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

Agnes Kovacs* Patrick Moran†

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Abstract

Financial innovation and deregulation have given households an unprecedented ability to access home equity. To what extent is this beneficial? On one hand, access to home equity enables households to better smooth consumption and self-insure against risk. On the other hand, if housing acts as a savings commitment device, there exists a trade-off, as more liquidity may weaken commitment. In this paper, we evaluate the costs and benefits of greater access to home equity by estimating a model that captures these two contrasting channels. Model estimates are validated using a reform that abruptly legalized home equity withdrawal in Texas. In both the data and the model, we observe a 3% increase in nondurable consumption following the reform. We find that half of the observed increase in consumption comes from weakened commitment, while the remainder comes from consumption smoothing. Finally, we estimate that welfare declines by 2.6% due to home equity withdrawal, as the consumption smoothing benefit is outweighed by the cost of weakened commitment.

JEL Classification: D15, E21, E71, G51, G28
Keywords: Housing, Mortgages, Commitment, Savings, Liquidity, Household Finance

*The University of Manchester and Institute for Fiscal Studies (agnes.kovacs@manchester.ac.uk)
†The University of Oxford and Institute for Fiscal Studies (patrick.donnellymoran@economics.ox.ac.uk)
1 Introduction

In the United States, the median household keeps approximately 80% of its wealth in housing. Traditionally, housing wealth has been very difficult to access, but this changed between the 1980s and mid-2000s, as home equity withdrawal became cheaper and easier due to financial innovation. This led to an increase in borrowing and debt-financed consumption, causing widespread concern among policy makers. To what extent were these developments beneficial? In traditional models, more liquidity is always welfare enhancing, as it allows households to better smooth consumption. However, if housing acts as a savings commitment device, there exists a trade-off, as more liquidity may weaken commitment.

In this paper, we disentangle the costs and benefits of greater access to home equity. While the consumption smoothing benefit has already received much attention, the importance of weakened commitment has been relatively less studied. The key mechanism that we consider is that housing may help households commit to a self-imposed savings plan. The introduction of home equity withdrawal, however, may result in temptation to extract and consume home equity for short-term gratification. To evaluate the consequences of increased liquidity in housing, we develop a life-cycle model that captures two contrasting channels: consumption smoothing and weakened commitment. We estimate the relative importance of these two channels in the model using data on consumption growth, liquid assets, and housing from the Panel Study of Income Dynamics (PSID). We then validate the predictive power of our model using a quasi-experiment in Texas where home equity withdrawal, long illegal, was suddenly legalized in 1998.

We find evidence that housing has traditionally acted as a savings commitment device, but that recent innovations in home equity withdrawal have weakened the commitment benefit of housing. When home equity withdrawal is introduced, we observe a short-run 3% increase in nondurable consumption for homeowners in both the data and the model. We find a large role for commitment in explaining this response: half of the increase in consumption is due to breaking the commitment device, while the remainder comes from consumption smoothing. In the long-run, we predict that savings rates decline substantially, resulting in lower wealth at retirement, as well as reduced consumption and homeownership during old age. Finally, we find that welfare declines by 2.6% in consumption-equivalent terms when home equity withdrawal is introduced, as the consumption smoothing benefit is outweighed by weakened commitment. This decline in welfare is concentrated in the middle class.

To begin, we study households’ response to greater liquidity. This is performed using a quasi-experiment where home equity withdrawal was suddenly legalized in Texas in 1998.

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1 See Hurst and Stafford (2005), Lustig and Van Nieuwerburgh (2010), and Agarwal and Qian (2017).
Using data from the Consumer Expenditure Survey, we find that this policy reform resulted in a 3% increase in nondurable consumption for homeowners in Texas relative to other states. This increase is concentrated in luxury goods. That said, we cannot use the data alone to assess welfare or measure commitment. For these goals, we need a structural model that will allow us to analyze this policy reform.

We develop a model that is rich enough to capture the trade-off between consumption smoothing and weakened commitment, but that also imposes sufficient structure on the data to enable estimation of key model parameters. We start with a standard life-cycle model where risk averse households want to smooth consumption by moving resources from periods of high income to periods of low income. Households can invest in either liquid assets or illiquid housing. Housing provides flow utility, serves as collateral for mortgages, and gives realistic tax advantages. Households can borrow using fixed-rate, amortizing mortgages and can extract home equity, subject to transaction costs. The most novel feature of our model is that households value commitment because they face temptation, following Gul and Pesendorfer (2001). Temptation represents the idea that households suffer from self-control problems that make it difficult to achieve their optimal savings plan due to instantaneous gratification that is hard to resist. Households can mitigate the effects of temptation by “locking away” their wealth in housing. The commitment benefit of housing has been widely discussed, though without much attempt at quantification. An important challenge is to identify the importance of temptation and commitment in explaining the observed behavior of U.S. households.

We structurally estimate key model parameters using the method of simulated moments. We target the life-cycle profiles of consumption, liquid assets, housing wealth, and mortgages, as well as consumption growth dynamics. The relationship between consumption growth and liquid assets plays an important role in pinning down the presence and strength of temptation in our model. Temptation generates a positive relationship between consumption growth and liquid assets: more assets induce greater temptation, resulting in higher consumption growth. In contrast, without temptation, traditional consumption smoothing motives imply that there is no relationship between consumption growth and assets. When we estimate our model, we find that temptation is necessary to fit the positive relationship between consumption growth and liquid assets observed in the PSID.

Next we use our model to simulate a policy change where home equity withdrawal is

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2 For instance, Robert Shiller 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)

3 The positive relationship observed in the data is robust to year fixed-effects, household fixed-effects, instrumenting with lagged assets, and controlling for lagged consumption growth.
suddenly legalized after many years of prohibition, similar to the quasi-experiment in Texas. First, this allows us to assess the predictive power of our model when confronted with an exogenous policy change. We find that our model predicts an increase in consumption and mortgage balances that is similar in magnitude to the empirical evidence from Texas. Second, this allows us to decompose the drivers of the response in consumption. We find that weakened commitment explains roughly half of the short-term increase in consumption in Texas.

Finally, we analyze the welfare consequences to legalizing home equity withdrawal using our estimated model. Overall, we find that welfare declines by around 2.6% in consumption-equivalent terms when home equity withdrawal is introduced, as the cost of breaking the commitment device outweighs the benefit of more liquidity. We see that access to home equity increases consumption for young households, due to relaxed credit constraints and better self-insurance. It also leads, however, to a reduction in net wealth at the age of retirement and a decrease in homeownership for retirees. This is because it is now more difficult to accumulate wealth. When we examine the distributional consequences of this policy, we find that the welfare decline is largest for the middle class, the group traditionally most reliant upon the commitment benefit of homeownership.

Do our findings imply that we should outlaw home equity withdrawal? No. Our model suggests that we should regulate mortgages to provide the benefits of commitment during good times, as well as the benefits of flexibility during bad times. We show that this would be welfare enhancing in our estimated model and discuss current regulatory challenges that prevent the creation of such mortgages.

We believe that the commitment role of housing is a relatively understudied topic despite its potential importance for consumption, saving, and welfare. Housing wealth became substantially more liquid between the 1980s and mid-2000s, owing to a combination of regulatory changes and financial innovation. This led to an increase in debt-financed consumption and a decrease in the personal savings rate. Despite these significant changes, the impact of home equity withdrawal on welfare remains uncertain. Hurst and Stafford (2005) find large consumption smoothing benefits to home equity withdrawal.7 In a similar vein, Gorea and

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4 In contrast, there exists an extensive literature that studies the impact of house price changes on consumption-saving decisions (see for example Mian and Sufi, 2011; Mian, Rao, and Sufi, 2013; Browning, Gertz, and Leth-Petersen, 2013; Berger et al., 2017; Aladangady, 2017; Graham, 2018; Crossley, Levell, and Low, 2018; Cloyne et al., 2019).


7 Smoothing benefits have been well documented by Benito (2007), Gerardi, Rosen, and Willen (2010), Lustig and Van Nieuwerburgh (2010), and Agarwal and Qian (2017) among others.
Midrigan (2017) predict large welfare gains if home equity withdrawal were made cheaper. In contrast to these papers, we consider not only the consumption smoothing benefit of home equity withdrawal, but also the potential detriment of weakened commitment.

An important contribution of our paper is to evaluate the welfare trade-off to increased liquidity of housing. Our study builds upon papers that evaluate the implications of self-control problems for consumption and savings decisions. Laibson (1997) highlights the importance of illiquid assets as a commitment device, suggesting that financial innovation may have reduced savings rates by making assets more liquid. Nakajima (2012) shows that credit cards may reduce welfare by exacerbating self-control issues in a calibrated model. Krusell, Kuruşçu, and Smith (2009) show that savings subsidies may help mitigate the problems of temptation. Schlafmann (2016) shows that downpayment requirements and prepayment penalties may be beneficial in a calibrated model of homeownership. In contrast to these studies, we seek to estimate the importance of self-control problems in explaining the consumption behavior of U.S. households, thus allowing us to assess the relative benefits and disadvantages of increased liquidity.

Historically, it has been very difficult to identify the importance of self-control problems and commitment outside of the laboratory or a field experiment. Laibson, Maxted, Repetto, and Tobacman (2017) estimate the severity of self-control problems due to hyperbolic discounting by matching life-cycle moments of wealth and debt. But their method relies upon the restrictive assumption that housing taste is calibrated, an assumption that we relax. 8 We pursue an alternative approach to estimate the importance of self-control problems, following the insight from Bucciol (2012) and Kovacs and Low (2019), who demonstrate that temptation preferences produce testable implications that appear in the consumption Euler equation. Both authors use these methods to estimate temptation preferences using a semi-structural approach, relying upon the analytical link between the Euler equation and temptation, as well as the assumption of no credit constraints. In contrast, we estimate our model using indirect inference, jointly targeting life-cycle moments and consumption growth dynamics, thus allowing us to relax the assumption of no credit constraints.

There are a few caveats that are applicable to our analysis. First, while the focus of this paper is housing, we believe that retirement accounts also provide commitment. While we include simplistic retirement accounts in our model, we assume that these are both mandatory and perfectly illiquid. In reality, retirement accounts in the U.S. have also become substantially more liquid during recent years, due to increased availability of loans that allow

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8 Similarly, Kovacs and Moran (2019) estimate the severity of self-control problems by matching the share of households with zero liquid assets. Their identification strategy requires strong assumptions about homogeneous housing taste, an assumption that we do not require.
households to borrow from their pension (Beshears, Choi, Laibson, and Madrian, 2011). This suggests that commitment may have been weakened even more than our paper suggests.

Second, while our baseline model without temptation is relatively standard, there exist a large number of potential features that may be added to this model, some of which may generate a positive relationship between consumption growth and liquid assets. We extend our baseline empirical analysis to control for a number of these possibilities (e.g. aggregate uncertainty, asset shocks, persistent heterogeneity, and habit formation) and in all cases find evidence of a positive relationship between consumption growth and liquid assets. We are therefore assured that our finding of temptation is robust to these alternative modeling assumptions, although it is nevertheless impossible to control for all possible model extensions that may produce observationally equivalent results.

The rest of this paper proceeds as follows. Section 2 studies the consumption response to legalizing home equity withdrawal using a quasi-experiment in Texas. Section 3 develops a model that can capture potential benefits and disadvantages to legalizing home equity withdrawal. Section 4 provides analytical results showing how temptation can be identified in the context of our model. Section 5 discusses model estimation using indirect inference. Section 6 presents the estimated model parameters and model fit. Section 7 presents our counterfactual analysis and welfare results. Finally, Section 8 concludes.

2 Motivational Evidence

To what extent does home equity withdrawal impact consumption and savings decisions? To answer this question, we study the effects of a quasi-experiment where home equity withdrawal was effectively outlawed for over a century and then suddenly legalized. By comparing the behavior of households who were impacted by this policy change relative to households who were unaffected, it is possible to measure the effects of home equity withdrawal on consumption. Using data from the Consumer Expenditure Survey, we find that the legalization of home equity withdrawal resulted in a 3% increase in nondurable consumption for homeowners in Texas relative to homeowners in other states.

The setting of this quasi-experiment is Texas, where most forms of home equity withdrawal were prohibited prior to 1998. This prohibition was the result of a clause in the Texas Constitution of 1876 that protected homeowners from foreclosure except for the nonpayment of debt used to purchase property or fund home improvements. As a result, cash-out refinancing and home equity loans were effectively outlawed for any purpose other than home renovation. Following a state-wide referendum that narrowly passed in November 1997, the

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9 See for instance Deaton (1991); Attanasio and Browning (1995); Carroll (1997).
Texas Constitution was amended to allow households to perform home equity withdrawal for other purposes starting in January 1998. To the best of our knowledge, Texas was the only state to have had a prohibition on home equity withdrawal, therefore it provides an ideal setting to study the impact of home equity extraction on consumption.

Figure 1 shows the share of prime-age homeowners holding a home equity loan in Texas relative to other states in the southern United States. Data comes from the Consumer Expenditure Survey (CEX). We observe that 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. The existence of homeowners with home equity loans in Texas prior to 1998 is indicative of banks' willingness to lend for home improvement purposes, given that housing was always able to serve as collateral for loans of this type. Following the liberalization of mortgage lending in Texas in 1998, we observe an increase in home equity loans. This indicates that households now had more access to credit given that they could use their home as collateral. When we look at the share of homeowners with a home equity loan in the other southern states, we see that this fraction is relatively stable, hovering around 6%.

Figure 1: Share of Homeowners with a Home Equity Loan

To study the impact of this policy reform, we estimate a difference-in-differences specification using data spanning the period during which Texas legalized home equity withdrawal.

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10 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).
More specifically, we estimate the following equation:

\[ y_{i,s,t} = \beta_1 + \beta_2 \text{Post1998}_{s,t} \ast \text{Texas}_{s,t} + \gamma_1 X_{i,t} + \gamma_2 Z_{s,t} + \eta_s + \phi_t + \epsilon_{i,s,t} \]  

(1)

where \( y_{i,s,t} \) is the outcome variable (such as log nondurable consumption) for household \( i \) living in state \( s \) at time \( t \). \( \text{Post1998}_{s,t} \ast \text{Texas}_{s,t} \) is an indicator variable equal to one if the observation is recorded following January 1, 1998 and the household lives in Texas. \( X_{i,t} \) are household characteristics, \( Z_{s,t} \) are state characteristics, \( \eta_s \) are state fixed effects, and \( \phi_t \) are year-month fixed effects. All results are estimated using sample weights. Standard errors are clustered by state following Bertrand, Duflo, and Mullainathan (2004).

The household characteristics \( X_{i,t} \) 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 \( Z_{s,t} \) 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 significantly alter the results.

Data comes from the Consumer Expenditure Survey (CEX) which contains household-level data on income, consumption, housing, mortgages, and home equity loans for a representative sample of U.S. households. We restrict our sample to homeowners age 25-60 in the southern United States between 1995 and 2003. The time range was chosen purposefully to omit a policy change in 2004 which altered the ability of Texan households to take out home equity lines of credit. We focus on households in 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. We repeat our analysis using all states in Appendix A.8 and find similar results, though with slightly higher magnitudes.

Table 1 shows the results of our difference-in-differences estimation. First, we see that the legalization of home equity withdrawal led homeowners to take out additional mortgages. The policy change resulted in a 1.5 percentage point increase in the share of homeowners holding a home equity loan and a 3.6 percentage point increase in the share of homeowners holding a mortgage. This reflects the fact that not all home equity withdrawal was performed using home equity loans. In addition, we find that the legalization of home equity withdrawal resulted in a 3.01% increase in nondurable consumption for homeowners in Texas relative to the neighboring states. This increase in consumption is significant at the 5 percent level. Because the policy change was unanticipated, these results suggest a causal effect of the

\[^{11}\] In Appendix A.4, we repeat our analysis on renters as a placebo test. We find no significant effect of the policy change on consumption.
legalization of home equity withdrawal on nondurable consumption.

Table 1: Effect of Legalizing Home Equity Withdrawal

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1) HEL &gt; 0</th>
<th>(2) Mortgage &gt; 0</th>
<th>(3) Log Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post1998 * Texas</td>
<td>0.0149***</td>
<td>0.0359**</td>
<td>0.0301**</td>
</tr>
<tr>
<td></td>
<td>(0.00478)</td>
<td>(0.0129)</td>
<td>(0.0104)</td>
</tr>
<tr>
<td>Texas</td>
<td>-0.00195</td>
<td>-0.107***</td>
<td>-0.0129**</td>
</tr>
<tr>
<td></td>
<td>(0.00261)</td>
<td>(0.00450)</td>
<td>(0.00581)</td>
</tr>
<tr>
<td>Observations</td>
<td>36,766</td>
<td>36,766</td>
<td>36,766</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.016</td>
<td>0.153</td>
<td>0.276</td>
</tr>
<tr>
<td>Time FE</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>State FE</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Note: This table shows the response of home equity loans, mortgages, and consumption to the legalization of home equity withdrawal in Texas on January 1, 1998. Column 1 shows the effect on the probability of having a home equity loan, estimated using a linear probability model. Column 2 shows the effect on the probability of having positive mortgage debt, including junior liens. Column 3 shows the average effect on log nondurable consumption. State and year-month fixed effects are included. Standard errors are clustered at the state level. Significant at ***1%, **5%, and *10%.

These results are broadly consistent with Greenspan and Kennedy (2008) who examine U.S. national accounts and estimate that home equity withdrawal accounted for approximately 3% of personal consumption expenditure between 2000 to 2005. These results are also consistent with Abdallah and Lastrapes (2012) who find that the legalization of home equity withdrawal increased aggregate retail expenditure in Texas by around 2-5%, as well as Agarwal and Qian (2017) who find that a reduction in access to home equity in Singapore reduced credit card expenditure by 4%. Our results are slightly higher than the magnitudes reported by Leth-Petersen (2010), who studies the legalization of home equity withdrawal in Denmark using imputed expenditure data. In contrast to these four studies, we use detailed micro-data on household expenditure, rather than other proxies for this variable.

