consistent with the recent empirical evidence showing a gradual decline in MPCs based on shock size, thus suggesting a more important role for targeted fiscal stimulus.

6 Implications for Saving Behavior

The view of illiquidity that we highlight has important implications for saving behavior and wealth accumulation. As we demonstrated in Section 3, the ability to purchase a savings commitment device (in our case, housing) allows households to accumulate more wealth over the life-cycle. This occurs for two reasons: first, households are able to reduce temptation by locking their wealth in illiquid form; second, households are able to bind their future self to save by committing to regular mortgage payments that build up wealth in the form of home equity. In this section, we study two important policies that affect housing and mortgage decisions, which in turn may affect wealth accumulation.

[25] In their model, stimulus payments given to the entire population would imply that roughly 40% is consumed within one year, while stimulus payments given to the bottom half would imply that 55% is consumed within one year. In contrast, we find that 70% is consumed within one year if stimulus payments are targeted towards the bottom 20% of the income distribution.

6.1 Mandatory Amortization

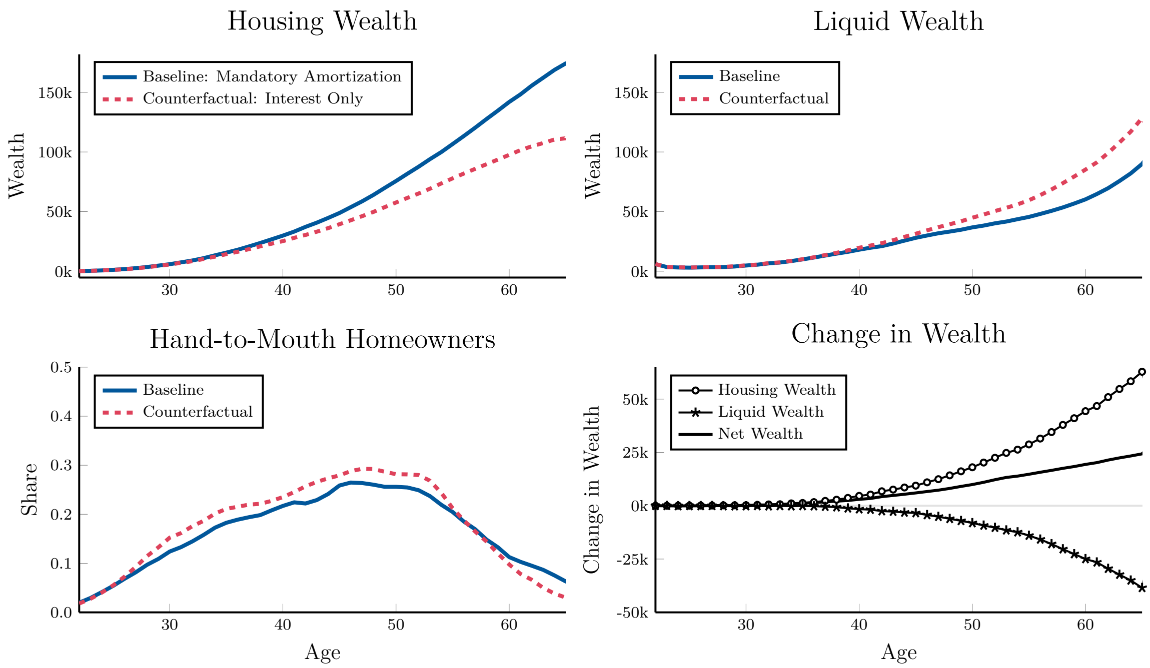
There exists a growing debate about the effect of mandatory amortization policies on household spending and wealth accumulation. While mandatory amortization requirements have recently been introduced by Sweden and the Netherlands, there exists concern that these policies may simply result in a re-balancing of household portfolios away from liquid assets and into illiquid hosuing, potentially resulting in reduced resilience to income shocks (Svensson, 2019, 2020). But if mortgage payments serve as a commitment device, then amortization might not result in simple portfolio re-balancing, but may also help households accumulate wealth.

We use our calibrated model to study the effect of mandatory amortization policies on household wealth accumulation and to quantify the role of commitment. To do so, we consider two different policy regimes. In the baseline, we assume that all mortgages are fully-amortizing, thus mortgagors are required to gradually pay back their mortgage using a periodic debt repayment plan that ends at the time of retirement. In the counterfactual, we assume that all mortgages are interest-only (IO), with a balloon payment covering the mortgage principal at the time of retirement. The latter option implies that homeowners will only be required to make small interest payments on their mortgage during the course of their working-life. This may potentially increase wealth accumulation, as it allows households to invest in the high-return liquid asset using the money that they otherwise would have been required to accumulate in the form of home equity. However, interest-only mortgages may instead decrease wealth accumulation if amortization payments serve as a savings commitment device.

Figure 8 shows the life-cycle profiles of wealth accumulation in the baseline model with mandatory amortization (the solid blue line) relative to the counterfactual model with interest-only mortgages (the dashed pink line). Overall, we find evidence of portfolio re-balancing from liquid to illiquid assets, but this is not a one-to-one effect, therefore overall wealth accumulation is increased.

The first two panels of Figure 8 show the life-cycle profiles of net housing wealth and liquid wealth in the two different models. Mandatory amortization increases housing wealth accumulation at the cost of slightly reduced liquid wealth accumulation. Overall, we find that every additional dollar of housing wealth reduces liquid assets by roughly 60 cents by the time of retirement. The third panel of Figure 8 shows the share of the wealthy hand-to-mouth in the two different models. We see that the share of the wealthy hand-to-mouth is very similar across the two different models, and in fact is very slightly higher in the model with interest-only mortgages. This suggests that mandatory amortization policies are not an important determinant of hand-to-mouth behavior. Finally, the fourth panel shows the difference in wealth accumulation in the model with mandatory

Figure 8: Effect of Mandatory Amortization



amortization relative to the model with interest-only mortgages. We find that mandatory amortization increases net wealth by around 10% by the time of retirement, relative to the model with interest-only mortgages.

