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**Breaking the Commitment Device: The  
Effect of Home Equity Withdrawal on  
Consumption, Saving, and Welfare**

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# Breaking the Commitment Device: The Effect of Home Equity Withdrawal on Consumption, Saving, and Welfare

## Abstract

This paper investigates the macroeconomic and welfare implications of permitting home equity withdrawal. We evaluate the trade-off between two opposing views: the benefit of improved consumption smoothing and the potential cost of weakened commitment. To disentangle their relative importance, we estimate a life-cycle model containing both channels. We find that the welfare cost of weakened commitment is substantial: approximately 1.7 times larger than the benefit of improved consumption smoothing. Both channels contribute equally to a 2.5 percentage point reduction in the personal saving rate. Welfare could be improved using state-contingent mortgages that better balance the trade-off between flexibility and commitment.

JEL Classification: D15, E21, E71, G28, G51

Keywords: Household consumption, Euler Equation, commitment, Mortgage Design

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March 22, 2022

## Abstract

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# 1 Introduction

Financial innovation has given households an unprecedented ability to access home equity. This development is often celebrated because it gives households greater flexibility. However, critics argue that home equity withdrawal may cause households to overborrow and overconsume. Countries have adopted either of two extreme policies. Some countries like the U.S. and U.K. allow easy access to home equity, while others such as Germany and Singapore prohibit it almost entirely. Which of these policies is better for household well-being and macroeconomic stability? And might alternative policies be superior to both?

The benefits of improved flexibility are substantial. Numerous studies show that access to home equity enables households to better smooth consumption over adverse shocks and over the life-cycle (e.g. Hurst and Stafford, 2004; Lustig and Van Nieuwerburgh, 2010; Agarwal and Qian, 2017). This has led to the view that financial innovation in mortgage products generates large welfare gains due to improved consumption smoothing (Cocco, 2013).

However, a separate strand of literature highlights the potential role of housing as a savings commitment device. If households suffer from self-control problems, then housing may serve as a commitment device because of its illiquidity, in the spirit of Strotz (1956). Financial innovation may thus be detrimental for households if it increases liquidity and eliminates commitment opportunities (Laibson, 1997). This has led to suggestions that weakened commitment may have contributed to the decline in personal savings and rise in household debt prior to the 2008 financial crisis (see e.g. Mian and Sufi, 2011). There is very little evidence, however, on the quantitative importance of weakened commitment.

The goal of this paper is to bridge the gap between these two vastly different strands of literature. If households value both flexibility and commitment, then there is a trade-off between giving households too much or too little access to home equity. Understanding this trade-off is crucial for the development of policies designed to improve welfare and stabilize the macroeconomy. For instance, rather than indiscriminately prohibiting or permitting home equity withdrawal, we may want to design policy to better balance the trade-off between flexibility and commitment. The quantitative importance of such a trade-off, however, is ultimately an empirical question and one which we seek to answer.

We begin by developing a life-cycle model of household behavior that will allow us to disentangle the relative importance of these two opposing views. In the model, households make consumption, housing, and mortgage decisions while faced with income and employment risk. Households benefit from home equity withdrawal because it provides greater flexibility to smooth consumption over adverse shocks and over the life-cycle. To capture the potential

downside to home equity withdrawal, we allow for the possibility that households suffer from temptation following Gul and Pesendorfer (2001, 2004). Temptation represents the idea that households find it difficult to save due to instantaneous gratification that is hard to resist. This generates a demand for commitment devices that enable households to lock away their wealth and restrict their choice set. In the absence of equity withdrawal, housing may act as such a commitment device not only because it is illiquid, but also because mortgages force homeowners to make regular payments and accumulate wealth in the form of home equity.<sup>1</sup> The ability to extract home equity, however, may weaken the commitment benefit of housing.

While the potential trade-off between flexibility and commitment has been known for many years, there remains strong disagreement about its quantitative importance. Seminal papers have repeatedly called for further research on the topic (Hurst and Stafford, 2004; Mian and Sufi, 2011). To the best of our knowledge, however, no study has been able to find empirical moments which identify the relative strength of these two opposing views. The present paper seeks to overcome this gap in the literature by developing a new approach to empirically identify the importance of flexibility and commitment in household decision-making.

We develop an estimation strategy that allows us to disentangle these different channels using the Method of Simulated Moments. The primary challenge in estimation is to differentiate between temptation and impatience, two features of the model that have drastically different implications for understanding household behavior. The conceptual basis for distinguishing between these different features is that temptation alters consumption growth in a manner that cannot be replicated by impatience. In particular, the model with temptation generates a positive relationship between consumption growth and liquid assets for households who are away from the credit constraint. In contrast, the traditional model without temptation generates the opposite prediction, regardless of the level of impatience (Carroll, 1997). This striking difference in consumption growth dynamics allows us to directly test for the presence of temptation and identify its importance in our quantitative framework.

Using the above approach, we estimate the preference parameters of the model using data on consumption and assets from the Panel Study of Income Dynamics (PSID). We show analytically and numerically that consumption growth dynamics are key to identification. Further, after evaluating the model’s fit of the targeted moments, we assess its out-of-sample performance when confronted with a relevant change in policy. We exploit a policy reform in Texas that legalized home equity withdrawal in 1998 after more than a century of prohibition, which helps to further validate the quantitative predictions of the model.

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<sup>1</sup>This view is expressed by Robert Shiller, 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” (Shiller, 2014). For recent evidence, see Bernstein and Koudijs (2021).

After taking the model to the data, we then evaluate the macroeconomic, welfare, and distributional implications of financial liberalization. One important contribution is that we quantify the welfare cost of weakened commitment relative to the benefit of improved consumption smoothing. Further, we evaluate how the personal saving rate has responded to the legalization of home equity withdrawal, using the estimated model to quantify the role of relaxed credit constraints versus weakened commitment.

Finally, we consider how policy makers could design mortgage contracts and policy to better balance the trade-off between flexibility and commitment. We evaluate the macroeconomic and welfare effects of various policy alternatives, including policies that have been implemented previously (e.g. debt-to-income caps) or proposed by the literature (e.g. state-contingent mortgages). Our results contribute to a growing finance literature studying the optimal design of mortgages, which has yet to consider the trade-off between flexibility and commitment.

Our first main finding is that temptation is necessary for our model to match the data. In the data, we document a positive relationship between consumption growth and liquid assets for households who are away from the credit constraint. This novel empirical finding stands in sharp contrast with the traditional life-cycle model, which generates the opposite prediction regardless of the level of impatience (see e.g. Carroll, 1997). We show that extending the traditional model to include temptation allows us to obtain a good fit of this and other features of the data.<sup>2</sup> In contrast, when we turn off temptation in our model, we find that no combination of the other parameters is able to generate consumption growth dynamics consistent with the empirical evidence. Reassuringly, we also find that the estimated model generates good out-of-sample fit when confronted with the policy reform in Texas, thus lending credibility to its quantitative predictions.

Our second main finding is that the welfare cost of weakened commitment dominates the benefit of improved consumption smoothing when home equity withdrawal is introduced. According to our baseline estimates, the cost of weakened commitment is 1.7 times larger than the benefit of improved consumption smoothing. While households value improved flexibility to consume when young, they are harmed by reduced consumption when old, as weakened commitment makes it more difficult for households to accumulate wealth. We find considerable heterogeneity: roughly a third of households benefit from home equity withdrawal, in particular, households with low income that is expected to rise.

Our third main finding is that welfare could be improved using state-contingent mortgages that better balance the trade-off between flexibility and commitment. More specifically, it

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<sup>2</sup>We also consider a number of alternative extensions to the traditional model, but find that these extensions are not able to explain other aspects of consumption growth behavior (Appendix D.3).

would be beneficial to design mortgages to automatically provide flexibility during periods of financial distress (such as unemployment or recessions), but otherwise restrict access to home equity. The economic intuition for this result is that the marginal benefit of flexibility is highest during periods of distress, while the marginal benefit of commitment is highest during periods of abundance. In contrast, we find that commonly-used debt-to-income (DTI) caps are detrimental because they restrict access to home equity during periods of low income, which is exactly when households would benefit most from flexibility.

Our findings have important implications for macroeconomic stability due to changes in household balance sheets. Financial liberalization initially reduces the sensitivity of consumption to adverse shocks, as households have more flexibility to borrow for consumption smoothing purposes, similar to Agarwal and Qian (2017). In the long-run, however, higher mortgage balances increase consumption sensitivity, reminiscent of Baker (2018). We find that this problem can be overcome using state-contingent mortgage policies.

Finally, through the lens of our model, we obtain new insight about the effect of financial liberalization of household saving. We find that the introduction of home equity withdrawal has reduced the saving rate by 2.5 percentage points in both the model and the data. Roughly half of this fall can be attributed to weakened commitment, while the remainder comes from improved consumption smoothing and self-insurance. We find that alternative mortgage policies may be highly effective in boosting the saving rate.

Taking stock, the main contribution of this paper is to evaluate the trade-off between consumption smoothing and weakened commitment. Our paper is the first to develop an empirical strategy that can be used to identify the relative importance of these two opposing views. We apply this strategy to gain a better understanding of the macroeconomic and welfare implications of giving households greater access to home equity. Further, we demonstrate that understanding this trade-off has crucial implications for the design of housing and mortgage policy. And while we focus on the role of housing as a commitment device, many of our results generalize to other forms of illiquid savings, such as retirement accounts, where there is a similar trade-off between flexibility and commitment, as well as growing concern about new financial products that make illiquid savings more accessible.

**Related literature.** This paper contributes to four different strands of literature. First, a large literature documents the effects of financial liberalization on household behavior. Between the 1980s and mid 2000s, home equity withdrawal became cheaper and easier due to regulatory changes and financial innovation (e.g. credit scoring).<sup>3</sup> This led to an increase in

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<sup>3</sup>See for instance Bennett et al. (2001), Dynan and Kohn (2007), Einav et al. (2013), Levitin and Wachter (2015), Favilukis et al. (2017). For recent developments, see Fuster et al. (2019).



household spending and a decline in personal saving (Greenspan and Kennedy, 2008). Further, home equity withdrawal played a central role in the run up of household spending and debt prior to the 2008 crisis (Mian and Sufi, 2011). Recent quasi-experimental studies demonstrate that access to home equity has crucial implications for household spending (Leth-Petersen, 2010; Abdallah and Lastrapes, 2012; Agarwal and Qian, 2017). For instance, Agarwal and Qian (2017) find that access to home equity increases spending substantially, especially among individuals with limited access to credit. However, the drivers of increased spending are not fully understood. Mian and Sufi (2011) note that the increase in spending due to home equity withdrawal may be driven by relaxed liquidity constraints or worsened self-control problems. While these authors do not attempt to disentangle the relative importance of the two competing channels, they note that it would be a “fruitful avenue for future research,” which the present paper attempts to tackle.

Second, this paper contributes to a growing literature studying the welfare effects of financial liberalization and innovation in mortgage markets. One prominent strand of this literature documents the benefits of improved flexibility. Hurst and Stafford (2004) and Lustig and Van Nieuwerburgh (2005, 2010) show that access to home equity helps households smooth consumption over adverse shocks. Gerardi, Rosen and Willen (2010) and Cocco (2013) demonstrate that new mortgage products help households smooth consumption over the life-cycle. That said, this positive view of financial innovation has been famously challenged by Laibson (1997), who develops a model where households value illiquidity and thus may be harmed by greater access to credit.<sup>4</sup> To the best of our knowledge, however, there is no empirical evidence on the quantitative strength of weakened commitment. This gap in the literature has been highlighted by Hurst and Stafford (2004), who note that evaluating the role of housing as a savings commitment device would be necessary to “compute accurately” the welfare effect of making home equity more accessible. Our paper seeks to fill this gap.

Third, our approach builds upon an emergent literature that models the potential trade-off between flexibility and commitment, conditional on the assumption that households suffer from self-control problems. Amador, Werning and Angeletos (2006) highlight the potential trade-off between flexibility and commitment and derive necessary and sufficient conditions for mandatory saving policies. Nakajima (2012) develops a model with temptation and argues that the rise in unsecured consumer credit during recent decades may be detrimental. Schlafmann (2021) develops a model with temptation and shows that down payment requirements and prepayment penalties may be beneficial if households suffer from sufficiently strong self-control

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<sup>4</sup>This paper has inspired a growing experimental/quasi-experimental literature confirming households’ desire for illiquidity. Recent examples are Cho and Rust (2017) and Beshears et al. (2020b). While these studies confirm the role of commitment, they say very little about the welfare effect of financial innovation.

problems. To the best of our knowledge, however, no study has been able to find empirical moments which identify the relative importance of flexibility and commitment in household decision-making.<sup>5</sup> As a result, there remains strong disagreement on the importance of these two opposing channels for life-cycle wealth accumulation and household wellbeing. We build upon the above papers by taking our model to the data, developing a new empirical strategy to identify the trade-off between flexibility and commitment. This approach allows us to test for the presence and strength of temptation rather than assume its importance. Further, given the close link between model and data, we are able to disentangle different motives driving observed household behavior: for instance, following the legalization of home equity withdrawal, we are able to determine how much of the fall in savings is due to relaxed liquidity constraints versus weakened commitment, something which no previous paper has attempted. Finally, the estimated model allows us to credibly evaluate a range of counterfactual policies, including some that have yet to be implemented, which enables us to derive novel insight on how to reconcile the conflict between these two opposing views.

Fourth, this paper contributes to a growing finance literature that advocates for mortgage contracts or policies that automatically provide flexibility to homeowners during periods of financial distress (e.g. Piskorski and Tchisty, 2010, 2011, 2017; Piskorski and Seru, 2018; Orr et al., 2011; Eberly and Krishnamurthy, 2014; Greenwald, Landvoigt and Nieuwerburgh, 2020; Guren, Krishnamurthy and McQuade, 2021; Campbell, Clara and Cocco, 2021). The main insight from these papers is that state-contingent contracts or policies provide a better risk-sharing arrangement between borrowers and lenders in the presence of either interest rate or house price risk. Our paper is the first in this literature to consider the trade-off between flexibility and commitment. We find that this trade-off generates a motive for state-contingent contracts or policies, above and beyond the risk-sharing benefits studied previously.

Finally, the estimation strategy that we develop builds upon a large literature using data on consumption growth dynamics to identify structural parameters (e.g. Hall, 1978; Attanasio and Weber, 1993, 1995; Dynan, 2000; Browning and Collado, 2007; Attanasio and Low, 2004; Alan and Browning, 2010; Guvenen and Smith, 2014; Alan, Atalay and Crossley, 2019). Our focus on the relationship between consumption growth and assets shares some similarities with Zeldes (1989). While semi-structural Euler equation estimation has been critiqued by Carroll (2001), we develop a fully-structural indirect inference approach that allows us to overcome the concerns expressed by that paper. This approach allows us to directly test for the presence of temptation using data on consumption and assets. The results may be beneficial for other studies that incorporate temptation preferences into macroeconomic

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<sup>5</sup>This challenge is expressed by Schlafmann (2021), who states, “To the best of my knowledge, there is no established way of choosing the self-control parameter  $\lambda$  or a consensus about plausible values.”

models and evaluate a wide-range of different questions (e.g. Krusell, Kuruscu and Smith, 2010; Buccioli, 2012; Angelini, Buccioli, Wakefield and Weber, 2020).<sup>6</sup>

## 2 Modeling the trade-off

We develop a life-cycle model of household behavior that will allow us to evaluate the trade-off between two opposing views of financial liberalization. On one hand, access to home equity makes it easier for households to smooth consumption over adverse shocks and over the life-cycle. On the other hand, the ability to extract home equity may weaken the commitment benefit of housing.

We begin with a life-cycle model of household behavior in the spirit of Deaton (1991), Attanasio and Browning (1995), and Carroll (1997). Households live for a finite number of periods, are subject to idiosyncratic income and unemployment shocks, receive utility from consumption and housing, and can save in liquid assets or illiquid housing. Households can borrow using long-term, fixed-rate mortgages, which allow home equity withdrawal for a fee. Access to home equity is beneficial because it enables households to smooth consumption over adverse shocks and achieve consumption more in line with their permanent income.

We then extend this model to allow for the possibility that households suffer from temptation following Gul and Pesendorfer (2001, 2004). Temptation generates a disutility to holding liquid wealth, thus making it more difficult for households to save. As a result, housing may act as a savings commitment device due to its illiquidity. The ability to extract home equity, however, may weaken the commitment benefit of housing.

We emphasize that our model does not seek to capture all potential benefits of home equity withdrawal.<sup>7</sup> Instead, we focus on understanding whether weakened commitment is important relative to improved consumption smoothing, which is a long-standing open question that Hurst and Stafford (2004) argue is critical for assessing the welfare effects of financial liberalization.

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<sup>6</sup>We view our approach as complementary to the large literature studying self-control and commitment in experimental or quasi-experimental settings. Recent studies include Toussaert (2018), Ganong and Noel (2019), Bernstein and Koudijs (2021), and Vihriälä (2021). These papers highlight the importance of self-control and commitment, but have fundamentally different goals than the present paper, as they do not seek to evaluate the welfare implications of financial liberalization.

<sup>7</sup>For instance, home equity withdrawal may help parents send their kids to college, invest in a small business, or make lumpy durable purchases. While we could extend our model to include such benefits, the benefits of equity withdrawal have been studied extensively, while in contrast there is very little evidence on the quantitative importance of weakened commitment for life-cycle consumption and saving decisions.

## 2.1 Household preferences

Households live for a maximum of  $T$  years and choose consumption ( $c_t$ ), housing ( $h_t$ ), and mortgage debt ( $m_t$ ) each year to maximize the sum of their expected discounted utility:

$$\max_{\{c_t, h_t, m_t\}_{t=0, \dots, T}} \mathbb{E}_0 \sum_{t=0}^T \beta^t U(c_t, h_t, \tilde{c}_t, \tilde{h}_t) \quad (1)$$

where the utility function  $U(\cdot)$  allows for the possibility of temptation following Gul and Pesendorfer (2001, 2004). Temptation represent the idea that there is a feasible alternative that is not chosen, but that still impacts utility. Thus the utility function  $U(\cdot)$  depends not only on chosen consumption and housing, but also on the most tempting consumption and housing alternatives ( $\tilde{c}_t$  and  $\tilde{h}_t$ ) that are feasible given the current period budget constraint. The utility function is defined as follows:

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

where  $\lambda \geq 0$  is the strength of temptation. The felicity function  $u(\cdot)$  is concave and increasing in both  $c_t$  and  $h_t$ . The term in square brackets represents the cost of resisting temptation, which is the difference between the felicity a household could feasibly experience  $u(\tilde{c}_t, \tilde{h}_t)$  and the felicity that a household actually experiences  $u(c_t, h_t)$ . The most tempting alternatives are those that maximize current period felicity:

$$\tilde{c}_t, \tilde{h}_t, \tilde{m}_t = \operatorname{argmax}_{c_t, h_t, m_t} u(c_t, h_t) \quad (3)$$

where  $\tilde{c}_t$  is the most tempting consumption alternative,  $\tilde{h}_t$  is the most tempting housing alternative, and  $\tilde{m}_t$  is the most tempting mortgage alternative. This optimization problem is subject to the current period budget constraint, which we define later.

Temptation is not the only way to model self-control problems. Many papers use hyperbolic discounting following Strotz (1956), Phelps and Pollak (1968), and Laibson (1997). Temptation preferences have three advantages given our goals. First, temptation preferences allow for internally-consistent welfare analysis, something which is problematic with hyperbolic discounting (Fang and Silverman, 2009; Bernheim, 2009). Second, temptation preferences are consistent with experimental evidence on self-control, including recent evidence that cannot be rationalized by hyperbolic discounting (Toussaert, 2018). Third, temptation generates testable implications for consumption growth dynamics, allowing us to identify its importance

using observational data on real-world consumption and saving decisions.<sup>8</sup> This allows us to estimate the strength of self-control problems internal to our model, rather than rely upon estimates from lab experiments which may suffer from poor external validity.

## 2.2 Assets

Households can save in two types of assets: liquid assets ( $a_t$ ) and illiquid housing ( $h_t$ ). We assume that liquid assets yield a fixed and known return  $r$  each period and are subject to a borrowing constraint of  $a_t \geq \underline{a}$ , where the borrowing limit  $\underline{a}$  may be either zero or negative.

Housing is on a discrete grid with  $K$  different sizes:  $h^k \in \{h^1, h^2, \dots, h^K\}$ . The price of each house  $p_t(h^k)$  depends on its size and is determined relative to the price index  $\bar{p}_t$ :

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

Households can own or rent any of the above housing options. Housing transactions incur a financial cost ( $F$ ) proportional to the house price. Households that rent must pay rent proportional to the house price,  $\chi_t^k = \eta * p_t(h^k)$ , where  $\eta \geq 0$  is the rental scale.

We abstract from house price uncertainty in order to reduce the computational burden of model estimation.<sup>9</sup> We assume that house prices grow at a constant rate,  $r^H$ , which represents the real risk-adjusted return on housing, and the evolution of the house price index is given by  $\bar{p}_t = (1 + r^H) * \bar{p}_{t-1}$  conditional on the initial price  $\bar{p}_1$ . We assess sensitivity to this simplifying assumption in Section 7.4, where we incorporate realistic house price uncertainty into the model and find that it has little effect on our quantitative results.

## 2.3 Mortgages

The most widely used mortgage contract in the U.S. is the amortizing fixed-rate mortgage. In our model, we assume that mortgages are of this kind, with mandatory mortgage payments that force households to gradually build 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 required mortgage payment each period.

The possibility of home equity withdrawal alters the liquidity of housing. Home equity

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<sup>8</sup>Identification comes from the fact that  $\beta$  and  $\lambda$  separably enter the consumption Euler equation (see Section 3). The same is not true of hyperbolic discounting, as  $\beta$  and  $\delta$  enter the Euler equation non-separably. A similar issue arises with the quasigeometric temptation preferences developed by Krusell et al. (2010), which introduce an additional free parameter that cannot be identified in our setting.

<sup>9</sup>This simplifying assumption aids in our ability to estimate all of the models' preference parameters. The computational burdens of model estimation are substantial, taking roughly 24 hours on the IFS HPC cluster. While we could estimate the model with house price risk, it would increase estimation time substantially.

withdrawal takes the form of cash-out refinancing, where households may obtain liquid assets by increasing the size of their mortgage balance.<sup>10</sup> This incurs a fixed cost ( $C^R$ ) and a proportional cost ( $F^R$ ) which capture both pecuniary and non-pecuniary costs.

Households are required to make regular mortgage payments each year, with the minimum mortgage payment given by  $mp(m_t)$ . Mortgage balances are constrained by a loan-to-value requirement. Based on these assumptions, next period's mortgage balance can be written as:

$$m_{t+1} \leq (1 + r^M) \begin{cases} \bar{\psi} p_t(h_t) & \text{if moving homes or extracting equity} \\ m_t - mp(m_t) & \text{otherwise} \end{cases} \quad (4)$$

where  $r^M$  is the mortgage interest rate and  $\bar{\psi}$  is the maximum loan-to-value ratio. Households are allowed to prepay their mortgage by reducing  $m_{t+1}$  in excess of the mandatory payment. The mandatory mortgage payment  $mp(m_t)$  depends on the term length ( $l$ ) of the mortgage. We require mortgage balances to be fully paid off by the end of the term length,  $m_{t+l} = 0$ , which yields the following mortgage payment:

$$mp(m_t) = \frac{(1 + r^M)^l}{\sum_{i=1}^{l-1} (1 + r^M)^i} m_t \quad (5)$$

which depends on the mortgage balance ( $m_t$ ), interest rate ( $r^M$ ), and term length ( $l$ ). The derivation of the mandatory mortgage payment is contained in Appendix A.4. If a household has a positive mortgage balance  $m_t > 0$  when selling their house, the value of the house is used to repay the debt and the remainder goes to the household. If a household receives a large negative shock such that they cannot make their mortgage payment, and does not have enough equity to extract, then they are forced to default. In this situation, households must sell their house and repay the remaining mortgage debt.<sup>11</sup>

Finally, we assume that households are required to repay their mortgage by the time of retirement and are not allowed to extract home equity after retirement. This is consistent with evidence showing that borrowing constraints tighten substantially after retirement (Nakajima and Telyukova, 2020).<sup>12</sup> Despite tighter borrowing constraints, housing wealth

<sup>10</sup>In reality, there exists a wide variety of mortgage products that allow homeowners to extract equity (cash-out refinancing, home equity loans, home equity lines of credit, second mortgages, etc.) We purposefully abstract away from these different products by assuming a single means of home equity withdrawal.