These results are also robust to the inclusion of house prices as an additional control. In Appendix A.3, we control for state-level house prices by quarter. We observe that the legalization of home equity withdrawal results in a significant 3.3% increase in nondurable consumption, only slightly higher than our baseline result.

The above analysis is dependent upon the assumption that there were parallel trends in nondurable consumption in Texas and the control group prior to the policy change in 1998. This assumption would need to be rejected if we observe a gradual increase in consumption in one of these groups but not the other. Figure 2 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. 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.

More formally, we test the assumption of parallel trends using an event study analysis. We expect to see a consumption response of zero prior to 1998 if the parallel trends assumption is valid. Results are reported in Appendix A.2. We find no statistically significant response in consumption prior to 1998, which reaffirms the validity of our research design.

As a falsification test, we estimate the effect of the policy change on nondurable expenditure of renters in Texas relative to the control group (Appendix A.4). We find that the policy change had no significant effect on the expenditure of renters, which confirms our research design. In addition, we also estimate the effect of the policy change on homeownership rates in Texas (Appendix A.5) and again find no significant effect.

We study heterogeneity in the treatment effect along a number of dimensions. For instance, we look at heterogeneity by employment status, as there exists disagreement about

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12 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 Pistaferri (2016).
the extent to which unemployed households are able to borrow (DeFusco and Mondragon, 2018; Braxton et al., 2019). Our results are contained in Appendix A.6. We find that the mortgage market liberalization increases nondurable consumption of employed households by around 4%, but has no significant effect on the consumption of unemployed households.

Finally, we study how home equity withdrawal affects different expenditure categories, as there exists substantial disagreement on the usage of funds extracted from home equity.\footnote{See for instance Canner, Dynan, and Passmore (2002), Cooper (2010), Mian and Sufi (2011), Disney, Gathergood et al. (2009), and Crossley, Levell, and Low (2018) among others.} We find that the largest increase in nondurable expenditure is observed for categories such as food away from home and entertainment. In contrast, we see no significant effect on food consumed at home. The results are contained in Appendix A.7. Overall, we find that household expenditure increases more for luxuries rather than necessities.

### The Need for a Structural Model

At this point it is worthwhile to take stock of what we can learn from the quasi-experiment in Texas. The data provide evidence that there is a causal link between the availability of home equity withdrawal and nondurable consumption. But what channels drive this increase in consumption and does home equity withdrawal encourage households to over-consume? Similarly, should policymakers be worried about the corresponding decline in savings rates? To answer these questions it will be necessary to turn to a structural model.

There are a few factors that limit the inferences that can be drawn without a structural model. First, in the data, we observe actual consumption decisions but cannot observe the extent to which households experience temptation. Second, it is difficult to think of a source of exogenous variation that would give households greater ability to smooth consumption without simultaneously increasing their temptation. This impedes our ability to use the data alone to determine the extent to which increased consumption in Texas is a result of increased temptation.\footnote{A similar point is made in Mian and Sufi (2011), who argue that it is not possible to use the data 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 households with self-control problems.} In contrast, in a structural model it is possible to turn off the effect of increased temptation, allowing us to distinguish between different channels. In Section 6.2, we use our structural model to decompose the relative importance of consumption smoothing versus increased temptation. Finally, without a model, it is not possible to assess welfare or consider counterfactual policies, such as the introduction of semi-flexible mortgages that restrict home equity withdrawal during good times but allow it fully during bad times.

In the remainder of this paper, we develop a model that is able to achieve the above
goals. While this model is rich enough to allow for such analysis, it also imposes sufficient
structure on the data to enable estimation of key model parameters related to time preference,
temptation, and housing utility. This will allow us to decompose the different channels
that drive an increase in consumption when home equity withdrawal is legalized. This
decomposition is critically important for assessing the welfare effects of this policy change,
as improved consumption smoothing will always be welfare enhancing, whereas weakened
commitment will be welfare reducing.

3 Model

To better understand the effects of home equity withdrawal, we develop a model that can
capture two contrasting views: the positive view, where access to home equity enables house-
holds to better smooth consumption and self-insure against risk, and the negative view, where
access to home equity weakens the commitment benefit of housing.

We begin with a relatively standard life-cycle model of consumption and saving (Deaton,
1991; Attanasio and Browning, 1995; Carroll, 1997). In this framework, households face
idiosyncratic income risk during their working life, followed by reduced income during re-
tirement. As a result, households accumulate wealth for two purposes: to self-insure against
income shocks and to maintain consumption during retirement.

We then augment this model with realistic housing and mortgages. We allow households
to invest in two different instruments: liquid assets and housing, where housing provides flow
utility, serves as collateral for mortgages, and provides tax advantages. Housing transactions
incur significant costs, thus making housing illiquid. Home equity withdrawal is available,
though costly, thus giving households the ability to increase their mortgage balance and
extract home equity when desired.

In addition, we allow for the possibility that households suffer from temptation, following
Gul and Pesendorfer (2001, 2004). Temptation represents the idea that households suffer
from self-control problems that make it difficult to achieve their optimal savings plan due to
instantaneous gratification that is hard to resist. As a result, households value illiquidity as
a savings commitment device.

Finally, we augment this model with a number of features that are necessary to cap-
ture the environment faced by U.S. households. These features include income taxation,
progressive social security, and pensions.
3.1 Temptation

Households with standard preferences have no demand for commitment devices because they are ex-post fully committed to their ex-ante choices. In order to generate demand for commitment, households have to exhibit some sort of present-biased behavior. In our model, we incorporate the temptation preferences of Gul and Pesendorfer (2001) that represent preferences for immediate gratification. The temptation model relaxes the standard model’s assumption about preference specification so that instantaneous utility depends partly on feasible alternatives that are not chosen, but which are tempting.

It is important to note that using the temptation framework is not the only way to model present-biased behavior. The alternative preference structure that has received considerable attention is the model with hyperbolic discounting, formally introduced by Phelps and Pollak (1968) and later popularized by Laibson (1997). Modeling present-bias in the temptation framework has two great advantages over the hyperbolic discounting approach. First, temptation preferences induce dynamically consistent choices, which makes welfare analysis straightforward.\textsuperscript{15} Second, the importance of temptation preferences can be tested based on their implications for consumption growth dynamics.

3.2 Preferences

Households maximize the sum of their expected, discounted lifetime utility, which can be written as:

$$\max E_t \sum_{t=0}^{T} \beta^t U_t.$$  \hspace{1cm} (2)

In contrast to standard preferences, the per period utility function under temptation preferences depends not only on the chosen consumption bundle, but also on the most tempting consumption bundle in the feasible choice set:

$$U(c_t, h_t, \tilde{c}_t, \tilde{h}_t) = u(c_t, h_t) - \lambda \left[ u(\tilde{c}_t, \tilde{h}_t) - u(c_t, h_t) \right]$$  \hspace{1cm} (3)

where the felicity function $u$ is a concave function that is increasing both in $c_t$ and $h_t$ and is specified later. $c_t$ and $h_t$ are the chosen level of nondurable consumption and housing status in period $t$, while $\tilde{c}_t$ and $\tilde{h}_t$ are the most desirable nondurable consumption and housing status. More specifically, households may be tempted to maximize their current period utility instead of maximizing their discounted lifetime utility. In particular, they may wish

\textsuperscript{15}For more information on the difficulty of welfare analysis under hyperbolic discounting, see Fang and Silverman (2009).
to spend all of their available liquid resources on nondurable consumption and housing, since
that is the most tempting alternative of all. Therefore the most tempting alternative, \((c_t, h_t)\)
maximizes their immediate utility, rather than lifetime utility\(^{16}\):

\[
[c_t, h_t] = \arg \max_{c_t, h_t} u(c_t, h_t),
\]

(4)

The term in square brackets in equation (3) represents the temptation motive of the house-
holds. It is the utility cost of not choosing the most tempting consumption alternative: the
difference between the temptation values of the most tempting and of the chosen consump-
tion bundles. When exposed to temptation, households can decide to exercise self-control
or succumb to temptation. If they exercise self-control they have to pay the utility cost of
temptation resistance. On the other hand, if households succumb to temptation then the
cost of self-control becomes zero and the utility function simplifies to its standard form.

### 3.3 Assets

Households who wish to save can invest in two types of assets: liquid assets \((a_t)\) or illiquid
housing \((h_t)\). The liquid asset yields a certain return \(r\) each period. As we abstract away
from asset risk, we calibrate our model using risk-adjusted returns.

Households also have the ability to purchase owner-occupied housing. Housing exists on
a discrete grid with \(k\) different sizes: \(h^k \in \{h_1, h_2, \ldots, h_k\}\). The price of each house \(p_t(h^k)\)
depends on its size and is determined relative to the price index \(\bar{p}_t\):

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

where \(g(h^k)\) represents the relative price of house \(k\).\(^{17}\) We assume that house prices grow at
a constant rate, \(R_H > 1\), which represents the gross risk-adjusted return on housing. The
evolution of the price index is as follows:

\[
\bar{p}_t = R_H\bar{p}_{t-1}, \quad \forall t \text{ given } \bar{p}_1
\]

(5)

Buying or selling a home incurs a cost \((F)\) that is proportional to the price of the home.

As an alternative to homeownership, households are also able to rent any housing unit.
Renters choose the size of their home from the \(k\) different housing options available. We

\(^{16}\text{Note that we later introduce mortgages into the model, which affects the domain of this maximization, as}\)
\text{the mortgage choices alter households’ budget constraints.}

\(^{17}\text{We require } 0 < g(h^k) \leq 1, g'(h^k) > 0 \text{ and } g''(h^k) < 0.\)
assume that the cost of renting is proportional to the price of the unit:

\[ \chi^k_t = \eta p_t(h^k). \]

where \( \chi^k_t \) is the rental cost of house \( k \) at time \( t \), while \( \eta \) represents the rental scale.

### 3.4 Mortgages

The most widely used mortgage contract in the U.S. is the fully-amortizing fixed-rate mortgage. Therefore we assume that mortgages are of this kind with regular required mortgage payments that force households to gradually build up wealth in the form of home equity. As a result, housing may act as a commitment device not only because of its illiquidity, but also because of the regular mortgage payments every period.

We assume that households are allowed to increase the size of their mortgage by performing home equity withdrawal.\(^{18}\) Extracting home equity incurs a fixed cost, \( C^R \), and a proportional cost, \( F^R \), which is a fraction of the home equity extracted. There is no cost when households prepay their mortgage, i.e. when they make mortgage payments in excess of their required mortgage payment. Note that the option of home equity withdrawal makes housing less illiquid, hence it weakens the role of housing as a savings commitment device.

When households decide to purchase a new house or to extract home equity, they are subject to a loan-to-value constraint, which restricts their mortgage take-out. If households do not adjust their housing, they have to keep repaying their mortgage, while this repayment can be higher than the minimum repayment given by \( mp(m_t) \), i.e. there is no penalty on early mortgage repayments. Based on these assumptions, next period’s mortgage balances can be written as follows

\[
m_{t+1} \leq (1 + r^M) \begin{cases} 
(1 - \psi^{\text{min}}) p_t(h_t) & \text{buy or extract home equity at time } t \\
m_t - mp(m_t) & \text{otherwise}
\end{cases}
\]

where \( \psi^{\text{min}} \) determines the maximum loan-to-value ratio.

We assume that mortgages are amortizing with constant-level payment plans, as is the case for the vast majority of mortgages in the United States. In other words, households are required to make regular mortgage payments \( mp(m_t) \) every year that they own the house until they pay off the mortgage. Using the condition of a mortgage that is taken out for \( l \)

\(^{18}\) In reality, there exists a wide variety of mortgage products that allow homeowners to perform home equity withdrawal. These include cash-out refinancing, home equity loans, home equity lines of credit, second mortgages, and other options. We purposefully abstract away from these different products by instead assuming a single means of home equity withdrawal.
years at time $t$

$$m_{t+1} = 0 \quad (7)$$

together with mortgage balances in equation (6), the fixed mortgage payment can be expressed based on the following formula:

$$mp(m_t) = \frac{(1 + r_M)^l}{\sum_{i=1}^{l-1} (1 + r_M)^i} m_t \quad (8)$$

where the required payment depends on the size of the mortgage, $m_t$, and the term length of the mortgage, $l$. If there exists a positive mortgage balance $m_t > 0$ at the time a house is sold, the value of the house is used to repay the mortgage and the remaining home equity goes to the household. Households are required to pay off their mortgages by the time of retirement and we assume that they cannot extract home equity after retirement. If a household receives a large negative income shock such that they cannot make their mandatory mortgage payment, they are forced to default. In this situation, households must sell their home and repay their remaining mortgage debt.$^{19}$

### 3.5 Income

Households face idiosyncratic shocks to labor productivity that are uncorrelated across households. 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. During a household’s working life, labor income $y_{i,t}$ is determined exogenously by a combination of deterministic and stochastic components, according to the following equation:

$$\ln y_{i,t} = g_t + z_{i,t} \quad (9)$$

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

$$z_{i,t} = \rho z_{i,t-1} + \varepsilon_{i,t} \quad (10)$$

$$\varepsilon_{i,t} \sim N(0, \sigma^2_\varepsilon)$$

$$z_{i,0} \sim N(0, \sigma^2_0).$$

$^{19}$In the case where mortgage debt is larger than the house value plus transaction costs, the remaining debt is written off and the government provides a minimum consumption floor. This modeling choice ensures that households never experience infinite negative utility.
Note that we let the initial variance of the income innovations, \( z_{i,0} \), to be different from the subsequent periods’ in order to account for initial heterogeneity in income at age 22 in the data.

We build progressive income taxation into the model following Keane and Wasi (2016), and express after-tax income for households by the following equation (see details in Appendix B.2):

\[
\tilde{y}_{i,t} = y_{i,t} - \tau(y_{i,t}, a_{i,t})
\]

During retirement \((t > W)\), households receive two sources of income: progressive social security income and annuitized disbursements from an individual retirement account. Details of how we calculate social security income and annuitized disbursement are in Appendix B.3-B.4. After retirement income is given by:

\[
y_{i,t} = y_{SS,i,t} + y_{IRA,i,t} \quad \forall t > W
\]

### 3.6 Functional Forms

#### Felicity Function

Turning to the choice of functional forms for the felicity function, we choose a flexible specification, as suggested by Attanasio et al. (2012), which we then estimate within our model. This strategy allows us to measure the importance of consumption in the presence of housing, while being agnostic about the nature of the relationship between consumption and housing. Further, we assume that the felicity function is affected by the size of households, which we introduce deterministically. For clarity, here we only present the functional forms without the effect of household size, while we show the full version we use in the Appendix.

\[
u(c_t, h_t) = \frac{c_t^{1-\gamma}}{1-\gamma} \exp \left[ \theta \phi(h_t) \right] + \mu \phi(h_t) - \kappa I_{h_t \neq h_{t-1}} \quad (11)
\]

where \( \gamma \) is the risk aversion parameter, \( \theta \) and \( \mu \) are housing preference parameters. Housing affects immediate utility both directly and via the marginal utility of consumption. The direct effect represented by \( \mu \) makes the utility function non-homothetic in consumption and housing. More specifically, it allows housing to be either a luxury \((\mu > 0)\) or a necessity \((\mu < 0)\). \( \theta \) affects the marginal utility of consumption, allowing housing and consumption to be either substitutes \((\theta < 0)\) or complements \((\theta > 0)\). \( \phi(h_t) \) represents the benefit of living.
in home \( h_t \), which depends on the size of the house and the ownership status:

\[
\phi(h_t) = \begin{cases} 
\ln(h_t) & \text{if owner} \\
\ln(\zeta h_t) & \text{if renter}
\end{cases}
\]  

(12)

Whenever households adjust housing, they suffer a utility cost, \( \kappa \) (\( I_{h_t \neq h_{t-1}} \) becomes 1 in equation (11)).\(^{20}\) The utility cost of adjustment together with corresponding financial costs play an important role in our model, as they make housing illiquid, hence more useful as a commitment device. As we later discuss, the premise of the current paper is to analyze how the introduction of cheaper and easier home equity withdrawal altered the usefulness of housing as a commitment device.

In Appendix B, we describe additional features of our model which we believe are important to match the environment faced by U.S. households. These include progressive taxes, progressive social security, pensions, housing subsidy through the mortgage interest tax deduction, variation in household composition over the life-cycle, and warm-glow bequest motives. Finally, we present the recursive formulation of our model.

4 Information in Consumption Growth

Before delving into the details of our estimation strategy, it is useful to provide a better understanding of the testable implications of temptation. If households suffer from temptation, how will this be revealed in their consumption behavior? What kind of empirical relationship would allow us to measure the degree of temptation? In this section, we derive our model-implied Euler equation for consumption and demonstrate the key implications for consumption growth that will be useful in the identification of temptation. For clarity of exposition, we focus on a simplified version of our model without housing (\( \theta = 0, \mu = 0, \zeta = 1, \eta = 0 \)).

Consumption Growth in the Temptation Model

We can write the Euler equation under temptation as follows (see detailed derivations in Appendix C.1).

\[
\frac{\partial U_t}{\partial c_t} = \beta R E_t \left[ \left( \frac{\partial U_{t+1}}{\partial c_{t+1}} + \frac{\partial U_{t+1}}{\partial \tilde{c}_{t+1}} \right) \right]
\]  

(13)

\(^{20}\)Here we think of the non-monetary cost of changing homes, like finding new schools, setting up new utility providers, facing stress, etc.
Note that the Euler equation only holds if the liquidity constraint is not binding. Using now the functional form for the utility function defined in equation (11) without housing, the Euler equation takes the following form\footnote{For clarity of exposition, in this section we abstract from housing, but in the appendix we reintroduce it and show that the conclusions extend to the case with housing choices.}

\[
\begin{align*}
c_t^{-\gamma} &= \beta R E_t \left[ c_{t+1}^{-\gamma} - \frac{\lambda}{1+\lambda} (\hat{c}_{t+1})^{-\gamma} \right] 
\end{align*}
\] (14)

This equation shows that if you give up one unit of consumption today, you must be compensated by additional consumption utility tomorrow, but you will also suffer from additional costs of temptation due to higher asset holdings next period. This comes from the fact that $\hat{c}_{t+1}$ enters into the right hand side of the consumption Euler equation. Note that the coefficient $\frac{\lambda}{1+\lambda} \in [0,1]$ denotes the relative strength of temptation compared to consumption.