The reason that wealth accumulation is increased is because mortgage amortization serves as a form of commitment. By purchasing a home using an amortizing mortgage, households not only lock-away their current wealth, but they also commit to accumulate wealth in the future in the form of home equity. This finding is consistent with recent empirical evidence from the Netherlands, showing that mandatory amortization results in increased wealth accumulation, as households accumulate more home equity due to this policy, but do not reduce their non-housing assets (Bernstein and Koudijs, 2020).

More specifically, Bernstein and Koudijs (2020) study the effect of mortgage amortization on wealth accumulation by exploiting a macroprudential policy change in the Netherlands that restricted the availability of interest-only mortgages for first-time home buyers starting in January 2013. These authors find that mandatory amortization results in a near 1-for-1 rise in net worth, with no observable change in non-housing savings, at least in the four years for which data is available. Our results are consistent with their findings. Moreover, our calibrated model allows us to evaluate the potential long-term effects of such a policy on household wealth accumulation. We find that the effect on wealth accumulation builds over time, with the largest increase in wealth occurring at age 65, when households in our model finish paying off their mortgage.[26]

[26] In this paper, we do not explore the welfare implications of mandatory amortization. That said, the presence of temptation generates an interesting trade-off between flexibility and commitment, which is

6.2 Housing Subsidies

There is a long-standing debate about the effect of tax benefits that incentivize wealth accumulation in illiquid assets such as housing or individual retirement accounts. In the United States and many other countries, a large number of tax advantages have been given to housing and retirement accounts. Some studies have argued that such tax incentives may result in an increase in overall savings (Venti and Wise, 1986, 1987), while others have argued that such incentives may only result in portfolio re-allocation from liquid to illiquid assets (Gale and Scholz, 1994; Attanasio and DeLeire, 2002). In addition, a growing literature argues that tax benefits to housing may distort household portfolio allocations, resulting in increased accumulation of housing wealth at the expense of reduced accumulation of non-housing assets.[27] Yet none of these papers consider the effect of making commitment more affordable, which could be an important channel through which governments may stimulate household saving.

Using our calibrated model, we evaluate the effect of housing subsidies on both portfolio allocation and overall wealth accumulation. We focus on two large subsides to homeownership which are present in the United States: the mortgage interest tax deduction and the tax exemption of capital gains on owner-occupied housing. We compare our baseline model, where both tax benefits exist, to a counterfactual model, where both tax benefits are eliminated.

Figure 9 shows the life-cycle profiles of wealth accumulation in the baseline model with housing subsidies (the solid blue line) relative to the counterfactual model without housing subsidies (the dashed pink line). We find evidence of some portfolio re-balancing from liquid to illiquid assets, however, this is not a one-to-one effect. As a result, overall wealth accumulation is increased due to the presence of housing subsidies.

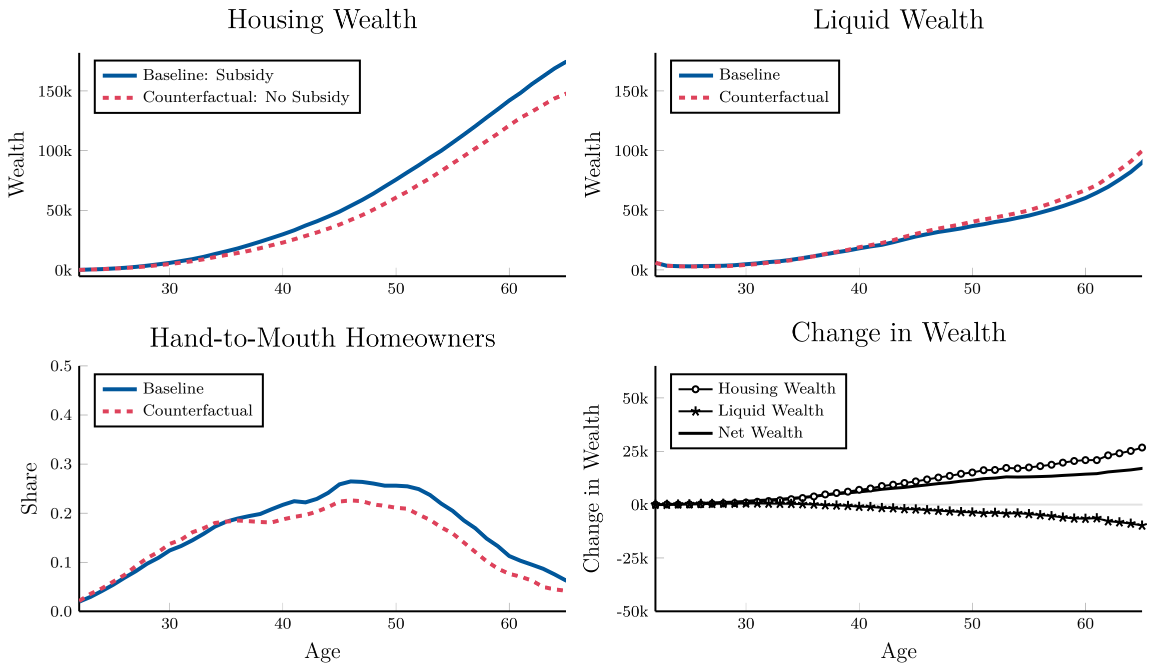
The first two panels of Figure 9 show the life-cycle profiles of net housing wealth and liquid wealth in the models with and without housing subsidies. We find that housing subsidies increase housing wealth accumulation at the cost of reduced liquid wealth accumulation. Every additional dollar of housing wealth reduces liquid assets by roughly 33 cents by the time of retirement.

The third panel of Figure 9 shows the share of hand-to-mouth homeowners in the two different models. We see that the share of hand-to-mouth homeowners is reduced only slightly by eliminating the tax benefits to housing. This is an important finding which differs substantially from a traditional model. In a model where wealthy hand-to-mouth households are generated by the assumption that illiquid assets deliver excess

absent in a traditional model. Kovacs and Moran (2020) study the implications of this trade-off as it relates to financial liberalization which has given households greater access to home equity withdrawal.