<sup>11</sup>When mortgage debt exceeds the house value, the excess debt is written off and the government provides a minimum consumption floor, ensuring that households never experience negative infinite utility.

<sup>12</sup>Caplin (2002) notes that many retired homeowners cannot extract equity using traditional mortgages because they fail to meet income requirements. Reverse mortgages are intended to overcome this problem, but this market remains tiny in the U.S. and almost nonexistent in other countries. Nakajima and Telyukova (2017) find that reverse mortgages are very costly due to insurance costs and hence rarely optimal to use.

still plays a crucial role in supporting living standards during retirement. Most importantly, retired homeowners do not need to pay rent, allowing them to consume a larger share of their retirement income and financial resources. In contrast, retired renters must devote a large share of their resources towards rent: in the PSID, retired renters devote roughly 36% of their spending to rent. Further, homeowners with larger homes are able to enjoy greater service flows from housing. As a result, housing wealth plays an important role in households' ability to maintain consumption and housing services post retirement.

## 2.4 Income

Households receive an exogenous stream of income. We assume that all households are made up of a 'primary' and 'secondary' earner. We explicitly model the income and unemployment risk faced by the primary earner, similar to O'Dea (2018). For the primary earner, employment ( $e_{i,t}$ ) evolves according to a first-order Markov process where the probability of employment  $\pi_e$  is conditional on last period's employment status. When employed, the primary earner's log income ( $\ln y_{i,t}^p$ ) is equal to the sum of a deterministic ( $g_t$ ) and stochastic component ( $z_{i,t}$ ):

$$\ln y_{i,t}^p = g_t + z_{i,t} \quad (6)$$

where we approximate the deterministic component with a third-order age-polynomial.<sup>13</sup> The stochastic component of income ( $z_{i,t}$ ) when employed evolves according to an AR(1) process:

$$\begin{aligned} z_{i,t} &= \rho z_{i,t-1} + \varepsilon_{i,t} \\ \varepsilon_{i,0} &\sim N(0, \sigma_0^2) \\ \varepsilon_{i,t} &\sim N(0, \sigma_\varepsilon^2) \quad \forall t > 0 \end{aligned} \quad (7)$$

where  $\rho$  captures the persistence of income shocks and  $\varepsilon_{i,t}$  represents i.i.d. shocks. We allow the variance of the initial shock to differ from subsequent periods to capture heterogeneity in initial earnings. When unemployed, the primary earner receives unemployment benefits,  $\ln y_{i,t}^p = \ln b$ . The details of unemployment are in Appendix A.5.

Household pre-tax income is the sum of the primary and secondary earners' income during the working-life. Following O'Dea (2018), we assume that the income of the secondary earner is exogenous and deterministic. Over the working life, household income is taxed using a progressive tax schedule which approximates the U.S. tax code. After retirement, which we assume to happen for all households at age  $W$ , households receive two sources of income:

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<sup>13</sup>Since income shocks are independent and identically distributed across households, we index the income process by  $i$ , although previous to this section we had omitted the subscript  $i$  for expositional clarity.

progressive social security income and annuitized disbursements from a mandatory retirement account. Details on taxation and retirement income are in Appendices A.1-A.3.

## 2.5 Functional forms

We specify preferences over consumption and housing using a functional form that closely follows Chambers et al. (2009). The per period felicity function is:

$$u(c_t, h_t) = (1 - \omega) \frac{c_t^{1-\gamma}}{1-\gamma} + \omega \frac{[\phi(h_t)]^{1-\alpha}}{1-\alpha} - \kappa \mathbb{I}_{h_t \neq h_{t-1}} \quad (8)$$

where  $\gamma$  and  $\alpha$  are the curvature of the felicity function with regards to consumption and housing respectively. The parameter  $\gamma$  can be interpreted as the coefficient of relative risk aversion in consumption. The share of housing in the felicity function is  $\omega$ . When households adjust housing ( $h_t \neq h_{t-1}$ ), they suffer a utility cost  $\kappa$  in addition to the financial cost  $F$  introduced previously. The utility cost captures the non-monetary cost of changing homes (i.e. searching for a new home, packing your belongings, setting up utility providers, etc.) The housing transaction costs play an important role in making housing illiquid and therefore more useful as a commitment device. Finally, the benefit of living in home  $h_t$  is given by  $\phi(h_t)$  which depends on the size of the house and the tenure decision:

$$\phi(h_t) = \begin{cases} h_t & \text{if owner} \\ \zeta h_t & \text{if renter} \end{cases} \quad (9)$$

where  $\zeta \leq 1$  represents the potential disutility of renting. The disutility of renting may arise due to principal-agent problems between the landlord and renter, among other factors.

Appendix A describes additional model features that help replicate the economic environment faced by U.S. households. These include progressive taxes, tax subsidies to housing, social security and pensions, and variation in household composition. Appendix A.7 presents the full household optimization problem in recursive formulation.

## 3 Temptation alters consumption growth dynamics

Before describing our estimation strategy, it is useful to think through one key challenge: how do we differentiate between temptation and impatience when estimating the model? This challenge arises because temptation and impatience both generate similar implications



for life-cycle consumption and saving behavior.<sup>14</sup> And yet, these two features of the model have drastically different implications for welfare.

In this section, we demonstrate that it is possible to differentiate between temptation and impatience using information on consumption growth dynamics. More specifically, we show that temptation generates a positive relationship between consumption growth and liquid assets for households who are away from the liquidity constraint. In contrast, when we turn off temptation in the model, no degree of impatience is able to generate a positive relationship between these two variables.

To provide intuition for this result, we first derive the consumption Euler equation, which characterizes consumption behavior for households who are away from the credit-constraint. We then use the model to simulate consumption growth dynamics, allowing us to account for the presence of credit-constraints. We assume a borrowing limit of  $\underline{a} = 0$  and show that credit-constraints generate qualitatively different predictions than temptation. For clarity of exposition, we focus on a simplified version of the model without housing and mortgages, but we later show in Section 5.3 that these results hold in the full model.

### 3.1 Analytical results from the consumption Euler equation

The model with temptation yields the following consumption Euler equation:

$$\frac{\partial u_t}{\partial c_t} = \beta(1+r)\mathbb{E}_t \left[ \left( \frac{\partial u_{t+1}}{\partial c_{t+1}} + \frac{\partial u_{t+1}}{\partial \tilde{c}_{t+1}} \right) \right] \quad (10)$$

This condition holds for households that are sufficiently far from the liquidity constraint. The derivation is contained in Appendix B.1. The Euler equation can be rewritten using the functional form for the felicity function, which yields the following equation:

$$c_t^{-\gamma} = \beta(1+r)\mathbb{E}_t \left[ c_{t+1}^{-\gamma} - \frac{\lambda}{1+\lambda} (\tilde{c}_{t+1})^{-\gamma} \right] \quad (11)$$

This equation shows that if a household gives up one unit of consumption today, it will benefit from additional consumption utility next period, but will also suffer from additional temptation costs next period. This is because the presence of temptation introduces an additional term in the Euler equation that depends on  $\tilde{c}_{t+1}$ , the most tempting consumption alternative. As this term is negative, the optimal marginal utility of consumption today is lower, therefore optimal consumption today is higher. In other words, temptation introduces

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<sup>14</sup>For instance, higher temptation and impatience both generate a desire to consume more in the present. As a result, both parameters have similar effects on the life-cycle profiles of consumption and wealth accumulation.

a utility cost to holding assets, resulting in greater consumption in the present and reduced consumption in the future. When we turn off temptation ( $\lambda = 0$ ), the additional term in the Euler equation disappears.

To highlight the implications for consumption growth, we log-linearize equation (11). The derivation is in Appendix B.2. The log-linearized Euler equation with temptation is:

$$\Delta \ln c_{t+1} = a_0 + a_1 \ln(1 + r) + a_2 \ln \tilde{c}_{t+1} + u_{t+1} \quad (12)$$

In contrast, in the model without temptation, the log-linearized Euler equation is:

$$\Delta \ln c_{t+1} = b_0 + b_1 \ln(1 + r) + v_{t+1} \quad (13)$$

There are two main takeaways for consumption growth, which we prove in Appendix B.3. First, consumption growth is depressed when households suffer from temptation, i.e.  $a_0 < b_0$ . The intuition for this result is that temptation causes households to increase consumption in the present due to the utility cost of delaying consumption. Second, temptation generates a positive relationship between consumption growth and tempting resources, i.e.  $a_2 > 0$  if  $\lambda > 0$ . The intuition behind this result is that the distortion caused by temptation is less pronounced for households with more resources.<sup>15</sup>

In contrast, in the model without temptation, a higher level of impatience can alter average consumption growth (via  $b_0$ ), but no degree of impatience can generate a positive relationship between consumption growth and resources. This is because consumption growth in equation (13) is pinned down by model parameters independently from asset holdings.

### 3.2 Numerical results from the model with and without temptation

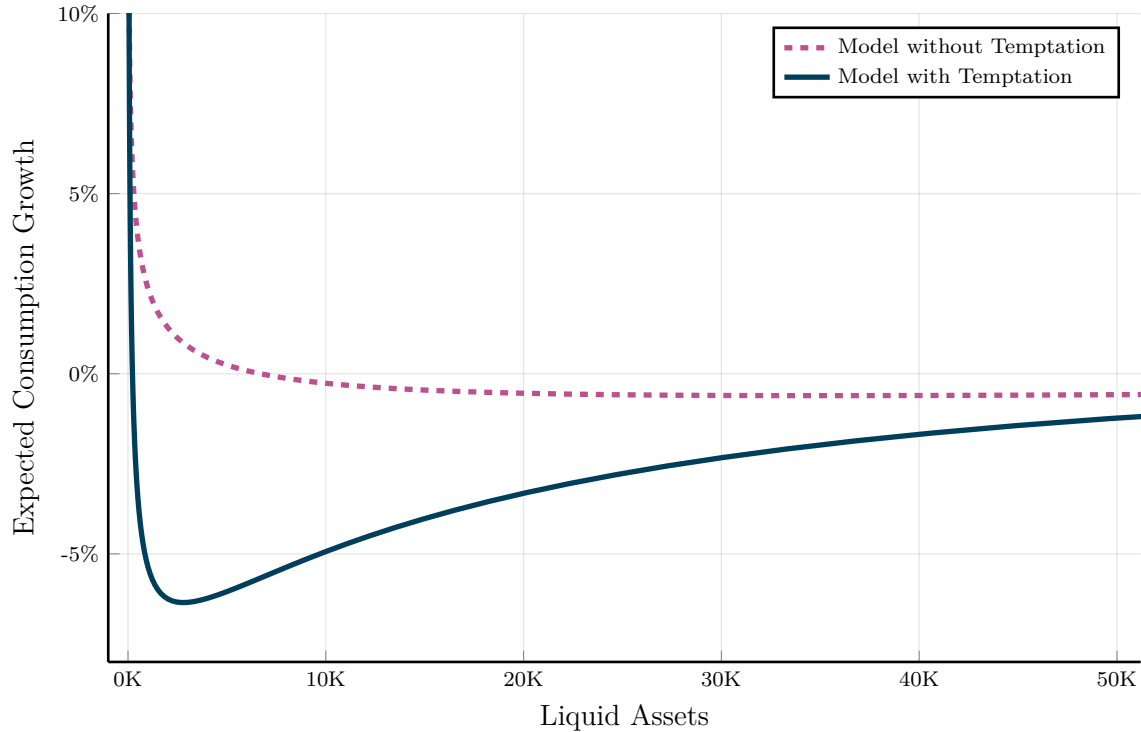
Figure 1 shows the relationship between consumption growth and liquid assets generated by the model. The solid blue line shows consumption growth in the baseline model with temptation, while the dashed pink line shows the restricted model without temptation. Apart from temptation ( $\lambda$ ), all other parameters are set to be equal in the two models.

In both models, we see a negative relationship between consumption growth and liquid assets for households near the liquidity constraint. This negative relationship is driven by the fact that households with low liquid assets would like to shift consumption from the future

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<sup>15</sup>Households with more wealth have higher optimal per-period consumption and therefore face less distortion from temptation due to the diminishing marginal benefit of consumption. For households with sufficiently high wealth, consumption growth eventually become similar to the model without temptation. To demonstrate this point, we plot the relationship between consumption growth and liquid assets in Figure 1.

Figure 1: The Impact of Temptation on Consumption Growth Dynamics



to the present but are not allowed to do so.

In the model without temptation, for households that are away from the liquidity constraint, there is essentially no relationship between consumption growth and liquid assets. This is because consumption growth is pinned down almost entirely by preference parameters, rather than asset holdings. This result has been well discussed by Carroll (1997).

In the model with temptation, we see that consumption growth is affected in two ways. First, temptation lowers consumption growth relative to the model without temptation. This is because households want to decrease temptation costs in the future by consuming more today. This is especially pronounced for households with relatively low liquid assets. For these households, a small increase in consumption today gives a large reduction in temptation disutility tomorrow.

Second, for households who are away from the liquidity constraint, temptation generates a positive relationship between consumption growth and liquid assets. This is driven by two facts. First, households with more assets have higher optimal per-period consumption. Second, due to the diminishing marginal benefit of consumption, households with higher consumption are less affected by temptation. As a result, as asset levels increase, household behavior in the model with temptation becomes more similar to the model without temptation.

Note that the positive relationship generated by temptation cannot be replicated by altering the level of impatience. More specifically, higher impatience would shift down average consumption growth, but could not generate a positive relationship between consumption growth and assets. In the next section, we develop an estimation strategy that uses this intuition to help pin down the preference parameters of the model.

## 4 Estimation strategy

We follow a two-step procedure to estimate the parameters of the model. First, we set the institutional parameters to reflect the economic environment faced by U.S. households. Second, we estimate the preference parameters by matching a number of targeted moments using the method of simulated moments.<sup>16</sup> The main challenge is to differentiate between temptation and impatience. To overcome this challenge, we target consumption growth dynamics, for which temptation and impatience generate qualitatively different predictions.

### 4.1 Data and sample

We estimate the model using data from the Panel Study of Income Dynamics (PSID). To the best of our knowledge, the PSID is the only representative panel to include information on income, consumption, housing, and wealth for a large number of U.S. households. This makes the PSID particularly well suited for our purposes, as we require panel data on consumption and assets to pin down the strength of temptation.

The PSID began in 1968 by collecting information on a sample of roughly 5,000 households. Since then, the PSID has followed both the original families and their split-offs with annual surveys until 1996 and biennial surveys starting in 1997. Detailed consumption questions were added to the PSID in 1999. We use the 1999 to 2015 waves of the PSID because it contains detailed information on assets and consumption, in addition to income and demographics. We follow the definition of nondurable consumption used by Blundell et al. (2016). Further details are contained in Appendix C.1.

### 4.2 Parameters set outside the model

We set the institutional parameters to broadly reflect the economic environment faced by U.S. households. This is performed by either directly estimating these parameters from the data or setting them with reference to the literature. This subsection describes the key institutional

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<sup>16</sup>This two-step procedure is a version of the method of simulated moments (Duffie and Singleton, 1993) where we fix a number of “nuisance” parameters before estimating the structural preference parameters. This two-step procedure is regularly applied in papers that estimate life-cycle models (e.g. Gourinchas and Parker, 2002; Laibson et al., 2017). A formal justification is provided by Dridi, Guay, and Renault (2007).

parameters, while Table C.1 in Appendix C shows the values of these parameters.

*Demographics* – Decisions in the model take place at an annual frequency. All households enter the labor market at age 22 ( $t = 1$ ), retire at age 65 ( $W = 44$ ), and die no later than age 80 ( $T = 59$ ). Between age 65 and 80, the probability of death is given by the Actuarial Life Table published by the Social Security Administration (2016). We take into account the evolution of household composition over the life-cycle by modelling the arrival of kids exogenously (see Appendix A.6).

*Income* – We estimate the earning process using the two-step minimum distance approach by Guvenen (2009) and Low et al. (2010). In the first step, we estimate the parameters of the deterministic component of income ( $g_t$ ) by approximating it with a third-order age-polynomial. This allows us to identify the stochastic income component of the primary earner as  $z_{i,t} = \ln y_{i,t}^p - g_t$ . In the second step, we estimate the persistence of income risk ( $\rho$ ), the variance of income innovations ( $\sigma_\varepsilon^2$ ), and the variance of initial income ( $\sigma_0^2$ ). Estimation is performed by minimising the distance between the empirical variance-covariance matrix of the stochastic income component and its theoretical counterpart. The parameter estimates of the income process, presented in Table C.1, are in line with the previous literature. In particular, income innovations are found to be very persistent, with a coefficient of  $\rho = 0.97$ . Details about the estimation strategy and results can be found in Appendix C.2.2.

*Asset Returns* – We calibrate the model using real risk-adjusted returns. We set  $r = 0.0069$  based on the real risk-adjusted return of the 3 Month T-Bill. We set  $r^H = 0.021$  based on the real risk-adjusted return on housing, which we compute using the Case-Shiller house price index augmented with housing service flows, maintenance costs, and home insurance (Appendix C.2.4). This calibration is broadly consistent with Kaplan and Violante (2014), and the heterogeneous agent macro literature, which assume that illiquid assets deliver a higher return than liquid assets.<sup>17</sup> Finally, we set the interest rate on mortgage debt as  $r^M = 0.041$ , based on the average real rate for a 30 year fixed rate mortgage, computed using data from the Primary Mortgage Market Survey conducted by FreddieMac (1972 to 2016).

*House Sizes and House Prices* – We allow for eight different sizes of housing ( $K = 8$ ). Given that we only observe house prices for households who have chosen to buy, it is challenging to identify the set of house sizes that are available. Our strategy is to calculate the distribution of house prices for households below age 25, and use this distribution to define the different house sizes available to households in our model. We keep the different house sizes constant over time but allow the price of each size to change following Section 2.2. In our model we set the initial maximum house price (size) at eight times average income,

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<sup>17</sup>Attanasio et al. (2021) study wealthy hand-to-mouth behavior when there is a high-return liquid asset.

corresponding to the 90th percentile of observed house prices for this age group in the data. Similarly, we set the minimum price at two times average income, roughly corresponding to the 10th percentile. We allocate the remaining points on the house size grid using a logarithmic scale, following Nakajima and Telyukova (2020).

*Borrowing* – We follow Deaton (1991) by assuming an unsecured borrowing limit of  $\underline{a} = 0$  in our baseline analysis, but also consider a negative borrowing limit in Section 7.4 and find that it has very little impact on our quantitative results. For mortgages, we assume a maximum loan-to-value (LTV) constraint of  $\bar{\psi} = 0.9$ , following Gorea and Midrigan (2017). While this LTV constraint is slightly high compared to the value of 0.8 used in some other studies, we find that the higher LTV constraint is necessary to match the upper tail of the LTV distribution observed in the data. We set the length of mortgages  $l = 30$  to capture the prevalence of thirty year mortgages in the United States. In the Consumer Expenditure Survey, we see that 67.76% of mortgages have a term length of thirty years.<sup>18</sup> The cost of home equity withdrawal includes both a fixed and proportional cost, which we calibrate as  $C^R = \$3,000$  and  $F^R = 0.05$  respectively. The fixed cost represents a range of fees including inspection fees, filing charges, legal costs, title insurance, and nonpecuniary costs such as time. The proportional cost represents the loan origination fee, discount points charged by the lender, and in some cases mortgage insurance. These parameters are in line with the breakdown of costs published by the Federal Reserve Board (2008). We experimented with a lower cost of refinancing, but found that it resulted in an implausibly high share of homeowners performing home equity withdrawal in the model relative to the PSID.

### 4.3 Estimated parameters and targeted moments

We estimate the preference parameters of the model using the method of simulated moments. The parameters are temptation ( $\lambda$ ), time preference ( $\beta$ ), risk aversion ( $\gamma$ ), housing utility curvature ( $\alpha$ ), housing utility share ( $\omega$ ), the disutility of renting ( $\zeta$ ), and the utility cost of moving ( $\kappa$ ).<sup>19</sup> These preference parameters are estimated by targeting a combination of life-cycle and aggregate moments, which we describe in turn.<sup>20</sup>

*Life-Cycle Moments* – We target the mean life-cycle profiles of log nondurable consumption,

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<sup>18</sup>We also experimented with mortgages that have fixed repayments every period between loan origination and retirement. This was operationalized by setting  $l = T_R - t + 1$ , thus making the length of the mortgage depend on time to retirement. While this has attractive properties (for instance, fixed repayments across time) it unfortunately also results in implausibly high mortgage repayments immediately prior to retirement.

<sup>19</sup>While a growing number of macro papers study temptation (e.g. Amador et al., 2006; Krusell et al., 2009; Nakajima, 2012; Buccioli, 2012; Schlafmann, 2021; Kovacs et al., 2021), very few attempt to estimate its importance (Buccioli, 2012; Kovacs et al., 2021).

<sup>20</sup>The objective function and weight matrix used for estimation are given in Appendix C.3.

liquid assets, and net housing wealth for households between the ages of 25 and 60. Detailed definitions of these variables are given in Appendix C.1. In both the model and the data, the liquid asset profiles are top-coded at the 95th percentile to mitigate the impact of the very wealthy, following O’Dea (2018). Further, in order to take logs, the liquid asset and housing wealth profiles are both conditional on having positive liquid assets or housing wealth respectively. We choose not to explicitly target the behavior of households over age 60 because there are several unmodeled features that will likely be relevant for their behavior (e.g. early retirement, medical shocks, spousal survival).

The life-cycle profiles in the data may be contaminated by time and cohort effects that do not exist in the model. To overcome this issue, we flexibly remove time and cohort effects from the data using the procedure developed by Schulhofer-Wohl (2018) to handle the classic age-period-cohort identification problem. Appendix C.4 briefly describes the procedure.

*Aggregate Moments* – We target five aggregate moments that we believe to be informative. The moments are (1) the average homeownership rate, (2) the average loan-to-value ratio, (3) the share of homeowners who extract equity each period, (4) the share of households who move each period, and (5) the relationship between consumption growth and liquid assets. We choose to target the last relationship based on the results in Section 3, where we show that that temptation and impatience have qualitatively different implications for consumption growth dynamics. We verify the informative nature of consumption growth in Section 5.3.