The log-linearized Euler equation for the model with temptation is:

\[
\begin{align*}
\Delta \ln c_{t+1} &= a_0 + a_1 \ln R + a_2 \ln \hat{c}_{t+1} + u_{t+1}
\end{align*}
\] (15)

where $a_0$ includes the log of the discount factor and the unconditional means of second and higher moments of consumption growth and $\ln \hat{c}_{t+1}$, while $a_1 = 1/\gamma$. In Appendix C.3, we also prove that $a_2 \geq 0$. The residual $u_{t+1}$ includes expectational errors and deviations of second and higher moments from their unconditional means.

**Consumption Growth in a Model without Temptation**

Now we contrast the Euler equation derived from our temptation model with the Euler equation derived from the model without temptation by setting $\lambda = 0$. Without temptation, the Euler equation becomes

\[
\begin{align*}
c_t^{-\gamma} &= \beta R E_t \left[ c_{t+1}^{-\gamma} \right] 
\end{align*}
\] (16)

Without temptation, the log-linearized Euler equation is:

\[
\begin{align*}
\Delta \ln c_{t+1} &= b_0 + b_1 \ln R + u_{t+1}
\end{align*}
\] (17)

where $b_0$ includes the log of the discount factor and the unconditional means of second
and higher moments of consumption growth, while $b_1 = 1/\gamma$. The residual $v_{t+1}$ includes expectational errors and deviations of second and higher order moments of consumption growth from their unconditional means.

Note that average consumption growth is lower when households suffer from temptation. In Appendix C.3, we prove that $a_0 < b_0$. In other words, the constant term in the log-linearized Euler equation with temptation is less than the constant term in the Euler equation without temptation. The intuition for this result is that temptation causes households to increase consumption in the present, due to the cost of holding liquid assets, thus mechanically reducing consumption in the future.

Testable Implication

The log-linearized Euler equation from the temptation model, equation (15), and the log-linearized Euler equation from the model without temptation, equation (17), are different. Allowing for temptation results in an additional term in equation (15), the most tempting consumption alternative ($\tilde{c}_{t+1}$), which affects the growth rate of consumption. As we have shown in Section 3.2, the most tempting consumption alternative is a positive function of available liquid resources, hence $\tilde{c}_{t+1} = f(a_{t+1})$, which implies that in the temptation model, liquid assets enter the Euler equation even when liquidity constraints are not binding. Unfortunately, there is no analytical solution for $f$, therefore in the following example, we graphically demonstrate the relationship between consumption growth and liquid assets in the model with and without temptation.

Figure 3 shows the relationship between expected consumption growth and liquid assets in our model. This figure was created using the policy function for consumption. The solid blue line comes from our baseline model with temptation, whereas the dashed pink line comes from our model when we turn off temptation ($\lambda = 0$).

In the model without temptation, we see a negative relationship between liquid assets and consumption growth, as demonstrated by Carroll (1997). Due to liquidity constraints, households with low liquid assets expect large and positive consumption growth. These households would like to shift consumption from the future to the present but are unable to do so, thus consumption in the present is depressed. In contrast, households with high liquid assets expect less consumption growth. These households are less affected by liquidity constraints, therefore they are better able to smooth consumption across periods. This implies a negative relationship between assets and consumption growth, as the impact of liquidity constraints is less severe for households with greater assets.

In the model with temptation, we observe similar behavior when liquid asset holdings are very low. Liquidity constraints again imply a strong negative relationship between con-
consumption growth and liquid assets. But as a result of temptation, we observe the opposite relationship when households are further from the constraint.

Temptation lowers consumption growth relative to the standard model. 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 (e.g. $5,000). This is because a small increase in consumption today gives a large reduction in temptation tomorrow \(u(\tilde{c}_{t+1}) \downarrow\), thus greatly reducing consumption next period. As a result, consumption growth is lower than it would be without temptation \(\Delta c_{t+1} \downarrow\). This effect is less pronounced for households with high liquid assets (e.g. $50,000). This is because a small increase in consumption today has little impact on temptation tomorrow,\(^{22}\) thus only slightly reducing consumption next period. As a result, consumption growth is lower than it would be without temptation, but greater than it would be with lower liquid assets. This implies a positive relationship between consumption growth and liquid assets due to temptation.

In conclusion, the relationship between consumption growth and liquid assets is affected by two opposing forces under temptation. Liquidity constraints imply a negative relationship between consumption growth and liquid assets, while temptation implies a positive relation-

\(^{22}\) Recall in equation (3) that temptation inherits the shape of the felicity function \(u(.)\) which is concave.
ship. In contrast, when we turn off temptation in our model, this relationship is negative.

In the next section, we develop an estimation strategy that uses this insight to pin down the importance of temptation in our model.

5 Estimation and Model Fit

5.1 Estimation

We follow a two-step procedure to estimate the parameters of our model. First, we set the institutional parameters to broadly reflect the economic environment faced by households in the United States. This is performed either by directly estimating these parameters from the data or by setting them with reference to the literature. Second, we estimate the preference parameters by matching model-implied moments to their counterparts in the data. More specifically, we match a combination of consumption growth dynamics and life-cycle moments (including nondurable consumption, liquid assets, net housing wealth, and mortgage debt). The consumption growth dynamics allow us to pin down the importance of temptation versus impatience and other factors in explaining household behavior. Our approach is fundamentally a version of the simulated method of moments (Duffie and Singleton, 1993) where we fix a number of “nuisance” parameters before estimating the structural parameters.

Before providing detailed information on estimation, the next subsection introduces the primary data source for model estimation, defines the sample, and describes the variables.

5.1.1 Data and Sample

We require a long-panel of nondurable consumption at the household level, as well as detailed information on asset holdings, in order to pin down the strength of temptation in our model. For this reason, we estimate our 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 accumulation for a large number of households in the United States.

While our baseline model without temptation is relatively standard (see for instance Deaton, 1991; Attanasio and Browning, 1995; Carroll, 1997), there exists a large number of potential additions that may be added to this model, some of which would be able to generate a positive relationship between consumption growth and liquid assets. In Section 5.3.1, we consider four such additions to our model and show how to control for these in the data.

This two-step procedure is regularly applied in papers that estimate structural life-cycle models. See among others Gourinchas and Parker (2002), Low and Pistaferri (2015), and Laibson et al. (2017). A formal justification of this approach is provided by Dridi, Guay, and Renault (2007).

Unfortunately the CEX is not sufficient to estimate our model. The CEX only follows households for a maximum of four quarters and, moreover, only asks about asset holdings in the final interview.
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 (e.g. children who have formed new families) with annual surveys until 1996 and biennial surveys starting in 1997. We use the 1999-2015 waves of the PSID because it collects detailed information on asset holdings and consumption expenditure, in addition to income data and demographics. Detailed consumption expenditure questions were added to the PSID in 1999. Throughout our analysis, we follow the definition of nondurable consumption used by Blundell, Pistaferri, and Saporta-Eksten (2016).

5.1.2 Parameters set outside the model

We set the institutional parameters to broadly reflect the economic environment faced by U.S. households. This is performed either by directly estimating these parameters from the data or by setting them with reference to the literature. This subsection describes the parameter choices, while Table 13 in Appendix D shows the values of these parameters.

Demographics – Decisions in the model take place at an annual frequency. 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).

Initial Asset Holdings – We use observed asset holdings of PSID households aged 22 to calibrate the age \( t = 1 \) asset holdings in the model. More specifically, we estimate the share of households at age 22 with zero liquid assets to be \( a^\text{zero}_0 = 0.433 \). 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 \( h_0 = 0.09 \).

Asset Returns – We calibrate \( r_h = 0.021 \) based on the real risk-adjusted return on housing computed using Case-Shiller house price index. We augment this index to include housing service flows, maintenance costs, and home insurance. We assume that liquid assets generate no excess returns relative to housing, thus we set \( r = r_h \). Finally, we calibrate 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).

Housing – We allow for eight different sizes of housing \( (N = 8) \). We calibrate the housing transaction cost to be \( F = 0.05 \) following Attanasio, Bottazzi, Low, Neisham, and Wakefield

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\(^{26}\) Our definition of liquid assets comprises cash, checking accounts, savings accounts, directly-held stock, and mutual funds. As some of these components generate lower returns than housing, while others generate higher returns than housing, we decide it is best to set the return to liquid assets equal to the return to housing so that excess returns do not drive our results.
(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 calibrate the rental scale to be \( \eta = 0.035 \). Finally, the initial house price is calibrated to be \( P_1 = \$300,000 \). By the end of the life-cycle, this house is worth roughly \$1 million.

**Mortgages** – Households have access to mortgages that are collateralized against the value of their house. The maximum loan-to-value constraint is set as \( \bar{\psi} = 0.9 \), 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 \( l = 30 \) in order to capture the prevalence of thirty year fixed rate mortgages in the United States. In the Consumer Expenditure Survey, we see that 67.76% of mortgages have a term length of thirty years.\(^{27} \) The cost of home equity withdrawal includes both a fixed and proportional cost, which we calibrate as \( C^R = \$5,000 \) 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 roughly in line with the breakdown of costs published by the Federal Reserve Board (2008), although they are higher than the costs assumed by Agarwal, Driscoll, and Laibson (2013). While we experimented with a lower cost of refinancing, we found that it resulted in an implausibly high share of homeowners performing home equity withdrawal in our model relative to the PSID.

**Income** – We calibrate the persistence of idiosyncratic earnings risk \( \rho = 0.95 \) following the literature which generally finds high persistence in income innovations, see for example Hubbard, Skinner, and Zeldes (1994) and Storesletten, Telmer, and Yaron (2004). We calibrate the standard deviation of income innovations as \( \sigma = 0.217 \) following Choukhmane (2019). We calibrate the standard deviation of initial income \( \sigma_0 = 0.428 \) to match heterogeneity in log income at age 22 in the data. Finally, we estimate the deterministic component of the earnings process, \( g_t \), which is given by a third-order age-polynomial. Estimation is performed by minimizing the distance between mean log income (by age) in our model and the PSID. Parameter values are given in Table 13.

In Appendix D.1 we give detailed information on the remaining parameters that we set outside the model. This includes parameters related to taxation, retirement, and bequests.

\(^{27} \) 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.
5.1.3 Method of simulated moments estimation

Seven preference parameters remain and are estimated using the method of simulated moments. These parameters are temptation ($\lambda$), time preference ($\beta$), risk aversion ($\gamma$), the utility cost of moving ($\kappa$), additive housing utility ($\mu$), multiplicative housing utility ($\theta$), and the disutility of renting ($\zeta$). These preference parameters are estimated by targeting a combination of life-cycle and dynamic moments.

**Life-Cycle Moments** – We target the mean life-cycle profiles of nondurable consumption, liquid assets, net housing wealth, and mortgage debt. In addition, we target the mean homeownership rate over the life-cycle. The liquid asset moments are top-coded in both the data and the simulations at the 95th percentile in order to mitigate the impact of the very wealthy, following O’Dea (2018). When targeting life-cycle moments, we focus on the behavior of households aged 25 to 60. Older households are not included because there are several unmodeled features (e.g., early retirement, medical shocks, the survival of one spouse) that will likely be relevant for their behavior.

**Consumption Growth Dynamics** – In addition, we target the relationship between consumption growth and liquid assets estimated using household-level data. This is informative since temptation affects consumption growth dynamics, as seen in Section 4. More specifically, we target $\psi$ in the following auxiliary model that we estimate on both the data and the simulated model:

$$
\Delta \ln c_{i,t} = \psi \ln a_{i,t} + \sum_{j=25}^{60} \alpha_j A g e_{i,t}^j + \epsilon_{i,t}
$$

(18)

In the auxiliary model, we regress consumption growth on log liquid assets and a series of age dummies. In both the data and the model, this equation is estimated on the sample of households with $a_t > \$500$. We choose to restrict our sample in this manner so that we can focus on households who are further from the liquidity constraint, as the effect of temptation on consumption growth is more stark for such households.

By targeting $\psi$ from a consumption growth regression, we are adopting an indirect inference approach to model estimation. One benefit of this approach is that the auxiliary model need not be correctly specified to deliver consistent estimates of the structural model param-

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28 We find that our estimate of $\hat{\psi}$ in the PSID is relatively robust to the inclusion of a wide variety of controls, including year fixed effects, changes in family size, and lagged consumption growth (Section 5.3.1).

29 Unfortunately 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 for liquid assets. We explore an alternative cutoff criteria based on the definition of hand-to-mouth households in Kaplan and Violante (2014). While this alternative cutoff slightly changes the magnitude of $\hat{\psi}$, it does not change the sign of that parameter and thus does not affect our key finding that households suffer from temptation.
eters (Smith, 1993). In our case, the presence of credit constraints implies that Equation 18 is likely to be misspecified (i.e. $E[\epsilon_{i,t}] \neq 0$ resulting in bias in $\hat{\psi}$).\textsuperscript{30} This would be a problem if we were following the method of Bucciol (2012) and Kovacs and Low (2019), who estimate a consumption Euler equation to identify the importance of temptation.\textsuperscript{31} Fortunately, our estimation strategy is consistent even in the presence of credit constraints, as Equation 18 simply serves as a binding function that map the parameters of our structural model into the parameters of the auxiliary model. Since liquidity constraints exist in the model, they will result in the same form of misspecification in the binding function as in the data.\textsuperscript{32}

It is worthwhile to consider which aspects of variation in the data will be most important in pinning down each of the model parameters. Total wealth contributes substantially to pinning down the time preference parameter – greater wealth accumulation implies that households are more patient and will have a higher $\beta$. Liquid asset holdings early in life are important for precautionary purposes and therefore contribute substantially to pinning down the risk aversion parameter – greater liquid assets early in life indicate that households are more risk averse, implying a higher $\gamma$. The share of wealth held in housing is important in determining the strength of housing taste, with the life-cycle profiles of housing, wealth, and consumption playing a key role to distinguish between additive and multiplicative housing utility.\textsuperscript{33} In addition, the share of homeowners is important to determining the disutility of renting – a higher share of homeowners implies a lower $\zeta$.

Finally, the most difficult parameter to pin down is $\lambda$. This cannot be pinned down using life-cycle moments alone, as impatience, low risk aversion, and temptation generate very similar life-cycle implications. Instead, the relationship between consumption growth and liquid assets ($\psi$) is important in pinning down the strength of temptation. A more positive relationship implies that households suffer more from temptation, while a negative relationship implies that we cannot reject the null hypothesis that households do not suffer from temptation. In contrast, there is no way for impatience or any of the other model parameters to generate a positive relationship.

\textsuperscript{30} 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 3.

\textsuperscript{31} These authors use a semi-structural Euler equation approach to estimate $\lambda$. This relies upon an analytical mapping between the parameters of the auxiliary model (i.e. $\psi$) and the structural parameter $\lambda$. Unfortunately in the presence of credit constraints, it is impossible to derive such an analytical relationship. The benefit of our approach is that it does not rely upon such an analytical mapping and therefore is not biased due to credit constraints.

\textsuperscript{32} This is similar to the insight from Carroll (2001), who suggests targeting the coefficients of a consumption growth regression as a way to avoid issues of misspecification in consumption Euler equations.

\textsuperscript{33} If consumption and housing move together over the life-cycle, then $\theta$ will be higher as this generates more complementarity between consumption and housing.
5.2 Estimation Results

Table 2 shows the estimated parameters of our model. The first column presents the estimation results from our baseline model where we allow for the possibility of temptation. The second column presents the estimation results from a restricted model where we turn off temptation by setting $\lambda = 0$.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Temptation Model</th>
<th>Non-Temptation Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temptation</td>
<td>$\lambda$</td>
<td>0.387 (0.011)</td>
</tr>
<tr>
<td>Risk Aversion</td>
<td>$\gamma$</td>
<td>2.120 (0.037)</td>
</tr>
<tr>
<td>Time Preference</td>
<td>$\beta$</td>
<td>0.972 (0.001)</td>
</tr>
<tr>
<td>Housing Utility (Additive)</td>
<td>$\mu$</td>
<td>0.077 (0.002)</td>
</tr>
<tr>
<td>Housing Utility (Multiplicative)</td>
<td>$\theta$</td>
<td>0.249 (0.005)</td>
</tr>
<tr>
<td>Disutility of Renting</td>
<td>$\zeta$</td>
<td>0.731 (0.017)</td>
</tr>
<tr>
<td>Utility Cost of Moving</td>
<td>$\kappa$</td>
<td>0.795 (0.015)</td>
</tr>
</tbody>
</table>

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

The estimate for the strength of temptation is statistically significant at $\lambda = 0.387$. As the baseline model nests the standard model, this confirms that households suffer from temptation. To interpret the strength of temptation, it is worthwhile to compare the cost of temptation to the benefit of consumption. Given our estimate of lambda, we find that the weight on the utility cost of temptation is roughly a quarter of the weight on the utility benefit of consumption.$^{34}$

It is worthwhile to compare our estimated value of $\lambda$ with other studies in the literature. Kovacs and Low (2019) estimate a consumption Euler equation and then use the analytical

$^{34}$ Note that the relative strength of temptation shows up in the Euler equation as $\frac{\lambda}{1+\lambda}$ (equation 13). Thus in our case we obtain that the relative cost of temptation is $\frac{\lambda}{1+\lambda} = 0.279$. 