[27] See for instance Rosen (1985), Poterba (1992), Gervais (2002), Chambers, Garriga, and Schlagenhauf (2009), Floetotto, Kirker, and Stroebel (2016), and Nakajima (2020).

Figure 9: Effect of Housing Subsidies



returns relative liquid assets, such as Kaplan and Violante (2014), we would expect that a reduction in tax benefits to illiquid assets would have a large effect on the share of hand-to-mouth households, since it reduces the gap in returns between illiquid and liquid assets. In contrast, in our model, hand-to-mouth homeowners exist not due to excess returns on housing, but rather due to a desire to lock away wealth in illiquid form.

Finally, the fourth panel of Figure 9 shows the difference in wealth accumulation in the model with housing subsidies relative to the model without housing subsidies. We find that overall wealth accumulation is increased by roughly 7% by the time of retirement when there are tax-benefits to housing. This demonstrates that although tax-benefits to housing do result in distortion, as households accumulate more housing and less liquid assets, these subsidies also increase overall wealth accumulation by making the commitment device more affordable.[28]

6.3 Mandatory Amortization, Housing Subsidies, and MPCs

Finally, our calibrated model allows us to analyze the effect of these two policies on households' responsiveness to income shocks. This is an important consideration, as there is concern that mandatory amortization policies might reduce households' resilience to income shocks by encouraging illiquid wealth accumulation at the expense of reduced

[28] In future work, it may be interesting to evaluate other ways that governments can make commitment devices more accessible to households. For instance, home buyer tax credits targeted towards low-income households may be an attractive way to help households onto the housing ladder (giving the benefit of commitment) without the regressive tax implications of the mortgage interest tax deduction. It would be straightforward to extend our model to study such a policy.

liquid wealth accumulation (Svensson, 2019, 2020). If true, this would substantially undermine the macroprudential motives for which mandatory amortization policies were implemented. Similarly, if housing subsides result in portfolio re-balancing from liquid to illiquid assets, then policy makers may be concerned that such policies could reduce households' resilience to income shocks and therefore such subsidies should be eliminated for macroprudential reasons.

To evaluate the effect of mandatory amortization and housing subsidies on household resilience, we compute the average MPC in response to a transitory income shock under three different policy regimes. Table 5 presents our results. The first row presents the average annual MPC in the baseline model. The second row presents the average MPC in the counterfactual model without mandatory amortization. We find that the average MPC is slightly lower without mandatory amortization, however, the difference is small and therefore unlikely to be economically meaningful. For instance, in response to a $1,000 income shock, the MPC is 0.43 in the baseline model versus 0.41 in the counterfactual model without mandatory amortization.

Table 5: Average MPC under Different Policy Regimes

	SHOCK SIZE		
	$1,000	$5,000	$10,000
MPC in Baseline Model	0.43	0.37	0.29
MPC in Model without Mandatory Amortization	0.41	0.36	0.27
MPC in Model without Housing Subsidies	0.42	0.37	0.29

Note: Each coefficient represents the average annual MPC in our calibrated model. The procedure used to compute MPCs is described in Appendix A.5.

The final row of Table 5 presents the average MPC in the model without housing subsidies. We find an average MPC of 0.42 in response to a $1,000 income shock, only 1 percentage point lower than in the baseline model with large and realistic housing subsides as in the United States. The difference is even smaller in response to larger income shocks. These results are in line with the previous finding that housing subsidies are not an important determinant of wealthy hand-to-mouth behavior and therefore do not have an economically meaningful effect on the average MPC.

While many policy makers might be interested in policies that can be used to reduce households' responsiveness to income shocks, we find that mandatory amortization and housing subsidies have very little effect on the average MPC. This is because households' desire from illiquidity does not come simply from a desire to exploit better interest rates on different types of assets, but instead comes from a fundamental difficulty to accumulate wealth in liquid form, which thus generates a desire for illiquidity. For this reason, policy makers might want to focus on policies that provide temporary liquidity relief to households who have experienced income loss, such as the mortgage forbearance policy studied by Boar, Gorea, and Midrigan (2020).

7 Conclusion

In this paper, we integrate the idea of temptation preferences, proposed by Gul and Pesendorfer (2001), into a life-cycle model with incomplete markets. We show that this model is able to explain the existence of the wealthy hand-to-mouth by emphasizing the role of illiquid housing as a savings commitment device. We document the model's ability to generate consumption, saving and portfolio behaviour that are in line with observed choices. Specifically, our model is able to match the large share of the wealthy hand-to-mouth despite the fact that housing deliver higher returns than equities, which is hard to reconcile with traditional life-cycle models. Moreover, the model rationalizes households' overwhelming preference for illiquidity.

Using the Method of Simulated Moments, we internally calibrate the preference parameters of our model once with temptation and once when we shut down temptation. Parameters are pinned down by the life-cycle patterns of households consumption and portfolio compositions. Crucially, we target the observed large fraction of wealthy hand-to-mouth households. The model without temptation is not to able to explain the existence of the wealthy hand-to-mouth, even though it has great flexibility that allows it to have different types of housing taste (direct and indirect via consumption), utility cost of housing adjustment, risk attitude and impatience. In contrast, the model with temptation generates the observed life-cycle profiles, including the share of households who own housing wealth but no liquid wealth.

Households' illiquidity has important consequences for aggregate consumption and saving behavior, which in turn crucially affects the design of fiscal policies. We use our model to analyse the impacts of three important policies: the targeting fiscal stimulus, the mandatory amortization of mortgages and the tax deductability of mortgage interest payments. We find that targeted fiscal stimulus is more powerful than previously believed: targeting households at the bottom of the income distribution results in the largest aggregate consumption response. This result is largely driven by the finding that the average MPC declines slowly with shock size. While this is consistent with a number of recent empirical studies (Fagereng, Holm, and Natvik (2019), Bunn et al. (2018), and Kueng (2018)), there exist relatively few empirical papers that study the consumption response to large income shocks and it would therefore be interesting to see additional empirical research in this direction.

