HOUSING, MORTGAGES, AND SELF CONTROL

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Abstract

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JEL Classification: D91, E21

Keywords: Housing, Mortgages, Self Control, Temptation, Commitment Device

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Housing, Mortgages, and Self Control

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Abstract

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Since the recent crisis in the housing and mortgage market, regulators across the globe have been assessing the usefulness and dangers of mortgage products. For example, both in the United States and in the United Kingdom regulators recently issued rules which limit the use of mortgage types which are deemed to harm consumers’ welfare (Consumer Financial Protection Bureau, 2013; Financial Services Authority, 2012). However, to assess if certain aspects of mortgage products are harmful to consumers’ welfare it is necessary to understand what determines housing and mortgage decisions. In this context, regulators are particularly worried that consumers might not behave fully rationally. For instance, Martin Wheatley, the first head of the Financial Conduct Authority in the U.K., stated that he wants to “adapt our regulation to their [the consumers’] behavioral traits” (Wheatley, 2012). In the U.S. Oren Bar-Gill and Elizabeth Warren argued for the creation of an agency which later became the Consumer Financial Protection Bureau by stating that “consumers, their families, their neighbors, and their communities are paying a high price for systematic cognitive errors. [...] To restore efficiency to consumer credit markets, [...] basic safety

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regulation is needed.” (Bar-Gill and Warren, 2008). The purpose of this paper is to formalize these concerns by investigating in a quantitative theoretical analysis how lack of self control, a form of limited rationality extensively studied in other contexts, influences housing and mortgage decisions of consumers and how regulation of mortgage products affects the welfare of people with different degrees of self control. By doing so the paper contributes to the literature of household finance (see, e.g., the presidential address by Campbell (2006)) and to how consumer financial protection can change consumer welfare (see, e.g. Campbell et al. (2011)).

The results show that self control plays a crucial role for housing and mortgage choice in two respects. First, it directly affects the housing and mortgage decisions. People with higher costs of self control are less likely to own a house, own smaller houses and have higher loan-to-value ratios. Second, their degree of self control determines if households benefit or are harmed by regulation policies which limit the use of certain mortgage products. While the availability of subprime mortgages with low down payment requirements is welfare decreasing for people with problems of self control, mortgages with severe prepayment penalties can be beneficial. In the absence of self control problems these effects would be the opposite.

Problems of self control are particularly interesting in the context of housing and mortgages because buying a house and taking out a mortgage can serve as commitment for saving. Houses are an illiquid investment and mortgages require continuous payments, so both assets can alleviate problems of self control. At the same time, however, purchasing a house requires making a down payment and saving for this down payment is more difficult for people with low degrees of self control. The results I obtain show that the latter effect dominates so that people with stronger problems of self control are less likely to become home owners even though they would particularly benefit from it as a commitment device. Moreover, I find that regulation which further increases the barriers when buying a house can in fact be beneficial. The results in this paper hence show that houses and mortgages are only a suboptimal commitment device.

The paper analyzes how problems of self control affect housing and mortgage decisions in a quantitative life-cycle model. Agents face uninsurable, idiosyncratic income risk as in Deaton (1991) and Carroll (1997) which makes the investment in a house risky since it is only partly reversible. Problems of self control are modeled by assuming that households have Dynamic Self Control Preferences (Gul and Pesendorfer, 2001, 2004) in the sense that they are always tempted to maximize their current utility instead of their expected life-time utility. The model is calibrated to the U.S. economy allowing for heterogeneity in the degree of self control. In the calibrated model reasonably small costs of self control lead to economically significant effects on the housing and mortgage choice. I find that households with problems of self control are up to 50% less likely to be home owners. This indicates that even though houses serve as commitment for saving, exactly the people who need the commitment device the most are the ones who are the least likely to make use of it. Moreover, if they become home owners, their houses are up to 7% smaller and their loan-to-value ratios are up to 23% higher. The model is then used to analyze the effects of regulating two
features of mortgage contracts: the maximum loan-to-value ratio and the prepayment option. In both cases more restrictive mortgage regulation is better for people with sufficiently strong problems of self control, even though such regulation makes purchasing a house - and hence obtaining the commitment device - more difficult.