To target consumption growth dynamics, we estimate the following consumption growth regression on both the model and the data:

$$\Delta \ln c_{i,t} = \psi \ln a_{i,t} + \sum_{j=25}^{60} \alpha_j \text{Age}_{i,t}^j + \epsilon_{i,t} \quad (14)$$

This regression captures the relationship between consumption growth, log liquid assets, and a series of age dummies. The object of interest is  $\psi$ , which is the relationship between consumption growth and liquid assets. We include  $\psi$  as one of the targeted moments in our estimation routine. This represents an indirect inference approach to model estimation, as we use equation (14) as an auxiliary model to generate a targeted moment.<sup>21</sup>

Section 3 shows that consumption growth dynamics are informative of temptation provided that households are away from the credit constraint. For this reason, in both the data and the model, we estimate equation (14) on the subsample of households with liquid assets  $a_t > \$500$ . We restrict the sample in this manner as any potential effect of temptation on

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<sup>21</sup>We choose a parsimonious auxiliary model to ensure a close mapping between the model and the data. That said, we find that our estimate of  $\hat{\psi}$  is robust to a wide variety of additional controls (Appendix D.3).

consumption growth would only appear for households with sufficient assets.<sup>22</sup> We further discuss the challenge posed by credit constraints, and how our estimation strategy allows us to overcome this challenge, in Appendix C.5.

Finally, we briefly consider which aspects of variation in the data will be most important in pinning down each of the preference parameters. The relationship between consumption growth and liquid assets ( $\psi$ ) is especially important in determining the strength of temptation. In addition, the life-cycle profiles of wealth accumulation play an important role in determining the time preference parameter. Liquid asset holdings early in life are important for precautionary purposes and therefore contribute substantially to pinning down risk aversion. The share of wealth held in housing helps determine the utility share of housing  $\omega$ , while the curvature of the life-cycle profiles of housing and consumption play a key role pinning down the curvature of housing utility  $\alpha$ . The share of homeowners rate helps determine the disutility of renting  $\zeta$ . And the share of movers helps pin down the utility cost of moving  $\kappa$ .

## 5 Estimation results and model fit

We estimate two different version of the model. First, we estimate the baseline model that allows for the possibility of temptation. Second, we estimate a restricted version of the model without temptation, where we impose the assumption that  $\lambda = 0$ . We find that the baseline model obtains a good fit of the targeted moments, including the evidence on consumption growth dynamics. In contrast, the restricted model without temptation fails to match the positive relationship between consumption growth and assets.

### 5.1 Estimated parameter values

**Baseline model.** Table 1 shows the estimated preference parameters. The first column presents the estimation results from the baseline model. We find that the strength of temptation is significantly different from zero with a value of  $\lambda = 0.339$ . As the baseline model nests the restricted model, this allows us to reject the null hypothesis that households do not suffer from temptation. We can interpret  $\frac{\lambda}{1+\lambda}$  as the relative cost of temptation.<sup>23</sup> Our estimate of  $\lambda$  implies that the utility cost of temptation is roughly a quarter of the utility benefit of consumption.

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<sup>22</sup>There is no clear threshold at which households cease to be liquidity constrained. While our benchmark results are based on the \$500 criteria, we could have easily chosen a different cutoff. We explore an alternative cutoff based on the definition of hand-to-mouth households in Kaplan and Violante (2014). The alternative cutoff only slightly alters the magnitude of  $\hat{\psi}$  and has little effect on our findings.

<sup>23</sup>Equation (2) can be rearranged to show that the utility cost of temptation relative to the utility benefit of consumption is  $\frac{\lambda}{1+\lambda}$ . Our estimate of  $\lambda$  implies that  $\frac{\lambda}{1+\lambda} = 0.279$ .



Table 1: Estimated Model Parameters

		Baseline Model	Restricted Model
Temptation	$\lambda$	0.339 (0.036)	–
Time Preference	$\beta$	0.993 (0.010)	0.993 (0.008)
Risk Aversion	$\gamma$	2.062 (0.054)	2.431 (0.159)
Housing Utility Curvature	$\alpha$	1.060 (0.284)	1.213 (0.022)
Share of Housing	$\omega$	0.260 (0.007)	0.297 (0.024)
Utility Cost of Moving	$\kappa$	0.339 (0.036)	0.085 (0.078)
Disutility of Renting	$\zeta$	0.848 (0.044)	0.749 (0.008)

**Note:** The first column presents parameter estimates from our baseline model, whereas the second column presents parameter estimates when we impose the restriction that  $\lambda = 0$ .

We evaluate how the relative cost of temptation that we estimate compares with the previous literature. Our value of  $\frac{\lambda}{1+\lambda} = 0.279$  is within the range of 0.22-0.28 estimated by Kovacs et al. (2021), but higher than the value of 0.05 estimated by Bucciol (2012). The difference between the temptation parameter estimated by Bucciol (2012) and estimated using our approach can be attributed to differences in targeted moments.<sup>24</sup>

The coefficient of relative risk aversion  $\gamma$  is estimated at 2.06, which is well within the range commonly estimated in the literature, see for instance Attanasio et al. (1999), Gourinchas and Parker (2002), and Cagetti (2003). The time preference parameter  $\beta$  is 0.993, which implies a substantial degree of patience. This estimate is similar to what others have found when households are allowed to suffer from self-control problems (e.g. Laibson et al., 2017; Ganong and Noel, 2019).

Moving to housing, we find that the curvature of housing utility is  $\alpha = 1.06$ . Given that

<sup>24</sup>First, we target consumption growth dynamics, while Bucciol (2012) does not. Second, we use a different definition of illiquid wealth: Bucciol (2012) focuses on retirement accounts, while we focus on housing. In Bucciol (2012), the targeted share of illiquid wealth is relatively low, between 20-40% depending on age. In contrast, the share of illiquid wealth that we target is substantially higher, roughly 80% depending on age. The latter is closer to the share of illiquid wealth documented in the United States (Angeletos et al., 2001). This finding is consistent with Kaplan and Violante (2014) and Gorea and Midrigan (2017) who note that housing, rather than retirement accounts, constitute the vast majority of households' illiquid wealth.

the curvature of housing utility is lower than the curvature of consumption utility ( $\alpha < \gamma$ ), the marginal utility of housing exhibits slower diminishing returns than consumption. As a result, as income increases, households spend a larger fraction of their income on housing. The share of housing in the utility function is estimated to be roughly one fourth,  $\omega = 0.26$ . We find that  $\zeta = 0.84$ , meaning that the effective size of rental units is only 84% of their owner-occupied counterparts, consistent with the view that certain housing amenities can only be obtained through homeownership. Finally, we find that the utility cost of moving is  $\kappa = 0.339$ . In financial terms, this implies that the average 25 year old homeowner would be willing to pay roughly \$5400 to avoid the disutility of moving.

**Restricted model.** The second column of Table 1 shows the estimation results from the restricted model without temptation. We find that the restricted model obtains a similar  $\beta$ , but higher values of  $\gamma$  and  $\alpha$  relative to the baseline model. In addition, the restricted model obtains a slightly lower value of  $\zeta$  and substantially lower value of  $\kappa$ . The low  $\kappa = 0.085$  implies that the utility cost of moving is very small. In consumption equivalence terms, the average 25 year old homeowner would view the utility cost of moving as only \$700. The low value of  $\kappa$  makes housing substantially more liquid than in the baseline model.

## 5.2 Model fit

Table 2 shows the relationship between consumption growth and liquid assets ( $\hat{\psi}$ ) observed in the data and generated by the estimated model. In the data, we document a positive and significant relationship between consumption growth and liquid assets. We show in Appendix D.3 that this positive relationship is robust to a wide variety of additional controls, which helps mitigate concern about omitted variable bias arising from unmodeled features of household behavior. For instance, we find that the positive value of  $\hat{\psi}$  in the PSID is not driven by heterogeneity in time-preferences: when we control for potential  $\beta_i$  heterogeneity by including a household fixed-effect, we find that  $\hat{\psi}$  only becomes more positive.

Table 2: Model Fit: Consumption Growth Dynamics

Moment	PSID	Baseline Model	Restricted Model
Relationship between $\Delta c$ and $a(\hat{\psi})$	0.0039**	0.0039	-0.0017

**Note:** Data comes from the PSID waves 1999-2015. We restrict the sample to households aged 25 to 60. The relationship between consumption growth and liquid assets ( $\hat{\psi}$ ) is estimated using equation (14).

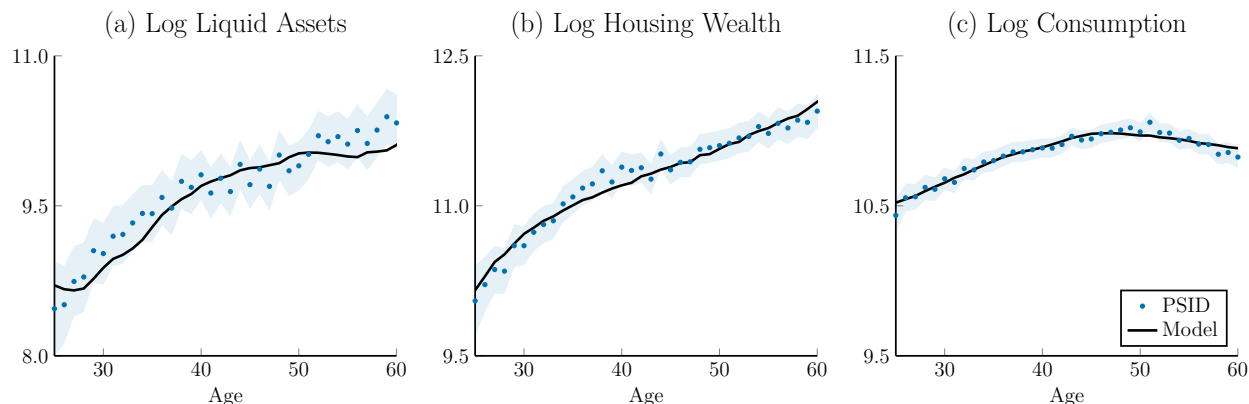
We find that the baseline model obtains a good fit of the positive relationship between consumption growth and liquid assets ( $\hat{\psi}$ ), successfully matching both the sign and magnitude

of this relationship. In contrast, the restricted model is unable to replicate the positive  $\hat{\psi}$  observed in the data, instead generating a counterfactually negative relationship.

Why does the restricted model fail to match the positive  $\hat{\psi}$  observed in the data? In the model without temptation, consumption growth is pinned down by preference parameters, rather than asset holdings, provided that households are sufficiently far from the credit constraint. This result is well known and applies to a broad class of life-cycle models, including Carroll (1997). As a result, no degree of impatience, risk aversion, or taste for housing is able to generate a positive relationship between consumption growth and assets (for further discussion, see Section 5.3). Moreover, the presence of credit constraints implies a slight negative relationship between consumption growth and assets.

Figure 2 shows the fit of the targeted life-cycle moments. The baseline model matches the gradual profile of wealth accumulation and the hump-shaped profile of nondurable consumption, which peaks around age 50. In both the model and the data, the share of wealth held in illiquid form is relatively stable over the life-cycle, around 80% on average. In contrast, we find that the restricted model without temptation obtains a relatively poor fit of the targeted life-cycle moments (Appendix D).

Figure 2: Model Fit: Life-Cycle Moments



**Note:** This figure shows the life-cycle moments that we target in the PSID (the blue dots) relative to the corresponding life-cycle moments from the estimated model (the black lines) using the baseline parameter estimates from Table 1. The blue shaded area shows the 95% confidence interval from the data.

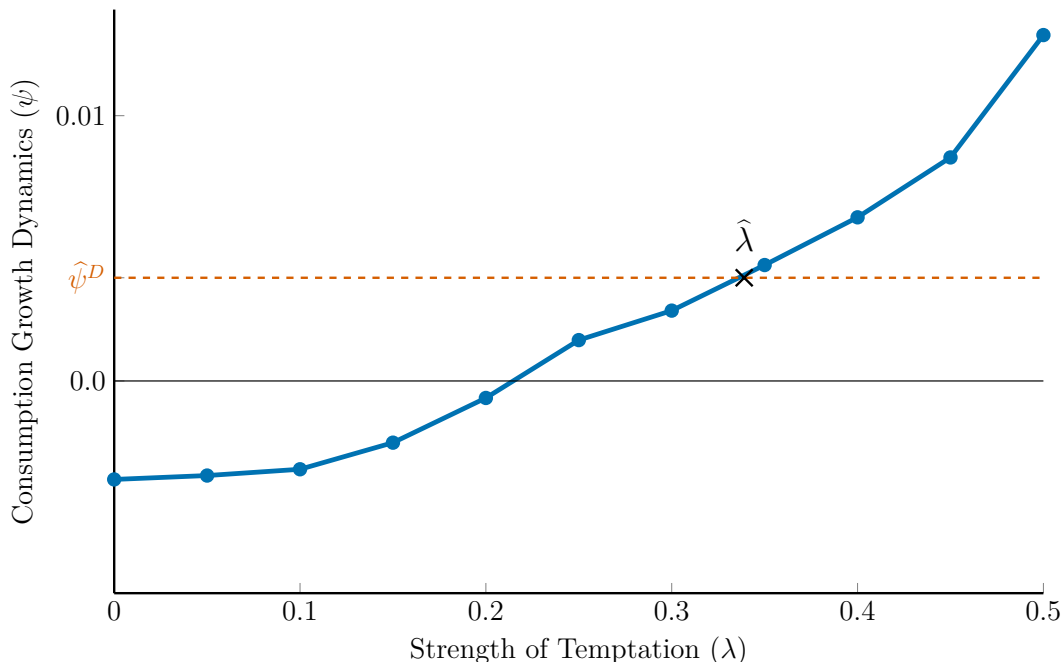
### 5.3 Identification

While all targeted moments play a role in determining the model parameters, we find that the relationship between consumption growth and liquid assets ( $\psi$ ) is especially important for pinning down temptation. This section describes the findings that lead us to this view.

Figure 3 shows how variation in temptation ( $\lambda$ ) alters the model-implied relationship

between consumption growth and liquid assets ( $\psi$ ). We find that  $\psi$  is negative in the absence of temptation, when  $\lambda = 0$ , but gradually rises as the degree of temptation is increased. The model matches the targeted value of  $\widehat{\psi}^D$  observed in the data when  $\lambda = 0.34$ . In contrast, when  $\lambda$  is larger than 0.34, the model generates a  $\psi$  that is implausibly large compared to the data. This demonstrates the crucial role played by consumption growth dynamics in disciplining the strength of temptation in the model.<sup>25</sup>

Figure 3: The effect of temptation ( $\lambda$ ) on consumption growth dynamics ( $\psi$ )



**Note:** This figure shows how variation in temptation ( $\lambda$ ) alters the relationship between consumption growth and liquid assets ( $\psi$ ). We obtain  $\psi$  by estimating the consumption growth regression, equation (14), on model generated data. We vary  $\lambda$  while keeping the other parameters fixed at their estimated values. Blue dots show the results from the model. The dashed orange line shows the targeted moment ( $\widehat{\psi}^D$ ) from the PSID.

Moreover, a similar pattern emerges when we allow the other preference parameters to vary over the parameter space. The results are shown in Appendix D.1. We find that no combination of impatience, risk aversion, taste for housing, or other preference parameters is able to generate a positive  $\psi$  in the absence of temptation.

Further evidence of the importance of  $\psi$  comes from re-estimating the model while excluding  $\psi$  from the set of targeted moments. We perform this exercise in Appendix D. If we do not target  $\psi$ , we obtain a lower estimate of  $\widehat{\lambda} = 0.145$ . Temptation is poorly identified

<sup>25</sup>This result is consistent with the intuition developed in Section 3, where we show that temptation enters the Euler equation and thus alters consumption growth dynamics. As a result, the model with temptation is able to generate a positive  $\psi$ , while the model without temptation generates the opposite prediction.

by the restricted set of targeted moments, however, since  $\beta$  and  $\lambda$  have similar implications for the life-cycle profiles of consumption and wealth accumulation.

Finally, we evaluate the sensitivity of temptation to targeted moments following the approach developed by Andrews et al. (2017). We find that variation in the relationship between consumption growth and liquid assets observed in the data ( $\widehat{\psi^D}$ ) has a meaningful effect on the estimated value of  $\widehat{\lambda}$ . The results are contained in Appendix D.2.

**Robustness.** Key to the estimation strategy is the finding that our model cannot generate a positive relationship between consumption growth and liquid assets without temptation. Although our model is relatively standard, building upon the workhorse models developed by Deaton (1991), Attanasio and Browning (1995), and Carroll (1997), we may be concerned about potential model additions that could generate a positive relationship. We address this concern in Appendix D.3, where we discuss a number of potential model additions that may pose a threat to identification. We find that it is possible to extend the consumption growth regression to account for these potential concerns. For instance, while we may be concerned about heterogeneity in time preferences, we can control for this by adding a household fixed effect to equation (14). We find that even when we account for these potential concerns in the consumption growth regression,  $\widehat{\psi}$  remains positive and significant.

## 6 Validating model predictions using a policy change in Texas

Having established the importance of temptation to fit the targeted moments, we now assess whether the estimated model generates reasonable out-of-sample predictions when confronted with a policy change that alters households' ability to access home equity.

We exploit a reform in Texas that legalized home equity withdrawal in 1998, following more than a century of prohibition. We document the effect of this reform on household behavior, then use the estimated model to simulate a similar reform. We find that the model predicts an increase in spending and mortgage balances that is consistent with the quasi-experimental evidence, lending credibility to the model's empirical predictions.

This approach is inspired by a growing literature which argues that structural models should be assessed by their ability to make reasonable quantitative predictions when confronted with a relevant change in policy (see e.g. Keane, 2010; Low and Meghir, 2017). While such a validation exercise does not constitute a test of the model, it does provide reassurance that the model's predictions are in line with the empirical evidence even when there is a change in policy – which of course is one of the primary goals of using a structural model. In contrast, if the model were to generate an implausibly small or large response in spending compared

to the data, there would be little reason to trust its quantitative predictions.<sup>26</sup>

## 6.1 Methodology

Texas legalized home equity withdrawal in 1998. Prior to this reform, most forms of equity withdrawal were prohibited by a “homestead protection” clause in the Texas Constitution of 1876, which protected homeowners from foreclosure except for the nonpayment of debt used to purchase the property or fund home improvement. As a result, home equity loans and cash-out refinancing were prohibited for any purpose other than home improvement. Following a state-wide referendum that narrowly passed in November 1997, the Texas Constitution was amended to allow households to extract home equity for other purposes starting on January 1, 1998. To the best of our knowledge, Texas was the only U.S. state that had a prohibition on home equity withdrawal.

We evaluate the effect of this reform on household behavior using data from the Consumer Expenditure Survey (CEX). We estimate a difference-in-differences specification that identifies the average treatment effect based on changes in behavior for homeowners in Texas relative to homeowners in other southern states before and after the reform. The empirical specification is described and the validity of the research design is tested in Appendix E.1.

We then use the baseline model with the estimated parameter values from Table 1 to implement a similar reform. We simulate multiple overlapping generations under the assumption that home equity withdrawal is initially prohibited, then suddenly legalized. We compare the consumption and mortgage behavior of households who are subject to the policy change relative to a control group where home equity withdrawal has always been permitted. Details are contained in Appendix E.2.

## 6.2 Results

Table 3 shows the response of household behavior when home equity withdrawal is introduced. The first column shows the response in the data, the second column shows standard errors, and the third column shows the prediction from the baseline model.

We find that the model predicts an increase in consumption that is roughly consistent with the empirical evidence. In the data, the reform results in a 3% increase in consumption for homeowners in Texas relative to homeowners in other southern states, which is consistent

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<sup>26</sup>Validation is distinct from identification, as emphasized by Keane (2010). Identification relies upon the testable implications for consumption growth discussed in Sections 3-5. In contrast, identification could not be achieved using the quasi-experimental evidence alone, for the reasons discussed in Appendix E.3. As a result, no quasi-experimental study on home equity withdrawal has attempted to identify the role of commitment (Leth-Petersen, 2010; Abdallah and Lastrapes, 2012; Agarwal and Qian, 2017).

Table 3: Response to the Legalization of Home Equity Withdrawal

	Data	S.E.	Model
Homeowners:			
Change in Log Consumption	0.030**	(0.010)	0.026
Change in Log Mortgage Balances	0.162*	(0.084)	0.134
Change in Share of Mortgagors	0.036*	(0.013)	0.012
Renters:			
Change in Log Consumption	-0.017	(0.012)	0.002

**Note:** This table shows households' response to the legalization of home equity withdrawal. The first row shows the change in log nondurable consumption,  $\Delta \log(c)$ , the second row shows the change in log mortgage balances,  $\Delta \log(m + 100)$ , and the third row shows the change in the share of households with a mortgage,  $\Delta I_{m>0}$ . Results are for working age households. For the empirical results, state and time fixed effects are included. Standard errors are clustered at the state level. Significant at \*\*\*1%, \*\*5%, and \*10%.

with previous estimates discussed in Appendix E.1.4. In the estimated model, the reform generates a similar 2.6% increase in consumption for homeowners in the treatment group relative to homeowners in the control.

Further, we find that the model obtains a good fit of the response of mortgage balances, even though it under-predicts the extensive margin of adjustment. The reform generates a 16% increase in log mortgage balances in the data and a similar 13% increase in the model. This captures the change in mortgage balances along both the intensive and extensive margins. When we focus on just the extensive margin, we find that the reform results in a 3.6% increase in the share of mortgagors in the data and a 1.2% increase in the model. This demonstrates that the extensive margin is less important in the model than the data. However, we think that this distinction is relatively unimportant for the model's welfare and policy results.

Finally, we estimate the effect of the reform on renters, which serves as a falsification test for our quasi-experimental research design. We observe no significant change in spending for renters in both the data and the model.

Taking stock, we find that the estimated model generates a reasonable fit of the change in consumption and mortgage balances following the legalization of home equity withdrawal.<sup>27</sup> This finding provides reassurance for the estimated model's quantitative predictions.

<sup>27</sup>We focus on the baseline model given our rejection of the restricted model in Section 5. We conducted a similar analysis using the restricted model and found that it predicts a consumption increase of 1.4%, less than half of the response in the data. While it is reassuring that the baseline model has better out-of-sample fit than the restricted model, we do not emphasize this result for the reasons discussed in Appendix E.3.

## 7 The effect of financial liberalization on household wellbeing

In this section, we evaluate the welfare trade-off between consumption smoothing and weakened commitment. While the benefit of improved consumption smoothing is substantial, we find that the cost of weakened commitment is even more important, approximately 1.7 times larger than the consumption smoothing benefit.

The results in this section highlight two important benefits of using an estimated model. First, the model allows us to quantify the welfare effect of giving households greater access to home equity. Second, the model enables us to disentangle the different channels affecting household behavior and wellbeing. Both of these tasks would be impossible using the quasi-experiment alone.

### 7.1 Measuring welfare changes

As mentioned previously, one important advantage of temptation preferences by Gul and Pesendorfer (2001, 2004) is that they allow for internally consistent welfare analysis. In contrast, welfare analysis in a model with hyperbolic discounting is often viewed as problematic (Fang and Silverman, 2009; Bernheim, 2009). In this subsection we describe our approach to measuring the welfare effect of giving households greater access to home equity.