We also find that the mandatory amortization policies as well as subsidies to home ownership stimulate total savings of households. Mandatory amortization policies increase overall wealth accumulation by around 10% by the time of retirement, while tax deductability of mortgage interest payments increase overall wealth accumulation by around 7% by the time of retirement. These results stem from the existence of temptation and the resulting demand for commitment in our model: mandatory amortization helps households to stick to their future savings plans, while subsidies to home ownership incentivize households to lock away their wealth from temptation by making housing more attractive.

The view of illiquidity that we highlight in this paper helps us better understand a number of features of the data, as well as design policies to stimulate household saving. For instance, our model is consistent with a desire for illiquidity in saving accounts which has been documented in a number of experimental studies (Thaler and Benartzi, 2004; Ashraf, Karlan, and Yin, 2006; Beshears et al., 2020) and that households have difficulty saving in advance of predictable declines in income (Ganong and Noel, 2019). In the case of housing, our model is consistent with empirical evidence showing that homeownership plays an important role in household wealth accumulation (Di, Belsky, and Liu, 2007; Turner and Luea, 2009; LeBlanc and Schmidt, 2017; Kaas, Kocharkov, and Preugschat, 2019). Moreover, the view of illiquidity that we highlight is consistent with evidence that households have limited demand for mortgage flexibility (Vihriälä, 2019) and that mortgage amortization boosts overall wealth accumulation (Bernstein and Koudijs, 2020). These findings may have important implications for the regulation of financial products that give households greater access to credit (Kovacs and Moran, 2020).

A Appendix

A.1 Model Parameters

Table A.1: External Parameter Values

Parameter	Definition	Value
	Timing	
T	number of years as adult	59
W	number of years as worker	44
	Utility Parameters	
λ	temptation parameter	0.28
	Asset Returns, Prices	
r	stock return	0.054
r^H	housing return	0.021
r^M	mortgage interest rate	0.040
η	rental scale	0.03
F	fixed cost of moving	0.05
ψ	down-payment requirement	0.10
$p_1^{\max}$	initial house price	\$250,000
	Income Process	
ρ	stochastic process: income persistence	0.90
σ_ε^2	stochastic process: std. dev. income shock	0.05
σ_0^2	stochastic process: std. dev. initial income	0.184
g_0	deterministic process: constant	6.391
g_1	deterministic process: *age*	0.256
g_2	deterministic process: age^2	-0.045
g_3	deterministic process: age^3	0.002
	Taxes and Social Security	
τ_1	income tax function: constant	-4.034
τ_2	income tax function: progressivity	1.226
τ_d	income tax function: deduction	\$6,116
	social security: income floor	\$10,998[1]
	social security: PIA bend points	[\$816, \$4,917]
	social security: wage base	\$118,500

[1] Supplemental Security Income is \$8,796 for individuals and \$13,200 for couples. From the 2015 Bureau of Labor Statistics Report we know that about half of the population is married (50.2%) and the other half is single, therefore average households get \$10,998 as SS income.

A.2 Asset Returns

In this section, we calculate the real risk-adjusted returns of housing and publicly traded equitites. We start with the consumption-based pricing equation, which expresses asset returns in terms of prices and dividends:

$$r_{t+1} = \frac{p_{t+1} + d_{t+1} - p_t}{p_t} \tag{A.1}$$

where r_{t+1} is the net return on the asset between periods t and $t+1$, p_t is the price of the asset in period t, while d_{t+1} is the dividend in period $t+1$. We use this pricing formula to calculate the return on housing. Households who invest in housing in period t enjoy housing service flows between periods t and $t+1$, but also pay the costs related to home ownership over the same period. More explicitly, we can write the return on housing similarly to equation (A.1) as

$$r^{\mathrm{h}}_{t+1} = \frac{p_{t+1} + s_{t+1} - c^{\mathrm{m}}_{t+1} - c^{\mathrm{i}}_{t+1} - p_t}{p_t} \tag{A.2}$$

with p_t is the price of the house in period t, while s_{t+1} and and c_{t+1} are the housing service flow and the costs that arise between periods t and $t+1$. Maintenance cost is denoted by c^{m}, and the cost of home insurance by c^{i}. Note that we implicitly assume that depreciation is roughly equal to the maintenance cost.

In what follows we measure aggregate house prices by the Case-Shiller house price index,[29] while we use data from the Bureau of Economic Analysis (BEA) to calculate the average housing service flow. We follow the approach of Kaplan and Violante (2014) to calibrate the size of different ownership-related costs. Housing service flow and related costs are all proportional to the value of the house. Given that these costs are relatively constant over time in terms of the value of the house, in the rest of the paper we use constant fractions of changing house value in order to calculate these variables. Under these conditions equation (A.2) can be rewritten as

$$r^{\mathrm{h}}_{t+1} = \frac{p^{\mathrm{h}}_{t+1} + (s - c^{\mathrm{m}} - c^{\mathrm{i}} - 1)p^{\mathrm{h}}_t}{p^{\mathrm{h}}_t} \tag{A.3}$$

where s, c^m and c^i are the housing service flows and different costs relative to the value of the house.

We compute imputed rents using the balance sheet approach, following Piazzesi, Schneider, and Tuzel (2007) and Kaplan and Violante (2014), among others. We use housing gross value added at current dollars from the BEA to approximate the housing service flow and use residential fixed assets at current dollars to approximate the housing stock.[30] The average of gross housing value added over residential fixed assets between

[29] The Case-Shiller house price index is available at `http://www.econ.yale.edu/~shiller/data.htm`.

[30] Gross value added can be found in Table 7.4.5, "Housing Sector Output, Gross Value Added and Net Value Added" in National Income and Product Accounts (NIPA) of the BEA. Residential fixed assets can be found in Table 1.1, "Current-Cost Net Stock of Fixed Assets and Consumer Durable Goods" of the Fixed Asset Tables of the BEA.