27
link between the parameters of this equation and the structural model to recover the value of $\lambda$. While our result is slightly higher than their point estimate of $\lambda = 0.305$, our estimate falls well within their 95% confidence interval. That said, one disadvantage of their semi-structural approach is that it relies upon the analytical link between the structural and reduced form models, which we know to be misspecified in the presence of credit constraints. This would produce downward bias in the estimate of lambda, which may explain why their estimate is lower than ours.

There exist three papers that estimate temptation by targeting life-cycle moments. These papers generally find weaker temptation, but greater impatience. Bucciol (2009) estimates a $\lambda$ of 0.19, while Bucciol (2012) estimates a $\lambda$ of 0.05. The reason we obtain a higher value is because we target consumption growth dynamics, in addition to life-cycle moments. Kovacs and Moran (2019) obtain an estimate of $\lambda = 0.16$. The reason we obtain a higher value is twofold. First, they do not target consumption growth dynamics, and second, our model has home equity withdrawal while theirs does not.

The coefficient of relative risk aversion ($\gamma$) is estimated to be 2.1 and 2.2 in the models with and without temptation, respectively. These values are well within the range commonly estimated in the literature, see for instance Attanasio et al. (1999), Gourinchas and Parker (2002), and Cagetti (2003). Meanwhile, the time preference parameter ($\beta$) is estimated to be 0.97 in the model with temptation. This estimate is relatively standard and lies between the values reported by Gourinchas and Parker (2002) and ODea (2018). In comparison, we find that the model without temptation requires households to be more impatient with $\beta = 0.92$, although this parameter is still within the range commonly assumed by previous studies.

We find that households get substantial utility flows from housing and that it is both a luxury good (as $\mu > 0$) and a complement to consumption (as $\theta > 0$). This is in line with the results from Attanasio, Bottazzi, Low, Neisham, and Wakefield (2012). Moreover, there exists a strong premium to living in owner-occupied housing (as $\zeta < 1$). Our estimate of $\zeta$ implies that the “effective size” of rental units is only 73% of their owner-occupied counterparts. This is consistent with the common view that there exist certain housing amenities that can only be obtained by home ownership.

In the model without temptation, we see that taste for housing is substantially higher,

---

35 Kovacs and Low (2019, Table 1) estimate the relative strength of temptation to be $\tau = 0.234$ with a standard error of 0.14. This can be converted to the temptation parameter with the formula $\lambda = \frac{\tau}{1-\tau}$.

36 In a Monte Carlo experiment, we test whether it is possible to obtain a coefficient on consumption growth that is in line with the data when assuming a $\lambda$ of 0.05, but we find that this is not possible. See Figure 9 in the Appendix.

37 In their model, this implies that housing is a very strong commitment device, thus for a given value of beta and lambda, households will accumulate more housing wealth. Thus in estimation, the lack of home equity withdrawal drives down their estimates of $\beta$ and $\lambda$. 

28
with a particularly large increase in $\mu$ suggesting that housing is much more of a luxury relative to the baseline model. Moreover, the estimate of $\zeta$ is lower, implying greater disutility to renting rather than owning. The higher taste for housing and greater impatience observed in the model without temptation is likely driven by the fact that most household wealth is held in illiquid assets.\textsuperscript{38} For the model without temptation to match this fact, it is necessary to assume high taste for housing and high impatience. In contrast, the temptation model makes it difficult to hold liquid assets relative to illiquid housing, thus generating a large share of illiquid asset holdings.\textsuperscript{39}

5.2.1 Fit of Life-Cycle Moments

We find that the baseline model with temptation and commitment obtains a good fit of the targeted life-cycle moments (Figure 7 in the Appendix). In both the model and the data, liquid asset holdings are relatively low prior to age 45, but then increase rapidly before retirement. In addition, the model matches the gradual accumulation of housing wealth throughout the life-cycle; the hump shaped profile of mortgage debt which peaks around age 40-45; and the hump shaped profile of nondurable consumption which peaks around age 50. We also find that the model has good out-of-sample fit when we look at untargeted moments such as the share of households extracting home equity or the extent of wealth inequality in the model. More detail on out-of-sample fit are contained in Appendix D.5.

The model without temptation also obtains a decent fit of the life-cycle moments (Figure 8 in the Appendix). This model fits the gradual accumulation of housing wealth throughout the life-cycle, as well as the hump shaped profile of consumption. That said, the model slightly under-predicts liquid assets later in life (ages 50-60) and also predicts a slightly later peak in mortgage debt relative to what is observed in the data. Overall, the life-cycle moments present no major failings for the model without temptation.

In contrast, when we look at the relationship between consumption growth and liquid assets, we see that the model with temptation performs much better (both quantitatively and qualitatively) than the model without temptation. The next section presents these results.

5.2.2 Fit of Consumption Growth Dynamics

We find that the model with temptation is able to match the positive relationship between consumption growth and liquid assets observed in the PSID. In contrast, the model without

\textsuperscript{38} For more detail, see for instance Kaplan and Violante (2014) and Kaplan, Violante, and Weidner (2014).

\textsuperscript{39} Kovacs and Moran (2019) demonstrate that a model with temptation and commitment obtains a good match of the large fraction of hand-to-mouth households, without having to assume large excess returns and low transaction costs to illiquid assets, as in Kaplan and Violante (2014).
temptation is incapable of matching this empirical evidence. This relationship is of vital importance to pinning down the strength of temptation in our estimated model.

Table 3 shows the results when we estimate the consumption growth regression on the PSID, the temptation model, and the non-temptation model. In the PSID, we see that the coefficient on liquid assets is positive and significant with an estimated value of 0.00447, meaning that households with greater liquid assets experience higher consumption growth. In the baseline model with temptation, we see that the coefficient on liquid assets is positive and significant with a value of 0.0037. In contrast, in the restricted model without temptation, we see that the coefficient on liquid assets has the opposite sign, with a value of -0.004.

Table 3: Model Fit: Consumption Growth Dynamics

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSID</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temptation Model</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Temptation Model</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquid Assets ((a))</td>
<td>0.00447***</td>
<td>0.0037**</td>
<td>-0.0040**</td>
</tr>
</tbody>
</table>

Note: This table shows the relationship between consumption growth and liquid assets \((\hat{\psi} in equation 18)\) in the PSID and our estimated models. The full list of age controls is included in Table 15.

5.3 Temptation Necessary to Fit Consumption Growth Dynamics

In our model, temptation is pinned down by a combination of its implications for consumption growth and its implications for life-cycle consumption-saving behavior. Let’s consider again the consumption growth regression:

\[
\Delta \ln c_{i,t} = \psi \ln a_{i,t} + \sum_{j=25}^{60} \alpha_j Age_{i,t} + \epsilon_{i,t}
\]  

We find that \(\hat{\psi}\) is positive and significant in the data, while in the context of our model, the sign of this coefficient can only be matched when temptation is allowed as shown in detail in Section 4.

Apart from temptation, we find that it is not possible for any other feature of our model (i.e. time preferences, risk aversion, housing taste, etc.) to generate a positive relationship between consumption growth and liquid assets. In Section D.4 of the Appendix, we show that this is robust for all combinations of parameters in our structural model, based on a quasi-random grid search over the estimated parameter space.
5.3.1 Sensitivity to Alternative Modeling Assumptions

Key to our estimation strategy is the fact that our model cannot generate a positive relationship between $\Delta \ln(c)$ and $\ln(a)$ without the existence of temptation. While our model without temptation is relatively standard, we may be concerned about potential additions to the model that could also generate a positive relationship between consumption growth and liquid assets. In this section, we address a number of alternative modeling specifications and discuss how these could be controlled for in the data. We find that uncertainty in asset returns, asset shocks, heterogeneous time preferences, and habit formation can all be accounted for using our estimation method.

Table 4 presents the estimation results from our baseline consumption growth regression, along with four alternative specifications. In all cases, we find that the coefficient on liquid assets is positive and significant. We now discuss the intuition behind each of the alternative specifications.

Table 4: Consumption Growth Regression (PSID)

<table>
<thead>
<tr>
<th></th>
<th>(1) Baseline</th>
<th>(2) Year FE</th>
<th>(3) IV</th>
<th>(4) HH FE</th>
<th>(5) Habits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid Assets ($a$)</td>
<td>0.00447***</td>
<td>0.00420**</td>
<td>0.00566***</td>
<td>0.01248***</td>
<td>0.00644***</td>
</tr>
<tr>
<td></td>
<td>(0.00170)</td>
<td>(0.00169)</td>
<td>(0.00172)</td>
<td>(0.00401)</td>
<td>(0.00177)</td>
</tr>
<tr>
<td>Age controls</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Observations</td>
<td>15780</td>
<td>15780</td>
<td>12087</td>
<td>15780</td>
<td>12098</td>
</tr>
</tbody>
</table>

Note: The full set of controls are included in Appendix D.2. Standard errors in parentheses.

\* $p < 0.10$, \** $p < 0.05$, \*** $p < 0.01$

**Aggregate Uncertainty** – Consider the possibility that asset returns (e.g. interest rates) are subject to aggregate shocks. In a year where households receive unexpectedly high interest, 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 uncertainty. In Column 2 of Table 4, we see the coefficient on liquid assets is only 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 4, 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.\(^{40}\) In Column 4 of Table 4, 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.\(^{41}\)

**Habit Formation** – Consider the situation where past consumption impacts current 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), who shows that habit formation enters into the Euler equation in this manner. Column 5 of Table 4 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.\(^{42}\)

6 The Texas Experiment in the Model

In this section, we return to the quasi-experiment in Section 2 where home equity withdrawal was suddenly legalized in Texas. We now use our model to simulate a similar policy change where home equity withdrawal is legalized after many years of prohibition. This allows us to do two things. First, we assess the predictive power of our model when confronted with an exogenous policy change. We find that our model predicts an increase in consumption

---

40 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.

41 We choose not to include $\beta_i$ heterogeneity in our model, as we believe 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.

42 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-level consumption data and finds no evidence of habit formation at the annual frequency.
and mortgage balances that is consistent with the quasi-experimental evidence. Second, we decompose the drivers of the consumption and savings responses. We find that roughly half of the short-term increase in consumption in Texas is explained by weakened commitment.

More specifically, we simulate an unanticipated policy change where home equity withdrawal is suddenly legalized after many years of prohibition. To ensure that households of all ages are present when the policy change occurs, we simulate 80 cohorts born between 1918 and 1998, under the assumption that households have no access to home equity withdrawal. Then in 1998, we introduce a unanticipated policy change that permanently legalizes home equity withdrawal.

6.1 Model Validation

First, we assess the predictive power of our model based on its ability to match the response of consumption and mortgages in the data when home equity withdrawal is suddenly legalized. This form of model validation is vital given our eventual goal to perform welfare analysis using our estimated model (Keane, 2010; Low and Meghir, 2017). If our model were to generate an implausibly small or large response following the introduction of home equity withdrawal, then there would be little reason to believe the estimated welfare effects.

Table 5 shows the short-run response of consumption and mortgages when home equity withdrawal is suddenly legalized. The first column presents the response observed in the data based on the quasi-experiment in Section 2. The second column presents the response of our baseline model with temptation and commitment. We find that our model predicts an increase in consumption that is roughly consistent with the quasi-experimental evidence. In the data, we see that consumption increases by 3.03%, whereas in our estimated model we see that consumption rises by 3.26%. In contrast, the model without temptation predicts a rise in consumption of 1.05%, less than half that observed in Texas.

In the second row of Table 5, we observe the response of log mortgage balances plus one. This variable roughly captures the change in mortgage balances along both the intensive and extensive margin of adjustment. In the data, mortgage balances increase by roughly 34.3% after the introduction of home equity withdrawal. The temptation model predicts a response in mortgage balances that is slightly lower (27.8%) whereas the non-temptation model presents a response that is substantially lower (8.5%).

Finally, the third row of Table 5 shows the change in the share of households holding a mortgage, thus capturing the extensive margin of adjustment. In the data, we see a 3.6% increase in mortgagors, whereas in the temptation model this value is 2.0% and in the non-

\footnote{We effectively outlaw home equity withdrawal by assuming that $F^R = 1$ before 1998. This means that the proportional cost of equity extraction is equal to 100% of the extracted funds.}
### Table 5: Model Fit: Legalization of Home Equity Withdrawal

<table>
<thead>
<tr>
<th></th>
<th>CEX Data</th>
<th>Temptation Model</th>
<th>Non-Temptation Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in Log Consumption</td>
<td>0.0303***</td>
<td>0.0326</td>
<td>0.01053</td>
</tr>
<tr>
<td>Change in Log Mortgage</td>
<td>0.3430**</td>
<td>0.2786</td>
<td>0.0853</td>
</tr>
<tr>
<td>Change in Mortgage &gt; 0</td>
<td>0.0361**</td>
<td>0.0202</td>
<td>0.0063</td>
</tr>
</tbody>
</table>

**Note:** This table shows the short-run response of consumption and debt when home equity withdrawal is suddenly legalized. The first row represents the change in log nondurable consumption $\Delta \log(c)$, the second row represents the change in log mortgage balances $\Delta \log(m + 1)$, and the third row represents the change in the share of households with mortgage debt $\Delta I_{m>0}$. These statistics are presented first for the quasi-experiment in Texas, then for model with and without temptation. In all cases, we consider the post-reform period to be 1998-2003 and the pre-reform period to be 1994-1997, ensuring comparability between the model and the data. All results are for working age homeowners. *** $p<0.01$, ** $p<0.05$, * $p<0.01$

In our model, all mortgages have a default duration from the time of origination until retirement. This means that a large share of working age homeowners have mortgage debt, as only households with very high income choose to repay their mortgage prior to retirement. In contrast, in the real world, mortgages are of different duration and a substantial number of homeowners are required to repay their mortgage prior to retirement. This means that a substantial number of homeowners in Texas had already succeeded at paying off their mortgage prior to the policy change.

6.2 Model Decomposition: Drivers of the Consumption Response

What explains the observed increase in consumption? On one hand, there exists the traditional channel whereby greater access to home equity helps households smooth consumption and housing over the life-cycle. This channel has been well documented by Hurst and Stafford (2005), Benito (2007), Gerardi, Rosen, and Willen (2010), Lustig and Van Nieuwerburgh (2010), and Agarwal and Qian (2017) among others. When households have access to home equity, they are less affected by credit constraints and better able to self-insure against income shocks. They therefore require smaller buffer stocks of liquid assets, due to the improved self-insurance properties of housing. All together, this implies that households increase consumption.

**Footnote:** In our model, all mortgages have a default duration from the time of origination until retirement. This means that a large share of working age homeowners have mortgage debt, as only households with very high income choose to repay their mortgage prior to retirement. In contrast, in the real world, mortgages are of different duration and a substantial number of homeowners are required to repay their mortgage prior to retirement. This means that a substantial number of homeowners in Texas had already succeeded at paying off their mortgage prior to the policy change.
On the other hand, there exists the weakened commitment channel, whereby greater liquidity in housing reduces the ability of households to use housing as a savings commitment device. According to this theory, greater liquidity results in additional temptation to extract and consume home equity for short-term gratification. This results in over-borrowing and over-consumption relative to the alternative where households have access to a perfect commitment device. While no previous study has been able to estimate the effect of weakened commitment on consumption, Laibson (1997) uses a calibrated model to show that this channel may be important in explaining the long-run decline in savings rates in the United States. In addition, Schlafmann (2016) shows that welfare may decline due to greater access to home equity, using a calibrated model.\footnote{In addition, others have also alluded to the role of weakened commitment without attempting to quantify this channel, including for instance Hurst and Stafford (2005) and Mian and Sufi (2011).} To the best of our knowledge, we are the first to estimate the relative importance of this channel.

We first describe the method that we use to decompose the response between these two channels. We are able to distinguish between these two channels in our model by making a counterfactual assumption about what assets result in temptation. In our baseline model, households suffer from temptation over all assets. Their myopic choice, which determines their cost of temptation, is as follows:

\[
\left[ \tilde{c}_t, \tilde{h}_t, \tilde{m}_t \right] = \arg \max_{c_t, h_t, m_t} u(c_t, h_t) \tag{20}
\]

We see that the household is allowed to adjust their consumption, housing, and mortgage debt when making their myopic choice. In contrast, consider a counterfactual model where households suffer from temptation over consumption and housing, but do not consider the possibility of home equity withdrawal when choosing their most tempting alternative. Under this counterfactual, the myopic choice is as follows:

\[
\left[ \tilde{c}_t, \tilde{h}_t \right] = \arg \max_{c_t, h_t} u(c_t, h_t) \tag{21}
\]

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 importance of the weakened commitment channel.

Figure 4 shows the response to the legalization of home equity withdrawal in our baseline model (the solid line) relative to the counterfactual model where only the traditional
consumption smoothing channel is allowed to operate (the dashed line). Households are not allowed to extract home equity prior to year zero, at which point home equity withdrawal is suddenly legalized, as seen in the top left panel of the figure. We depict household behavior for twenty-five years, starting five years prior to the legalization of home equity withdrawal and continuing until twenty years after the legalization.

Figure 4: Response to Home Equity Withdrawal in our Model

![Graph showing the response to home equity withdrawal over time.](image)

**Note:** This figure shows the long-run response to the legalization of home equity withdrawal in our estimated model with temptation and commitment. The horizontal axis depicts years relative to the policy reform. Households are not allowed to extract home equity prior to year zero, denoted by the dotted vertical line. The solid black line shows the response in our baseline model, where the myopic mortgage choice is unconstrained. The dashed black line shows the response in our counterfactual model, where the myopic mortgage choice is constrained by the assumption that home equity withdrawal is impossible. All results are for working age households.

The top right panel of Figure 4 shows the average response of the most tempting consumption alternative in log terms ($\ln \tilde{c}_t$). We see that the legalization of home equity withdrawal results in an immediate 30% increase in the most tempting consumption alternative in the baseline model. This increase gradually deteriorates with time as households consume away some portion of their wealth, as will be seen later in the bottom right panel of this figure. In contrast, in the counterfactual model with only the traditional consumption smoothing channel, the most tempting consumption alternative is not changed during the first two years that home equity withdrawal is permitted. This is a mechanical result of having turned off the weakened commitment channel in the counterfactual model. With the passing of time, however, we again see that the most tempting consumption alternative gradually declines,
as households consume away some portion of their wealth, as will be explained shortly.