The effects of self control on housing and mortgage decisions are the result of two opposing effects. On the one hand, people with problems of self control find it harder to give up consumption because this would lead to current costs of self control. This is the impatience effect. It makes current consumption more important relative to future consumption. Accumulating enough wealth for the down payment of a house is thus more costly. On the other hand, people with costs of self control also take into account that their current actions affect the temptation that they will face in the future and hence their future costs of self control. This anticipation effect thus generates a desire for commitment. Houses can be such a commitment device since home equity is an illiquid form of investment which cannot easily be liquidated. People with costs of self control are thus not tempted to spend this part of their savings which reduces their costs of self control. In the calibrated model I show that both effects are important for the housing and mortgage decision. Overall, however, the quantitative results reveal that the impatience effect dominates the anticipation effect.

The model is used to analyze the welfare consequences of financial regulation in the mortgage market. For a standard consumer, policies which restrict his choice set are always weakly welfare reducing. However, if people have costs of self control these policies not only restrict their actual behavior but also change the temptation that they face each period. I show that welfare benefits from reducing temptation can overcome the welfare loss of having to alter one’s behavior. Agents with costs of self control can hence benefit from policies which would reduce the welfare of people without costs of self control. To assess the consequences of financial regulation it is therefore important to take costs of self control into account.

The paper looks at two specific policy experiments: First, I show that a substantial down payment requirement of 20% would be beneficial to people with problems of self control even if it makes it harder to purchase a house and hence to get access to the commitment device. Increasing the minimum down payment requirement forces households to pay a higher share of the purchase price up-front in the period in which they buy a house. For people without costs of self control this is the only effect and they can therefore never be better off with this policy. For people with costs of self control, however, there is a second effect. If the minimum down payment requirement is very low then they are tempted to buy a large house by taking out a large mortgage. Exercising self control to resist this temptation is hard. Increasing the minimum down payment hence reduces the temptation the agents face each time they consider buying a house. Moreover, for home owners it also reduces the amount of home equity that can be extracted. This strengthens the commitment aspect of the house. In the calibrated model I show that the reduction in temptation outweighs the negative effect of making a house purchase more difficult. Agents with costs of self control are hence better off with a substantial minimum down payment requirement.
Second, the paper shows that the option to prepay and hence to refinance a mortgage lowers welfare for people with sufficiently strong problems of self control. This is in contrast to people without problems of self control who are unambiguously better off if prepayment is possible. For all households the possibility to refinance their mortgage implies that they can more easily adjust their leverage position and use their home equity to smooth income shocks. However, the fact that people can easily access their home equity reduces the commitment value of the house since people are tempted to extract home equity for current consumption. In the calibrated model I find that the increase in temptation outweighs the gain of flexibility for sufficiently strong problems of self control. People with stronger problems of self control are hence better off if prepayment is restricted. Furthermore, the welfare gain is higher for wealthier households since they are more likely to be home owners and therefore benefit more if houses offer stronger commitment.

While this paper abstracts from general equilibrium effects, I still obtain welfare statements for the population as a whole in partial equilibrium. Using data from the Health and Retirement Study for the group sizes of self control types and weighing everyone equally, the optimal down payment requirement amounts to 23%. Moreover, despite substantial welfare benefits for people with strong problems of self control, restricting prepayment lowers welfare in the population as a whole. However, offering a menu of mortgages with and without a prepayment restriction would improve welfare for people with costs of self control without reducing the welfare of the rest of the population.

The current paper is related to the literature in two areas. First, it is related to papers on housing and mortgages in the context of household finance. This area has been the subject of great interest since the crisis in the housing and mortgage market. Quantitative theoretical studies which focus on life-cycle considerations include Chambers, Garriga and Schlenkhauf (2009), Attanasio et al. (2012), Iacoviello and Pavan (2013) and Campbell and Cocco (2015). The latter paper is particularly relevant for the present analysis since it emphasizes the importance of the choice between different mortgage products for mortgage default. Moreover, Cocco (2013) empirically analyzes the advantages and dangers of subprime mortgage contracts. The current paper contributes to this literature by analyzing how self control affects both housing decisions and the choice between mortgages with different down payment requirements. Ghent (2015) and Kovacs (2016) also consider housing in the presence of present biased preferences. Ghent (2015) compares in a general equilibrium framework how introducing low down payment mortgages affects the welfare of people who discount the future quasi-hyperbolically (a way to model time-inconsistency suggested by Laibson (1997)). While she concludes that low down payment mortgages are welfare improving for present biased households, the current paper obtains the opposite result. The discrepancy stems