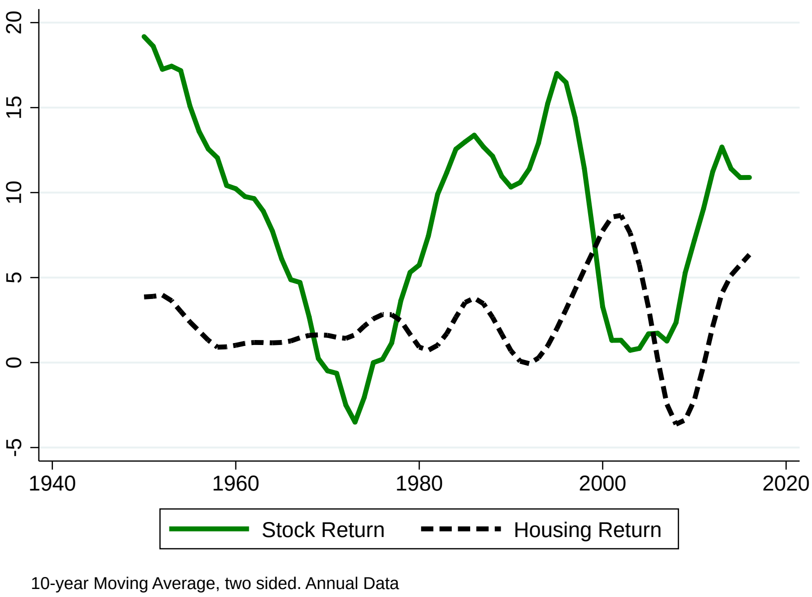


Figure A.1: Real Returns

1950 and 2016 is around 8%.

Following Kaplan and Violante (2014), we set the maintenance cost at 1% and the insurance cost at 0.35% of the value of housing. In Figure A.1 we plot the calculated real return on housing together with the returns on the S&P 500 between 1950 and 2016. The most important thing to notice is that stock returns are in general much higher than the return on housing. There was only a short period of time in the seventies and a couple of years in the early twenties when stocks underperformed housing.

A part of these return differences can obviously be interpreted as reflecting differences in the riskiness of these assets. To allow for this, we calculate the risk-adjusted returns. Following Kaplan and Violante (2014) in order to calculate the risk-adjusted returns on the three assets, we subtract the variance of the return from the expected return of the asset.

$$r^i_{adj} = E(r^i) - var(r^i) \tag{A.4}$$

where superscript i refers to the type of the asset, i.e. 3 Months T-Bill[31], S&P500 and housing. Since we are using the variance as a measure of riskiness, we cannot generate a similar graph of risk-adjusted returns as in Figure A.1. Instead, we have the average, risk-adjusted real returns over the period between 1950 and 2016, which is 0.69% for the T-bill, 5.40% for the stocks, while 2.10% for the housing asset as seen in Table A.2.

Table A.2 presents our results. We find that stock deliver substantially higher returns than housing, even when accounting for imputed rents and differential volatility in re-

[31]The 3 Month T-Bill times series is downloaded from the database of the Federal Reserve Bank of St. Louis (Fred).

Table A.2: Real Asset Returns

	Mean	St.Dev.	Risk-adj. Mean
Treasury Bill	0.74	2.12	0.69
Stock	8.24	16.82	5.40
Housing (Capital Gains)	0.70	5.06	0.01
Housing (Capital Gains + Imputed Rents)	2.34	5.06	2.10

Note: This table shows our baseline return calculations. Stock returns include both capital gains and dividend income from the S&P. Housing capital gains come from the Case-Shiller index. Imputed rents include the imputed rental income net of maintenance costs and home insurance, as described in Equation A.3.

turns. In our baseline results, we find that stock have delivered a risk-adjusted real return of 5.40% per year, while housing has delivered a risk-adjusted real return of 2.10%. It is important to note that most of the real return in housing comes from imputed rents. This is consistent with Shiller (2015), who notes that there has been essentially no real growth in house prices during the 20th century. That said, even when accounting for imputed rents, we find that housing has delivered substantially lower returns than equities.

For robustness, we also compute the Sharpe ratios for stocks and housing. The Sharpe ratio measures the expected value of the excess return of the asset relative to the standard deviation of the excess return. The higher the Sharpe ratio, the more attractive the asset, as it delivers better excess returns relative to its riskiness. We find a Sharpe ratio of 0.45 for stock and 0.30 for housing, including both capital gains and imputed rents. This leads further credibility to the result that housing yields a lower risk-adjusted return than stocks.

A.2.1 Sensitivity to Imputed Rents

We compute imputed rents using the above described balance sheet approach, following Piazzesi, Schneider, and Tuzel (2007) among others. Our results are consistent with a wide body of empirical literature including Flavin and Yamashita (2002), Goetzmann and Spiegel (2002), and Piazzesi, Schneider, and Tuzel (2007) who show that housing delivers worse risk-adjusted returns than stock, even when accounting for imputed rents and other benefits to homeownership. That said, Jordà et al. (2019) develop an alternative method to compute imputed rents. In this subsection, we explore sensitivity to alternative imputed rent calculations.

Using the data provided by Jordà et al. (2019), we calculated average risk-adjusted returns to housing and equities in the United States.[32] For comparability with our previous return calculations, we focus on the sample period between 1950 and 2016.

Table A.3 presents our results using data from Jordà et al. (2019). We find that stock deliver risk-adjusted returns that are very similar to housing. The risk-adjusted return to stock is 5.98% whereas the risk-adjusted return to housing (including both capital gains and imputed rents) 5.80%. This result is driven by the measure of imputed rents constructed by Jordà et al. (2019). When we look at just the capital gains to housing, we find a risk-adjusted real return of 0.65%, only slightly larger than our results when using the Case-Shiller index.

Table A.3: Real Asset Returns – Sensitivity to Alternative Data

	Mean	St.Dev.	Risk-adj. Mean
Stock	9.03	17.47	5.98
Housing (Capital Gains)	0.78	3.52	0.65
Housing (Capital Gains + Imputed Rents)	5.93	3.60	5.80

Note: This table shows alternative return calculations for the United States between 1950 and 2016. Data on stock, housing, and imputed rents come from Jordà et al. (2019).