The bottom left panel of Figure 4 shows the response of the average savings rate of working age households in our model. We define the savings rate as the change in net wealth over post-tax income. Prior to the introduction of home equity withdrawal, our model implies a personal savings rate of approximately 11%. This plummets when home equity withdrawal is introduced, before briefly rebounding, as households extract substantial home equity initially, thus restricting their home equity withdrawal in the following year. Eventually the savings rate reaches a long-run average of 5% in the baseline model and around 9% in the counterfactual model with only the traditional consumption smoothing channel. We therefore conclude that of the 6 percentage point long-run decline in the savings rate of working age households in our model, approximately two-thirds comes from the weakened commitment channel, while the remaining one third comes from the traditional consumption smoothing channel.\footnote{There exists a large literature that studies the link between home equity withdrawal and the decline in personal savings rates in the U.S. between the early 1980s and mid-2000s (Summers and Carroll, 1987; Manchester and Poterba, 1989; Greenspan and Kennedy, 2008; Aron et al., 2012; Caporale, Costantini, and Paradiso, 2013; Carroll, Slacalek, and Sommer, 2019, among others). A worthwhile avenue for future research would be to determine the extent to which this long-run decline in savings rates in the U.S. is explained by traditional consumption smoothing motives versus the weakened commitment channel.}

The bottom right panel of Figure 4 depicts the average response of log consumption in our model. In the baseline model, we observe an increase in consumption that peaks at approximately 4% higher consumption three years after the policy reform. With time, consumption gradually declines as households now hold higher mortgage balances and must devote a larger fraction of their income towards servicing their debt. Twenty years after the policy is implemented, we see that consumption is approximately 1% lower than in the pre-reform period.\footnote{In the data, it may be interesting to study whether consumption declines in the long-run due to home equity withdrawal. Unfortunately, this is not possible in the quasi-experiment in Texas, as there exist other policy changes between 2004 and the present that would confound such long-run analysis. Moreover, both our baseline and counterfactual model predict a long-run decline in consumption, therefore the inference that could be drawn from this would be limited.} In contrast, in the counterfactual model, we see that consumption only rises about 2.5% at its peak. It then gradually declines over the following years, as households again must devote a larger fraction of their income towards servicing debt. Twenty years after the policy is implemented, consumption returns to the same levels as during the pre-reform period.\footnote{With the further passage of time, however, consumption eventually falls below its pre-reform levels (not pictured). After approximately 25 years, consumption is 1% lower than in the pre-reform period.}

It is important to understand why consumption increases. In the counterfactual model this is driven by three factors. First, homeowners who have experienced a series of negative income shocks are now able to extract and consume home equity. Second, young homeowners...
expect their income to rise and are now able to increase consumption (in the short run) by extracting equity. Third, since housing now acts as a more effective self-insurance mechanism, homeowners optimally reduce the size of their liquid asset buffer. In the baseline model, with both consumption smoothing and weakened commitment, there exists a fourth reason: the possibility of home equity withdrawal results in temptation to extract and consume home equity for short-term gratification.

Finally, if we restrict our analysis to the six years immediately after the policy reform, it is possible to compare our results to the quasi-experiment in Texas. During this period, average consumption increases by approximately 3.2% in the baseline model. In contrast, average consumption increases by roughly half that amount in the counterfactual model. We therefore conclude that weakened commitment explains approximately 50% of the observed short-term increase in consumption following the legalization of home equity withdrawal, with the remainder being explained by the traditional consumption smoothing channel.

7 Welfare Analysis

In this section, we study the effects of legalizing home equity withdrawal using the estimated model. We find that under temptation, welfare declines when home equity withdrawal is legalized: although households are better able to consumption smooth using home equity when young, home equity withdrawal “breaks the commitment device” and results in households accumulating less wealth by the time of retirement. In contrast, in a standard model, this trade-off does not occur and it is purely beneficial to make housing more liquid. Do we think that home equity withdrawal should be outlawed? No. What our model suggests is that we should design mortgages to give the benefits of commitment during good times and the benefits of flexibility during bad times. We study the effects of a government policy that allows conditionally flexible mortgages (currently outlawed in the United States) and demonstrate that this policy allows households to obtain both consumption smoothing and commitment benefits from housing.

7.1 Measuring Welfare Changes

To begin, we briefly describe the method used to measure changes in welfare as a result of legalizing home equity withdrawal. We measure welfare changes using consumption equivalent variation. First, we solve for the policy functions for consumption \(c(s)\), housing \(h(s)\), and

\[49\] As discussed in Section 2, we restrict our empirical analysis to the 1994-2003 period to avoid confounding effects from a policy change in Texas in 2004 that affected home equity lines of credit.
mortgages \( m(s) \) over all possible states of the world at every age, where \( s = (s_1, s_2, \ldots, s_T) \) represents the set of possible states of the world. We can then define expected utility as a function of these choices:

\[
EV_0(c(s), h(s), m(s))
\]  

(22)

A policy change (such as allowing households to extract home equity) has no impact on the value function \( EV_0 \), but will result in different choices as households change their behavior in response to the reform. If we denote the post-reform policy functions as \( c^{\text{post}}(s) \), \( h^{\text{post}}(s) \), and \( m^{\text{post}}(s) \), then we can write the new level of expected utility as

\[
EV_0(c^{\text{post}}(s), h^{\text{post}}(s), m^{\text{post}}(s))
\]  

(23)

We can then express the change in welfare induced by the policy reform as the change in consumption \((\Delta)\) that would be necessary to give to pre-reform households to equate their expected utility with post-reform households.

\[
EV_0(c(s)(1 + \Delta), h(s), m(s)) = EV_0(c^{\text{post}}(s), h^{\text{post}}(s), m^{\text{post}}(s))
\]  

(24)

Thus \( \Delta \) represents the consumption equivalent variation.\(^{50}\)

In our baseline analysis, we include the effect of temptation when computing welfare comparisons. This allows our welfare analysis to be fully model consistent. This is one of the benefits of our choice to use temptation preferences rather than hyperbolic discounting. The benefit of temptation preferences is that they are time-consistent, allowing for straightforward welfare evaluation. In contrast, hyperbolic discounting generate time-inconsistency, making it difficult to perform model consistent welfare analysis.\(^{51}\)

### 7.2 Aggregate Effect

Table 6 shows the effect of legalizing home equity withdrawal. We first present the results for our baseline model (Column 1), which we then decompose between the consumption smoothing channel (Column 2) and the weakened commitment channel (Column 3). Most

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\(^{50}\) This is similar to Conesa, Kitao, and Krueger (2009), Low, Meghir, and Pistaferri (2010), or Braun, Kopecky, and Koreshkova (2016). Note that it is possible to measure welfare effects without applying a proportional increase in the housing held by each household, given our modeling assumption that housing taste is uniform across households.

\(^{51}\) Evaluating welfare effects in a model with time-inconsistency is often viewed as problematic because utility flows will be valued differently by different selves of the same individual (Fang and Silverman, 2009). From the perspective of a social planner, it is not obvious whether to prioritize the preferences of all selves over time (as in Laibson, 1997) or a time-consistent self prior to life (as in O’Donoghue and Rabin, 1999).
importantly, we see that the legalization of home equity withdrawal lowers ex-ante welfare by 2.60% in consumption equivalent terms for the average household. This aggregate effect can be decomposed between the consumption smoothing benefit, which raises welfare by 2.61%, and the weakened commitment effect, which reduces welfare by 5.21%. In this section, we first compare our welfare results to the literature, then consider how consumption and saving decisions over the life-cycle drive these welfare results.

Table 6: Effect of Legalizing Home Equity Withdrawal

<table>
<thead>
<tr>
<th></th>
<th>Baseline Model</th>
<th>Consumption Smoothing Channel</th>
<th>Weakened Commitment Channel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welfare Effect (CEV)</td>
<td>-2.60</td>
<td>2.61</td>
<td>-5.21</td>
</tr>
<tr>
<td>Young</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumption</td>
<td>3.60</td>
<td>0.13</td>
<td>3.47</td>
</tr>
<tr>
<td>Homeownership</td>
<td>-3.46</td>
<td>11.43</td>
<td>-14.89</td>
</tr>
<tr>
<td>LTV</td>
<td>28.98</td>
<td>10.59</td>
<td>18.39</td>
</tr>
<tr>
<td>Interest Payments</td>
<td>12.65</td>
<td>6.79</td>
<td>5.86</td>
</tr>
<tr>
<td>Savings Rate</td>
<td>-7.73</td>
<td>-1.57</td>
<td>-6.16</td>
</tr>
<tr>
<td>Old</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumption</td>
<td>-15.84</td>
<td>-4.41</td>
<td>-11.43</td>
</tr>
<tr>
<td>Homeownership</td>
<td>-26.58</td>
<td>-7.09</td>
<td>-19.49</td>
</tr>
</tbody>
</table>

Note: This table shows the effect of permitting home equity withdrawal, relative to a counterfactual where it is prohibited. We define young households as those in the first 20 years of their working life, while old households are those aged 65 and above. The loan-to-value (LTV) ratio and interest payments are reported conditional on homeownership, while all other values are unconditional. We disentangle the effects of consumption smoothing and weakened commitment using the decomposition detailed in Section 6.2.

Our aggregate welfare result is in sharp contrast with papers that examine only the consumption smoothing benefits of home equity withdrawal – this is because we consider both the benefits and disadvantages of increased liquidity. For instance, Hurst and Stafford (2005) suggest large benefits to home equity withdrawal due to consumption smoothing, although they 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

52 More specifically, Hurst and Stafford (2005) say, “In future research, to compute accurately the welfare
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 fixed cost of home equity withdrawal were set to zero.

Our estimated welfare results reaffirm the importance of previous studies that have pointed to the existence of potential welfare losses due to greater credit availability. For instance, Laibson (1997) presents a hyperbolic discounting model where instantaneous credit may reduce welfare by providing “too much” liquidity. This welfare effect may be very large: in order to equate welfare, households would need to be compensated by somewhere between 1.6% and 69.6% more wealth in the initial period, depending on the strength of self-control problems. More recently, Schlafmann (2016) studies the effect of removing the possibility to refinance mortgages in a calibrated model with temptation. She finds that a ban on refinancing would raise welfare by 0.29% for a household with a temptation parameter of $\lambda = 0.12$, but would lower welfare by 0.31% for a household with $\lambda = 0$. In both of these studies, the calibrated strength of self-control problems is of crucial importance to welfare results. We build upon these papers by estimating a structural model in order to pin down the importance of temptation and commitment.

To gain better insight into the reasons why welfare deteriorates when home equity withdrawal is legalized, it is helpful to look at the bottom part of Table 6 which reports changes in consumption, homeownership, and other statistics. We see that the legalization of home equity withdrawal increases consumption for the young by 3.6%, while also lowering their savings rate by 7.73 percentage points. This is mostly driven by changes in housing: young households choose to hold significantly higher mortgage debt, resulting in an increase in both loan-to-value ratios and mortgage interest payments. As a result of these changes, we see that households have substantially less wealth by the time of retirement. In our baseline model, households have 28% less wealth when they retire at age 65. This results in a 15% decrease in consumption during retirement, as well as a 26 percentage point decrease in the homeownership rate of retirees.

It is interesting to note that home equity withdrawal results in slightly lower homeownership rates (3.46 percentage points) for young households in our model. As seen in Table 6, this is a result of the trade-off between the positive effects of consumption smoothing and the gains from making home equity more liquid, it would be valuable to explore the extent to which the home serves as a savings commitment.”

53 In this case we report results for $\beta \in \{0.2, 0.4, 0.6, 0.8\}$ (Laibson, 1997, Table II), where $\beta$ represents the short-term discount rate in the hyperbolic discounting model. If $\beta = 1$ then households would not suffer from self-control problems and would not require compensation.

54 We define the savings rate as the change in wealth over income, following the definition used by the flow of funds account. Thus the savings rate includes the accumulation of both liquid assets and home equity. The decline in the savings rate is driven by lower holdings of both liquid assets and housing.
negative effects of weakened commitment. On one hand, if we only consider the consump-
tion smoothing channel, then greater access to home equity makes housing serve as a more
effective self-insurance mechanism, thus increasing demand for housing by 11.4 percentage
points.\textsuperscript{55} On the other hand, breaking the commitment device reduces demand for housing
because it no longer provides the benefit of commitment. On net, these two effects roughly
cancel out and the aggregate effect on homeownership is very small. This is consistent with
our empirical evidence from the quasi-experiment, where we find no significant effect of home
equity withdrawal on homeownership rates in Texas.\textsuperscript{56}

7.3 Commitment Most Important for the Middle Class

Next we study the distributional effect of legalizing home equity withdrawal. We find that
the welfare loss due to weakened commitment is strongest for the middle class, as this is
the group that traditionally has been most reliant upon housing as a savings commitment
device.

To study the distributional effect, we compute the ex-ante welfare change conditional
on deciles of realized lifetime earnings. From a policy perspective, this will be relevant for
a social planner that is concerned about lifetime earnings inequality. Households in the
bottom decile of lifetime earnings have been consistently unlucky throughout their lives,
while households in the top decile have been consistently lucky.

Figure 5 shows the change in welfare when home equity withdrawal is legalized, condi-
tional on deciles of lifetime earnings. In the left panel, we see that the welfare decline caused
by home equity withdrawal has been particularly severe for the middle class: households in
the fifth and sixth deciles experienced a 3.5\% reduction in ex-ante welfare, whereas house-
holds in the first and tenth deciles only experienced a 1 to 2\% decline in welfare. In the
right panel, we decompose the welfare effect between the positive consumption smoothing
benefit and the negative weakened commitment effect. We see that both of these effects
are strongest for the middle class: the consumption smoothing benefit raises welfare for the
middle class by 3.5\%, although this is more than offset by the effect of weakened commitment
which results in a 7\% decline in welfare.

There are two factors driving these results. First, owner-occupied housing is not very
common among households in the bottom of the lifetime earnings distribution. As a re-

\textsuperscript{55} Similarly, greater liquidity allows young households to move into housing in line with their expected
future income, as emphasized in Gerardi, Rosen, and Willen (2010), further raising ownership among the
young.

\textsuperscript{56} Based on this empirical evidence, we choose not to build into our model the general equilibrium effect
of home equity withdrawal on house prices.
shocks, while only slightly reducing their ability to achieve commitment through homeown-
ership. Second, liquid asset holdings are much higher among households towards the top of
the lifetime earnings distribution. This means that these households already have substan-
tial assets available for consumption smoothing purposes and thus they benefit little from
greater access to home equity. Moreover, these households already face significant tempta-
tion from their liquid asset holdings, therefore access to home equity only slightly increases
their temptation.\footnote{As was emphasized in Section 4, although households with more assets suffer from more temptation, the marginal effect of temptation is weaker for these households.}

As a result of the above channels, the middle class experiences not only the greatest
deterioration in welfare, but also the most growth in mortgage debt and largest reduction in
wealth accumulation. This is consistent with recent empirical evidence showing the impor-
tant role of middle class borrowers in explaining the large increase in mortgage debt prior
to the financial crisis (Adelino, Schoar, and Severino, 2016; Albanesi, De Giorgi, and Nosal,
2017).

7.4 Reconciling the Trade-off: Semi-Flexible Mortgages

Do our findings suggest that we should return to the world of the 1950s where home equity
withdrawal was almost impossible? No. What our model implies is that we should design
mortgages to give the benefits of commitment during good times and the benefits of flexibility during bad times. In this section, we consider the welfare effect of semi-flexible mortgages: mortgages that are completely illiquid during good times, but that allow easy home equity withdrawal during bad times. We find that significant welfare gains would be possible if mortgages provided both commitment and flexibility. While there exist regulatory factors that prevent the widespread adoption of such mortgages, we point to two legal changes that would allow for the introduction of semi-flexible mortgages. More broadly, our results lend support to recent efforts by Pennsylvania and Connecticut to allow for greater mortgage payment flexibility during times of unemployment.

More specifically, we consider the effect of mortgages that allow home equity withdrawal when household income has fallen, but that are otherwise rigid and require regular mortgage repayments with no possibility of home equity withdrawal. More specifically, we only allow households to withdraw home equity when $\Delta y_{i,t} < 0$. When this occurs, home equity withdrawal is completely free, but the amount that can be extracted is capped based on the change in loan-to-value ratio. More specifically, we restrict $\Delta LTV_{i,t} \leq \delta_{LTV}$, where in the following example we calibrate $\delta_{LTV} = 20\%$. This policy is designed so that households will experience the benefits of flexibility during bad times, but also the benefits of commitment during good times.

Table 7 shows the effect of legalizing home equity withdrawal relative to a baseline where no home equity withdrawal is allowed. The first column represents the baseline model, where home equity withdrawal is always allowed. The second column represents semi-flexible mortgages, where limited home equity withdrawal is only allowed when income falls. We see that in the baseline model, access to home equity results in a welfare loss of 2.6% in consumption equivalent terms. In contrast, when semi-flexible mortgages are introduced, we see an increase in welfare of 1.35% relative to a policy where home equity withdrawal is prohibited. As a result, semi-flexible mortgages would greatly increase welfare relative to the current world where home equity withdrawal is always permitted.

This policy is beneficial as it allows households to combine the benefits of both commitment and liquidity when needed. Table 7 shows that semi-flexible mortgages allow households to increase both consumption and homeownership when young. This is because credit constraints for young households become less binding when home equity withdrawal is permitted. Furthermore, demand for housing increases as housing is now more substitutable with liquid assets for consumption smoothing purposes and also requires lower levels of asset holdings.