1 The current paper focuses on life-cycle aspects of the housing and mortgage choice in partial equilibrium with a realistically flexible choice set for households. Nevertheless, it is closely related to the literature on general equilibrium implications of housing decisions and mortgage underwriting standards. The most relevant papers are Corbae and Quintin (2015) and Favilukis, Ludvigson and Van Nieuwerburgh (forthcoming) who quantitatively analyze the aggregate effects of relaxing collateral requirements in mortgage contracts.
partly from the different representations of present bias in household preferences and partly from how the households’ choice set is modeled in both papers. The current paper allows for a very flexible choice set for households with continuous choices in both the house size and mortgage size subject to minimum down payment restrictions. This flexibility gives households more margins to adjust as a reaction to a policy change which leads to qualitatively and quantitatively different assessments of regulation policies. Kovacs (2016) estimates the average degree of self control using an Euler equation approach. The current paper has a different goal: It allows for heterogeneity in the degree of self control and analyzes how differences in self control affect the housing and mortgage decisions. It then emphasizes the differential welfare effect of regulation in the mortgage market on agents with different degrees of self control problems.

The second stream of literature that this paper directly relates to is the analysis of present bias in other household decisions. Temptation, self control, and a desire for commitment were found to play a role in various contexts, both non-financial and financial. In the context of household finance, Meier and Sprenger (2010) show empirically that the degree of present bias is an important determinant of credit card borrowing. Laibson, Repetto and Tobacman (2007) and Nakajima (2015) study the effects of present bias on credit card debt in a quantitative life-cycle model. Moreover, Heidhues and Koszegi (2010) show that regulation of late fees in credit contracts can improve welfare if people naïvely underestimate their time-inconsistency. Finally, Ameriks et al. (2007) find survey evidence that problems of self control are correlated with wealth accumulation. The contribution of the current paper is to study the effects of self control on the housing and mortgage decision - for most households the most important financial decision that they have to make during their life-time.

1 Model of Housing and Mortgages in the Presence of Self Control

In this section I describe the structural model that I use to analyze the effects of self control on the housing and mortgage choice. First, I specify how costs of self control are modeled and show what the main driving forces are in this preference specification. Second, I describe the life-cycle model of housing and mortgages.

1.1 Preference Specification

To model costs of self control I assume that households have Dynamic Self Control (DSC) Preferences (Gul and Pesendorfer, 2001, 2004). These preferences capture the idea that agents are subject to temptation and suffer from costs of self control if they want to resist this temptation. In this

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2Non-financial contexts where present bias and a desire for commitment were empirically found to be important include the choice of gym contracts (DellaVigna and Malmendier, 2006) and in the workplace (Kaur, Kremer and Mullainathan, 2015). From a theoretical perspective, Gul and Pesendorfer (2007) show that temptation preferences can be used to model drug addiction and Krusell, Kuruscu and Smith (2009, 2010) introduce self control problems in the context of a standard growth model.
paper, agents receive utility from nondurable consumption $C$ and housing services $H$. The detailed functional form of the per period utility is as follows:\(^3\)

$$U(C_t, H_t) = u(C_t, H_t) + \lambda \cdot (u(C_t, H_t) - T(B_t))$$

where $T(B_t) = \max_{\tilde{C}_t, \tilde{H}_t} u(\tilde{C}_t, \tilde{H}_t)$ \hspace{1cm} (1)

The per period utility consists of two terms. The first term refers to the felicity the agent receives from consuming a consumption bundle $\{C_t, H_t\}$. The second term shows that the agent has to exercise self control in order to implement this choice of consumption bundle. In particular, the agent always faces the temptation $T(B_t)$ to maximize his current period utility, i.e., to choose the consumption bundle $\{\tilde{C}_t, \tilde{H}_t\}$ within his budget set $B_t$ that would give the highest felicity in this period. However, agents do not maximize their current felicity but instead maximize their discounted life-time utility. Hence, the term $(u(C_t, H_t) - T(B_t))$ is typically negative and represents the costs of exercising self control. The parameter $\lambda$ governs how severe the temptation is. This is the central parameter to this specification of DSC preferences. If $\lambda$ is equal to zero the self control term drops out and per period utility simplifies to standard preferences without problems of self control. As $\lambda$ increases, however, the costs of self control become more severe.