Based on our reading of the literature, where the vast majority of studies find that stock deliver higher risk-adjusted returns than housing, we decide to adopt that result in our baseline calibration. That said, even if stock and housing delivered roughly similar risk-adjusted returns, this would still pose a challenge for the traditional returns-based explanation of wealthy hand-to-mouth behavior, as put forward by Kaplan and Violante (2014). If liquid and illiquid assets delivered equivalent risk-adjusted returns in their model, then the wealthy hand-to-mouth would disappear. For this reason, in Appendix A.7.1 we evaluate the sensitivity of our model calibration to the assumption that $r = r^H$ and find that it has little effect on our core results.

A.3 Data: Sample and Definitions

We calibrate our model using the Panel Study of Income Dynamics waves 1999 to 2015. While the PSID has collected information on income and demographics since 1968, the survey received a large overhaul in 1999 with the addition of detailed questions on household expenditure. We therefore use the modern PSID, which to the best of our

[32] We thank the authors for providing their data at `http://www.macrohistory.net/data/`.

knowledge is the only large scale U.S. panel to contain information on income, consumption, and wealth accumulation.

Sample Selection. We focus on households with a head between 25 and 65 years old with non-missing information on age, education, and state. We do not select our sample based on the working status of the household head or spouse. We include households from both the core sample of the PSID as well as households from the Survey of Economic Opportunity. To reduce the influence of measurement error, we drop observations with extremely high assets, for instance, observations with a total net worth higher than $20 million, following the criteria of Blundell, Pistaferri, and Saporta-Eksten (2016). In addition, we drop the top 5% of households by income due to evidence that the PSID performs well at measuring the wealth holdings of the bottom 95%, but not the top 5% of the distribution (Bosworth, Anders et al., 2008; Pfeffer et al., 2016).[33]

Consumption. We compute real nondurable consumption following the classification in Blundell, Pistaferri, and Saporta-Eksten (2016). Prior to 1999, the PSID collected data on very few components of consumption, namely food, rent, and child care. The coverage was greatly increased starting in 1999 to include many other components of nondurable consumption and services including transportation, utilities, gasoline, car maintenance, health expenditures, education, and childcare. In total, this allows the PSID to cover approximately 70 percent of consumption expenditure on nondurable goods and services. While additional categories such as clothing and entertainment were added to the survey in 2005, we exclude these categories to keep the consumption series consistent over time.

Assets. We compute liquid assets as the sum of bank account deposits and directly held stock. We believe that publicly traded stock are essentially liquid because there are very low transaction costs on these assets, thus it would be easy for households to sell their stock position for consumption smoothing purposes. We measure net housing wealth as the reported value of the household's main residency minus all mortgage debt on this home. We exclude net wealth from other real estate, net business wealth, and IRA/annuity wealth, as we want to focus our analysis on owner-occupied housing. We also exclude credit cards debt from our analysis, as the PSID did not collect information on this variable for the full period of our sample.

Movers. We target the average share of homeowners that move for non-work reasons each year. This is computed using detailed information on the timing and reasons for moving homes, collected by the PSID. We include all moves due to consumptive reasons (expansion of housing, contraction of housing, better neighborhood, better school, etc.) and ambiguous reasons (desire to save money, neighbors moving away, unknown). We

[33] As a result, the share of the wealthy hand-to-mouth in our sample is slightly higher than in the Survey of Consumer Finances. In our sample, the share of such households reach a peak of 25% at age 45, whereas in the Survey of Consumer Finances this number is 22% at age 45.

exclude moves for work reasons (to take another job, to get nearer to work) since these are outside the scope of our model.

A.4 Model Fit

Table A.4 presents the model fit of the average homeownership rate and share of homeowners moving each year. Both the model with temptation and the model without temptation obtain a good fit of both targeted moments.

Table A.4: Additional Targeted Moments

	PSID	Temptation Model	No Temptation Model
Homeownership rate	0.57 (0.006)	0.50	0.53
Share of movers	0.068 (0.004)	0.070	0.056

Note: This table shows fit of the average homeownership rate and share of movers each period. The average homeownership rate in our sample is 57%, slightly lower than the homeownership rate observed in the SCF. This is driven by two factors. First, our sample includes only working age households, who have less homeownership than retirees. Second, the PSID oversamples low income households.

A.5 MPC Caclulations

To calculate the consumption response to an unanticipated and transitory income shock of size x, we first generate N households, each with a different series of randomly drawn income shocks and initial heterogeneity. We simulate the behavior of each household, producing the state variable $\Omega_{i,t}$ and consumption behavior $c_{i,t}(\text{shock} = 0, \Omega_{i,t})$ for each household and each time period. Next, we simulate counterfactual consumption behavior in response to an unanticipated and transitory income shock at time t conditional on state $\Omega_{i,t}$, producing $c_{i,t}(\text{shock} = x, \Omega_{i,t})$ for all households and all time periods. We set the size of the transitory income shock x to be \$1,000 in our baseline simulation, though we also show results for shock of \$5,000 and \$10,000 respectively. The annual marginal propensity to consume is computed as follows:

$$\text{MPC}_{i,t}(x) = \frac{c_{i,t}(\text{shock} = x, \Omega_{i,t}) - c_{i,t}(\text{shock} = 0, \Omega_{i,t})}{x} \tag{A.5}$$

$$\text{MPC}(x) = \frac{1}{N}\frac{1}{W}\sum_{i=1}^{N}\sum_{t=1}^{W}\text{MPC}_{i,t}(x) \tag{A.6}$$

A.6 MPC Heterogeneity: The Importance of Liquidity

To evaluate the relationship between wealth and consumption behavior, we group simulated households into quartiles based on net wealth and cash-on-hand. We then estimate the average MPC in each of these categories. This is performed in a regression framework, allowing us to control for age, similar to Jappelli and Pistaferri (2014):

$$\text{MPC}_{i,t} = \beta_0 + \sum_{j=2}^{4} \gamma_j \text{CashQ}^j_{i,t} + \sum_{j=2}^{4} \delta_j \text{WealthQ}^j_{i,t} + \sum_{j=23}^{65} \psi_j \text{Age}^j_{i,t} + \epsilon_{i,t} \tag{A.7}$$

If low wealth is important in generating large MPCs, then we would expect to see a rapid decline of MPCs as we move from the lowest to the highest wealth quartiles. In contrast, if low cash-on-hand is more important in generating large MPCs, we would expect to see a rapid decline of MPCs as we move from the lowest to the highest quartile of cash-on-hand.