While semi-flexible mortgages increase both loan-to-value ratios and interest payments, we see that the increase is much smaller than when home equity withdrawal is legalized in our
Table 7: Effect of Semi-Flexible Mortgages

<table>
<thead>
<tr>
<th></th>
<th>Baseline Model</th>
<th>Semi-Flexible Mortgages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welfare Effect (CEV)</td>
<td>-2.60</td>
<td>1.35</td>
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<tr>
<td>Young</td>
<td></td>
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<tr>
<td>Consumption</td>
<td>3.60</td>
<td>3.06</td>
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<td>Homeownership</td>
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<tr>
<td>LTV</td>
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</tr>
<tr>
<td>Interest Payments</td>
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<td>3.37</td>
</tr>
<tr>
<td>Savings Rate</td>
<td>-7.73</td>
<td>-3.55</td>
</tr>
<tr>
<td>Old</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumption</td>
<td>-15.84</td>
<td>-6.34</td>
</tr>
<tr>
<td>Homeownership</td>
<td>-26.58</td>
<td>-8.61</td>
</tr>
</tbody>
</table>

Note: This table shows the effect of legalizing home equity withdrawal relative to a baseline where home equity withdrawal is not allowed. “Fully Flexible Mortgages” allow home equity withdrawal at any time, whereas “Semi Flexible Mortgages” allow home equity withdrawal only when income has fallen.

baseline model. Similarly, the decline in the savings rate is roughly half of that observed in the baseline model. As a result, households experience less reduction in wealth at retirement, as well as consumption and homeownership during retirement. This highlights the fact that semi-flexible mortgages allow households to better smooth utility throughout their lifetime, without experiencing as much difficulty saving wealth for retirement.

Regulatory Challenges to Semi-Flexible Mortgages

As our model suggests that semi-flexible mortgages would be welfare improving, it is important to consider the various regulatory factors that prevent the creation of such mortgages in the United States. We find at least two legal barriers to the creation of such mortgages.

First, federal law in the United States prohibits private contractual limitations on home equity withdrawal. This is an unintended consequence of the Garn-St. Germain Depository Institutions Act of 1982, as emphasized by Levitin and Wachter (2015), which 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 a unilateral right to obtain a home equity loan, line of credit, or alternative mortgage product without the consent of
the originator of the first lien mortgage.\footnote{In contrast, outside of the United States, contractual regulation of mortgage leverage is much more common (see for instance Green and Wachter, 2005).} This makes it impossible for a mortgage lender in the U.S. to provide households with a mortgage that prohibits home equity withdrawal through junior lien mortgages. In contrast, prior to 1982, such restrictions on home equity withdrawal were relatively common (Levitin and Wachter, 2015).

In addition, there exists regulation that encourages banks to offer mortgages that do not allow for interest only or negative amortization periods. For instance, the Dodd-Frank Wall Street Reform and Consumer Protection Act created the Qualified Mortgage (QM) category of loans. These loans provide the lender with a legal “safe harbor” against lawsuits brought about by distressed borrowers. According to federal regulation, QM loans cannot feature any period of negative amortization or interest only payments, among other criteria (Defusco, Johnson, and Mondragon, 2019). And yet as our counterfactual exercise indicates, it may be welfare improving to have a negative amortization period occur automatically when income falls due to a reduction in income, unemployment, or other negative shock.

It is important to note that we are not the first to suggest the potential benefits of mortgage contracts that automatically reduce payments or provide greater access to home equity during times of hardship. For instance, Eberly and Krishnamurthy (2014) advocate for the creation of “automatic stabilizer mortgage contracts” that automatically reduce mortgage payments during a downturn, thus providing additional liquidity to households during recessions. While our counterfactual exercise focuses on changes in income at the household level, it may be even more beneficial to write mortgage contracts that provide liquidity conditional on aggregate macroeconomic behavior. In a similar vein, Orr, Sporn, Tracy, and Huang (2011) advocate for the creation of a national mortgage assistance program that could automatically provide home equity withdrawal to unemployed borrowers, identified through unemployment insurance claims filed at the time of layoff. Their proposal is based on an assessment of Pennsylvania’s mortgage assistance program, a novel program that provides temporary support to homeowners unable to pay their mortgage during a spell of unemployment. Our counterfactual exercise lends strong support to such attempts to provide greater flexibility for unemployed homeowners.

8 Conclusion

In this paper, we evaluate the positive and normative implications of the introduction of home equity withdrawal. We estimate a structural model that is able to capture two contrasting views: on one hand, greater liquidity is beneficial because it improves the ability
of households to self-insure against shocks, but on the other hand, greater liquidity may be detrimental if it weakens the commitment benefit of housing, thus exacerbating self-control problems that impede wealth accumulation. We find that welfare declines by 2.6% in consumption-equivalent terms when home equity withdrawal is introduced, as the welfare benefit of improved consumption smoothing is outweighed by the welfare loss of weakened commitment. This decline is concentrated among the middle class, the group most reliant upon the commitment benefit of homeownership.

An important aspect of our approach is that it allows us to assess the value placed on housing as a savings commitment device using data on consumption and housing decisions over the life cycle. While there exists a vast literature documenting demand for commitment in laboratory or field experiments, there exist surprisingly few studies that assess the value placed on commitment using consumption-saving decisions over the life cycle. The results of our analysis are broadly consistent with experimental evidence showing that many households value the commitment benefit of illiquid savings accounts over the traditional benefits of liquidity (Ashraf, Karlan, and Yin, 2006; Beshears et al., 2015a).

While we have focused specifically on the impact of home equity becoming more liquid, it is important to note that this is part of a broader phenomenon where illiquid assets are becoming more liquid in the United States. For instance, the 1990s and 2000s witnessed an increase in the share of tax-advantaged retirement accounts that allow their holders to obtain a loan against their invested retirement assets (Beshears, Choi, Laibson, and Madrian, 2011). According to recent statistics, approximately 20 percent of workers with a 401(k) retirement account borrow against it at any given time (Lu, Mitchell, Utkus, and Young, 2017). Greater liquidity in retirement accounts may have important consequences for short-run consumption behavior and long-run retirement adequacy, similar to the mechanism studied in this paper.

More generally, we have developed a framework that allows for analysis of the potential benefits and disadvantages of making illiquid assets more liquid. This may be helpful when considering regulation on other financial products that allow households to borrow against their illiquid assets. For instance, the introduction of the 401(k) debit card in the mid-2000s was met with great controversy (Burton, 2008), including proposed legislation by Senators Herb Kohl and Charles Schumer to ban such cards. When considering such legislation, it is important to consider both the benefits and disadvantages of increased liquidity.

One factor that we do not consider is the impact of weakened commitment on households’ vulnerability to aggregate income or house price shocks. This may be an interesting avenue

59 See for instance Ariely and Wertenbroch, 2002; Gine, Karlan, and Zinman, 2010; Houser et al., 2010; Chow, 2011; Milkman, Minson, and Volpp, 2013; Royer, Stehr, and Sydnor, 2015; Kaur, Kremer, and Mullainathan, 2015; and Augenblick, Niederle, and Sprenger, 2015 among others.
for further research, as the weakened commitment channel that we identify implies that home equity withdrawal may increase macroeconomic instability. Our model predicts a temporary increase in debt-financed consumption, a persistent increase in loan-to-value ratios, as well as a long-run deterioration in savings rates, all consistent with the U.S. experience prior to the recent financial crisis. This may reduce the ability of households to withstand aggregate shocks. Related to this point, Mian and Sufi (2011) find that the increase in home equity withdrawal can account for as much 40 percent of new mortgage defaults between 2006 and 2008. Similarly, LaCour-Little, Yu, and Sun (2013) find that home equity lending is associated with higher rates of first mortgage default during the Great Recession.
### A Quasi-Experiment: Additional Details

#### A.1 Balance

Table 8: Summary Statistics

<table>
<thead>
<tr>
<th></th>
<th>mean</th>
<th>sd</th>
<th>p50</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Control</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Real Income (Before Tax)</td>
<td>28,641.68</td>
<td>28,714.25</td>
<td>24,088.95</td>
</tr>
<tr>
<td>Real Nondurable Consumption</td>
<td>11,021.75</td>
<td>6,615.58</td>
<td>9,637.83</td>
</tr>
<tr>
<td>Real Durable Consumption</td>
<td>1,433.27</td>
<td>3,054.03</td>
<td>511.07</td>
</tr>
<tr>
<td>Has Mortgage</td>
<td>0.78</td>
<td>0.41</td>
<td>1.00</td>
</tr>
<tr>
<td>Has Home Equity Loan</td>
<td>0.06</td>
<td>0.24</td>
<td>0.00</td>
</tr>
<tr>
<td>Real Mortgage Debt (excludes HELOC)</td>
<td>40,687.14</td>
<td>44,326.54</td>
<td>31,241.57</td>
</tr>
<tr>
<td>Age of Household Head</td>
<td>45.34</td>
<td>10.42</td>
<td>45.00</td>
</tr>
<tr>
<td>Number Family Members</td>
<td>2.92</td>
<td>1.46</td>
<td>3.00</td>
</tr>
<tr>
<td>Number of Income Earners</td>
<td>1.71</td>
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<td>2.00</td>
</tr>
<tr>
<td>Rural</td>
<td>0.02</td>
<td>0.14</td>
<td>0.00</td>
</tr>
<tr>
<td>White</td>
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<td>1.00</td>
</tr>
<tr>
<td>Black</td>
<td>0.15</td>
<td>0.35</td>
<td>0.00</td>
</tr>
<tr>
<td>Unemployed</td>
<td>0.12</td>
<td>0.33</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>Texas</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Real Income (Before Tax)</td>
<td>31,704.52</td>
<td>29,842.65</td>
<td>26,248.64</td>
</tr>
<tr>
<td>Real Nondurable Consumption</td>
<td>11,661.42</td>
<td>7,033.87</td>
<td>10,183.83</td>
</tr>
<tr>
<td>Real Durable Consumption</td>
<td>1,465.28</td>
<td>2,981.67</td>
<td>555.78</td>
</tr>
<tr>
<td>Has Mortgage</td>
<td>0.69</td>
<td>0.46</td>
<td>1.00</td>
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<tr>
<td>Has Home Equity Loan</td>
<td>0.04</td>
<td>0.19</td>
<td>0.00</td>
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<td>Real Mortgage Debt (excludes HELOC)</td>
<td>28,553.41</td>
<td>34,911.82</td>
<td>19,111.86</td>
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<tr>
<td>Age of Household Head</td>
<td>45.41</td>
<td>10.47</td>
<td>45.00</td>
</tr>
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<td>Number Family Members</td>
<td>3.16</td>
<td>1.60</td>
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<td>Number of Income Earners</td>
<td>1.75</td>
<td>0.90</td>
<td>2.00</td>
</tr>
<tr>
<td>Rural</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>White</td>
<td>0.86</td>
<td>0.34</td>
<td>1.00</td>
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<tr>
<td>Black</td>
<td>0.11</td>
<td>0.31</td>
<td>0.00</td>
</tr>
<tr>
<td>Unemployed</td>
<td>0.11</td>
<td>0.31</td>
<td>0.00</td>
</tr>
</tbody>
</table>
A.2 Event Study

We also study the dynamics of the consumption response surrounding the policy change. More specifically, we estimate the following distributed lag model:

\[ y_{i,s,t} = \sum_{j=1996}^{2003} \beta_j \times 1_{\text{year } j} \times 1_{\text{Texas}} + \gamma_1 X_{i,t} + \gamma_2 Z_{s,t} + \eta_s + \phi_t + \epsilon_{i,s,t} \]  

(25)

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 1995 (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 6: Event Study: Log Nondurable Consumption

![Figure 6: Event Study: Log Nondurable Consumption](image)

Figure 6 shows the change in log consumption of the treatment group relative to the control group for each year of our sample. Each point represents an estimate of \( \beta_j \) for a different year. We observe no statistically significant consumption response prior to 1998. 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 but insignificant increase in consumption on impact. Consumption gradually rises between 1999 and 2001, reaching a peak in 2001. At its peak, nondurable consumption is approximately 5-6% higher than it was in 1995 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 change gradually spreads.

A.3 Sensitivity to House Prices

There are many reasons why home equity withdrawal might result in an increase in consumption. One possibility is that home equity withdrawal may allow households to convert unanticipated house price gains into consumption. Mian and Sufi (2011) and Bhutta and Keys (2016) document that house price increases drive home equity withdrawal among young home owners in the United States. More recently, Andersen and Leth-Petersen (2019) use longitudinal survey data on house price expectations, linked with administrative wealth data from Denmark, and find that the marginal propensity to consume out of house price gains is between 2 and 5%. In order to control for the possibly important role of house price increases, we perform a robustness exercise where we control for state-level house prices across time. When controlling for house prices, we observe that the legalization of home equity withdrawal results in a 3.3% increase in nondurable consumption. This is slightly larger than the effect we found in our baseline results. This likely reflects the fact that Texas experienced low house price growth relative to the rest of the country during the sample period; thus unanticipated gains in house prices had a larger impact on consumption in the control group than in Texas.

A.4 Heterogeneity by Housing Status

Here we estimate the effect of the policy change in Texas on nondurable consumption for different households based on their housing status. Todo: add table

A.5 Homeownership

The change in home equity withdrawal can not only have an effect on the intensive margin (i.e. affecting homeowners), but can also alter housing choices themselves. To investigate the extensive margin, we estimate the effect of the policy change in Texas on homeownership
rates. As results show in Table A.5, the policy change itself has no significant effect on the homeownership rate in Texas.

Table 9: Homeownership

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>Ownership</th>
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<tbody>
<tr>
<td>Post1998 * Texas</td>
<td>-0.00257 (0.0115)</td>
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<tr>
<td>Texas</td>
<td>-0.132*** (0.0411)</td>
</tr>
<tr>
<td>Observations</td>
<td>54,704</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.201</td>
</tr>
<tr>
<td>Time FE</td>
<td>Yes</td>
</tr>
<tr>
<td>State FE</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

### A.6 Heterogeneity by Employment Status

There exists uncertainty about the extent to which unemployed households are able to borrow. On one hand, DeFusco and Mondragon (2018) show that employment documentation requirements constrain the ability of unemployed households to refinance and therefore significantly reduce refinancing rates. On the other hand, Braxton et al. (2019) present evidence that the unemployed can borrow more than expected. We weigh in on this debate by looking at the impact of the legalizing home equity withdrawal on the debt takeout and consumption behavior of unemployed households. This provides a natural quasi-experiment to test whether unemployed households also benefit from the ability to extract home equity.

Table 10 presents the result from our difference-in-differences where we interact the policy treatment (Post1998 * Texas) with employment status. We control for the same household characteristics $X_{i,t}$ as before, except for employment type and employment status. When we look at the share of homeowners holding mortgages, the policy reform results in a 7 percentage point increase in the share of unemployed homeowners with a mortgage, suggesting that unemployed households are able to tap into home equity when in need.

That said, we see no significant response in nondurable consumption for unemployed
Table 10: Heterogeneity by Employment Status

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1) HEL &gt; 0</th>
<th>(2) Mortgage &gt; 0</th>
<th>(3) Log Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post1998 * Texas * Unemployed</td>
<td>-0.0170</td>
<td>0.0723***</td>
<td>0.0112</td>
</tr>
<tr>
<td></td>
<td>(0.0115)</td>
<td>(0.0203)</td>
<td>(0.0185)</td>
</tr>
<tr>
<td>Post1998 * Texas * Employed</td>
<td>0.00764*</td>
<td>0.0145*</td>
<td>0.0410***</td>
</tr>
<tr>
<td></td>
<td>(0.00383)</td>
<td>(0.00803)</td>
<td>(0.00817)</td>
</tr>
<tr>
<td>Observations</td>
<td>36,766</td>
<td>36,766</td>
<td>36,766</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.014</td>
<td>0.150</td>
<td>0.264</td>
</tr>
<tr>
<td>Time FE</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>State FE</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Standard errors clustered by state. *** p<0.01, ** p<0.05, * p<0.1.

households. This suggests that unemployed homeowners are not able to increase consumption as a result of home equity withdrawal and that perhaps their increased mortgage holdings is going towards other purposes such as debt repayment. That said, it is difficult to draw strong conclusions, given the relatively small share of unemployed homeowners in Texas that we observe in the CEX. In contrast, when we look at the consumption response of employed households, we observe an even larger increase in nondurable consumption relative to our baseline results in Table 1. More specifically, employed homeowners increase consumption by 4% as a result of the legalization of home equity withdrawal.

A.7 Heterogeneity by Expenditure Category

There exists substantial disagreement on the usage of funds extracted through home equity withdrawal.\(^{60}\) One benefit of our approach is that it allows us to observe very detailed information on expenditure categories in the CEX.

Table 11 shows the effect of the policy change on a wide variety of different expenditure categories. Among nondurable expenditure categories, we see that the largest response in expenditure is for food away from home and entertainment, which increase 3.7% and 2% respectively.\(^{61}\) In contrast, we see no significant effect on food consumed at home or apparel expenditure. This likely reflects the fact that food away from home and entertainment

---

\(^{60}\) See for instance Canner, Dyman, and Passmore (2002), Cooper (2010), Mian and Sufi (2011), Disney, Gathergood et al. (2009), and Crossley, Levell, and Low (2018) among others.

\(^{61}\) Entertainment expenditure includes tickets, pets, lessons, and recreation expenditure.
expenditure are more elastic than food at home or apparel.