We measure the welfare effect using consumption equivalent variation. First, we solve for the policy functions for consumption  $c(\mathbf{s})$ , housing  $h(\mathbf{s})$ , and mortgages  $m(\mathbf{s})$  over all possible states of the world at every age, under the assumption that home equity withdrawal is prohibited.  $\mathbf{s} = (\mathbf{s}_1, \mathbf{s}_2, \dots, \mathbf{s}_T)$  represents the set of possible states. We define expected utility as a function of these choices:

$$EV_0(c(\mathbf{s}), h(\mathbf{s}), m(\mathbf{s})) \tag{15}$$

The legalization of home equity withdrawal may result in different consumption, housing, and mortgage decisions. We denote the policy functions as  $c^p(\mathbf{s})$ ,  $h^p(\mathbf{s})$ , and  $m^p(\mathbf{s})$  in the model where home equity withdrawal is permitted. We write the new level of expected utility as:

$$EV_0(c^p(\mathbf{s}), h^p(\mathbf{s}), m^p(\mathbf{s})) \tag{16}$$

We express the welfare effect as the change in consumption ( $\Delta$ ) that we would need to give to households in the world without home equity withdrawal to equate their expected utility



with households in the world with home equity withdrawal.

$$EV_0(c(\mathbf{s})(1 + \Delta), h(\mathbf{s}), m(\mathbf{s})) = EV_0(c^P(\mathbf{s}), h^P(\mathbf{s}), m^P(\mathbf{s})) \quad (17)$$

where  $\Delta$  represents consumption equivalent variation.<sup>28</sup>

We consider two different measures of welfare. In the baseline measure, we assume that the social planner has the same preferences as households (thus the planner internalizes the psychic cost of temptation). In the alternative measure, households still suffer from temptation, but we assume that the social planner ignores the psychic cost of temptation, i.e. the social planner has  $\lambda^{SP} = 0$ . The alternative welfare criterion captures the impact of temptation on household choices, while ignoring the psychic cost of temptation.

## 7.2 Weakened commitment and consumption smoothing are both important

Table 4 shows the welfare effect of legalizing home equity withdrawal based on our estimated model. The overall welfare effect (Column 1) can be decomposed between the benefit of improved consumption smoothing and the cost of weakened commitment (Columns 2 and 3). We find that both of the opposing channels are quantitatively important. While improved consumption smoothing improves welfare by 1.9% in terms of consumption equivalent variation, this benefit is offset by the cost of weakened commitment, which reduces welfare by 3.3%. Thus, within the lens of our model, welfare is reduced by approximately 1.4% due to the legalization of home equity withdrawal. We note, however, that our model does not seek to capture all potential benefits of home equity withdrawal. Instead, we focus on estimating whether weakened commitment is quantitatively important relative to improved consumption smoothing. We find that the cost of weakened commitment is substantial: slightly over 1.7 times the benefit of improved consumption smoothing (Column 4 of Table 4).

The second row of Table 4 shows the welfare effect when we assume that the social planner ignores the psychic cost of temptation. We find that the alternative welfare measure does not fundamentally alter our main conclusions. The cost of weakened commitment dominates the consumption smoothing benefit, thus access to home equity reduces welfare, although the effect is somewhat dampened. This result is consistent with Toussaert (2018), who notes that temptation preferences induce a psychic cost of temptation that is present even when agents successfully resist temptation. We find that the welfare cost of weakened commitment is approximately 1.5 times the benefit of improved consumption smoothing.

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<sup>28</sup>This is similar to Conesa et al. (2009), Low et al. (2010), and Braun et al. (2016). Note that it is possible to measure welfare effects without applying a proportional increase in the housing held by each household, given the assumption that housing taste is uniform across households.

Table 4: The Effect of Financial Liberalization on Household Welfare

	Overall Effect	Consumption Smoothing Channel	Weakened Commitment Channel	Relative Cost of Weakened Commitment
Welfare Effect	-1.45	1.90	-3.35	1.76
Welfare Effect (no psychic cost)	-0.75	1.52	-2.27	1.49

**Note:** This table shows the welfare effect of legalizing home equity withdrawal. The welfare effect is computed as the consumption equivalent variation (CEV) relative to a counterfactual where home equity withdrawal is prohibited. We decompose the importance of the two channels using the procedure described in Appendix G.1. The relative cost of weakened commitment is defined as the the cost of weakened commitment relative to the benefit of improved consumption smoothing.

Previous studies have broken ground by developing models that conceptually capture the potential cost of weakened commitment (Laibson, 1997; Nakajima, 2012; Schlafmann, 2021). To make quantitative insights, these models were calibrated with a variety of different parameters and this has led to a wide dispersion in the estimated effects of financial liberalization.<sup>29</sup> One of the key contributions of the present paper is to develop the first empirical strategy to identify the importance of weakened commitment.

Our results show that consumption smoothing and commitment are both quantitatively important. These results stand in contrast with many papers that examine only the benefits of financial liberalization. For instance, the results in Hurst and Stafford (2004) suggest large benefits to financial liberalization due to improved consumption smoothing, although the authors qualify their results by stating that they do not consider the commitment benefit of illiquidity and that this would be necessary “to compute accurately” the welfare effect of making home equity more liquid. More recently, Gorea and Midrigan (2017) study the severity of liquidity constraints in the U.S. and find that there would be substantial welfare gains if home equity withdrawal were made cheaper: welfare would increase by 1.19% in consumption equivalent units if the cost of home equity withdrawal were set to zero.

To better understand the welfare results presented above, we use our estimated model to evaluate the long-term implications of financial liberalization on household behavior and decompose the relative importance of the two competing channels. The results are in Table 5. This long-term analysis highlights another important benefit of using an estimated model,

<sup>29</sup>Laibson (1997) finds that the welfare cost of weakened commitment may vary between 1.6% and 69.6% depending on the calibrated strength of self-control problems. Nakajima (2012) finds that access to unsecured credit has reduced welfare by approximately 0.4% according to his calibrated model. Schlafmann (2021) finds that a ban on refinancing would raise welfare by 0.29% for households with temptation  $\lambda = 0.12$  and would lower welfare by 0.31% for households with  $\lambda = 0$ , but notes that, “To the best of my knowledge, there is no established way of choosing the self-control parameter  $\lambda$  or a consensus about plausible values.”

which allows us to go beyond the short-term empirical evidence in Section 6.<sup>30</sup>

Table 5: The Long-Term Effect of Financial Liberalization on Household Behavior

	Overall Effect	Consumption Smoothing Channel	Weakened Commitment Channel
Saving Rate	-2.55	-1.22	-1.33
Net Wealth at Retirement	-15.08	-6.24	-8.84
Sensitivity of Consumption to Unemployment	0.37	-1.59	1.96

**Note:** This table shows the change in household behavior due to legalizing home equity withdrawal. All variables are relative to a counterfactual where home equity withdrawal is prohibited. We decompose the importance of the two channels using the procedure described in Appendix G.1. Sensitivity of consumption to unemployment is defined as the fall in consumption growth when unemployed.

The main results are as follows. First, the legalization of home equity withdrawal decreases the saving rate by roughly 2.5 percentage points. Weakened commitment explains roughly half of this decrease, while improved flexibility to smooth consumption explains the remainder. Second, households accumulate substantially less wealth by the time of retirement. Our model predicts a 15% reduction in wealth at the time of retirement due to the introduction of home equity withdrawal. Weakened commitment and improved consumption smoothing each account for roughly half of this reduction. Third, consumption sensitivity increases in the long-term as a result of reduced saving. We find that the sensitivity of consumption growth to unemployment increases by roughly 0.4 percentage points due to the legalization of home equity withdrawal. This is driven by long-term changes in household balance sheets, which we discuss in Appendix F.2.

To better understand the effect of financial liberalization, we provide further detail on the evolution of household behavior and balance sheets following the introduction of home equity withdrawal in Appendix F.

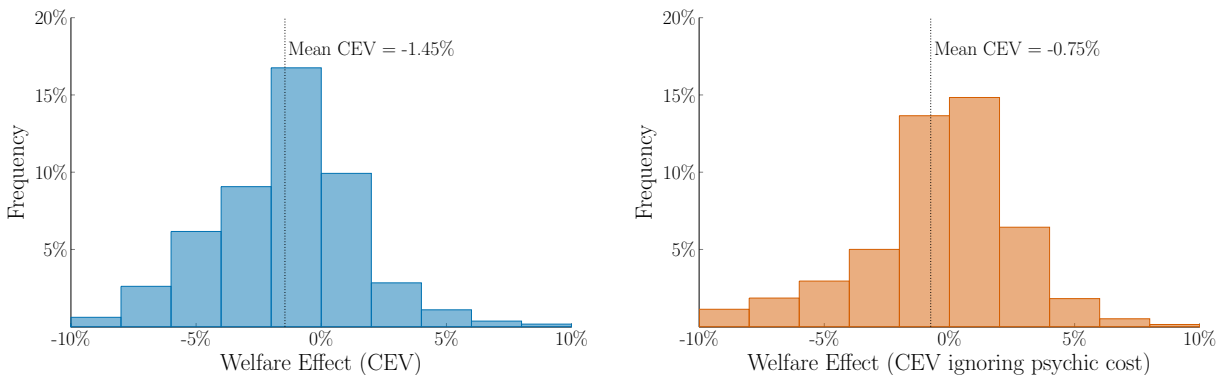
### 7.3 Substantial heterogeneity in welfare effects

We find that the aggregate welfare effect masks substantial heterogeneity across households. Figure 4 shows the underlying distribution of welfare changes across households. The first panel shows the baseline measure of welfare, while the second panel shows the alternative measure of welfare that ignores the psychic cost of temptation. In the baseline results, we

<sup>30</sup>Note that the quasi-experiment in Section 6 cannot be used to document the long-term implications of financial liberalization, as it would be unrealistic for the parallel trends assumption to hold in the long-term. For instance, Texas introduced another mortgage reform in 2004, therefore we limit our sample accordingly.

find that roughly two thirds of households are harmed by the legalization of home equity withdrawal, while the remaining one third benefit. The results are very similar when we consider the alternative welfare criterion.

Figure 4: Heterogeneity in the Welfare Effect of Legalizing Home Equity Withdrawal



**Note:** This figure shows the distribution of ex-post welfare changes that result from the legalization of home equity withdrawal. The welfare change is measured in terms of consumption equivalent variation. The first panel shows our baseline measure of welfare, while the second panel shows our alternative measure of welfare where we assume that the social planner does not care about the psychic cost of temptation.

What drives this heterogeneity across households? The winners of financial liberalization are households with relatively low income when young and higher than expected income when old. This is consistent with the view that financial liberalization, by relaxing credit constraints, allows households to achieve consumption more in line with their lifetime earning expectations, as documented by Gerardi et al. (2010) and Cocco (2013).

The biggest losers of financial liberalization are households with high income when young and lower than expected income when old. Financial liberalization causes these households to save less during the early part of their working-life, therefore making it more difficult to pay back their mortgage during the later part of their working-life. This is reminiscent of Cocco (2013), who notes that alternative mortgage products may be detrimental for households with expectations of higher future income that fails to materialize.

#### 7.4 Sensitivity to alternative modeling assumption

We evaluate the sensitivity of our baseline welfare results to alternative modeling assumptions, which we describe in Appendix G.2. The main results are shown in Table 6. In all cases, we find that weakened commitment generates large welfare costs relative to the benefits of improved consumption smoothing.

*Unsecured Borrowing* – We extend the baseline model to include unsecured borrowing in the form of credit cards. That said, it is not straightforward to calibrate this feature of

the model given that (i) not all households have credit cards and (ii) there is substantial variation in credit card limits across years. We choose to calibrate a liquid borrowing limit of  $\underline{a} = -\$34,000$  based on evidence that we discuss in Appendix G.2. We find that the introduction of credit cards slightly lowers the relative cost of weakened commitment. The economic intuition for this result is that housing is slightly less effective as a commitment device when households have access to credit cards, due to the fact that credit cards introduce additional temptation. However, the magnitude of this effect is small: the relative cost of weakened commitment becomes 1.62 compared to a baseline estimate of 1.76.<sup>31</sup>

Table 6: Sensitivity to Alternative Modeling Assumptions

	Relative Cost of Weakened Commitment
Baseline	1.76
Unsecured Borrowing	1.62
No Withdrawal if Unemployed	2.27
House Price Risk	1.80

**Note:** The relative cost of weakened commitment in each model is defined as the the welfare cost of weakened commitment relative to the benefit of improved consumption smoothing.

*No Withdrawal when Unemployed* – There is uncertainty about the extent to which unemployed homeowners are able to borrow.<sup>32</sup> In our baseline analysis, we allow households to extract home equity during any period in their working life, in order to give the best possible chance to the consumption smoothing benefits of home equity withdrawal. If we instead assume that households are unable to extract when unemployed, we find that our results are even more stark: households benefit less from improved consumption smoothing relative to the cost of weakened commitment.

*House Price Risk* – We augment the model with aggregate house price risk parameterized using the Case-Shiller house price index. We find that the presence of house price risk adds an additional channel by which financial liberalization is beneficial (the ability to consume out of unanticipated house price gains) and an additional channel by which it is detrimental (the temptation to increase consumption when house prices are temporarily elevated). We find that the quantitative importance of these two additional channels are similar, with the benefits and costs of home equity withdrawal both increasing by roughly the same amount.

<sup>31</sup>We find that the model also succeeds at matching the finding that many households carry revolving credit card debt while also holding illiquid housing wealth, as discussed in Laibson et al. (2017).

<sup>32</sup>For instance, DeFusco and Mondragon (2018) show that income requirements often prevent unemployed homeowners from refinancing, while Braxton, Herkenhoff and Phillips (2020) show that unemployed individuals have significant access to credit which they use for consumption smoothing purposes.

As a result, the relative cost of weakened commitment remains substantial, roughly 1.80 times the benefit of improved flexibility, only slightly higher than our baseline estimate.

## 8 Implications for mortgage design and public policy

How should policy makers design and regulate mortgages to improve household wellbeing and stabilize the macroeconomy? As mentioned previously, most countries have adopted one of two polar opposite policies. Countries like the U.S. and U.K. have made home equity withdrawal cheaper and more accessible to households, while others such as Germany and Singapore have prohibited equity withdrawal almost entirely.

In this section, we demonstrate that neither of these two extreme policies are optimal. Instead, welfare could be improved using state-contingent policies that provide the benefits of flexibility and commitment when they are valued the most. To give just one example of such a policy, we show that it would be welfare enhancing to design mortgages contracts to provide automatic flexibility during periods of financial distress, but otherwise restrict access to home equity. We then discuss a number of practical considerations about how such policies could be implemented.

### 8.1 Alternative mortgage policies

We use our estimated model to evaluate the following policy alternatives:

1. *Home equity withdrawal permitted.* This is the baseline version of the model, calibrated to the U.S. institutional setting.
2. *Home equity withdrawal permitted, subject to debt-to-income cap.* We impose a maximum debt-to-income (DTI) ratio of 4.5 at the time of mortgage origination or equity extraction, similar to the policy implemented by the United Kingdom in June 2014.
3. *Home equity withdrawal prohibited.* We impose the restriction that households can only take out mortgage debt at the time of home purchase, thus eliminating the possibility of home equity withdrawal. This is similar to restrictions in Germany, Singapore, Japan, and a handful of other countries (IMF, 2008).
4. *State-dependent access to home equity.* We implement a policy where home equity withdrawal is permitted only during periods of financial distress. We define financial distress to be a period of unemployment, though there are alternative ways that this could be implemented, as we discuss later.<sup>33</sup>

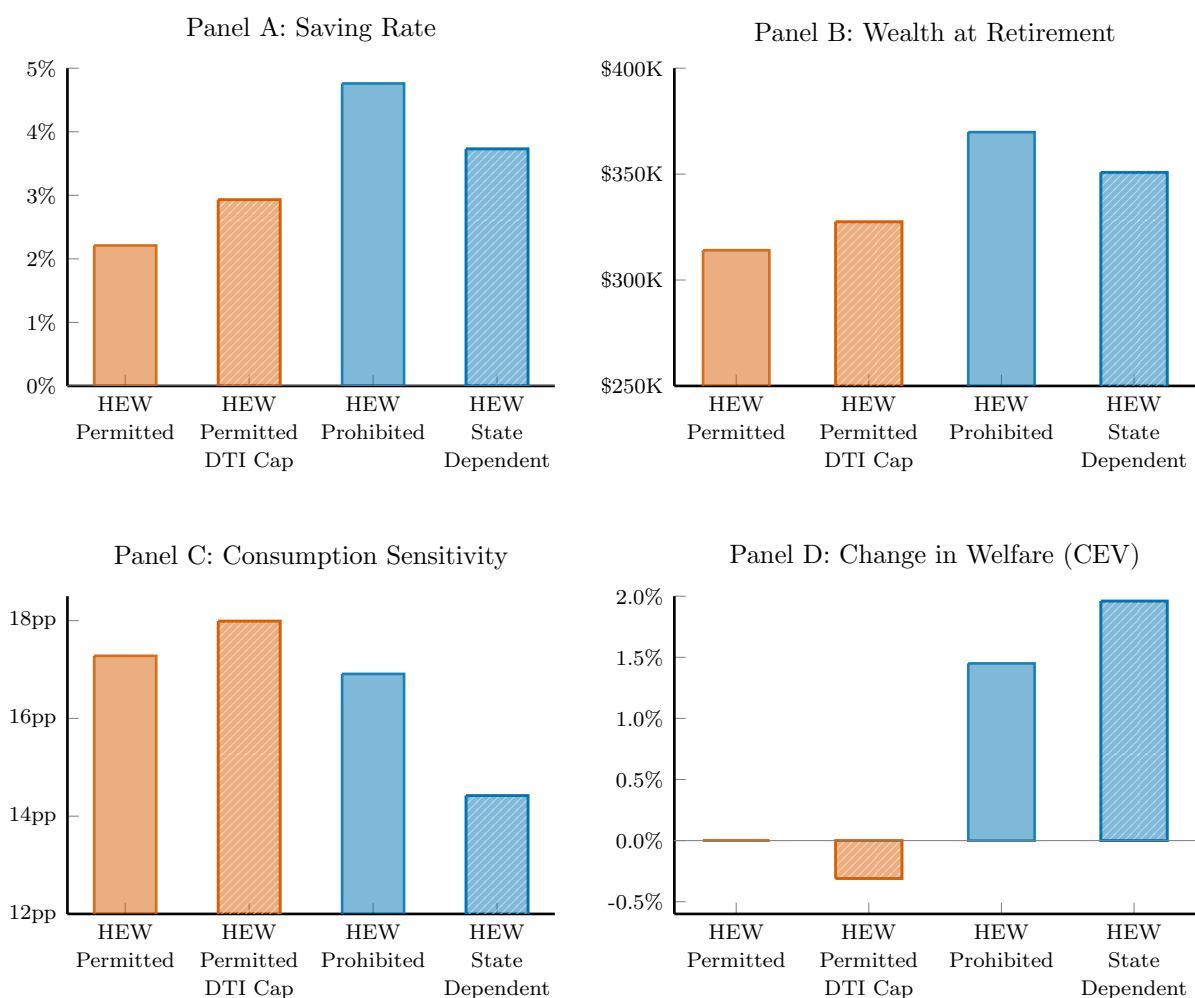
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<sup>33</sup>The definition of financial distress that we use is inspired by Pennsylvania's Homeowners' Emergency

## 8.2 Households benefit from state-contingent mortgage policies

Figure 5 presents the effect of these four different policies on household behavior and wellbeing. Panel A shows the working-age personal saving rate, Panel B shows net wealth at retirement, Panel C shows the sensitivity of consumption growth to unemployment, and Panel D shows the change in welfare relative to baseline. The first bar depicts the baseline policy where equity withdrawal is permitted, while the subsequent bars depict the alternative policies.

Figure 5: Household Behavior and Wellbeing across Alternative Policies



**Note:** This figure shows statistics for the four policy options that we consider using the estimated model. Panel A gives the saving rate of working age households, Panel B gives net wealth at the time of retirement, Panel C gives consumption growth sensitivity to unemployment, and Panel D gives the change in welfare relative to the policy where home equity withdrawal is fully permitted. Consumption growth sensitivity to unemployment is given by the difference in log consumption growth when employed and unemployed.

Mortgage Assistance Program, which provides home equity loans to homeowners who have suffered job loss or other forms of financial hardship (Orr et al., 2011). An alternative approach would be to define financial distress based on the aggregate state of the economy, which we believe would give similar results.

We find that all of the alternative policies result in higher saving rates relative to the baseline where home equity withdrawal is fully permitted (Panel A). This translates to higher wealth at retirement under all of the alternative policies (Panel B). Reduced access to credit prevents households from consuming as much when young or middle aged. Of the alternative policies we consider, a complete prohibition on home equity withdrawal results in the highest saving rate and wealth at retirement.

The alternative policies have starkly different effects on consumption sensitivity. We find that the DTI cap increases consumption sensitivity relative to baseline, while state-dependent access to home equity reduces consumption sensitivity (Panel C). The DTI cap makes it more difficult for households to smooth consumption, since the constraint is more likely to bind after a fall in income, thus preventing households from accessing home equity to support consumption. In contrast, the state-dependent policy results in a substantial reduction in consumption sensitivity. By providing state-dependent access to home equity, this policy enables households to smooth consumption during periods of low income. Moreover, by limiting households' ability to extract home equity during normal times, the policy mitigates the problem of weakened commitment, thus helping households build a larger buffer of housing wealth which they can draw upon during periods of distress.

Turning to welfare, we find that the largest benefit comes from the state-dependent policy, while in contrast, the commonly-used debt-to-income cap reduces welfare (Panel D). The state-dependent policy provides the largest improvement to welfare (1.96% in CEV) because it better balances the trade-off between flexibility and commitment compared to either of the extreme policies that fully permit or prohibit home equity withdrawal. The economic intuition for this result is that the marginal benefit of flexibility is highest during periods of financial distress, while the marginal benefit of commitment is highest otherwise. Thus a state-dependent policy provides the benefits of flexibility and commitment when they are valued the most. In contrast, a DTI cap restricts access to home equity when income is low, and the marginal benefit of flexibility is high, thus harming household wellbeing.

Finally, we have also used the model to evaluate a conditional mortgage forbearance policy, where households are required to make regular mortgage payments during normal times, but receive automatic mortgage forbearance during periods of financial distress. (For the sake of brevity we omit the results from Figure 5.) The results are similar to the policy of state-dependent access to home equity, although the consumption smoothing benefits are slightly muted. For instance, we find that conditional mortgage forbearance increases welfare by 1.62% relative to the baseline where equity withdrawal is fully permitted. Overall, this policy is better than most of the alternatives, but does not provide the same level of benefit



as allowing households to tap into home equity during periods of financial distress.

### 8.3 Practical considerations for policy design

The above results demonstrate that complete bans on home equity withdrawal go too far, eliminating some of the most important benefits of improved flexibility. That said, households may still benefit from some carefully designed restrictions, given the important role of housing as a savings commitment device. The goal of this section is to consider the practical design and implementation of such policies.

First, our model does not seek to capture every potential benefit of home equity withdrawal. We focus on consumption smoothing given its prominent role in the literature. However, we must make some simplifying assumptions for our model to remain tractable. For instance, we exclude the ability to extract home equity for renovation or home improvement purposes, among other examples. How should we design policy given the other unmodeled benefits to equity withdrawal? One solution may be to allow home equity withdrawal conditional on a broad set of preapproved reasons. This approach has some precedent: for instance, while Texas prohibited most forms of home equity loans prior to 1998, they had an exception that allowed banks to offer home equity loans for the purpose of renovation or home improvement.<sup>34</sup> While we believe that the policy in Texas was too strict, eliminating the ability to smooth consumption, it may provide a useful conceptual framework. Policy makers could instead implement a policy that allows for a much broader set of approved reasons, which may include many of the following: divorce, home renovation, education spending, medical bills, financial distress, unemployment, reduced income, small business investment, etc. Such a policy would help improve the commitment benefit of housing, while also providing substantially more flexibility than is currently permitted in countries like Germany and Singapore.

Second, there are multiple ways that state-contingent contracts or policies could be implemented in practice. Eberly and Krishnamurthy (2014) propose the creation of “automatic stabilizer mortgage contracts” that would reduce mortgage payments during downturns. Alternatively, Orr et al. (2011) propose a national mortgage assistance program that could provide home equity loans to unemployed homeowners, identified through unemployment insurance claims filed at the time of layoff. While our counterfactual policy is most closely related to the latter proposal, we believe the results would be similar if we considered contracts that provide state-contingent flexibility conditional on macroeconomic indicators.