The results are presented in Table A.5. We find that the average MPC declines very quickly with cash-on-hand. Households in the lowest quartile of cash-on-hand have the highest average MPC. Households in the second quartile have an average MPC that is 0.18 lower. This is even more pronounced in the third and fourth quartiles. In short, low liquidity is an important determinant of high MPCs.

Table A.5: MPC Heterogeneity by Household Type

		MPC	
		Coefficient	Standard Error
CASH-ON-HAND			
Quartile			
	2^{nd}	-0.181^{***}	(0.006)
	3^{rd}	-0.368^{***}	(0.006)
	4^{th}	-0.595^{***}	(0.007)
NET WEALTH			
Quartile			
	2^{nd}	-0.062^{***}	(0.005)
	3^{rd}	-0.093	(0.007)
	4^{th}	-0.055^{***}	(0.008)
Constant		0.821^{***}	(0.012)

Note: MPCs are based on a $1,000 transitory income shock. We control for age using Equation A.7. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

In contrast, once we have controlled for cash-on-hand, net wealth has very little effect on the average MPC. The average MPC is only 0.06 smaller when moving from the lowest to second lowest net wealth quartile. Moreover, we see that even the richest households still have a large average MPC: households in the top wealth quartile have an MPC that is just as large as households in the bottom quartile, once we control for cash-on-hand.

These results are consistent with a wide body of empirical evidence that finds that the average MPC declines only slowly, if at all, with net wealth, while it declines quickly with cash-on-hand. Jappelli and Pistaferri (2014) show that households in the top quintile of cash-on-hand have an avereage MPC that is 0.44 lower than that of households in the bottom quintile, affirming the importance of cash-on-hand for MPCs.[34] Similarly, Fagereng, Holm, and Natvik (2019) find that net wealth is unimportant in explaining MPC heterogeneity, once controlling for liquid wealth.[35]

The reason behind these empirical observations is that households might have substantial wealth, but if it is kept in illiquid form, it cannot be used easily for consumption-smoothing purposes. As a result, wealth is a less important determinant of MPCs than cash-on-hand. This reaffirms the importance of modeling household illiquidity (using a two asset model) in order to study consumption behavior in response to transitory income shocks. In this regard, our model delivers similar results to Kaplan and Violante (2014) who also find that liquid wealth is more important than total wealth in explaining MPC heterogeneity. In contrast, these empirical results are almost impossible to justify using a traditional heterogeneous agent model with only one asset. For instance, Jappelli and Pistaferri (2014) study whether an Ayiagari model with heterogeneous households and a standard calibration is able to replicate the slow decline of MPCs by wealth. They find that this requires implausibly impatient households: β has to be 0.6 or lower.

A.7 Sensitivity

In this section we evaluate the sensitivity of our results presented in Sections 4 and 5. We consider two modification to our baseline model. First, we change the return structure in the model by assuming that housing and equities provide equivalent risk-adjusted returns ($r = r^H$). Second, we modify the asset structure of households by assuming that they receive annuitized disbursements from individual retirement accounts after retirement. Our core findings are robust to these modifications: both the calibrated parameters of the model and the MPC results are similar to our baseline results.

[34] Jappelli and Pistaferri (2014) use Italian survey data to study the consumption response to unexpected transitory income shocks. They exploit the survey question from the 2010 Italian Survey of Household Income and Wealth, which asks households how much of an unexpected transitory income change they would spend.

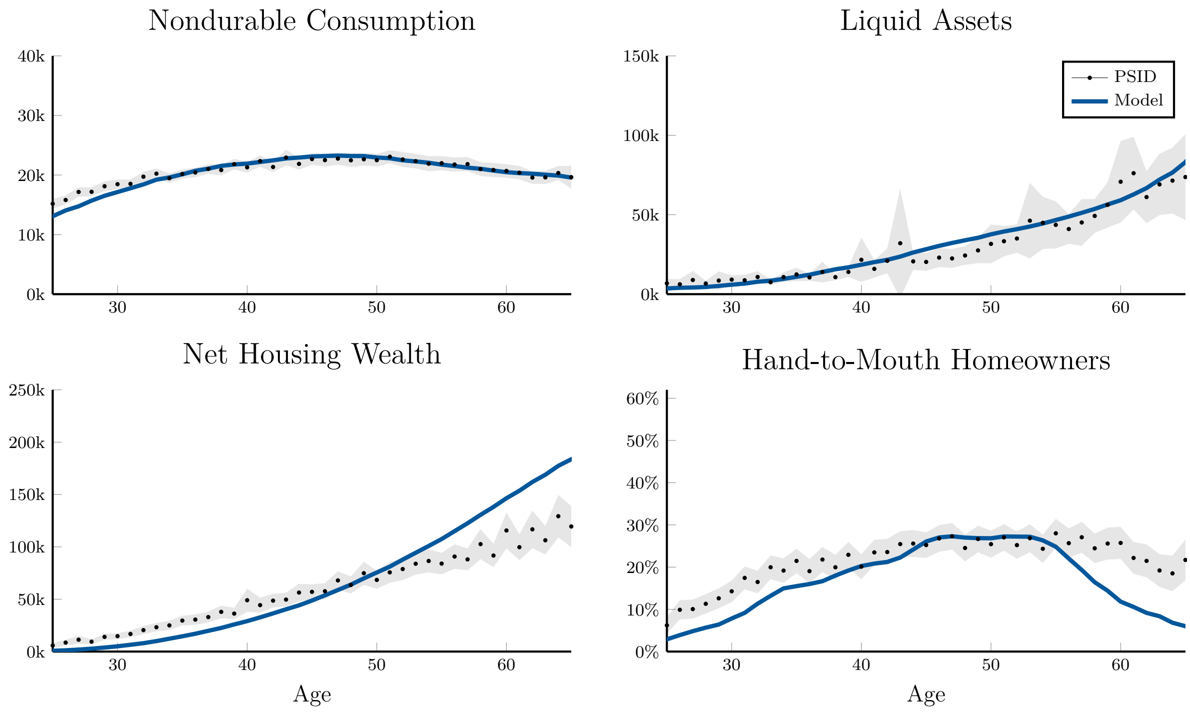
[35] Fagereng, Holm, and Natvik (2019) study the consumption response to winning the lottery in Norway. This study is unique in the quality of its data: the authors use administrative tax data from Norway, which contains rich information on household income and asset holdings.