### Table 11: Heterogeneity across Expenditure Categories

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food In</td>
<td>-0.00640</td>
<td>0.0377**</td>
<td>0.0146**</td>
<td>0.0203*</td>
<td>0.00869</td>
</tr>
<tr>
<td>Food Away</td>
<td>(0.00566)</td>
<td>(0.00711)</td>
<td>(0.00380)</td>
<td>(0.00766)</td>
<td>(0.00711)</td>
</tr>
<tr>
<td>HH Services</td>
<td>36,766</td>
<td>36,766</td>
<td>36,766</td>
<td>36,766</td>
<td>36,766</td>
</tr>
<tr>
<td>Entertainment</td>
<td>0.309</td>
<td>0.118</td>
<td>0.037</td>
<td>0.105</td>
<td>0.117</td>
</tr>
<tr>
<td>Apparel</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Alcohol</td>
<td>0.0209</td>
<td>0.0105**</td>
<td>-0.000273</td>
<td>0.0418*</td>
<td>0.0316*</td>
</tr>
<tr>
<td>Public Utilities</td>
<td>(0.00266)</td>
<td>(0.00245)</td>
<td>(0.00319)</td>
<td>(0.0149)</td>
<td>(0.0120)</td>
</tr>
<tr>
<td>Gasoline</td>
<td>36,766</td>
<td>36,766</td>
<td>36,766</td>
<td>36,766</td>
<td>36,766</td>
</tr>
<tr>
<td>Durables</td>
<td>0.070</td>
<td>0.155</td>
<td>0.196</td>
<td>0.090</td>
<td>0.059</td>
</tr>
<tr>
<td>Vehicle</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

HH Services includes cleaning, babysitting, repairs, rentals, elderly care
Entertainment includes tickets, pets, lessons, recreation, etc
Clustered standard errors in parentheses. ** p < 0.01, * p < 0.05

In addition, Table 11 shows the effect of the policy change on durable expenditure. We see that durable expenditure increases by 4.1% when home equity withdrawal is legalized. Within this category, the effect is especially large on vehicle expenditure, which increases by 3.1%. It is logical that durable expenditure would increase when credit constraints are relaxed, as households may have more flexibility to the timing of their durable expenditure. For the remainder of this paper, we focus only on nondurable consumption expenditure.

### A.8 Full U.S.

The U.S. has more home equity loan usage than the southern U.S., therefore we focus on the south which we believe is more directly comparable to Texas. When we look at the consumption response using the full U.S. as the control group, we find an even larger
consumption response to legalizing home equity withdrawal.

![Fraction of Homeowners with Home Equity Loan](image_url)

Similar results relative to the full U.S.

Table 12: Response to the Legalization of Home Equity Withdrawal (Full U.S. Sample)

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home Equity Loan</td>
<td>Log Consumption</td>
<td></td>
</tr>
<tr>
<td>1.post#1.treated_state</td>
<td>0.0143*</td>
<td>0.0320**</td>
</tr>
<tr>
<td></td>
<td>(0.00561)</td>
<td>(0.00810)</td>
</tr>
<tr>
<td>Texas = 1</td>
<td>0.0136**</td>
<td>0.0341**</td>
</tr>
<tr>
<td></td>
<td>(0.00252)</td>
<td>(0.00484)</td>
</tr>
<tr>
<td>Observations</td>
<td>76,051</td>
<td>76,051</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.024</td>
<td>0.312</td>
</tr>
<tr>
<td>Time FE</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>State FE</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Standard errors clustered by state. ** p<0.01, * p<0.05

A.9 Full List of Controls

Full list of controls used in baseline regression results.
<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1) HEL &gt; 0</th>
<th>(2) Mortgage &gt; 0</th>
<th>(3) Log Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post1998 * Texas</td>
<td>0.0149***</td>
<td>0.0359**</td>
<td>0.0301***</td>
</tr>
<tr>
<td></td>
<td>(0.00478)</td>
<td>(0.0129)</td>
<td>(0.0104)</td>
</tr>
<tr>
<td>Texas</td>
<td>-0.00195</td>
<td>-0.107***</td>
<td>-0.0129**</td>
</tr>
<tr>
<td></td>
<td>(0.00261)</td>
<td>(0.00450)</td>
<td>(0.00581)</td>
</tr>
<tr>
<td>age of the head</td>
<td>0.00332*</td>
<td>0.0153***</td>
<td>0.0272***</td>
</tr>
<tr>
<td></td>
<td>(0.00158)</td>
<td>(0.00286)</td>
<td>(0.00494)</td>
</tr>
<tr>
<td>age2</td>
<td>-2.89e-05</td>
<td>-0.000252***</td>
<td>-0.000264***</td>
</tr>
<tr>
<td></td>
<td>(1.75e-05)</td>
<td>(3.21e-05)</td>
<td>(5.39e-05)</td>
</tr>
<tr>
<td>log_income</td>
<td>0.00142***</td>
<td>0.00491***</td>
<td>0.0167***</td>
</tr>
<tr>
<td></td>
<td>(0.000385)</td>
<td>(0.00102)</td>
<td>(0.00131)</td>
</tr>
<tr>
<td>fam_size_trunc = 2</td>
<td>-0.00499</td>
<td>-0.0111</td>
<td>0.270***</td>
</tr>
<tr>
<td></td>
<td>(0.00995)</td>
<td>(0.00977)</td>
<td>(0.0193)</td>
</tr>
<tr>
<td>fam_size_trunc = 3</td>
<td>-0.00916</td>
<td>0.00636</td>
<td>0.367***</td>
</tr>
<tr>
<td></td>
<td>(0.0104)</td>
<td>(0.0106)</td>
<td>(0.0208)</td>
</tr>
<tr>
<td>fam_size_trunc = 4</td>
<td>-0.00239</td>
<td>0.0290**</td>
<td>0.431***</td>
</tr>
<tr>
<td></td>
<td>(0.0107)</td>
<td>(0.0127)</td>
<td>(0.0239)</td>
</tr>
<tr>
<td>fam_size_trunc = 5</td>
<td>-0.00610</td>
<td>0.0243</td>
<td>0.449***</td>
</tr>
<tr>
<td></td>
<td>(0.00946)</td>
<td>(0.0182)</td>
<td>(0.0415)</td>
</tr>
<tr>
<td>fam_size_trunc = 6</td>
<td>-0.0108</td>
<td>0.00561</td>
<td>0.447***</td>
</tr>
<tr>
<td></td>
<td>(0.00941)</td>
<td>(0.0291)</td>
<td>(0.0682)</td>
</tr>
<tr>
<td>fam_size_trunc = 7</td>
<td>0.0151</td>
<td>-0.0658</td>
<td>0.393***</td>
</tr>
<tr>
<td></td>
<td>(0.0150)</td>
<td>(0.0873)</td>
<td>(0.0850)</td>
</tr>
<tr>
<td>fam_size_trunc = 8</td>
<td>0.00202</td>
<td>-0.0527</td>
<td>0.508***</td>
</tr>
<tr>
<td></td>
<td>(0.0336)</td>
<td>(0.116)</td>
<td>(0.111)</td>
</tr>
<tr>
<td>urban/rural = 2, Rural</td>
<td>-0.0686***</td>
<td>-0.253***</td>
<td>-0.127***</td>
</tr>
<tr>
<td></td>
<td>(0.00257)</td>
<td>(0.00689)</td>
<td>(0.00920)</td>
</tr>
<tr>
<td>race of the head = 2, Black</td>
<td>0.00938</td>
<td>-0.00326</td>
<td>-0.159***</td>
</tr>
<tr>
<td></td>
<td>(0.00661)</td>
<td>(0.0115)</td>
<td>(0.0272)</td>
</tr>
<tr>
<td>race of the head = 3, Other</td>
<td>-0.0315***</td>
<td>-0.0317</td>
<td>-0.103**</td>
</tr>
<tr>
<td></td>
<td>(0.00640)</td>
<td>(0.0368)</td>
<td>(0.0448)</td>
</tr>
<tr>
<td>Number of earnere in CU = 1</td>
<td>0.00505</td>
<td>0.139***</td>
<td>0.113***</td>
</tr>
<tr>
<td></td>
<td>(0.0107)</td>
<td>(0.0255)</td>
<td>(0.0314)</td>
</tr>
<tr>
<td>Number of earnere in CU = 2</td>
<td>0.0163</td>
<td>0.209***</td>
<td>0.211***</td>
</tr>
<tr>
<td></td>
<td>(0.0127)</td>
<td>(0.0283)</td>
<td>(0.0437)</td>
</tr>
<tr>
<td>Number of earnere in CU = 3</td>
<td>0.0318**</td>
<td>0.181***</td>
<td>0.278***</td>
</tr>
<tr>
<td></td>
<td>(0.0115)</td>
<td>(0.0335)</td>
<td>(0.0510)</td>
</tr>
<tr>
<td>Number of earnere in CU = 4</td>
<td>0.0214</td>
<td>0.140***</td>
<td>0.331***</td>
</tr>
</tbody>
</table>

Number of observations: 36,766
Adjusted R-squared: 0.016, 0.153, 0.276
Time FE: Yes, Yes, Yes
State FE: Yes, Yes, Yes

Standard errors clustered by state. *** p < 0.01, ** p < 0.05, * p < 0.1.
B Model Appendix

In this section, we describe additional features of our model which we believe are important to match the environment faced by U.S. households. Finally, we present the recursive formulation of our model.

B.1 Mortgage Schedule

Length mortgage: \( l \). \( m_{t+l} = 0 \) and equation (6) implies \( m_{t+l-1} = mp \). Then using this relationship in the mortgage balance equation between periods 29 and 30, we get:

\[
mp = (m_{t+l-2} - mp)(1 + r^M) \\
mp = (1 + r^M)m_{t+l-2} - (1 + r^M)mp
\]

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

\[
mp = (1 + r^M)[(m_{t+l-3} - mp)(1 + r^M)] - (1 + r^M)mp \\
mp = (1 + r^M)^2m_{t+l-3} - (1 + r^M)mp - (1 + r^M)^2mp
\]

\[
\sum_{i=0}^{(t+l-1)-(t+l-3)} (1 + r^M)^i mp = (1 + r^M)^{t+l-1-(t+l-3)}m_{t+l-3}
\]

we can use this rule iteratively in equation to get \( m_{t+1} \):

\[
mp \sum_{i=0}^{t+l-1-(t+1)} (1 + r^M)^i = (1 + r^M)^{t+l-1-(t+1)}m_{t+1}
\]

we also know the relationship between \( m_{t+1} \) and \( m_t \): \( m_{t+1} = (1 + r^M)m_t \)

\[
mp \sum_{i=0}^{l-2}(1 + r^M)^i = (1 + r^M)^{l-2}(1 + r^M)m_t
\]

\[
mp = \frac{(1 + r^M)^{l-1}}{\sum_{i=0}^{l-2}(1 + r^M)^i}m_t \\
mp = \frac{(1 + r^M)^l}{\sum_{i=1}^{l-1}(1 + r^M)^i}m_t
\]
B.2 Taxes

We build progressive income taxation into the model following Keane and Wasi (2016), who assume a nonlinear tax function:

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

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 \( r a_{i,t} \), 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. In our case, we allow \( \tau_d \) to be the sum of the standard deduction \( \tau_d^{\text{standard}} \) and 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 U.S. This results in an after-tax income for households given by the following equation:

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

B.3 Social Security

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

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

where 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, \( y_{i,W} \).\(^{62}\) We calibrate the social security income floor and primary insurance amount based on U.S. legislation from 2015.\(^{63}\)

\(^{62}\)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.

\(^{63}\)The PIA is a piecewise linear function with two break points. Currently, the PIA is computed as 90% of AIME up to breakpoint 1, 32% of AIME up to breakpoint 2, and 15% of AIME up to the social security wage base.
B.4 Retirement Accounts

In addition, households receive annuitized disbursements from an individual retirement account. This serves as an alternative savings commitment device that helps households accumulate wealth for retirement. We make the assumption that households have no choice over the size of their retirement account or the timing at which they withdraw from their retirement account, i.e. retirement contributions are mandatory and must be converted to an annuity at age $W$. This assumption implies that households suffer zero temptation to consume their retirement account, therefore it acts as a perfect commitment device. 

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

$$y_{i,t}^{IRA} = \eta_1 \cdot \text{IRA}_{i,W+1}$$ (38)

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 who purchases an annuity at age $j$, given the survival probability $s_t$ is as follows:

$$\eta_1 = \left[ \sum_{t=j}^{T} \frac{s_t}{(1+r)^{t-j}} \right]^{-1}$$ (39)

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 their first year of retirement ($j = W + 1$) using the entirety of their retirement account.

We assume that the size of the retirement accounts is a linear function of the household’s last working period income. This simplifying assumption allows us to include retirement

---

64 This is a conservative assumption, as retirement accounts in the U.S. are not perfectly illiquid (Beshears, Choi, Hurwitz, Laibson, and Madrian, 2015b), therefore households may still suffer temptation to consume these accounts when young. By making the assumption that retirement accounts serve as a perfect commitment device, it means that the welfare effects of breaking housing’s role as a commitment device will be a lower bound estimate of the true welfare effects. Moreover, it is important to note that retirement accounts have also become more liquid during recent years, therefore their commitment benefit may have been similarly weakened. (Beshears, Choi, Laibson, and Madrian, 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).

65 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,
accounts without the introduction of an additional state variable. The size of the retirement account is given by the following simple formula:

\[ \text{IRA}_{i,W+1} = \eta_2 * y_{i,W} \]  \hspace{1cm} (40)

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

**B.5 Housing Subsidy**

Our model matches the U.S tax code by allowing households to deduct all mortgage interest payments from their taxable income and levying no capital gains tax on housing.

**B.6 Kids**

\[ u(c_t, h_t, n_t) = \left( \frac{n_t}{n_{i}} \right)^{1-\gamma} \exp \left[ \theta \phi(h_t, n_t) + \mu \phi(h_t, n_t) - \kappa I_{h_t \neq h_{t-1}} \right] \]  \hspace{1cm} (41)

where \( n_t \) is the exogenously given equivalence scale capturing the evolution of household composition over the life-cycle and

\[ \phi(h_t, n_t) = \frac{\left( \frac{h_t}{n_t} \right)^{1-\alpha}}{1-\alpha} \]

**B.7 Bequest**

We assume that households value bequest through a function used by De Nardi (2004) and O’Dea (2018) and given by

\[ b(a^b) = \theta^b \left( a^b + K \right)^{1-\gamma} \]  \hspace{1cm} (42)

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.

\[ a^b_{t+1} = a_{t+1} + p_{t+1}(h_t) \]  \hspace{1cm} (43)

evidence that is consistent with the view that households suffer from temptation.
B.8 Recursive Formulation.

We assume that 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:

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

(44)

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:

$$V_t^0(\Omega_t) = \max \left\{ c_t, m_t+1 \right\} U(c_t, h_t, \tilde{c}_t, \tilde{h}_t) + s_t \beta E_t V_{t+1}(\Omega_{t+1}) + (1 - s_t) b(a_{t+1}^b),$$

(45)

subject to:

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

(46)

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

where we use indicator function $\Pi_t^O$ to flag owners at time $t$ and $\Pi_{HEW}^t$ 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:

$$V_t^1(\Omega_t) = \max \left\{ c_t, h_t, \tilde{c}_t, \tilde{h}_t \right\} U(c_t, h_t, \tilde{c}_t, \tilde{h}_t) + s_t \beta E_t V_{t+1}(\Omega_{t+1}) + (1 - s_t) b(a_{t+1}^b),$$

(47)
subject to:

\[ a_{t+1} = R \left\{ a_t + \tilde{y}_t - c_t - (1 - \Pi_t^O) \chi_t - \left(1 + F\right) p_t(h_t) + \frac{m_{t+1}}{1 + r_M} + (1 - F)p_t(h_{t-1}) - m_t \right\} \]

\[ m_{t+1} \leq (1 + r_M) \begin{cases} (1 - \psi_{\min})p_t(h_t), & \text{if } \Pi_{t+1}^O \\ 0, & \text{if } 1 - \Pi_t^O \end{cases} \]

\[(48)\]

C Information in Consumption Growth: Derivations

C.1 Deriving the Euler Equation

For the ease of exposition, we focus on a stylized version of our model with no housing. The Bellman equations represented by equations (46) and (48) under this assumption simplify to the following Bellman equation:

\[ V_t(\Omega_t) = \max_{c_t} U(c_t, \tilde{c}_t) + s_t \beta \mathbb{E}_t V_{t+1}(\Omega_{t+1}) + (1 - s_t)b(a_{t+1}^b) \]

subject to:

\[ a_{t+1} = R(a_t + \tilde{y}_t - c_t) \]

\[(49)\]

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:

\[ \frac{\partial U_t}{\partial c_t} = \beta R \mathbb{E}_t \left[ \frac{\partial V_{t+1}(\Omega_{t+1})}{\partial a_{t+1}} \right] \]

\[(50)\]

The envelope condition with respect to \( a_t \) is:

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

\[(51)\]

Now combining the first order condition with the envelope condition, we can get:

\[ \frac{\partial V_t(\Omega_t)}{\partial a_t} = \frac{\partial U_t}{\partial \tilde{c}_t} \frac{\partial \tilde{c}_t}{\partial a_t} + \frac{\partial U_t}{\partial c_t} \]

\[(52)\]
Shifting equation (52) by one period ahead and use it again in the first order condition, we can formulate the Euler Equation in its most general form:

$$\frac{\partial U_t}{\partial c_t} = \beta R E_t \left[ \frac{\partial U_{t+1}}{\partial c_{t+1}} + \frac{\partial U_{t+1}}{\partial \tilde{c}_{t+1}} \frac{\partial \tilde{c}_{t+1}}{\partial a_{t+1}} \right]$$

(53)

Using now the functional form for the utility function defined in equation (11) while assuming no housing ($\mu = 0$, $\theta = 0$),

$$U_t = (1 + \lambda) c_t^{1-\gamma} - \lambda \frac{c_t^{1-\gamma}}{1-\gamma}$$

(54)

the Euler equation takes the following form:

$$c_t^{-\gamma} = \beta R E_t \left[ c_{t+1}^{-\gamma} - \frac{\lambda}{1+\lambda} (\tilde{c}_{t+1})^{-\gamma} \right]$$

(55)

### C.2 Log-Linearizing the Euler Equation

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

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

(56)

Note that in case there is no temptation, equation (56) becomes

$$k_{t+1} = \beta \left( \frac{c_{t+1}}{c_t} \right)^{-\gamma}$$

(57)