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<sup>34</sup>More specifically, banks were only allowed to foreclose upon homeowners for debt that was used to purchase or construct the home. The latter was interpreted broadly, allowing for renovation/home improvement. Banks in Texas thus had an incentive to ask borrowers for documentation on how they would use their loan.

Third, households may differ in their desire for self-control and commitment. While it would be possible to extend our model to include heterogeneity in  $\lambda$ , we have decided not to do so for simplicity, therefore our estimate of  $\lambda$  should be viewed as the average across households.<sup>35</sup> How should policy be altered given the possibility of preference heterogeneity? One solution is to offer a menu of different contracts that allow households to choose mortgages that offer varying levels of commitment and/or flexibility. This would allow households to self-select into the mortgage contract that is most suitable given their needs. Unfortunately, such mortgage contracts are currently prohibited by U.S. law, which we discuss below.

Why do banks not offer mortgages that provide state-contingent access to home equity? There are a number of regulatory barriers. First, U.S. federal law currently prohibits private contractual limitations on home equity withdrawal.<sup>36</sup> Second, recent legislation discourages banks from offering mortgages that feature interest-only or negative-amortization periods.<sup>37</sup> Third, the tax treatment of state-contingent mortgage contracts is unclear. Piskorski and Seru (2018) further discuss the design and implementation challenges of ex ante and ex post debt relief solutions using state-contingent mortgage contracts and policies.

Our results complement a growing finance literature that advocates for mortgage contracts and policies that automatically provide flexibility to homeowners during financial distress. As discussed previously, numerous studies demonstrate that state-contingent contracts provide a better risk-sharing arrangement between borrowers and lenders, particularly as relates to house price or interest rate risk. Our paper is the first in this literature to consider mortgage design when there is a trade-off between flexibility and commitment, which further strengthens the need for state-contingent flexibility.

Despite the regulatory challenges above, there are growing efforts to provide flexibility to homeowners during periods of financial distress. For instance, the U.S. provided mortgage forbearance to borrowers who suffered a pandemic-related loss of income (Cherry et al., 2021). Many other countries have implemented similar mortgage repayment holidays (Albuquerque and Varadi, 2022). State-contingent mortgage policies may be a powerful new tool to assist

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<sup>35</sup>It would be straightforward to extend our analysis to investigate heterogeneity in  $\lambda$  across households grouped by observable characteristics. We have investigated this possibility and found a small degree of heterogeneity across education groups, although we suffer from reduced power due to smaller sample sizes.

<sup>36</sup>The Garn-St. Germain Act prohibits the enforcement of mortgage clauses that accelerate mortgage repayment upon the encumbrance of a property with a junior lien. As a result, households have the ability to obtain home equity loans without the consent of the first lien originator (Levitin and Wachter, 2015). In contrast, prior to the passage of this law in 1982, contractual restrictions on leverage were common.

<sup>37</sup>The Dodd-Frank Act created the Qualified Mortgage (QM) category of loans, which provide lenders with a legal “safe harbor” against lawsuits brought by distressed borrowers. According to current regulation, QM loans cannot contain interest-only or negative-amortization periods (DeFusco et al., 2019). This disincentives the creation of state-dependent mortgages that automatically reduce payment during times of hardship.

in the task of macroeconomic stabilization.

## 9 Conclusion

In this paper, we evaluate the impact of home equity withdrawal on consumption, saving, and welfare. On one hand, access to home equity improves the ability of households to self-insure against income shocks, but on the other hand, access to home equity may weaken the commitment benefit of housing. We estimate the relative importance of these two channels and find that the cost of weakened commitment is large, around 1.7 times larger than the benefit of improved consumption smoothing.

An important aspect of our approach is that we disentangle the relative importance of these two opposing channels using observational data on consumption and assets. While there is a vast literature documenting demand for commitment in laboratory and field experiments, there are surprisingly few studies that assess the value placed on commitment using observed life-cycle decisions. We view these two approaches as complementary. While experimental methods have given us valuable insight into behavior, there are benefits to using data from real-world markets with large financial decisions, as this approach gives greater external validity and is better suited to policy analysis. Our findings are generally consistent with the experimental literature.<sup>38</sup>

There is a growing policy debate about how to regulate financial products that give households greater access to credit (Bar-Gill and Warren, 2008). When considering such regulation, policy makers need to evaluate the benefits of improved flexibility against the costs of weakened commitment. Our framework allows for such analysis. While we have focused on home equity withdrawal, it may be interesting to extend our analysis to study interest-only and negative-amortization mortgages, both of which experienced rapid growth in popularity during the early and mid-2000s (Amromin et al., 2018). While these products allow households to purchase larger homes, they also reduce required mortgage payments, which may have an important impact on household saving behavior.<sup>39</sup>

Finally, while we have focused on the impact of home equity becoming more liquid, it is important to note that this is part of a broader trend where illiquid assets are becoming more liquid in the United States. During recent decades, financial innovation has given households greater ability to borrow from their retirement accounts (Beshears et al., 2011; Lu

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<sup>38</sup>For instance, Ashraf et al. (2006) and Beshears et al. (2020b) document that many individuals value illiquid savings products over their liquid counterparts, consistent with our estimated model.

<sup>39</sup>Recent quasi-experimental evidence from the Netherlands indicates that amortization payments play an important role in wealth accumulation, consistent with our model (Bernstein and Koudijs, 2021).

et al., 2017). In addition, some banks have begun offering debit cards allowing households to instantaneously borrow from their retirement accounts, leading to debate in the U.S. Congress about whether to ban such financial products (Burton, 2008). This has generated a discussion about the optimal level of illiquidity in retirement accounts (Beshears et al., 2020a). Greater liquidity in retirement accounts may have important implications for household consumption and saving behavior, similar to the mechanism studied in this paper.

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# Internet Appendix

## A Additional Model Details

### A.1 Taxes

Household pre-tax income ( $y_{i,t}$ ) is the sum of the primary and secondary earners' income during the working-life and taxed using a progressive tax schedule  $\tau(\cdot)$ . We follow Keane and Wasi (2016) and assume a nonlinear tax function:

$$\tau(y_{i,t}, a_{i,t}) = e^{\tau_1 + \tau_2 \log(y_{i,t} + ra_{i,t} - \tau_d)} \quad (\text{A.1})$$

where the parameters  $\tau_1$  and  $\tau_2$  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,  $\tau_d$  represents the deduction which is subtracted from income before the tax is applied. We define  $\tau_d$  to be the greater of either the standard deduction  $\tau_d^{\text{standard}}$  or the mortgage interest payments made in that period. 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 household income given by  $\tilde{y}_{i,t} = y_{i,t} - \tau(y_{i,t}, a_{i,t})$ .

### A.2 Social security

Following retirement ( $\forall t > W$ ), households receive two sources of income: progressive social security income and annuitized disbursements from an individual retirement account:

$$y_{i,t} = y_{i,t}^{SS} + y_{i,t}^{IRA} \quad \forall t > W \quad (\text{A.2})$$

The progressive social security-style pension is determined by the following rule:

$$y_{i,t}^{SS} = \max \left\{ \text{SS Income Floor, Annual PIA}(y_{i,W}) \right\} \quad (\text{A.3})$$

where  $\text{Annual PIA}(y_{i,W})$  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,  $y_{i,W}$ .<sup>40</sup> We calibrate the social security income floor and primary insurance amount based on U.S. legislation from 2015.<sup>41</sup>

### A.3 Retirement accounts

Annuitized disbursements from an individual retirement account serve as an alternative savings commitment device that helps households accumulate wealth for retirement. We assume that retirement contributions are mandatory and must be converted to an annuity at age  $W$ . This assumption implies that households suffer zero temptation to consume their retirement account.<sup>42</sup>

During each year of retirement, households receive annuitized disbursements that depend on the actuarially fair annuity rate  $\eta_1$  and the size of their account at retirement  $IRA_{i,W+1}$ :

$$y_{i,t}^{IRA} = \eta_1 * IRA_{i,W+1} \quad (\text{A.4})$$

The value of these disbursements depend on the age of retirement, life expectancy, and the household's income during its final working period. The actuarially fair annuity rate for a household that purchases an annuity at age  $j$ , given the survival probability  $s_t$ , is:

$$\eta_1 = \left[ \sum_{t=j}^T \frac{s_t}{(1+r)^{t-j}} \right]^{-1} \quad (\text{A.5})$$

This annuity rate is actuarially fair as it enables the purchase of a guaranteed income stream until death, where the price of the annuity is equal to its expected discounted value, conditional on the interest rate and survival probabilities. We require all households to purchase an annuity in the first year of retirement using the entirety of their retirement account.

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<sup>40</sup>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.

<sup>41</sup>The PIA is a piecewise linear function with two break points: 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.

<sup>42</sup>This is a conservative assumption, as retirement accounts in the U.S. are not perfectly illiquid (Beshears et al., 2015), therefore households may still suffer temptation to consume these accounts when young. By assuming that retirement accounts provide perfect commitment, our estimate of the welfare effect of giving households greater access to home equity will be a lower bound estimate of the true welfare effect. That said, retirement accounts have also become more liquid during recent years, therefore their commitment benefit may have been similarly weakened. Beshears et al. (2011) document that the share of 401(k) pension accounts that allow their holders to obtain a loan against their invested assets increased during the 1990s and 2000s. Moreover, the introduction of the 401(k) debit card has made it even easier to borrow from retirement accounts and been the subject of much controversy (Burton, 2008). This has generated a discussion about the optimal level of illiquidity in retirement saving accounts (Beshears et al., 2020a).

We assume that the size of the retirement account is a linear function of the household's last working period income.<sup>43</sup> 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 simple formula:

$$\text{IRA}_{i,W+1} = \eta_2 * y_{i,W} \quad (\text{A.6})$$

The relationship between last period income and the size of retirement accounts ( $\eta_2$ ) can then be estimated using PSID data.

#### A.4 Mortgage amortization schedule

We assume that mortgages require regular amortization payments.<sup>44</sup> Mortgages have term length  $l$ . We require  $m_{t+l} = 0$ . Equation (4) implies  $m_{t+l-1} = mp$ . Then iterating to the previous period we get:

$$mp = (m_{t+l-2} - mp)(1 + r^M) \quad (\text{A.7})$$

$$mp = (1 + r^M)m_{t+l-2} - (1 + r^M)mp \quad (\text{A.8})$$

as again  $m_{t+l-2} = (m_{t+l-3} - mp)(1 + r^M)$ , we get

$$mp = (1 + r^M)^2 m_{t+l-3} - (1 + r^M)mp - (1 + r^M)^2 mp \quad (\text{A.9})$$

we can use this rule iteratively to get:

$$mp \sum_{i=0}^{t+l-1-(t+1)} (1 + r^M)^i = (1 + r^M)^{t+l-1-(t+1)} m_{t+1}. \quad (\text{A.10})$$

Using the evolution of mortgage,  $m_{t+1} = (1 + r^M)m_t$ , the relationship between  $mp$  and  $m_t$  is:

$$mp = \frac{(1 + r^M)^l}{\sum_{i=1}^{l-1} (1 + r^M)^i} m_t \quad (\text{A.11})$$

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<sup>43</sup>In reality, few countries have compulsory retirement accounts. One notable exception is Singapore where working age households are required to put at least 20% of their income into the Central Provident Fund each year. Agarwal, Pan and Qian (2019) provide evidence that this has an important impact on consumption, evidence that is consistent with the view that households suffer from temptation.

<sup>44</sup>Housing may act as a commitment device not only because it is illiquid, but also because it requires regular amortization payments. Bernstein and Koudijs (2021) provide evidence that amortization payments increase wealth accumulation.

## A.5 Unemployment

Our model incorporates the possibility of unemployment. We assume that when unemployed the primary earner receives unemployment benefits ( $\ln y_{i,t}^p = \ln b$ ) that is the same for all households. Although unemployment benefits in the U.S. depend on past income, they are capped at a low level, therefore the dependence on past income is low compared to other countries (Hsu et al., 2018). Following a period of unemployment, the stochastic component of income  $z_{i,t}$  is drawn from a normal distribution  $N(\mu_u, \sigma_\varepsilon^2)$ , where  $\mu_u < 0$  represents potential income scarring following unemployment.

## A.6 Functional forms

For ease of exposition, in the main text we present the felicity function assuming that household composition is constant over the life-cycle. In reality, however, changes in household composition are important to match life-cycle behaviour. For this reason, we allow the felicity function to vary with household composition as follows:

$$u(c_t, h_t, n_t) = n_t \left( (1 - \omega) \frac{\left(\frac{c_t}{n_t}\right)^{1-\gamma}}{1-\gamma} + \omega \frac{[\phi(h_t, n_t)]^{1-\alpha}}{1-\alpha} - \kappa \mathbb{I}_{h_t \neq h_{t-1}} \right) \quad (\text{A.12})$$

where  $n_t$  is the exogenously given equivalence scale. The utility benefit of housing is:

$$\phi(h_t, n_t) = \begin{cases} \frac{h_t}{n_t} & \text{if owner} \\ \zeta \frac{h_t}{n_t} & \text{if renter} \end{cases} \quad (\text{A.13})$$

We assume that households value bequests, following De Nardi (2004):

$$b(a^b) = \theta^b \frac{(a^b + K)^{1-\gamma}}{1-\gamma} \quad (\text{A.14})$$

where  $a^b$  are assets bequeathed,  $\theta^b$  measures the importance of the bequest motive, while  $K$  is a constant ensuring that the marginal utility of leaving no bequest is finite.  $K$  also determines the extent to which bequests are a luxury. Assets bequeathed are a composition of liquid assets and housing asset.

$$a_{t+1}^b = a_{t+1} + p_{t+1}(h_t) \quad (\text{A.15})$$



## A.7 Recursive formulation.

Households live for a maximum  $T$  periods, and after retirement they face death with a given probability, depending on their age. Survival probability,  $s_t$ , captures the probability of the household to survive to age  $t$  conditional on them having survived to age  $t - 1$ . In order to solve households' optimization problem we define the following recursive formulation:

$$V_t(\Omega_t) = \max \left\{ V_t^0(\Omega_t), V_t^1(\Omega_t) \right\} \quad (\text{A.16})$$

where  $V_t^0(\Omega_t)$  and  $V_t^1(\Omega_t)$  are the value functions conditional on not adjusting housing, and adjusting housing. Those who choose not to adjust their house in period  $t$  solve the following dynamic problem:

$$V_t^0(\Omega_t) = \max_{\{c_t, m_{t+1}\}} U(c_t, h_t, \tilde{c}_t, \tilde{h}_t) + s_t \beta \mathbb{E}_t V_{t+1}(\Omega_{t+1}) + (1 - s_t) b(a_{t+1}^b), \quad (\text{A.17})$$

subject to:

$$a_{t+1} = (1 + r) \left\{ a_t + \tilde{y}_t - c_t - \mathbb{I}_t^O mp(m_t) - (1 - \mathbb{I}_t^O) \chi_t - \mathbb{I}^{HEW} \left[ C^R + F^R \left( \frac{m_{t+1}}{1 + r^M} - m_t \right) \right] \right\}$$

$$m_{t+1} \leq (1 + r^M) \begin{cases} (1 - \psi^{\min}) p_t(h_t), & \text{if } \mathbb{I}_t^O \text{ and } \mathbb{I}_t^{HEW} \\ m_t - mp(m_t), & \text{if } \mathbb{I}_t^O \text{ and } 1 - \mathbb{I}_t^{HEW} \end{cases}$$

where we use indicator function  $\mathbb{I}_t^O$  to flag owners at time  $t$  and  $\mathbb{I}_t^{HEW}$  to flag owners who extract home equity at time  $t$ . Those who choose to adjust their house in period  $t$  solve the following dynamic problem:

$$V_t^1(\Omega_t) = \max_{\{c_t, h_t, \tilde{c}_t, \tilde{h}_t\}} U(c_t, h_t, \tilde{c}_t, \tilde{h}_t) + s_t \beta \mathbb{E}_t V_{t+1}(\Omega_{t+1}) + (1 - s_t) b(a_{t+1}^b), \quad (\text{A.18})$$

subject to:

$$a_{t+1} = (1 + r) \left\{ a_t + \tilde{y}_t - c_t - (1 - \mathbb{I}_t^O) \chi_t - (1 + F) p_t(h_t) + \frac{m_{t+1}}{(1 + r^M)} + (1 - F) p_t(h_{t-1}) - m_t \right\}$$

$$m_{t+1} \leq (1 + r^M) \begin{cases} (1 - \psi^{\min}) p_t(h_t), & \text{if } \mathbb{I}_{t+1}^O \\ 0, & \text{if } 1 - \mathbb{I}_t^O \end{cases}$$

## B Implications of temptation for consumption growth dynamics

### B.1 Deriving the Euler equation

For the ease of exposition, we focus on a stylized version of the model without housing. The Bellman equations represented by equations (A.18) and (A.19) under this assumption simplify to the following Bellman equation:

$$\begin{aligned} V_t(\Omega_t) &= \max_{c_t} U(c_t, \tilde{c}_t) + s_t \beta \mathbb{E}_t V_{t+1}(\Omega_{t+1}) + (1 - s_t) b(a_{t+1}^b) \\ &\text{subject to:} \\ a_{t+1} &= (1 + r)(a_t + \tilde{y}_t - c_t) \end{aligned} \tag{B.1}$$

Note that  $\tilde{c}_t$  is a function of liquids asset available at time  $t$ ,  $a_t$ , as the most tempting consumption alternative without housing or mortgage options is simply  $\tilde{c}_t = a_t + \tilde{y}_t$ . Further, we use the notation  $U_t = U(c_t, \tilde{c}_t)$  for simplicity and derive the first order conditions for the problem with respect to  $c_t$ , which is:

$$\frac{\partial U_t}{\partial c_t} = \beta(1 + r) \mathbb{E}_t \left[ \frac{\partial V_{t+1}(\Omega_{t+1})}{\partial a_{t+1}} \right] \tag{B.2}$$

The envelope condition with respect to  $a_t$  is:

$$\frac{\partial V_t(\Omega_t)}{\partial a_t} = \frac{\partial U_t}{\partial \tilde{c}_t} \frac{\partial \tilde{c}_t}{\partial a_t} + \beta(1 + r) \mathbb{E}_t \left[ \frac{\partial V_{t+1}(\Omega_{t+1})}{\partial a_{t+1}} \right] \tag{B.3}$$

Combining the first order condition with the envelope condition we can formulate the Euler Equation in its most general form:

$$\frac{\partial U_t}{\partial c_t} = \beta(1 + r) \mathbb{E}_t \left[ \frac{\partial U_{t+1}}{\partial c_{t+1}} + \frac{\partial U_{t+1}}{\partial \tilde{c}_{t+1}} \frac{\partial \tilde{c}_{t+1}}{\partial a_{t+1}} \right] \tag{B.4}$$

Using the functional form for the utility function defined in equation (8) and assuming no housing ( $\mu = 0$ ,  $\theta = 0$ ), the Euler equation takes the following form:

$$c_t^{-\gamma} = \beta(1 + r) \mathbb{E}_t \left[ c_{t+1}^{-\gamma} - \frac{\lambda}{1 + \lambda} (\tilde{c}_{t+1})^{-\gamma} \right] \tag{B.5}$$

Note that these results rely on the assumption that households are sophisticated. If households were naive, then  $\tilde{c}_{t+1}$  would not appear in the Euler equation. This informs our modeling decisions. We model households as sophisticated because this form of preferences generates

testable implications for consumption growth that we can use to pin down its importance.

## B.2 Log-linearizing the Euler equation

First, let us express the Euler equation in the form of  $1 = (1+r)\mathbb{E}_t k_{t+1}$ , where we define  $k_{t+1}$  as the pricing kernel in period  $t+1$ . Therefore  $k_{t+1}$  can be written as:

$$k_{t+1} = \beta \left( \frac{c_{t+1}}{c_t} \right)^{-\gamma} \left[ 1 - \frac{\lambda}{1+\lambda} \left( \frac{\tilde{c}_{t+1}}{c_{t+1}} \right)^{-\gamma} \right] \quad (\text{B.6})$$

Assuming that all the variables in the pricing kernel are stationary, we can take log-linear approximation around their steady states. First, we take logs of both sides

$$\ln k_{t+1} = \ln(\beta) - \gamma \ln \left( \frac{c_{t+1}}{c_t} \right) + \ln \left[ 1 - \frac{\lambda}{1+\lambda} \left( \frac{\tilde{c}_{t+1}}{c_{t+1}} \right)^{-\gamma} \right], \quad (\text{B.7})$$

we then take the first-order Taylor approximation around the steady state

$$\widehat{k}_{t+1} = -\gamma \widehat{\left( \frac{c_{t+1}}{c_t} \right)} + \gamma \Upsilon_1 \widehat{\left( \frac{\tilde{c}_{t+1}}{c_{t+1}} \right)} \quad (\text{B.8})$$

where  $\Upsilon_1 = \frac{\lambda}{(1+\lambda) \left( \frac{\tilde{c}}{c} \right)^{\gamma} - \lambda}$ . Now we apply approximation  $\tilde{x}_t \approx \ln x_t - \ln x$  to get

$$\ln k_{t+1} - \ln k = -\gamma \ln \left( \frac{c_{t+1}}{c_t} \right) + \gamma \Upsilon_1 \left[ \ln \left( \frac{\tilde{c}_{t+1}}{c_{t+1}} \right) - \ln \frac{\tilde{c}}{c} \right] \quad (\text{B.9})$$

From equation (B.7), we also know that  $\ln k = \ln(\beta) + \ln \left[ 1 - \frac{\lambda}{1+\lambda} \left( \frac{\tilde{c}}{c} \right)^{-\gamma} \right]$ , which we can substitute into equation (B.9) to get

$$\ln k_{t+1} = \ln(\beta) + \ln \left[ 1 - \frac{\lambda}{1+\lambda} \left( \frac{\tilde{c}}{c} \right)^{-\gamma} \right] - \gamma \ln \left( \frac{c_{t+1}}{c_t} \right) + \gamma \Upsilon_1 \left[ \ln \left( \frac{\tilde{c}_{t+1}}{c_{t+1}} \right) - \ln \frac{\tilde{c}}{c} \right] \quad (\text{B.10})$$

Using  $0 = \ln(1+r) + \mathbb{E}_t[\ln k_{t+1}]$  we can derive the estimable version of the Euler equation

$$\ln \left( \frac{c_{t+1}}{c_t} \right) = a_0 + a_1 \ln(1+r) + a_2 \ln \left( \frac{\tilde{c}_{t+1}}{c_{t+1}} \right) + u_{t+1} \quad (\text{B.11})$$

where

$$a_0 = \frac{\ln \beta + \ln \left[ 1 - \frac{\lambda}{1+\lambda} \left( \frac{\tilde{c}}{c} \right)^{-\gamma} \right]}{\gamma}, \quad a_1 = \frac{1}{\gamma}, \quad a_2 = \frac{\lambda}{(1+\lambda) \left( \frac{\tilde{c}}{c} \right)^\gamma - \lambda}.$$

Note that without temptation, the log-linearized Euler equation becomes:

$$\ln \left( \frac{c_{t+1}}{c_t} \right) = b_0 + b_1 \ln(1+r) + v_{t+1} \quad (\text{B.12})$$

with

$$b_0 = \frac{\ln \beta}{\gamma}, \quad b_1 = \frac{1}{\gamma}.$$

Both  $u_{t+1}$  and  $v_{t+1}$  includes expectational errors, and higher order approximation errors for the appropriate variables. In Section 3, we use equations (B.11) and (B.12) to show the relevance of these results and to discuss the intuition of these Euler equations.