It is important to notice that DSC preferences are defined not only over the actually chosen consumption bundle but over the whole budget set $B_t$. Specifically, the most tempting option within the budget set directly enters the utility. In order to understand the behavior of DSC agents it is therefore crucial to understand how their current actions affect their future budget set and hence their future costs of self control. To illustrate the different driving forces of DSC preferences it is instructive to consider a simple dynamic consumption-savings optimization problem without housing:

$$V(X_t) = \max_{C_t \in B_t} U(C_t) + \beta \cdot V(X_{t+1})$$

$$= \max_{C_t \in B_t} u(C_t) + \lambda \cdot (u(C_t) - T(B_t)) + \beta \cdot V(X_{t+1})$$

where $X_t$ is available cash-on-hand that follows a law of motion $X_{t+1} = (1+r)S_t$ and $S_t$ are savings. The budget set $B_t$ is defined by the constraint that $C_t + S_t \leq X_t$. Optimizing over savings leads to the following Euler Equation:

$$-(1 + \lambda) \frac{\partial u(C_t)}{\partial S_t} = \beta \cdot \left[ \frac{\partial u(C_{t+1})}{\partial S_t} + \lambda \cdot \left( \frac{\partial u(C_{t+1})}{\partial S_t} - \frac{\partial T(B_{t+1})}{\partial S_t} \right) \right]$$

Equation (4) emphasizes that the problem of self control has two effects: First, as can be seen on the left-hand-side, the marginal utility of giving up consumption is increased which makes the agent

\(^3\)The present formulation is a special case of the specification in Gul and Pesendorfer (2001, 2004) in the sense that commitment utility and temptation utility have the same functional form up to a constant $\lambda$. 

effectively more impatient.\textsuperscript{4} This effect is what I refer to as impatience effect. Second, on the right-hand-side, the effects of current choices on future costs of self control enter the optimality condition. In particular, the agent takes into account that his current choices change tomorrow’s budget set $B_{t+1}$ and hence tomorrow’s temptation $T(B_{t+1})$. I call this second effect anticipation effect.\textsuperscript{5} Note that in this illustrative example there is only one choice variable which is continuous. The anticipation effect will become even more important, however, when discrete choices are considered such as buying a house instead of renting or defaulting on a mortgage. The reason is that these discrete choices lead to non-convex changes in future budget sets.

From the introduction of DSC preferences in this section we thus make two observations. First, the preferences are defined on the whole budget set of the agent, not only on the actions actually taken. It is hence crucial to identify the most tempting option in the choice set since all possible actions are evaluated against this temptation. Second, there are two driving forces behind DSC preferences: an impatience effect and an anticipation effect. The optimal decision will trade off these two effects.

1.2 Model of Housing and Mortgages

The model I use to analyze the effects of self control on the housing and mortgage choice is a life-cycle model of optimal household behavior. The agents optimize their consumption and portfolio choices over the life-cycle for given prices.\textsuperscript{6} All agents are born in period $t = 1$ and live for $T$ periods. They work for the first $T^R$ periods of their lives and are in retirement for the last $T - T^R$ periods.

There are three types of assets in this model: Liquid savings $S$, houses $H$, and mortgages $M$. Liquid savings are risk free and can be used for saving. However, there is no unsecured borrowing in this model so liquid savings can never be negative. The second type of asset, houses, serve two purposes. On the one hand, agents receive utility from consuming housing services. The felicity function has the following form:

$$u(C, H) = \frac{(C^{1-\theta} (\mu H)^{\theta})^{1-\sigma}}{1 - \sigma}$$

where $\mu$ is the ownership benefit: The housing services that renters receive are equal to the house size they rent ($\mu = 1$), whereas home owners receive housing services that exceed their house size ($\mu > 1$). On the other hand, houses are an illiquid form of investment. The illiquidity is modeled in the sense that if agents decide to sell their house this transaction will only take place with a delay

\textsuperscript{4}An equivalent way of expressing this effect would be to divide the equation by $(1+\lambda)$ so that the effective discount factor would be $\beta/(1+\lambda) \leq \beta$.

\textsuperscript{5}This effect arises since agents are sophisticated in the sense that they fully anticipate their problem of self control in the future.

\textsuperscript{6}Throughout the paper I will use the terms agent and household interchangeably since I abstract from intra-household optimization.
of one period. This is in contrast to liquid savings which can be spent immediately. The third class of assets, mortgages, can be used to finance the purchase of a house. These mortgages are modeled as fixed rate mortgages and the repayment schedule is explicitly modeled. As with the house size, agents have a continuous choice of mortgage size but have to satisfy two constraints: First, there is a loan-to-value constraint (LTV) such that the agent can only borrow up to a certain fraction of the house value. The second constraint is a loan-to-income constraint (LTI) which restricts the mortgage to be smaller than a maximum multiple of the agent’s income.