A.7.1 Asset Returns

First we consider a model where the two assets give equivalent risk-adjusted returns ($r = r^H$). It is important to note that this return structure would pose a challenge for the traditional returns-based explanation of wealthy hand-to-mouth behavior. If liquid and illiquid assets delivered equivalent returns in a model of the type proposed by Kaplan and Violante (2014), then the wealthy hand-to-mouth would disappear.

In contrast, we find that the model with temptation and commitment doesn't require excess return on housing to explain the existence of wealthy hand-to-mouth households. Figure A.2 shows the model fit when we re-calibrate the preference parameters of the model. We find that the model with equal returns obtains a good fit of the large share of wealthy hand-to-mouth households, as well as the other targeted moments, despite the fact that housing and liquid assets deliver equivalent returns.

Figure A.2: Model Fit with Equal Returns



Note: This figure shows the life-cycle moments from our model with equal returns (solid blue line) and the PSID (black dotted line). The moments from the PSID are shown with bands of 1.96 standard deviations around the mean.

The calibrated parameter results are reported in Table A.6. When the asset returns are equal (column 2), we find that that households are more patient and more risk averse relative to the baseline calibration (column 1). More specifically, β and γ are slightly higher than in our baseline calibration.

In addition, the alternative return structure has little impact on the main MPC results. Table A.7 shows the MPC by shock size. The average MPC in response to a \$1,000 shock is 0.40 in the model with equal returns (the second row), which is only slightly lower

Table A.6: Model Parameters – Alternative Modeling Assumptions

PARAMETER	Baseline	Equal Returns ($r = r^H$)	Retirement Accounts
β	0.959	0.970	0.955
γ	2.415	2.795	2.596
μ	0.291	0.317	0.455
θ	0.160	0.267	0.295
χ	0.437	0.552	0.869

Note: This table shows our calibrated model parameters under alternative modeling assumptions. In the model with equal returns, we set $r = r^H = 0.021$. In the model with retirement accounts, we add retirement accounts as defined in Section A.7.2. The temptation parameter is set at $\lambda = 0.28$ following Kovacs, Low, and Moran (2020).

than in our baseline model (the first row). In addition, we find that the average MPC declines only gradually with respect to shock size. The average consumption response to a \$10,000 shock is 0.27, only slightly lower than our baseline result of 0.29.

Table A.7: MPC Heterogeneity – Alternative Modeling Assumptions

	SHOCK SIZE		
MPC	\$1,000	\$5,000	\$10,000
MPC in Baseline Model	0.43	0.37	0.29
MPC in Model with Equal Returns	0.40	0.33	0.27
MPC in Model with Retirement Accounts	0.43	0.38	0.28

Note: This table shows the average MPC in the temptation model. In the model with equal returns, we set $r = r^H = 0.021$. In the model with retirement accounts, we add retirement accounts as detailed in Section A.7.2.

A.7.2 Individual Retirement Accounts

In order to evaluate sensitivity to alternative modeling assumptions about the resources that are available to save for retirement, we extend our model by assuming that households have an individual retirement accounts (IRAs) from which they then receive annuitized disbursements after retirement. We make the simplifying assumption that households have no choice over the size of their retirement account or the timing at which they withdraw from their retirement account, i.e. retirement contributions are mandatory and must be converted to an annuity at the age of retirement (W). This assumption implies that households suffer zero temptation to consume their retirement account.

We require all households to purchase an annuity in the first year of retirement using the entirety of their retirement account. This ensures equal payments throughout the remainder of their life. During each year of retirement, households receive annuitized disbursements that depend on the replacement rate η_1 and the size of their IRA at retirement:

$$y_{i,t}^{IRA} = \eta_1 * \text{IRA}(y_{i,W}) \tag{A.8}$$

We assume that the size of the retirement account is a linear function of last working period income. This simplifying assumption allows us to include retirement accounts without the introduction of an additional state variable. The size of the retirement account is given by the following formula:

$$\log[\text{IRA}(y_{i,W})] = \eta_2 * \log(y_{i,W}) \tag{A.9}$$

The relationship between last period income and the size of the retirement account (η_2) is estimated using the PSID. Estimation is performed on a sample of households where the head is age 60 to 65 and currently employed. We find a value of $\hat{\eta}_2 = 0.99$.

Finally, the annuity is priced equal to its discounted value, giving the following replacement rate during retirement:

$$\eta_1 = \left[\sum_{t=W}^{T} \frac{s_t}{(1+r)^{t-W}} \right]^{-1} \tag{A.10}$$

We then re-calibrate the preference parameters of the model, under the assumption that households have individual retirement accounts as just described. The third column of Table A.6 shows the parameter results. We find that the impatience parameter (β) and the risk aversion (γ) hardly change, compared to the baseline model. On the other hand, modifying the asset structure of households increases the housing preference parameters significantly (μ, θ, κ).

The third row of Table A.7 shows the MPC by shock size for our alternative model with IRAs. We find that the average MPCs are almost identical in this alternative model, and there still exists a sizable consumption response to large income shocks. For instance, we find an MPC of 0.28 in response to a \$10,000 shock, only slightly smaller than the MPC of 0.29 in our baseline model.

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