### B.3 Derivation: $a_0 < b_0$ and $a_2 > 0$

To see that the constant term in the log-linearized Euler equation of the model with temptation is less than the constant term in the Euler equation of the model without temptation ( $a_0 < b_0$ ), we need to prove that

$$\ln \left[ 1 - \frac{\lambda}{1+\lambda} \left( \frac{c}{\tilde{c}} \right)^\gamma \right] < \ln 1 \quad (\text{B.13})$$

As the most tempting consumption alternative ( $\tilde{c}$ ) is, by definition, higher or equal to actual consumption ( $c$ ), we know that  $\left( \frac{c}{\tilde{c}} \right)^\gamma \leq 1$ . Now, given that  $\lambda > 0$  in the temptation model, it is straightforward to show that

$$0 < \frac{\lambda}{1+\lambda} \left( \frac{c}{\tilde{c}} \right)^\gamma < 1$$

and therefore the inequality in equation (B.13) holds, implying  $a_0 < b_0$ .

In order to see that the coefficient on the tempting consumption alternative in the Euler equation of the model with temptation is greater than zero ( $a_2 > 0$ ), we need to prove that

$$\frac{\lambda}{(1+\lambda) \left( \frac{\tilde{c}}{c} \right)^\gamma - \lambda} > 0 \quad (\text{B.14})$$

$$\left( \frac{\tilde{c}}{c} \right)^\gamma > \frac{\lambda}{1+\lambda}$$

Using condition  $\left(\frac{\tilde{c}}{c}\right)^\gamma \geq 1$  again together with the fact that  $\lambda > 0$  in the temptation model, we can see that

$$\left(\frac{\tilde{c}}{c}\right)^\gamma \geq 1 > \frac{\lambda}{1 + \lambda} \quad (\text{B.15})$$

Therefore the inequalities in equation (B.14) hold, implying  $a_2 > 0$ .

## C Estimation strategy

### C.1 Data and Sample

The PSID began collecting detailed information on household spending in 1999, after adding numerous additional spending questions to the survey. We take advantage of the post 1999 data and adopt the definition of nondurable spending used by Blundell et al. (2016). Nondurable spending includes food at home, food away from home, food stamps, gasoline, nondurable transportation, rent, utilities, home insurance, health insurance, health services, education, and child care.

We define liquid assets as the sum of all checking and saving accounts, money market funds, certificates of deposit, government saving bonds, treasury bills, and shares of stock in publicly held corporations, mutual funds, or investment trusts, not including any assets held in employer-based pensions or IRAs. We define net housing wealth as the self-reported value of the household's house or apartment if sold today, minus any mortgages, home equity loans, home improvement loans, lines of credit, or other debts secured against the property.

In our baseline analysis, we focus on married households between the ages of 25 and 60. We restrict the sample to married households to ensure consistency between the model and data, while abstracting from issues of household formation. A previous version of this paper estimated the model using data for both single and married households, finding broadly similar results.<sup>45</sup>

### C.2 Parameters set outside the model

Table C.1 shows the parameters set outside the model. Most of these have been described in Section 4.2. Here we describe the remaining model parameters. For the parameters of the non-linear tax function, we use the estimation results by Keane and Wasi (2016), converted to 2015 dollars. Income after retirement is not subject to any risk. After retirement, households

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<sup>45</sup>When including single households in the sample, we find a positive and significant  $\hat{\psi} = 0.00447$  in the PSID and  $\hat{\lambda} = 0.387$  in the model. Both estimates are slightly higher than our baseline results using married households, suggesting that single households are slightly more tempted than married households. We therefore view our baseline estimates as conservative lower bounds. Full results available upon request.

Table C.1: Parameters set outside the model

Parameter	Symbol	Value	Source
Income Persistence	$\rho$	0.97	PSID 1999-2015
Std Dev Income Shocks	$\sigma_\varepsilon$	0.180	PSID 1999-2015
Initial Income	$\sigma_0$	0.410	PSID 1999-2015
Income Constant	$d_0$	8.2007	PSID 1999-2015
Income <i>Age</i> Effect	$d_1$	0.1378	PSID 1999-2015
Income <i>Age</i> <sup>2</sup> Effect	$d_2$	-0.0019	PSID 1999-2015
Income <i>Age</i> <sup>3</sup> Effect	$d_3$	0.000007	PSID 1999-2015
Income Constant (Second earner)	$d_0^s$	8.7853	PSID 1999-2015
Income <i>Age</i> Effect (Second earner)	$d_1^s$	0.0203	PSID 1999-2015
Income <i>Age</i> <sup>2</sup> Effect (Second earner)	$d_2^s$	0.0004	PSID 1999-2015
Income <i>Age</i> <sup>3</sup> Effect (Second earner)	$d_3^s$	-0.000006	PSID 1999-2015
Unemployment probability	$\pi_u$	0.053	PSID 1999-2015
Re-employment probability	$\pi_{re}$	0.397	PSID 1999-2015
Scarring effect of unemployment	$\mu_u$	-0.388	PSID 1999-2015
Unemployment benefit	$b$	\$11270	Hsu et al. (2018)
Housing Transaction Cost	$F$	0.05	Attanasio et al. (2012)
Maximum Loan-to-Value	$\bar{\psi}$	0.9	Gorea and Midrigan (2017)
Additive Refi Cost	$f_0$	\$3100	Federal Reserve Board (2008)
Multiplicative Refi Cost	$f_1$	0.05	Federal Reserve Board (2008)
Rental Scale	$\eta$	0.035	Leombroni et al. (2020)
Housing asset return	$r^H$	0.021	Case-Shiller Data
Liquid asset return	$r$	0.0069	3 Month T-Bill
Mortgage rate	$r^M$	0.041	Primary Mortgage Market Survey
Share with zero initial assets	$a_0^{\text{zero}}$	0.433	PSID 1999-2015
Cond. mean initial assets	$\mu_{a_0}$	7.117	PSID 1999-2015
Cond. std dev initial assets	$\sigma_{a_0}$	1.972	PSID 1999-2015
Share with initial housing	$h_0$	0.09	PSID 1999-2015
Share of consumption in PSID	$c_{\text{scale}}$	0.5	PSID 1999-2015

receive progressive social security income and regular pension payments, both of which are a function of households last working period income.

We use observed asset holdings of PSID households aged 22 to set the initial distribution of assets. We estimate the share of households at age 22 with zero liquid assets to be  $a_0^{\text{zero}} = 0.433$ . Conditional on holding positive liquid assets, mean log liquid asset holdings are estimated to be  $\mu_{a_0} = 7.117$  with a conditional standard deviation of  $\sigma_{a_0} = 1.972$ . Finally, based on the PSID we set the fraction of homeowners in the first period to be  $h_0 = 0.09$ .

We set the housing transaction cost to be  $F = 0.05$  following Attanasio, Bottazzi, Low, Neisham and Wakefield (2012). This represents the financial cost of real estate agents, inspectors, lawyers, and moving companies and is consistent with empirical evidence that

moving costs in the United States are at least 5% of the house value (OECD, 2011). We set the rental scale to be  $\eta = 0.035$ . This is the lower bound of the rent-to-price ratio time series reported by Leombroni, Piazzesi, Schneider and Rogers (2020).

Our estimation strategy focuses on the behavior of households aged 25 to 60. For that reason, we choose not to estimate the two parameters related to bequest motives, as it is preferable to calibrate these parameters based on papers that dedicate more attention to the behavior of retirees. We calibrate the constant term in the bequest motive as  $K = 11.6$ , following De Nardi (2004). This parameter is a constant that ensures a positive marginal utility of leaving no bequest, therefore it has a large impact on the share of households leaving zero or little bequest, a fact used by Following De Nardi (2004) in calibration. In addition, we calibrate the importance of the bequest motive as  $\theta^b = 0.04$ , which is the approximate midpoint of the estimates produced by O’Dea (2018).

### C.2.1 Unemployment

Although unemployment benefits in the United States depend on past income, they are capped at a low level, therefore the dependence on past income is relatively low compared to other countries. We calibrate the unemployment benefit to be \$11,270 per year, which is the maximum benefit averaged across states reported in Hsu et al. (2018), adjusted to 2015 dollars. To compute the employment transition probabilities, we use data from the PSID. We restrict our sample to household heads aged 50 or below, in order to avoid the potential effect of early retirement. As our data is biannual, we first compute the two-year probability of transitioning from employment to unemployment or out of the labor force. We then convert this to an annual probability ( $\pi_u$ ). We use the same procedure to estimate the probability of re-employment ( $\pi_{re}$ ).

### C.2.2 Estimating the income process for the primary earner

We estimate the earning process for the main earners who stay employed using the two-step minimum distance approach similar to Guvenen (2009) and Low et al. (2010). The earning process in the model is given by equation (6) in Section 2.4. The empirical version of this earning process only differs in one aspect: variables in the empirical income equation are subject to measurement errors. As a result, the the error term of the empirical income equation does not only include the idiosyncratic income shock,  $z_{i,t}$ , but also the measurement

error,  $\iota_{i,t}$ , which we assume to be serially uncorrelated.

$$\begin{aligned}
\ln y_{i,t}^p &= g_t + \tilde{z}_{i,t} & (C.1) \\
g_t &= d_0 + d_1 t + d_2 t^2 + d_3 t^3 \\
\tilde{z}_{i,t} &= z_{i,t} + \iota_{i,t} \\
z_{i,t} &= \rho z_{i,t-1} + \varepsilon_{i,t} \\
\varepsilon_{i,0} &\sim N(0, \sigma_0^2) \\
\varepsilon_{i,t} &\sim N(0, \sigma_\varepsilon^2) \\
\iota_{i,t} &\sim N(0, \sigma_\iota^2).
\end{aligned}$$

In the first step of our estimation, we approximate the deterministic part of the income process with a third-order age-polynomial,  $g_t$ . After that, we can identify the error term,  $\tilde{z}_{i,t}$ , in the data. There are four parameters of the stochastic income process left, which need to be determined: the coefficient of autocorrelation of the idiosyncratic income shock ( $\rho$ ), the variances of the first and subsequent innovations to the idiosyncratic income shock ( $\sigma_0^2$  and  $\sigma_\varepsilon^2$ ) and the variance of the measurement error ( $\sigma_\iota^2$ ). In the second step of our estimation, we identify these four parameters by minimizing the distance between the empirical variance-covariance matrix of the error term ( $\tilde{z}_{i,t}$ ) and its theoretical counterpart.

Using the variance-covariance restrictions we made in our statistical model, defined by equation (C.1), it is relatively straightforward to set up the theoretical variance-covariance matrix of  $\tilde{z}_{i,t}$ . First, we assume that  $z_t$  and  $\iota_t$  are mutually independent, which defines the variance and autocovariances of  $\tilde{z}_t$  as:

$$\begin{aligned}
\text{var}(\tilde{z}_t) &= \text{var}(z_t) + \text{var}(\iota_t) & (C.2) \\
\text{cov}(\tilde{z}_t, \tilde{z}_{t+j}) &= \text{cov}(z_t, z_{t+j}) + \text{cov}(\iota_t, \iota_{t+j})
\end{aligned}$$

Second, we assume that  $z_t$  follows an AR(1) process and that its initial variance is given, which allows us to define variances and autocovariances of  $z_t$  recursively as:

$$\begin{aligned}
\text{var}(z_1) &= \sigma_0^2 & (C.3) \\
\text{var}(z_t) &= \rho^2 \text{var}(z_{t-1}) + \sigma_\varepsilon^2 \quad \forall t \geq 2 \\
\text{cov}(z_t, z_{t+1}) &= \rho \text{var}(z_t) \\
\text{cov}(z_t, z_{t+j}) &= \rho \text{cov}(z_t, z_{t+j-1}) \quad \forall t \geq 2
\end{aligned}$$



Finally, we assume that the measurement error,  $\iota_t$ , is serially uncorrelated, therefore:

$$\begin{aligned} \text{var}(\iota_t) &= \sigma_\iota^2 \\ \text{cov}(\iota_t, \iota_{t+j}) &= 0 \end{aligned} \tag{C.4}$$

These restrictions allow us to construct the theoretical variance-covariance matrix of  $\tilde{z}$  and minimize the distance between the theoretical variance-covariance matrix and its empirical counterpart. This procedure makes it possible to identify the remaining parameters of the stochastic income component  $(\rho, \sigma_0^2, \sigma_\varepsilon^2, \sigma_\iota^2)$ . We collect the results in Table C.1.

### C.2.3 Income process for the second earner

The income of the second earner is modeled as an exogenous lump sum contribution to household income. We assume that this income is changing over the life-cycle deterministically but does not differ at the household-level. Using the PSID, we approximate the income with a third-order age-polynomial, similarly to the main earner's deterministic income component:

$$g_t^s = d_0^s + d_1^s t + d_2^s t^2 + d_3^s t^3. \tag{C.5}$$

### C.2.4 Asset returns

We calibrate the model with real risk-adjusted asset returns.<sup>46</sup> We start with the consumption-based pricing equation, which expresses asset returns in terms of prices and dividends:

$$r_{t+1} = \frac{p_{t+1} + d_{t+1} - p_t}{p_t} \tag{C.6}$$

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 as:

$$r_{t+1}^H = \frac{p_{t+1} + s_{t+1} - c_{t+1}^m - c_{t+1}^i - p_t}{p_t} \tag{C.7}$$

---

<sup>46</sup>For simplicity, our model abstracts from house price risk. However, the estimation strategy would still work if we included house price risk in the model. While we do not evaluate household behavior in response to house price shocks, this may be an interesting avenue for future research.

where  $p_t$  is the price of the house in period  $t$ , while  $s_{t+1}$  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.

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. Under these conditions equation (C.7) can be rewritten as

$$r_{t+1}^H = \frac{p_{t+1} + (s - c^m - c^i - 1)p_t}{p_t} \quad (\text{C.8})$$

where  $s$ ,  $c^m$  and  $c^i$  are the housing service flows and different costs relative to the value of the house. We measure aggregate house prices by the Case-Shiller house price index. We use the housing gross value added at current dollars from the Bureau of Economic Analysis (BEA) to approximate the housing service flow and use residential fixed assets at current dollars to approximate the housing stock.<sup>47</sup> The average of gross housing value added over residential fixed assets between 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.

We calculate the real return on liquid assets using the 3 Months T-Bill. Part of the difference in returns between liquid assets and housing reflects differences in the riskiness of these assets. For this reason, we calculate the risk-adjusted returns on the two assets by subtracting the variance of the return from the expected return of the asset (as suggested by Kaplan and Violante (2014)).

$$r_{adj}^i = E(r^i) - var(r^i) \quad (\text{C.9})$$

where superscript  $i$  refers to the type of the asset, i.e. 3 Months T-Bill and housing. The average, risk-adjusted real return over the period between 1950 and 2016 is 0.69% for the 3 Month T-bill and 2.10% housing.

### C.3 Method of simulated moments

We estimate the structural preference parameters of the model  $\Theta = (\lambda, \beta, \gamma, \alpha, \omega, \kappa, \zeta)$  using the Method of Simulated Moments. We choose these parameters to minimize the distance

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<sup>47</sup>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.

between moments in the data and their simulated counterparts from the model:

$$\hat{\Theta} = \underset{\Theta}{\operatorname{argmin}} H'(\Theta)\Omega H(\Theta) \quad (\text{C.10})$$

where  $H(\Theta)$  is the difference between the targeted moments from the data ( $\hat{m}^D$ ) and the corresponding simulated moments from our model ( $\hat{m}^S(\Theta)$ ), averaged over  $S$  simulations, for given model parameter values  $\Theta$ :

$$H(\Theta) = \hat{m}^D - \frac{1}{S} \sum_{s=1}^S \hat{m}^S(\Theta) \quad (\text{C.11})$$

We choose the weight matrix,  $\Omega$ , to be the inverse of the squared diagonal matrix of the targeted moments in the data, following Gorea and Midrigan (2017), among others. This implies that our estimate  $\hat{\Theta}$  is chosen to minimize the square of the percent deviations of each of the targeted moments. This gives us the benefit of targeting the moments that we believe to be most economically meaningful, although it comes at the cost of slightly higher standard errors.

Finally, we compute the variance covariance matrix of the estimated parameters  $\hat{\Theta}$  using the following formula (see Low and Pistaferri, 2015, among others):

$$\operatorname{var}(\hat{\Theta}) = (J'\Omega J)^{-1} J'\Omega V\Omega J (J'\Omega J)^{-1} \quad (\text{C.12})$$

where  $J = \frac{\partial \hat{m}^S(\Theta)}{\partial \Theta}$  is the Jacobian of the simulated moments with respect to the structural parameters and  $V = (1 + \frac{1}{S})VCV$  is the variance-covariance matrix of the moments ( $VCV$ ) adjusted for simulation error. The value of  $J$  is calculated by finite difference, while  $VCV$  is obtained by using bootstrap.

#### C.4 Age-time-cohort problem

As discussed in the main text, different variables from the data are not only affected by age effects but also by cohort and time effects, which we do not incorporate in our structural model. For this reason, we modify the observed empirical data by removing time and cohort effects. In doing so, we follow the procedure recently proposed by Schulhofer-Wohl (2018), which provides an elegant solution for the classical problem of jointly identifying age, cohort and time effects. Next, we outline the basic idea of this procedure.

Considering an outcome variable  $y_{a,t}$  for households who are age  $a$  at time  $t$ , one would like to recover the empirical age profile that is not contaminated by cohort and time effects

by regressing  $y_{a,t}$  on a full set of age, time and cohort dummies:

$$y_{a,t} = \xi + \alpha_a + \beta_t + \gamma_c + u_{a,t} \quad (\text{C.13})$$

where  $c$  is the birth cohort. Coefficients  $\alpha_a$  can be interpreted as the age profile of variable  $y$  after controlling for time and cohort effects. This linear regression model suffers from a well-known identification problem, because cohort can be expressed as the difference between time and age,  $c = t - a$ , and therefore equation (C.13) can be rewritten as:

$$y_{a,t} = \xi + (\alpha_a + ka) + (\beta_t - kt) + (\gamma_c + kc) + u_{a,t}, \quad (\text{C.14})$$

where  $k$  is some arbitrary non-zero scalar. As equation (C.14) holds for any real number  $k$ , any trend in the data can be interpreted either as a time trend or trends in ages and cohorts that are equal but of opposite sign. As a result, we can not identify age effects. To overcome this issue, we use a method recently proposed by Schulhofer-Wohl (2018), which estimates  $k$  together with the structural model parameters. In practice, we implement the method by modifying equations (C.10) and (C.11) and solving the following optimization problem:

$$(\hat{\Theta}, \hat{k}) = \underset{\Theta, k}{\operatorname{argmin}} \left[ \hat{m}^D + ka - \frac{1}{S} \sum_{s=1}^S \hat{m}^S(\Theta) \right]' \Omega \left[ \hat{m}^D + ka - \frac{1}{S} \sum_{s=1}^S \hat{m}^S(\Theta) \right]$$

## C.5 The challenge of credit constraints

One important benefit of our indirect inference approach is that it allows us to estimate the structural parameters of the model despite the presence of credit constraints. Historically, it has been difficult to estimate models with credit constraints, due to the fact that one cannot rely upon an analytical mapping between reduced form and structural parameters. Indirect inference allows us to overcome this difficulty by using an auxiliary model as a binding function that maps the parameters of the structural model into the parameters of the auxiliary model. Moreover, Smith (1993) shows that the auxiliary model need not be correctly specified to deliver consistent estimates of the structural parameters. For instance, the presence of credit constraints implies that equation (14) may be misspecified (i.e.  $\mathbb{E}[\epsilon_{i,t}] \neq 0$  resulting in bias in  $\hat{\psi}$ ).<sup>48</sup> This misspecification would be a problem if we were to estimate the model using a semi-structural Euler equation approach.<sup>49</sup> By using an indirect inference approach, however,

<sup>48</sup>The presence of credit constraints would create downward bias in  $\hat{\psi}$ , due to the negative relationship between consumption growth and liquid assets when households are near the constraint, as seen in Figure 1.

<sup>49</sup>Kovacs et al. (2021) use an Euler equation approach to estimate temptation. This relies upon an analytical mapping between the parameters of the auxiliary model and the parameters of the structural model.

we are able to obtain consistent estimates of the model parameters despite the presence of credit constraints. Since credit constraints exist in the model, they will result in the same form of misspecification in the binding function as in the data, therefore ensuring consistency of the structural parameter estimates. In this way, our estimation strategy builds upon the insights in Carroll (2001), who suggests targeting the coefficients of a consumption growth regression as a way to avoid issues of misspecification in consumption Euler equations.

## D Estimation results and model fit

To better understand the role of consumption growth dynamics in model estimation, we re-estimate the model while excluding  $\psi$  from the set of targeted moments. The results are shown in Table D.1. Columns 1 and 3 show the parameter estimates from the preferred estimation strategy using the baseline model and restricted model. Columns 2 and 4 show the parameter estimates from the alternative estimation strategy that excludes  $\psi$ .

Table D.1: Model Parameter Estimates – Alternative Estimation Strategies

		(1) Baseline Model	(2) Baseline Model No $\psi$	(3) Restricted Model	(4) Restricted Model No $\psi$
Temptation	$\lambda$	0.339	0.145	–	–
Time Preference	$\beta$	0.993	0.975	0.993	0.952
Risk Aversion	$\gamma$	2.062	2.310	2.431	2.474
Housing Utility Curvature	$\alpha$	1.060	2.133	1.213	2.028
Share of Housing	$\omega$	0.260	0.104	0.297	0.091
Utility Cost of Moving	$\kappa$	0.339	0.392	0.085	0.454
Disutility of Renting	$\zeta$	0.848	0.912	0.749	0.993

**Note:** This table shows estimated parameter values from alternative specifications and estimation strategies. Columns 1 and 2 show estimates from the baseline model, while Columns 3 and 4 show estimates from the restricted model without temptation. When estimating the model, we use the full set of targeted moments in Columns 1 and 3, but exclude  $\psi$  from the set of targeted moments in Columns 2 and 4.

We find that consumption growth dynamics play an important role in pinning down the strength of temptation. If we exclude  $\psi$  from the set of targeted moments, we obtain a substantially lower estimate of temptation in the baseline model:  $\lambda$  falls from 0.339 to 0.145. This is seen in Column 2 of Table D.1, which shows the parameter estimates of the baseline model when we do not target  $\psi$ . In addition, the alternative estimation strategy results in

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Unfortunately in the presence of credit constraints, it is impossible to derive such an analytical relationship. Indirect inference does not require an analytical mapping and can thus accommodate credit constraints.

less patient households. Now that temptation is weaker, the model requires a lower  $\beta$  and higher  $\alpha$  to match the life-cycle profiles of wealth accumulation.

Next we consider the implications for model fit. As reported in the main text, the baseline model (Column 1) obtains a good fit of the data. Similarly, the baseline model under the alternative estimation strategy (Column 2) also obtains a good fit of the targeted life-cycle moments, almost identical to the fit of our baseline model (figure available upon request). However, the model has bad out-of-sample fit of consumption growth dynamics, generating a negative  $\psi$ , which is the opposite sign of what we observe in the data (Table D.2).