Households face uninsurable, idiosyncratic income risk as in Deaton (1991) and Carroll (1997). During working life, the income process has the following form:

$$ Y_{it} = \bar{Y}_{it} \cdot V_{it} $$

$$ \bar{Y}_{it} = G_t \cdot \bar{Y}_{it-1} \cdot N_{it} , \quad t = 1 \ldots T $$

Income $Y_{it}$ of household $i$ in period $t$ can be decomposed in a permanent income component $\bar{Y}_{it}$ and a mean one transitory shock $V_{it} \sim \log N(-\sigma_V^2/2, \sigma_V)$. The permanent income component follows a random walk with drift, where $N_{it} \sim \log N(-\sigma_N^2/2, \sigma_N)$ is a permanent shock and $G_t$ reflects a deterministic, hump-shaped life-cycle profile.\(^7\) During retirement there is no income uncertainty and the agents receive a fraction $\varsigma$ of their permanent income in the last working life period:

$$ Y_{it} = \varsigma \cdot \bar{Y}_{iT^R} , \quad t = T^R + 1 \ldots T $$

The choice set of the agents differs whether they own a house or not. In the next subsections I will describe the two optimization problems in detail. Moreover, for both renters and home owners I will discuss the most tempting option in their choice set and how this temptation is affected by their previous actions and by the market environment.

### 1.2.1 Optimization Problem of a Renter

If the agent enters the period as a renter he has the choice to keep renting or to buy a house. If he keeps renting he solves the following optimization problem:\(^8\):

$$ V_{t}^{rent}(X_t, \bar{Y}_t) = \max_{S_t, H_t} (1 + \lambda) \cdot u(C_t, H_t) - \lambda \cdot T_t^{noh}(X_t, \bar{Y}_t) + \beta \cdot \mathbb{E} \left[ V_{t+1}^{noh}(X_{t+1}, \bar{Y}_{t+1}) \right] $$

s.t.

$$ C_t = X_t - S_t - P_t^R \cdot H_t $$

$$ X_{t+1} = S_t(1 + r_S) + Y_{t+1} $$

Given the state variables cash-on-hand $X_t$ and permanent income $\bar{Y}_t$ he has two continuous choice variables: Savings $S_t$ and house size to be rented $H_t$. $T_t^{noh}(X_t, \bar{Y}_t)$ is the temptation that an agent

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\(^7\)Note that in this model, period $t$ is equivalent to a specific age of the household since all households start their life in period $t = 1$.

\(^8\)To simplify notation I drop the subscript $i$ for all subsequent optimization problems.
faces who enters the period without a house. Equation (10) determines the implied nondurable consumption $C_t$ where $P_R^t$ is the rental price of one unit of housing services. Next period, the agent will enter the period still without a house and with cash-on-hand $X_{t+1}$ which is determined according to the law of motion in equation (11), where $r_S$ is the interest rate on liquid savings.

If the agent chooses to buy a house, his optimization problem is the following:

$$V_t^{\text{buy}}(X_t, \bar{Y}_t) = \max_{S_t, H, M_t} (1 + \lambda) u(C_t, \mu \bar{H}) - \lambda T_t^{\text{noh}}(X_t, \bar{Y}_t) + \beta \cdot \mathbb{E} \left[ V_{t+1}^{\text{house}}(X_{t+1}, \bar{H}, M_{t+1}, 1, \bar{Y}_{t+1}) \right]$$

subject to

$$C_t = X_t - (1 + \delta_B) \cdot P_R^t \bar{H} + (1 - \delta_M) \cdot M_t - S_t$$

$$M_t \leq \phi_v \cdot P_R^t \bar{H}$$

$$M_t \leq \phi_y \cdot \bar{Y}_t$$

$$X_{t+1} = S_t(1 + r_S) + Y_{t+1}$$

$$M_{t+1} = M_t(1 + r_M)$$

There are now three continuous choice variables: liquid savings $S_t$, the size of the house to buy $\bar{H}$, and the size of the mortgage $M_t$. To buy a house, the agent has to pay transaction costs on the house ($\delta_B$) and on the mortgage ($\delta_M$). Equations (14) and (15) represent the restrictions on the mortgage size: The ratio of mortgage to house value cannot exceed the fraction $\phi_v$ which is the maximum loan-to-value ratio. Moreover, the loan-to-income restriction implies that the mortgage balance must not exceed a multiple $\phi_y$ of the agent’s permanent income. Equations (16) and (17) lastly give the laws of motion for cash-on-hand and the mortgage balance, respectively. Note that in the period in which the mortgage is taken out the agent does not make a mortgage payment such that next period’s mortgage balance is equal to the current balance subject to the mortgage rate $r_M$.