Assuming that all the variables in the pricing kernel are stationary $\left( \frac{c_{t+1}}{c_t}, \frac{\tilde{c}_{t+1}}{c_{t+1}} \right)$, we can take log-linear approximation around their steady states. First, we take logs of both sides

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

(58)

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

$$\hat{k}_{t+1} = -\gamma \left( \frac{c_{t+1}}{c_t} \right) + \gamma \Upsilon_1 \left( \frac{\tilde{c}_{t+1}}{c_{t+1}} \right)$$

(59)
where

\[ \gamma_1 = \frac{\lambda}{(1 + \lambda) \left( \frac{\bar{c}}{c} \right)^\gamma} - \lambda. \]

Without temptation equation (59) becomes

\[ \hat{k}_{t+1} = -\gamma \left( \frac{c_{t+1}}{c_t} \right) \quad (60) \]

Now we apply approximation \( \hat{x}_t \approx \ln x_t - \ln x \) to equation (59) to get

\[ \ln k_{t+1} - \ln k = -\gamma \ln \left( \frac{c_{t+1}}{c_t} \right) + \gamma \gamma_1 \left[ \ln \left( \frac{\hat{c}_{t+1}}{c_{t+1}} \right) - \ln \frac{\bar{c}}{c} \right] \quad (61) \]

From equation (58), we also know the steady state level of \( \ln k \)

\[ \ln k = \ln(\beta) + \ln \left[ 1 - \frac{\lambda}{1 + \lambda} \left( \frac{\bar{c}}{c} \right)^{-\gamma} \right], \quad (62) \]

which we can substitute into equation (61) to get

\[ \ln k_{t+1} = \ln(\beta) + \ln \left[ 1 - \frac{\lambda}{1 + \lambda} \left( \frac{\bar{c}}{c} \right)^{-\gamma} \right] - \gamma \ln \left( \frac{c_{t+1}}{c_t} \right) + \gamma \gamma_1 \left[ \ln \left( \frac{\hat{c}_{t+1}}{c_{t+1}} \right) - \ln \frac{\bar{c}}{c} \right] \quad (63) \]

Following equation (60), without temptation we get

\[ \ln k_{t+1} = \ln(\beta) - \gamma \ln \left( \frac{c_{t+1}}{c_t} \right) \quad (64) \]

We now can return to the log-linearized Euler equations by using the approximation \( 0 = \ln R + \mathbb{E}_t[\ln k_{t+1}] \). So we get

\[ \gamma \ln \left( \frac{c_{t+1}}{c_t} \right) = \text{constant} + \ln R + \gamma \gamma_1 \ln \left( \frac{\hat{c}_{t+1}}{c_{t+1}} \right) + \epsilon_{t+1} \]

with an estimable version of

\[ \ln \left( \frac{c_{t+1}}{c_t} \right) = a_0 + a_1 \ln R + a_2 \ln \left( \frac{\hat{c}_{t+1}}{c_{t+1}} \right) + u_{t+1} \quad (65) \]
for the model with temptation, where

\[ a_0 = \frac{\ln \beta + \ln \left[ 1 - \frac{\lambda}{1+\lambda} \left( \frac{\tilde{c}}{c} \right)^{-\gamma} \right]}{\gamma} \]

\[ a_1 = \frac{1}{\gamma} \]

\[ a_2 = \frac{\lambda}{(1+\lambda) \left( \frac{\tilde{c}}{c} \right)^{\gamma} - \lambda}. \]

While without temptation, the log-linearized Euler equation is:

\[ \ln \left( \frac{c_{t+1}}{c_t} \right) = b_0 + b_1 \ln R_{t+1} + v_{t+1} \] (66)

with

\[ b_0 = \frac{\ln \beta}{\gamma} \]

\[ b_1 = \frac{1}{\gamma} \]

Both \( u_{t+1} \) and \( v_{t+1} \) includes expectational errors, and higher order approximation errors for the appropriate variables. In Section 4, we use equations (65) and (66) to show the relevance of these results and to discuss the intuition of these Euler equations.

### C.3 Deriving \( a_0 \leq b_0 \) and \( a_2 \geq 0 \)

To see that the constant term in the log-linearized Euler equation with temptation is less or equal than the constant term in the Euler equation without temptation (\( a_0 \leq b_0 \)), we need to prove that

\[ \frac{\ln \beta + \ln \left[ 1 - \frac{\lambda}{1+\lambda} \left( \frac{\tilde{c}}{c} \right)^{-\gamma} \right]}{\gamma} \leq \frac{\ln \beta}{\gamma} \]

\[ \ln \left[ 1 - \frac{\lambda}{1+\lambda} \left( \frac{c}{\tilde{c}} \right)^{\gamma} \right] \leq 0 \] (67)

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

\[ 0 \leq \frac{\lambda}{1 + \lambda} \left( \frac{\tilde{c}}{c} \right)^{\gamma} \leq 1 \]

and therefore the inequality in equation (67) has to hold and therefore \( a_0 \leq b_0 \).

In order to see that the coefficient on the tempting consumption alternative in the Euler equation \( a_2 \) is higher or equal to zero, we need to prove that

\[ \frac{\lambda}{(1 + \lambda) \left( \frac{\tilde{c}}{c} \right)^{\gamma} - \lambda} \geq 0 \]

\[ (1 + \lambda) \left( \frac{\tilde{c}}{c} \right)^{\gamma} \geq \lambda \] 

(68)

\[ \left( \frac{\tilde{c}}{c} \right)^{\gamma} \geq \frac{\lambda}{1 + \lambda} \]

As the most tempting consumption alternative \( \tilde{c} \) is, by definition, higher or equal to actual consumption \( c \), we know that \( \left( \frac{\tilde{c}}{c} \right)^{\gamma} \geq 1 \). Again using that \( \lambda \geq 0 \), it is straightforward to see that

\[ \left( \frac{\tilde{c}}{c} \right)^{\gamma} \geq 1 \geq \frac{\lambda}{1 + \lambda} \] 

(69)

Therefore we proved that the inequality in equation (68) holds, hence \( a_2 \geq 0 \).
### D Model Estimation: Additional Details

#### D.1 Parameters set outside the model

Table 13: Parameters set outside the model

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Income Persistence</td>
<td>$\rho$</td>
<td>0.95</td>
<td>Storesletten, Telmer, and Yaron (2004)</td>
</tr>
<tr>
<td>Std Dev Income Shocks</td>
<td>$\sigma$</td>
<td>0.217</td>
<td>Choukhmane (2019)</td>
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<td>Initial Income</td>
<td>$\sigma_0$</td>
<td>0.429</td>
<td>PSID 1999-2015</td>
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<tr>
<td>Income Constant</td>
<td>$a_0$</td>
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<td>PSID 1999-2015</td>
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<td>Income $Age$ Effect</td>
<td>$a_1$</td>
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<td>PSID 1999-2015</td>
</tr>
<tr>
<td>Income $Age^2$ Effect</td>
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<td>PSID 1999-2015</td>
</tr>
<tr>
<td>Income $Age^3$ Effect</td>
<td>$a_3$</td>
<td>0.002639</td>
<td>PSID 1999-2015</td>
</tr>
<tr>
<td>Housing Transaction Cost</td>
<td>$F$</td>
<td>0.05</td>
<td>Attanasio et al. (2012)</td>
</tr>
<tr>
<td>Maximum Loan-to-Value</td>
<td>$\bar{\psi}$</td>
<td>0.9</td>
<td>Gorea and Midrigan (2017)</td>
</tr>
<tr>
<td>Additive Refi Cost</td>
<td>$f_0$</td>
<td>$5000$</td>
<td>-</td>
</tr>
<tr>
<td>Multiplicative Refi Cost</td>
<td>$f_1$</td>
<td>0.05</td>
<td>-</td>
</tr>
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<td>Share with zero initial assets</td>
<td>$a_0^{zero}$</td>
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<td>PSID 1999-2015</td>
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<td>Cond. mean initial assets</td>
<td>$\mu_{a0}$</td>
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<td>Cond. std dev initial assets</td>
<td>$\sigma_{a0}$</td>
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<td>PSID 1999-2015</td>
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<td>Share with initial housing</td>
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<td>PSID 1999-2015</td>
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<td>Housing asset return</td>
<td>$r_h$</td>
<td>0.021</td>
<td>Case-Shiller</td>
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<td>Mortgage rate</td>
<td>$r_m$</td>
<td>0.041</td>
<td>Primary Mortgage Market Survey</td>
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<td>Liquid asset return</td>
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<td>-</td>
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<td>Rental scale</td>
<td>$a_{rent}$</td>
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<td>-</td>
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<td>Share of Consumption in PSID</td>
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<tr>
<td>Taste Shocks Scale</td>
<td>$\sigma_{taste}$</td>
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<td>-</td>
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</table>

Table 13 shows the parameters set outside the model. Most of these have been described in Section 5.1.2. The remainder are explained below.

**Taxes** – For the parameters of the non-linear tax function we use the estimation results by Keane and Wasi (2016) and convert them to 2015 units. Income after retirement is not subject to any risk.
Retirement Income – After retirement, households receive progressive social security income and regular pension payments, both of which are a function of households last working period income.

Bequest Motive – 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 ODoea (2018).

D.2 Consumption Growth Regression (PSID)

Table 14: Consumption Growth Regression (PSID)

<table>
<thead>
<tr>
<th></th>
<th>(1) Baseline</th>
<th>(2) Year FE</th>
<th>(3) IV</th>
<th>(4) HH FE</th>
<th>(5) Habits</th>
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<tbody>
<tr>
<td>Liquid Assets ($a$)</td>
<td>0.00447***</td>
<td>0.00420**</td>
<td>0.00566***</td>
<td>0.01248***</td>
<td>0.00644***</td>
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<td>(0.00172)</td>
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<td>0.04161**</td>
<td>0.09375***</td>
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<td>0.05193**</td>
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<td></td>
<td>(0.01836)</td>
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<td>(0.01923)</td>
<td>(0.09423)</td>
<td>(0.02314)</td>
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<td>Age30</td>
<td>0.03516**</td>
<td>0.08555***</td>
<td>0.08711***</td>
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<td></td>
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<td>Age35</td>
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<td>0.08213***</td>
<td>0.08972***</td>
<td>-0.00470</td>
<td>0.03970*</td>
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<td>(0.01851)</td>
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### D.3 Estimation Results

#### D.3.1 Fit of Life-Cycle Moments

Figure 7 shows the model fit of life-cycle moments in our baseline model with temptation and commitment.

<table>
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<tr>
<th></th>
<th>Age55</th>
<th>Age60</th>
<th>wave=2003</th>
<th>wave=2005</th>
<th>wave=2007</th>
<th>wave=2009</th>
<th>wave=2011</th>
<th>wave=2013</th>
<th>wave=2015</th>
<th>( \Delta c_{-2} )</th>
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<tr>
<td></td>
<td>-0.05106***</td>
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<td>(0.01925)</td>
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<td>(.)</td>
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<td>wave=2007</td>
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<td>(0.01244)</td>
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<td>wave=2011</td>
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<td>0.02745**</td>
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<td>0.02158*</td>
<td>-0.07672**</td>
<td>0.02209*</td>
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<td>(0.01278)</td>
<td>(0.03496)</td>
<td>(0.01244)</td>
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<td></td>
<td>wave=2015</td>
<td>-0.05404***</td>
<td>0.00000</td>
<td>-0.11379***</td>
<td>-0.01619</td>
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<tr>
<td></td>
<td>(0.01238)</td>
<td>(.)</td>
<td>(0.04003)</td>
<td>(0.01254)</td>
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<td>( \Delta c_{-2} )</td>
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<td></td>
<td></td>
<td>-0.35200***</td>
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<td>(0.00834)</td>
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<td>Constant</td>
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<td>-0.01057</td>
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<td>(0.01989)</td>
<td>(0.07248)</td>
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</table>

Observations 15780 15780 12087 15780 12098
Figure 7: Model Fit in the Temptation Model

Note: This figure shows the life-cycle moments that we target in the PSID (the dashed lines) relative to the corresponding life-cycle moments in our estimated model with temptation (the solid lines).

Figure 8 shows the model fit of life-cycle moments when we estimate our model with the restriction that \( \lambda = 0 \), thus shutting off the possibility of temptation.
Figure 8: Model Fit in the Non-Temptation Model

Note: This figure shows the life-cycle moments that we target in the PSID (the dashed lines) relative to the corresponding life-cycle moments in our estimated model without temptation (the solid lines).
D.3.2 Fit of Consumption Growth Dynamics

Table 15: Model Fit: Consumption Growth Dynamics

<table>
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<th>(1)</th>
<th>(2)</th>
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<tr>
<td>Liquid Assets ($a$)</td>
<td>0.0045</td>
<td>0.0037</td>
<td>-0.0040</td>
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<tr>
<td>Age 25</td>
<td>0.0416</td>
<td>0.0587</td>
<td>0.1706</td>
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<td>Age 30</td>
<td>0.0352</td>
<td>0.0150</td>
<td>0.1197</td>
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<td>Age 35</td>
<td>0.0328</td>
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<td>0.0878</td>
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<td>Age 40</td>
<td>0.0200</td>
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<td>Age 45</td>
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<td>0.0551</td>
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<td>Age 50</td>
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<td>-0.0712</td>
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<td>Age 55</td>
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<td>Age 60</td>
<td>-0.0523</td>
<td>-0.0702</td>
<td>0.0032</td>
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</table>

Note: This table shows the consumption growth dynamics obtained when we estimate the consumption growth regression (equation 18) on the PSID, the temptation model, and the non-temptation model. The results show how consumption growth depends on liquid assets and a vector of age dummies.

D.4 Temptation Necessary to Fit Consumption Growth Dynamics

In our model, temptation is necessary to fit the positive relationship between consumption growth and liquid assets. We find that it is not possible for any other feature of our model (i.e. time preferences, risk aversion, multiplicative or additive housing taste, etc.) to generate this positive relationship. To test this theory, we generate 2,000 quasi-random draws of the estimated parameters of our structural model using a Sobol sequence. For each parameter draw, we solve and simulate the structural model, then estimate the consumption growth regression (Equation 18) on the simulated data. Finally, we perform a local optimization using the BOBYQA algorithm by Powell (2009) using multiple start points.

Figure 9 shows the results from this procedure. The vertical axis shows the relationship between consumption growth and liquid assets ($\hat{\psi}$ in Equation 18) conditional on the temptation parameter $\lambda$. Each dot represents a different draw of the parameters of our structural model.
model. We see that when $\lambda = 0$, no combination of the other structural parameters is able to generate a positive coefficient on liquid assets; instead, $\hat{\psi}$ ranges between -0.02 and -0.008. The negative coefficient reflects the fact that liquidity constraints produce a negative relationship between consumption growth and liquid assets, in the absence of temptation.

Figure 9: Coefficient on Liquid Assets

![Figure 9: Coefficient on Liquid Assets](image)

Note: This figure shows the relationship between consumption growth and liquid assets ($\hat{\psi}$ in Equation 18) conditional on the temptation parameter $\lambda$. Each dot represents a different draw of the parameters of our structural model.

As the strength of temptation ($\lambda$) increases, we see that the relationship between consumption growth and liquid assets moves upward and eventually becomes positive, as the effect of temptation eventually dominates the effect of liquidity constraints. The relationship observed in the model becomes most similar to that observed in the data when the value of $\lambda$ is between 0.35 and 0.5.

We should note that for any given value of $\lambda$, there exists a range of estimates of $\hat{\psi}$ that can be generated, depending on the other values of the structural parameters. Of the other structural parameters, risk aversion $\gamma$ plays the most important role in determining the magnitude of this relationship, although it is nevertheless unable to affect the sign of this
relationship.\footnote{\textbf{66} The reason that $\gamma$ is important in determining the magnitude is because it affects the desire of households to smooth consumption across periods. For this reason, $\gamma$ shows up inversely in the log-linearized consumption Euler equation derived in Section C.2.} For this reason, we need a combination of life-cycle moments and dynamic moments to pin down the different parameters in our model. These other moments play an important role in pinning down the other structural parameters, which in turn pin down the relationship between temptation ($\lambda$) and consumption growth dynamics ($\hat{\psi}$).

### D.5 Out-of-Sample Fit

We assess out-of-sample fit along multiple different dimensions. First, Figure 10 shows the share of homeowners performing home equity withdrawal by age, while Figure 11 shows the degree of wealth inequality in the model compared to the data. Along both dimensions we see that the model obtains a reasonable match of the data.

**Figure 10: Out of Sample Fit – Home Equity Withdrawal**

Note: This figure shows the share of homeowners performing home equity withdrawal in our baseline model and in the PSID.

Second, Table 15 shows consumption growth by age – these are moments from the consumption growth regression that we do not target in our estimation procedure. In line with the data, we see that the model with temptation predicts substantial consumption growth during the early years of one’s working life, as well as a substantial decline in consumption during the final years of one’s working life. These two results are driven by the hump shaped

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\textsuperscript{66} The reason that $\gamma$ is important in determining the magnitude is because it affects the desire of households to smooth consumption across periods. For this reason, $\gamma$ shows up inversely in the log-linearized consumption Euler equation derived in Section C.2.
Note: This figure shows the Lorenz Curve based on net wealth in our model and in the PSID.

income process, combined with credit constraints that prevent households from borrowing against future income growth.

Third, we assess the predictive power of the model when confronted with an exogenous policy change. We describe this validation exercise in Section 6.
References


Benito, Andrew. 2007. “Housing equity as a buffer: evidence from UK households.”


Carroll, Christopher Dixon. 2001. “Death to the log-linearized consumption Euler equation!(And very poor health to the second-order approximation).” Advances in Macroeconomics 1 (1).


Crossley, Thomas F, Peter Levell, and Hamish Low. 2018. “Consumption spending, housing investments and the role of leverage.”


Laibson, David, Peter Maxted, Andrea Repetto, and Jeremy Tobacman. 2017. “Estimating Discount Functions with Consumption Choices over the Lifecycle.”