Table D.2: Model Fit: Aggregate Moments

	PSID	Baseline Model	Baseline Model No $\psi$	Restricted Model	Restricted Model No $\psi$
Consumption Growth ( $\psi$ )	0.0039**	0.0039	-0.0024	-0.0017	-0.0051
Share of Homeowners	0.84***	0.73	0.84	0.99	0.86
Share of Extractors	0.19***	0.22	0.16	0.12	0.14
Share of Movers	0.10***	0.08	0.07	0.07	0.06
Loan-to-Value Ratio	0.49***	0.54	0.32	0.17	0.27

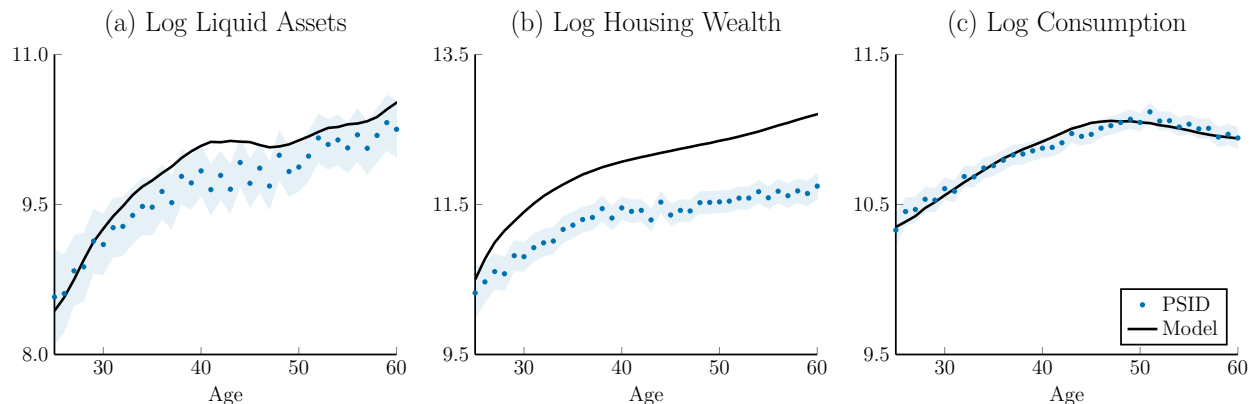
**Note:** Data comes from the PSID waves 1999-2015. We restrict the sample to married households aged 25 to 60. The relationship between consumption growth and liquid assets ( $\psi$ ) is estimated using equation (14).

In contrast, the restricted model (Column 3) fails to fit the data when we target the full set of moments. Figure D.1 shows the restricted model’s fit of the life-cycle moments. The restricted model matches the hump-shaped profile of nondurable consumption, but predicts implausibly high housing wealth accumulation. Table D.2 shows the fit of the aggregate moments. The restricted model fails to match the positive  $\psi$  observed in the data, obtaining a qualitatively different result.

Why does the restricted model generate such a poor fit of the targeted life-cycle moments? This is driven by the fact that the restricted model is unable to generate a positive  $\psi$ , therefore the estimation routine sets the other parameters to generate a  $\psi$  as close to zero as possible. More specifically, the restricted model requires highly patient households who are willing to accumulate substantial wealth, which keeps them away from the credit constraint. This allows the estimation routine to obtain a  $\psi$  close to zero, despite the fact that it implies an over-accumulation of liquid assets and housing wealth compared to the data.<sup>50</sup>

<sup>50</sup>The presence of credit constraints implies a negative relationship between consumption growth and assets (Figure 1). As a result, the estimation routine selects a large  $\beta$  to ensure that most households are far from

Figure D.1: Fit of the Restricted Model



**Note:** This figure shows the life-cycle moments that we target in the PSID (the blue dots) relative to the corresponding life-cycle moments in our estimated model without temptation (the black lines).

Finally, we consider the performance of the restricted model when we exclude  $\psi$  from the set of targeted moments (Column 4). We find that the model obtains a good fit of the targeted life-cycle profiles, similar to the baseline model (figure available upon request). However, the restricted model has bad out-of-sample fit of consumption growth dynamics, generating a  $\psi$  which is strongly negative, in sharp contrast to the data. This is observed in the last column of Table D.2, where we see that the model generates a  $\psi = -0.0051$ .

### D.1 Relationship between temptation and consumption growth dynamics

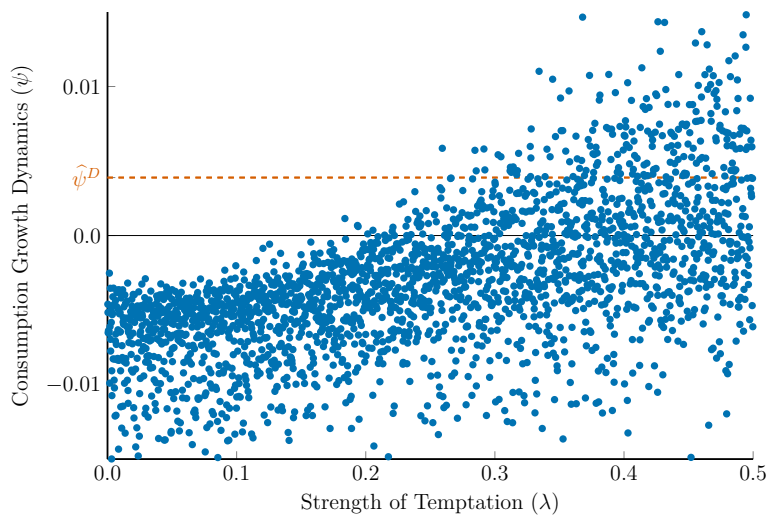
Temptation is necessary for our model to obtain a positive relationship between consumption growth and liquid assets ( $\psi$ ). In the absence of temptation, no combination of the other preference parameters is able to generate a positive  $\psi$ . Figure D.2 shows the model-implied  $\theta$  generated by 2,500 quasi-random draws of the structural parameters  $\Theta$ . For each parameter draw, we solve and simulate the model, then estimate the consumption growth regression, equation (14), on the simulated data. When  $\lambda = 0$ , no combination of the other parameters can generate a positive  $\psi$ . Instead, the model generates  $\psi < 0$  due to the presence of liquidity constraints, as discussed in Section 3. As  $\lambda$  increases,  $\psi$  also increases and eventually becomes positive for some parameterizations where the positive effect of temptation dominates the negative effect of liquidity constraints. Note that for any given value of  $\lambda$ , the model can generate a range of estimates of  $\psi$  depending on the other preference parameters.<sup>51</sup> For this reason, we need both life-cycle and aggregate moments to pin down the model parameters.

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the credit constraint, which helps the model-implied  $\psi$  be close to zero. In contrast, if we estimate the restricted model without targeting  $\psi$ , we obtain a substantially lower  $\beta$ , and therefore a more negative  $\psi$ .

<sup>51</sup>Of the other parameters, risk aversion  $\gamma$  plays the most important role in determining the magnitude of  $\psi$ , although it is unable to alter the sign of this relationship.  $\gamma$  influences the desire of households to smooth consumption across periods, thus it appears in the log-linearized Euler equation in Section B.2.

Figure D.2: The unconditional effect of temptation ( $\lambda$ ) on consumption growth dynamics ( $\psi$ )



**Note:** This figure shows how variation in temptation ( $\lambda$ ) alters the model-implied relationship between consumption growth and liquid assets ( $\psi$ ). We obtain  $\psi$  by estimating the consumption growth regression (equation 14) on simulated data generated by preference parameters  $\Theta$ . We vary  $\Theta$  using a quasi-random Sobol search over the estimated parameter space. Each dot represents a different draw of the parameters. The dashed orange line shows the targeted moment ( $\hat{\psi}^D$ ) from the PSID.

## D.2 Sensitivity of temptation to targeted moments

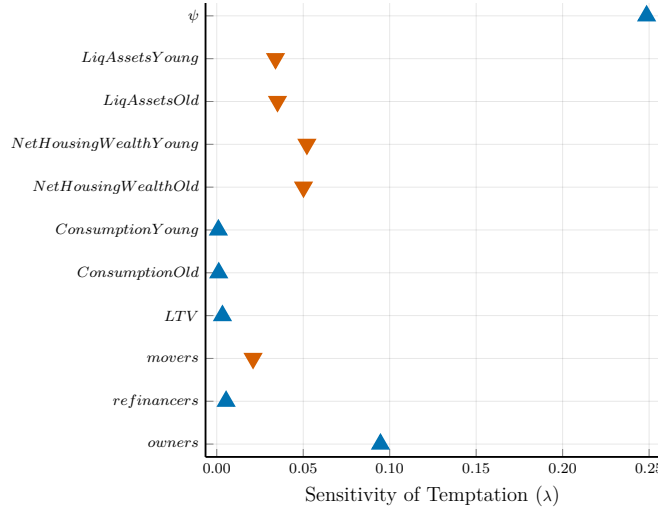
We study the sensitivity of temptation to targeted moments using the approach developed by Andrews et al. (2017). The approach allows us to evaluate how small variation in the targeted moments affects the parameter estimates. This is performed using the sensitivity matrix  $\Lambda = -(J'\Omega J)^{-1}J'\Omega$ , where  $J$  is the Jacobian of  $\hat{m}^S(\Theta)$  with respect to  $\Theta$  and  $\Omega$  is the weighting matrix.

Figure D.3 shows the sensitivity of  $\lambda$  to the targeted moments. Sensitivity values are scaled to reflect the percentage change in  $\lambda$  induced by 1 percent violation of the targeted moment (or a 1 percentage point violation of the targeted moment in the case of fractions, such as the share of homeowners). The first main takeaway is that many different moments affect temptation, similar to the results in Figure D.2. Second,  $\psi$  plays a crucial role in determining the strength of temptation. We find that a 1 percent increase in the targeted value of  $\psi$  results in a 0.25 percent increase in  $\lambda$ .

Other targeted moments also affect the estimated strength of temptation. The home-ownership rate has a positive effect on  $\lambda$ . This is consistent with the view that temptation encourages a desire for illiquidity as highlighted in Attanasio et al. (2021). In addition, increases in housing wealth and liquid assets both imply a lower  $\lambda$ . This reflects the fact that temptation makes it more difficult for households to accumulate wealth.



Figure D.3: Sensitivity of Temptation to Targeted Moments



**Note:** This figure shows the sensitivity of  $\lambda$  to targeted moments based on the sensitivity matrix  $\Lambda$  defined by Andrews et al. (2017). Sensitivity values are scaled to reflect the percentage change in  $\lambda$  induced by either a 1 percent change in the targeted moment (for  $\psi$ , liquid assets, housing wealth, and consumption) or a 1 percentage point in the targeted moment (for the LTV, share of movers, share of extractors, and share of owners). For clarity of exposition, life-cycle moments are condensed to reflect either young or old households. Targeted moments that have a positive effect on  $\lambda$  are denoted with upward facing blue triangles, while moments with negative effects are denoted with downward facing orange triangles.

### D.3 Potential threats to identification

In our model, temptation is necessary to generate a positive relationship between consumption growth and liquid assets ( $\psi$ ). This provides identification of temptation within the context of our model. However, we may be concerned that additional model features could also generate a positive  $\psi$ , potentially posing a threat to identification.

In this section, we consider these potential features and discuss how these could be controlled for in the data. In each case, we extend our consumption growth regression to account for the potential feature. Table D.3 presents the results. In all cases, we find that  $\hat{\psi}$  remains positive and significant even when accounting for these potential concerns. This demonstrates that even if we were to add one or more of these additional features to the model, we would still need temptation to fit the positive relationship between consumption growth and assets. We now discuss the intuition behind each of the alternative specifications.

*Aggregate Uncertainty* – Consider the possibility that asset returns are subject to aggregate shocks. In a year where households receive unexpectedly high returns, they will have both higher asset holdings and higher consumption growth. A natural way to control for this in our consumption growth regression is by adding a year fixed effect to capture the effects of such shocks. In Column 2 of Table D.3, we see that the coefficient on liquid assets is only

Table D.3: Consumption Growth Regression (PSID)

	(1)	(2)	(3)	(4)	(5)
	Baseline	Year FE	IV	HH FE	Habits
Liquid Assets ( <i>a</i> )	0.00389** (0.00189)	0.00344* (0.00188)	0.00449** (0.00208)	0.00925** (0.00420)	0.00671*** (0.00196)
Age controls	✓	✓	✓	✓	✓
Observations	12460	12460	12460	12460	9922

**Note:** This table shows the results from our consumption growth regression estimated on the PSID. The first column shows the result using our baseline specification (equation 14). The subsequent columns each show the result from an extended version of the consumption growth regression. Standard errors in parentheses. Significant at \*\*\*1%, \*\*5%, and \*10%.

slightly modified by the inclusion of year fixed effects.

*Asset Shocks* – Consider the possibility that households receive shocks to their liquid assets (e.g. lottery winnings or inheritances). In a year where households receive lottery winnings, they will have both higher asset holdings and higher consumption growth. We can account for such a possibility in the data by instrumenting liquid assets using lagged liquid assets. In Column 3 of Table D.3, we see that the coefficient on liquid assets is slightly higher.

*Heterogeneous Time Preferences* – Consider the possibility of persistent heterogeneity in time preferences across households ( $\beta_i$ ). More patient households (with high  $\beta_i$ ) will not only hold more liquid assets, but will also exhibit higher consumption growth, due to their willingness to delay gratification. Fortunately, there exists a natural solution to control for persistent heterogeneity, as  $\beta_i$  will show up in the constant term of the consumption growth regression.<sup>52</sup> In Column 4 of Table D.3, we control for persistent heterogeneity in time preferences by adding a household-level fixed-effect to the consumption growth regression. We find that the coefficient on liquid assets remains positive and becomes larger when we control for household-level fixed-effects.<sup>53</sup>

*Habit Formation* – Consider the situation where past consumption impacts current

<sup>52</sup> The consumption growth regression will take the form:  $\Delta \ln(c_{i,t+1}) = c_0 + \frac{1}{\gamma} \ln(\beta_i R_i) + \epsilon_{i,t}$ . Note that since  $R_i$  also shows up in the constant term, we can also control for persistent heterogeneity in  $R_i$  using a household-level fixed-effect.

<sup>53</sup> We choose not to include  $\beta_i$  heterogeneity in our model, as past studies show that such heterogeneity is relatively minimal. Runkle (1991) tests for the presence of persistent heterogeneity in time preferences, but finds no evidence of persistent differences across households. Dynan (2000) repeats these tests and also finds no evidence of persistent heterogeneity.

consumption preferences due to habit formation. In this case, a household that suddenly experiences a large increase in persistent income will save in liquid assets and gradually increase their consumption over multiple years due to habits. This may generate a positive relationship between  $\Delta \ln(c)$  and  $\ln(a)$ . It is possible to control for the presence of habit formation by augmenting the consumption growth regression with lagged consumption growth, following Dynan (2000). Column 5 of Table D.3 shows the results when we include lagged consumption growth as an additional control. We see that the coefficient on liquid assets is still positive and significant.<sup>54</sup>

## E Validating model predictions using a policy change in Texas

To what extent does home equity withdrawal affect household consumption behavior? To answer this question, we exploit a policy reform in Texas that legalized home equity withdrawal in 1998 following more than a century of prohibition.

### E.1 Empirical methodology

To study the impact of this reform, we estimate a difference-in-differences specification using household data between 1995 and 2003. We estimate the following equation:

$$y_{i,s,t} = \beta_1 + \beta_2 \text{Post1998}_{s,t} * \text{Texas}_{s,t} + \gamma_1 \mathbf{X}_{i,t} + \gamma_2 \mathbf{Z}_{s,t} + \eta_s + \phi_t + \epsilon_{i,s,t} \quad (\text{E.1})$$

where  $y_{i,s,t}$  is the outcome variable (such as log nondurable consumption) for household  $i$  in state  $s$  at time  $t$ .  $\text{Post1998}_{s,t} * \text{Texas}_{s,t}$  is an indicator variable equal to one if the observation is recorded following January 1, 1998 and the household lives in Texas.  $\mathbf{X}_{i,t}$  is a vector of household characteristics,  $\mathbf{Z}_{s,t}$  is a vector of state characteristics,  $\eta_s$  is a state fixed effect, and  $\phi_t$  is a year-month fixed effect. All results are estimated using sample weights. Standard errors are clustered by state (Bertrand et al., 2004).

The household characteristics ( $\mathbf{X}_{i,t}$ ) include household income, family size, number of earners, urban status, and detailed information on the household head including age, race, sex, employment type, and employment status (full time, part time, or unemployed). The state characteristics ( $\mathbf{Z}_{s,t}$ ) include the monthly unemployment rate by state and the monthly oil price interacted with state dummies. We include this latter control as the economy of Texas is very dependent on oil, although we find that the inclusion of this control does not

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<sup>54</sup> We decide not to include habit formation in our model. While the macroeconomic literature usually finds evidence of consumption habits when using aggregate time-series data, the microeconomic literature has not found evidence of habit formation using household-level data. Dynan (2000) tests for the presence of habit formation in household consumption and finds no evidence of habit formation at the annual frequency.

significantly alter the results.

In our baseline analysis, we restrict our sample to working-age homeowners in the southern United States between 1995 and 2003. This time period is chosen purposefully to omit a policy change in 2004 that altered the ability of Texans to borrow using home equity lines of credit, which we exclude from our analysis. We focus on the southern U.S. as this region has more similarity to Texas along important dimensions, including a slightly lower take up of home equity loans than the rest of the country. Finally, we focus on working-age households where the primary earner is between the ages of 25 and 60.

We test the validity of our research design by explicitly testing for parallel trends in consumption using an event study analysis (Appendix E.1.2). Further, as a falsification test, we estimate the effect of the reform on renters, who should be relatively unaffected by the reform. Both tests support the validity of our empirical methodology. In our baseline results, we focus on nondurable spending and mortgage balances, as these variables have direct model analogues and therefore can be used to evaluate out-of-sample fit. We evaluate heterogeneity across spending categories in Appendix E.1.5.

### **E.1.1 Data**

We use data from the Consumer Expenditure Survey (CEX), which records consumption, housing, and mortgage balances for a representative sample of U.S. households. The data are well suited to our analysis because they provide a larger cross-sectional dimension than the PSID, thus allowing us to study changes in spending in Texas compared to other states.<sup>55</sup> We include homeowners located in the southern U.S. or any state within a two state radius from Texas.<sup>56</sup> This gives a sample of 36,766 household-wave observations.

We document parallel trends in home equity lending and nondurable spending. In the data, there are relatively few homeowners with home equity loans in Texas prior to 1998. After the reform, the share of homeowners with a home equity loan increases substantially in Texas but not in the other southern states. We find similar trends in nondurable spending both before and after the reform, with a level shift upward in Texas in 1998.

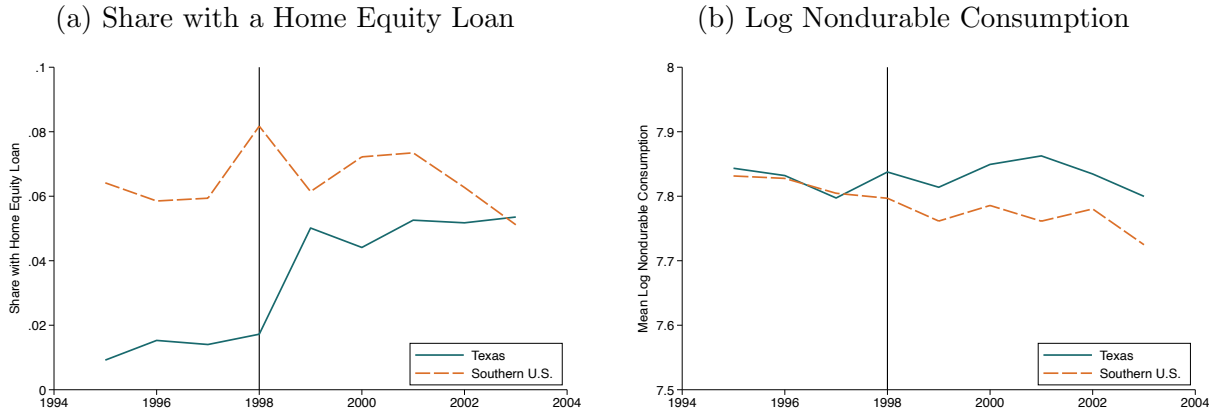
Figure E.1 Panel a shows the share of prime-age homeowners with a home equity loan in

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<sup>55</sup>While the CEX is an ideal choice to study financial liberalization in Texas, it would not be well suited to model estimation due to its limited panel dimension. The CEX only follows households for a maximum of four quarters and only collects information on asset holdings in the final interview.

<sup>56</sup>We follow the Bureau of Economic Analysis definition of the Southeast and Southwest. This includes Alabama, Arizona, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, New Mexico, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia. In addition, we include Utah, Colorado, Kansas, and Missouri, as these states are within a two state radius from Texas.

Figure E.1: Trends in Home Equity Lending and Consumption



**Note:** This figure shows the behavior of homeowners in Texas (the solid blue line) and other southern states (the dashed orange line). Panel (a) shows the share of homeowners aged 30 to 60 with a home equity loan. Panel (b) shows mean log nondurable consumption. The vertical line indicates the first year that home equity withdrawal became available in Texas. Data are from the Consumer Expenditure Survey.

Texas relative to the share in the rest of the southern United States. Home equity loans were held by less than 2% of homeowners in Texas prior to 1998, but that this fraction increased to roughly 5% following the policy reform.<sup>57</sup> The existence of homeowners with home equity loans in Texas prior to 1998 is indicative of banks' willingness to lend for home improvement, given that housing was always able to serve as collateral for such loans. The level shift upward following the liberalization of mortgage lending in Texas is indicative of increased ability to use housing as collateral. Meanwhile, the share of homeowners with a home equity loan in the other southern states remains relatively stable during this period, hovering around 6%.

Figure E.1 Panel b shows mean log nondurable consumption for Texas and the rest of the southern U.S. We see that consumption follows a similar trend in both regions before and after the policy reform in 1998, with a level shift upwards in the year of the policy change.<sup>58</sup> Nevertheless, consumption is higher in Texas following the policy reform, likely reflecting the fact that Texas has slightly higher income than its neighboring states, but was constrained by mortgage market regulations prior to 1998.

### E.1.2 Event study

We test the assumption of parallel trends using an event study. We expect to see a consumption response of zero prior to 1998 if the parallel trends assumption is valid. To achieve this goal,

<sup>57</sup>This is consistent with the American Housing Survey Reports, where the share of Texan homeowners with a home equity loan rose from 2.5% in 1997 to 4.5% in 1999 (Abdallah and Lastrapes, 2012).

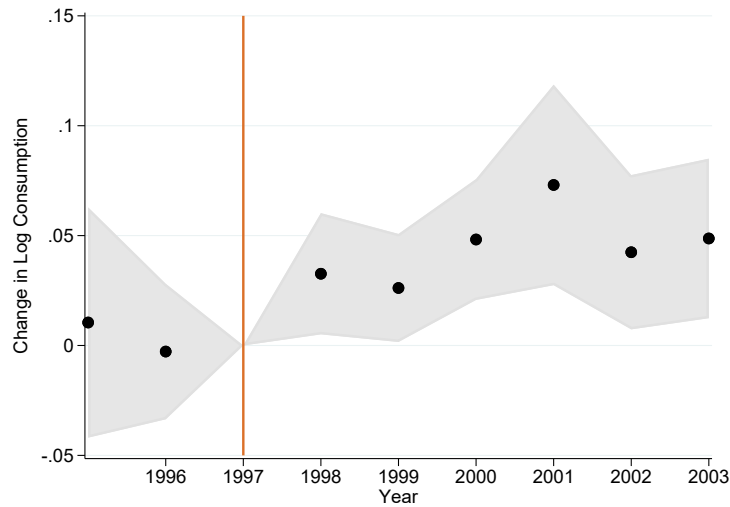
<sup>58</sup>We see a gradual decline in consumption over time in both regions. This likely reflects the decline in the share of aggregate expenditure captured by the CEX, documented by Attanasio and Pistaferrri (2016).

we estimate the following distributed lag model:

$$y_{i,s,t} = \sum_{j=1995}^{1996} \beta_j \times 1_{\text{year } j} \times 1_{\text{Texas}} + \sum_{j=1998}^{2003} \beta_j \times 1_{\text{year } j} \times 1_{\text{Texas}} + \gamma_1 \mathbf{X}_{i,t} + \gamma_2 \mathbf{Z}_{s,t} + \eta_s + \phi_t + \epsilon_{i,s,t} \quad (\text{E.2})$$

The results can be interpreted as an event study following Gross and Souleles (2002). The coefficient  $\beta_j$  measures the treatment group’s consumption change (in percentage terms) in year  $t$  as a percentage change from year 1997 (the absorbed dummy), relative to the consumption change of the control group. The dynamic pattern of the consumption response helps us understand the impact of home equity withdrawal on consumption over time. We include the pretreatment years to explicitly test for the existence of differences in the trends between the treatment group and the control group. We expect to see a consumption response of zero prior to 1998 if the parallel trends assumption is valid.

Figure E.2: Event Study: Log Nondurable Consumption



**Note:** This figure shows consumption dynamics before and after the policy change in Texas. The black dots represent the estimated change in consumption ( $\hat{\beta}_j$ ) in year  $j$  relative to log consumption in 1997. The gray region shows the 95% confidence interval of these estimates.

Figure E.2 shows the change in log consumption of the treatment group relative to the control group for each year of our sample. We observe no statistically significant consumption response prior to 1997. This is consistent with the assumption of parallel trends in consumption between Texas and our control group. When the policy change is implemented in 1998, we see a small increase in consumption on impact. Consumption gradually rises between 1999 and 2001, reaching a peak in 2001. At its peak, nondurable consumption is approximately 6-7% higher than it was in 1997 in Texas relative to the control group. This is consistent with the theory that households do not immediately increase consumption when home equity

withdrawal is legalized, but rather increase their consumption gradually as news of the policy spreads.

### **E.1.3 Sensitivity to alternative specifications**

In our baseline specification, we find that nondurable spending increases by 3.0% following the policy reform. We find that this result is robust to a number of alternative specifications.

For instance, when we include state-quarter house prices as an additional control, we find that the legalization of home equity withdrawal results in a significant 3.3% increase in nondurable consumption, only slightly higher than our baseline result. This result likely reflects the fact that Texas experienced low house price growth relative to the rest of the southern U.S. during the sample period. As a result, unanticipated gains in house prices likely had a larger effect on consumption in the control group than in Texas.

In addition, we find that the magnitude of the spending response only changes slightly when we expand or contract the number of states included in our sample. For instance, if we repeat our analysis using the entire U.S., we find that the legalization of home equity withdrawal in Texas results in a 3.2% increase in nondurable spending.

Finally, the policy reform can affect not only spending, but also the decision to purchase housing. To investigate this possibility, we estimate the effect of the policy change in Texas on homeownership rates. We find that the policy change had no significant effect on the homeownership rate. This finding is consistent with our estimated model, where we also find that the policy change had no meaningful effect on the homeownership rate.

### **E.1.4 Relationship to previous literature**

Our results are consistent with previous studies that have used aggregate data to study the effect of home equity withdrawal on household spending. For instance, Greenspan and Kennedy (2008) examine U.S. national accounts and estimate that home equity withdrawal accounted for almost 3% of personal consumption expenditure between 2000 to 2005. Similarly, Abdallah and Lastrapes (2012) use aggregate retail spending and find that the legalization of home equity withdrawal in Texas increased retail expenditure by 2 to 5%.

Our estimates are also within the range reported by previous studies using alternative measures of household spending. Leth-Petersen (2010) studies the legalization of home equity withdrawal in Denmark in 1992 using “imputed spending”. He finds that the policy change increased imputed expenditure by 0.3%.<sup>59</sup> In addition, Agarwal and Qian (2017) use debit and

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<sup>59</sup>The policy reform in Denmark occurred following a 30% fall in house prices, therefore homeowners had

credit card data to study a policy change in Singapore that reduced the ability of households to extract home equity by moving homes. They find that this policy reduced spending by 4%. Our empirical results fall well within these estimates. Overall, the out-of-sample performance of the model gives credibility to its long-term predictions.

### E.1.5 Heterogeneity by spending category

There exists substantial uncertainty and disagreement on the usage of funds extracted from home equity.<sup>60</sup> To shed light on this issue, we use our empirical methodology to study the effect of home equity withdrawal on different spending categories. Overall, our results suggest that home equity withdrawal leads households to spend more on luxuries than necessities.

Table E.1 shows the effect of the policy change on different subcomponents of spending. Within the subcomponents of nondurable spending, the largest response is for food away from home and entertainment, which increase 3.8% and 2.0%. In contrast, there is no significant spending response in food consumed at home. As restaurant and entertainment spending are luxuries relative to food consumed at home, we interpret these results as suggestive evidence that equity withdrawal leads households to spend more on luxuries than necessities.

Table E.1: Heterogeneity across Spending Categories

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Food In	Food Away	Housing Services	Entertainment	Apparel	Alcohol	Public Utilities	Gasoline	Durables	Vehicle
Post1998 x Texas	-0.006 (0.006)	0.038*** (0.007)	0.015*** (0.004)	0.020** (0.008)	0.009 (0.007)	0.002 (0.003)	0.011*** (0.002)	-0.001 (0.003)	0.042** (0.015)	0.032** (0.012)
Obs.	36,766	36,766	36,766	36,766	36,766	36,766	36,766	36,766	36,766	36,766
Adj. $R^2$	0.309	0.118	0.037	0.105	0.117	0.070	0.155	0.196	0.090	0.059
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

**Note:** This table shows the response of spending categories when home equity withdrawal is legalized. Housing services include cleaning, babysitting, repairs, rentals, elderly care. Entertainment includes tickets, pets, lessons, recreation. Standard errors are clustered at the state level. Significant at \*\*\*1%, \*\*5%, and \*10%.

In addition, durable spending increases by 4.2% when home equity withdrawal is legalized. Within this category, the effect is especially large for vehicle expenditure, which increases by 3.2%. This suggests that home equity withdrawal may give households greater flexibility on the timing of their durable expenditure. We abstract from durable spending in our model, however, in order to reduce the computational burden of model estimation. For this reason, we focus on nondurable spending in our baseline analysis.

very little home equity available. In contrast, we study a policy change during a relatively normal period.

<sup>60</sup>See for instance Canner et al. (2002), Cooper (2010), Mian and Sufi (2011), Disney et al. (2009), DeFusco (2018), and Crossley et al. (2018).



## E.2 Model counterpart

We use the estimated model to implement a similar reform where home equity withdrawal is suddenly legalized after many years of prohibition. We simulate 80 overlapping generations of households that exist in two “states” with different laws on home equity withdrawal.

In the first state, the “treatment group”, we assume that home equity withdrawal is initially prohibited for many generations. We then introduce an unanticipated policy change that permanently legalizes home equity withdrawal. The latter policy represents the baseline used in estimation. In the second state, the “control group”, we assume that home equity withdrawal is fully permitted across all generations. In both states, we assume that each generation is identical in their initial distribution of income and wealth, as well as the shocks that they receive during their lives.

We assume that the reform is unanticipated, which we believe is a reasonable assumption for most households in Texas for the following reasons: (1) the referendum occurred less than two months before the proposed policy change, (2) the vote was relatively close, (3) a previous referendum in the early 1990s failed to legalize equity withdrawal. For these reasons, we believe that any anticipation effect would be relatively modest.

We then evaluate the change in consumption that occurs between the two groups during the five years after the policy reform is implemented in the treatment group. This allows us to evaluate the model’s predictions relative to the empirical evidence from Texas.<sup>61</sup> We focus on the behavioral response during the first five years after the policy reform is implemented, in order to ensure consistency with the data.

## E.3 Limitations of the quasi-experimental evidence

It is worthwhile to take stock of what we can learn from the quasi-experiment in Texas. The data provide evidence for a causal link between the ability to extract home equity and nondurable consumption. However, there are a few factors that limit the inference that can be drawn from the quasi-experiment alone. First, in the data, we observe actual consumption decisions but cannot observe the extent to which households suffer from temptation. Second, there is no source of exogenous variation that would give households greater ability to smooth consumption using home equity without simultaneously increasing their temptation. This

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<sup>61</sup>In a previous version of this paper, we conducted a simple pre-post difference for the treatment group, without including a control group. However, we found that our results were unaffected by the inclusion of a control group. The intuition for this result is that the level of consumption and mortgage balances is stationary across time in the control group. Thus when we perform a difference-in-differences, the level of consumption and mortgage balances in the control group simply nets out between the pre and post period. This result lends support to the empirical methodology in Section E.1.

means that we cannot use the quasi-experiment to determine the extent to which increased consumption is a result of temptation.<sup>62</sup>

More generally, there will always exist some  $\beta$  for which the restricted model without temptation is able to generate a change in consumption consistent with the quasi-experimental evidence. For this reason, it is necessary to target some feature of the data for which temptation and impatience have qualitatively different predictions: namely, the relationship between consumption growth and liquid assets. This allows us to differentiate between temptation and impatience for the reasons discussed in Sections 3 and 5.3.

## **F The evolution of household behavior after liberalization**

We use our quantitative framework to study the dynamics of household behavior after the introduction of home equity withdrawal. As in Section 6, we simulate multiple overlapping generations under the assumption that home equity withdrawal is initially prohibited, then suddenly introduced. We then evaluate how home equity withdrawal alters household balance sheets and behavior over the years. Overall, we find that access to home equity greatly reduces the personal saving rate, wealth accumulation, and consumption following retirement.

### **F.1 Working-age households increase consumption and reduce saving**

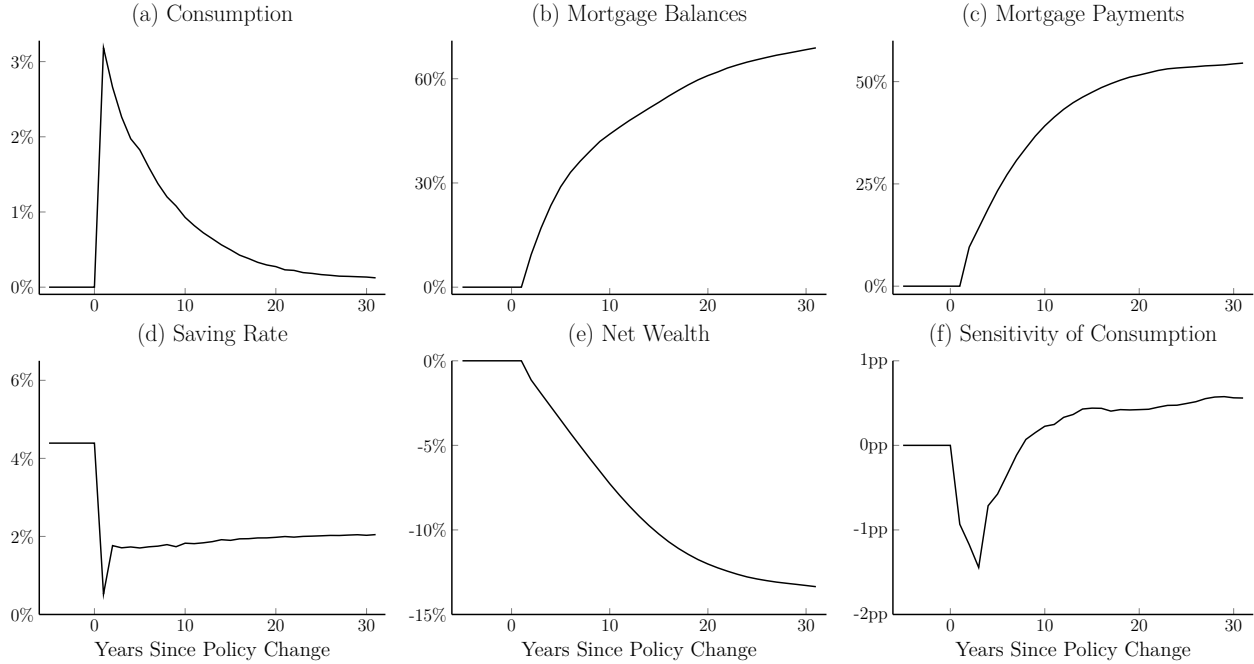
Figure F.1 shows the behavior of working-age households following the introduction of home equity withdrawal. Overall, the introduction of home equity withdrawal results in a temporary increase in consumption, gradually leading to a large rise in mortgage balances and mortgage payments. This generates an immediate and permanent reduction in the personal saving rate.

When home equity withdrawal is introduced, consumption immediately increases by roughly 3%, but then gradually returns to its pre-reform level. The sharp increase in consumption immediately after financial liberalization is driven by three different factors. First, homeowners who have experienced adverse shocks can now extract equity for consumption smoothing purposes (Hurst and Stafford, 2004; Lustig and Van Nieuwerburgh, 2005, 2010; Sodini et al., 2016). Second, credit-constrained homeowners can now achieve a life-cycle consumption profile more in line with their lifetime earning expectations (Gerardi et al., 2010; Cocco, 2013). Third, since housing now provides improved self-insurance, homeowners can optimally reduce the size of their liquid asset buffer (reminiscent of Carroll, 1997).

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<sup>62</sup>A similar point is made by Mian and Sufi (2011), who note that it is not possible to differentiate between consumption that stems from relaxed credit constraints versus self-control problems, as the characteristics that predict credit constraints at the household level (e.g. high credit card utilization, low credit scores) are also likely to predict self-control problems.

Figure F.1: Long-Term Implications of Permitting Home Equity Withdrawal



**Note:** This figure shows the long-term implications of legalizing equity withdrawal in our estimated model. The horizontal axis depicts years relative to the policy reform. Households are not allowed to extract home equity prior to year zero. For consumption, mortgages, and wealth, the black line represents the percentage change relative to  $t = -1$ . For the saving rate, the black line represents the level of the saving rate. For the sensitivity of consumption, the solid line represents percentage point change relative to  $t = -1$ . Sensitivity of consumption is defined as the difference in consumption growth when employed versus unemployed. All results are for working age households.

Why does consumption gradually return to its pre-reform level? This is driven by changes in household balance sheets. As households carry larger mortgage balances, they are required to make larger mortgage payments. In the long-run, mortgage payments increase by over 50% before eventually leveling out. As households now devote more resources towards servicing their debt, they must eventually reduce consumption accordingly.

The saving rate falls substantially following the introduction of home equity withdrawal. We define the saving rate as the change in wealth over income, following the definition used in the Flow of Funds accounts. Prior to the policy reform, our model generates a working-age personal saving rate of approximately 4.5%. This plummets when home equity withdrawal is introduced, before slightly rebounding. This is driven by the fact that households extract substantial home equity immediately following the reform, thus restricting their home equity withdrawal in the following year. Eventually the savings rate reaches a long-run average of around 2%.<sup>63</sup> This has a large effect on wealth accumulation: access to home equity

<sup>63</sup> Our findings are generally consistent with a large literature that highlights the link between greater access to home equity and the decline in the U.S. personal saving rate (Summers and Carroll, 1987; Manchester and

eventually reduces average net wealth by approximately 14%.

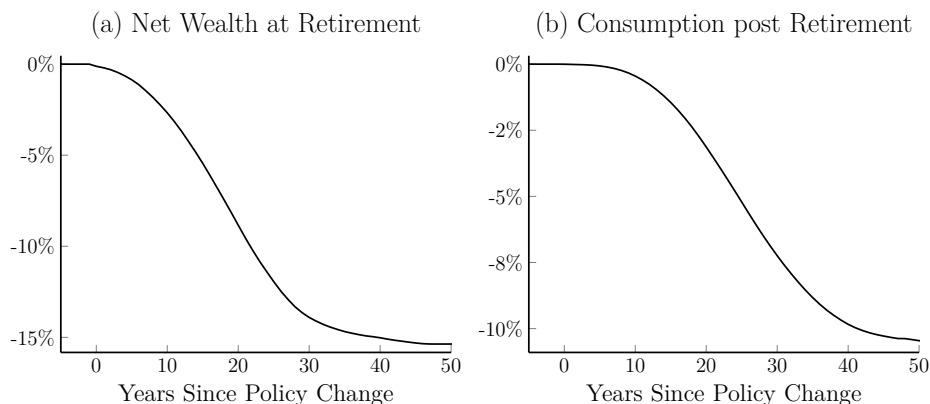
## F.2 Households exhibit increased consumption sensitivity to unemployment

The final panel of Figure F.1 shows the impact of this reform on the sensitivity of consumption growth to unemployment. This is defined as the difference in consumption growth when employed versus unemployed. In the short-term, consumption sensitivity falls by approximately 1.5 percentage points as households are now able to access home equity to smooth consumption, reminiscent of Agarwal and Qian (2017). In the long-run, however, consumption sensitivity increases due to changes in household balance sheets, reminiscent of Baker (2018).

The economic intuition for this result is that higher mortgage balances make household spending more sensitive to adverse shocks. Following the policy reform, households carry larger mortgage balances, thus they must devote a larger share of their income towards mortgage payments. This implies that discretionary income (i.e. income net of taxes and mortgage payments) experiences a larger fall for any given fall in income. In this way, access to home equity may reduce macroeconomic stability, since a temporary increase in unemployment will result in a larger reduction in aggregate spending.

## F.3 Elderly households cut back on consumption

Figure F.2: Long-Term Implications for Retired Households



We find that access to home equity results in less wealth at retirement and reduced consumption following retirement. Figure F.2 presents our results. In the short-term, access to home equity has essentially no effect on net wealth at retirement, as households have still benefited from the commitment properties of housing for most of their working lives. In the long-term, however, access to home equity results in a roughly 13-14% reduction in wealth (Poterba, 1989; Greenspan and Kennedy, 2008; Aron et al., 2012; Caporale et al., 2013; Carroll et al., 2019).

at retirement. This has a large effect on spending, resulting in a roughly 10% decrease in consumption of elderly households that only stabilizes about 40-50 years after home equity withdrawal is introduced.

## G The effect of financial liberalization on household wellbeing

### G.1 Disentangling flexibility and commitment

We use the estimated model to disentangle the effect of consumption smoothing and weakened commitment. This is performed by making a counterfactual assumption about what assets result in temptation. In the baseline model, households suffer from temptation over all assets. The myopic choice, which determines the cost of temptation, is as follows:

$$\left[ \tilde{c}_t, \tilde{h}_t, \tilde{m}_t \right] = \arg \max_{c_t, h_t, m_t} u(c_t, h_t) \quad (\text{G.1})$$

The household is allowed to adjust their consumption, housing, and mortgage debt when making the myopic choice. In contrast, consider a counterfactual model where households suffer from temptation over consumption and housing, but are not tempted by the possibility of home equity withdrawal. Under this counterfactual, the myopic choice is:

$$\left[ \tilde{c}_t, \tilde{h}_t \right] = \arg \max_{c_t, h_t} u(c_t, h_t) \quad (\text{G.2})$$

In this case, the household chooses  $\tilde{c}_t$  and  $\tilde{h}_t$  under the assumption that home equity withdrawal is impossible. This means that the commitment benefit of housing is just as strong as it was when home equity withdrawal was outlawed. The effect is that the weakened commitment channel is shut down in the counterfactual model. By comparing the decisions of households in the baseline model relative to the counterfactual model, it is possible to determine the relative importance of weakened commitment.

### G.2 Sensitivity to alternative modeling assumptions

We discuss the sensitivity of our main welfare results to alternative modeling assumptions in Section 7.4 while keeping the preference parameters fixed at their baseline estimates. Here we describe the various model additions that we have implemented.

*Liquid Borrowing* – We recalibrate the liquid borrowing limit ( $\underline{a}$ ) to capture the existence of credit cards. As mentioned previously, it is not straightforward to calibrate this parameter given the fact that (i) not all households have credit cards and (ii) there is substantial variation in credit card limits across years. We base our calibration on the results from

Narajabad (2012), who reports the average credit limit conditional on having a credit card for various waves of the Survey of Consumer Finances (SCF). We choose the highest reported value, which occurred in 2007, and is \$34,000 in 2015 dollars. We calibrate  $\underline{a}$  using the credit limit conditional on having a credit card (roughly 70% of the SCF) therefore we view our estimate as an upper bound on the effect of credit cards.

*No Equity Withdrawal when Unemployed* – To capture the possibility of constraints to home equity withdrawal during unemployment, we alter equation (4) in the baseline model, which governs the evolution of mortgage balances. More specifically, we impose a new constraint, which states that households are only allowed to extract home equity when employed, therefore equation (4) becomes:

$$m_{t+1} \leq (1 + r^M) \begin{cases} \bar{\psi} p_t(h_t) & \text{if moving homes} \\ \bar{\psi} p_t(h_t) & \text{if employed and extracting equity} \\ m_t - mp(m_t) & \text{otherwise} \end{cases} \quad (\text{G.3})$$

*House Price Risk* – In our baseline model, we assume that house prices grow deterministically. This simplifying assumption helps keep the model tractable and aids in our ability to estimate all of the preference parameters using the method of simulated moments.<sup>64</sup> One important question, however, is whether our baseline results are highly sensitive to this assumption. To incorporate aggregate house price risk into the model, we assume that the log house price index  $\bar{p}_t$  evolves based on the following stochastic process:

$$\ln \bar{p}_t = d_0 + d_1 t + \rho_{\bar{p}} \ln \bar{p}_{t-1} + v_t, \quad v_t \sim N(0, \sigma_v^2) \quad (\text{G.4})$$

which is an AR(1) process with a linear trend that allows us to capture the upward drift of house prices over time. This formulation, and the nested random walk case when  $\rho_{\bar{p}} = 1$ , is relatively common in the literature (see e.g. Attanasio et al., 2012; Berger et al., 2017). We assume that house price shocks and earnings shocks are uncorrelated, which reflects a decision to model income risk as arising from idiosyncratic shocks and house price fluctuations as arising from aggregate shocks.<sup>65</sup> House price shocks affect the value of housing but not the utility flow it generates.

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<sup>64</sup>As noted previously, the computational burdens of model estimation are substantial. It takes roughly 24 hours to estimate the model in Julia using the IFS HPC cluster with 16 core Xeon processors. While it is possible to estimate the model with house price risk, it would increase estimation time substantially.

<sup>65</sup>If the goal of the paper were to capture business cycle fluctuations, then it would be important to extend the model to allow for comovement between house prices and income, which would likely reduce the consumption smoothing benefits of home equity withdrawal.

We estimate the parameters of the house price process using the augmented Case-Shiller house price index. We estimate an AR(1) process with a linear trend over the years 1950 to 2016, with the Case-Shiller index converted to real values using the consumer price index. We obtain an estimated persistence parameter ( $\rho_{\bar{p}}$ ) of 0.9049 and a standard deviation of the shock ( $\sigma_v$ ) equal to 0.0496. We treat house price shocks as aggregate.<sup>66</sup>

When analyzing the welfare effects of financial liberalization, we do so behind the “veil of ignorance” by simulating many potential realizations of the house price series which may occur and then computing the degree of compensation which would be necessary to make households indifferent between being able to access or not access home equity. We believe that this is the most relevant welfare criteria for governments looking to design policy for the future where house price realizations are uncertain.<sup>67</sup>

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<sup>66</sup>While we do not explicitly reestimate the preference parameters of the model, we show in Appendix D.3 that identification would be little changed by the presence of aggregate house price shocks.

<sup>67</sup>One potentially interesting extension which would be straightforward to implement using our model is to study how the welfare effects of financial liberalization may have varied for different cohorts of households who experienced different realizations of house price shocks. For instance, households born into a cohort that experienced higher than expected house price growth may benefit more from the ability to consume out of unanticipated house price gains and vice versa. We leave such historical welfare analysis for further research.