Finally, the decision to buy a house or to keep renting is determined by which behavior yields the higher value. The value of entering the period without a house can hence be summarized as follows:

$$V_t^{\text{noh}}(X_t, \bar{Y}_t) = \max \left\{ V_t^{\text{rent}}(X_t, \bar{Y}_t), V_t^{\text{buy}}(X_t, \bar{Y}_t) \right\}$$

**Temptation of a Renter** To understand the behavior of agents with costs of self control it is important to understand what the most tempting option is in their choice set, i.e., the temptation $T_t^{\text{noh}}(X_t, \bar{Y}_t)$ they evaluate their actual choice against. For a renter this could be one of two possibilities. First, it could be most tempting to keep renting and to spend all available cash-on-hand on current consumption and on renting a house:

$$T_t^{\text{rent}}(X_t, \bar{Y}_t) = \max_{\bar{H}_t} u(X_t - P_R^t \cdot \bar{H}_t, \bar{H}_t)$$
Second, the temptation could be to buy a house, make only the minimum down payment required for this house, and spend the remaining cash-on-hand on current consumption.

\[ T^\text{buy}_t(X_t, \bar{Y}_t) = \max_{\hat{H}, \hat{M}} u(\hat{C}_t, \mu \hat{H}) \]  

s.t.  
\[ \hat{C}_t = X_t - (1 + \delta_B) \cdot P_t^H \hat{H} + (1 - \delta_M) \cdot \hat{M}_t \]  
\[ \hat{M}_t \leq \phi_v \cdot P_t^H \hat{H} \]  
\[ \hat{M}_t \leq \phi_y \cdot \bar{Y}_t \]  

In both cases, the temptation is to spend all available cash-on-hand in the current period. The overall temptation that the agent faces is the maximum of the two options:

\[ T^\text{nah}_t(X_t, \bar{Y}_t) = \max \{ T^\text{rent}_t(X_t, \bar{Y}_t), T^\text{buy}_t(X_t, \bar{Y}_t) \} \]

Which of these options is more tempting depends crucially on the minimum down payment requirement. If it is low then the agent can buy a very large house while hardly paying anything at the time of purchase. This gives high instantaneous utility and is hence very tempting. If, on the other hand, the down payment requirement is high, then either the agent can only buy a much smaller house for the same down payment or he has to cut down consumption. Either way, the instantaneous utility and hence the temptation is much lower.

### 1.2.2 Optimization Problem of a Homeowner

An agent who enters the period as a homeowner has four possibilities: he can keep the house and keep repaying his mortgage, he can refinance his mortgage, decide to sell the house, or default on his mortgage.\(^9\) If he decides to keep his house and keep repaying his mortgage then he has to solve the following optimization problem:

\[ V^\text{repay}_t(X_t, \bar{H}, M_t, a, \bar{Y}_t) = \max_{S_t} (1 + \lambda) \ u(C_t, \mu \bar{H}) - \lambda \ T^\text{house}_t(X_t, \bar{H}, M_t, a, \bar{Y}_t) \]

\[ + \beta \cdot \mathbb{E} \left[ V^\text{house}_{t+1}(X_{t+1}, \bar{H}, M_{t+1}, a+1, \bar{Y}_{t+1}) \right] \]  

s.t.  
\[ C_t = X_t - Q(M_t, a, t) - \psi M P^H t \bar{H} - S_t \]  
\[ X_{t+1} = S_t(1 + r_S) + Y_{t+1} \]  
\[ M_{t+1} = (M_t - Q(M_t, a, t))(1 + r_M) \]

He enters the period with five state variables: cash-on-hand \(X_t\), the size of his house \(\bar{H}\), the balance of his outstanding mortgage \(M_t\), the time since origination of his mortgage \(a\) and his permanent

\(^9\)In reality, another option of home owners is to access their home equity by taking out a home equity line of credit (HELOC). Since this paper abstracts from interest rate risk, extracting home equity in this way would be equivalent to refinancing to a higher mortgage.
income $\bar{Y}_t$. The agent makes the mortgage payment $Q$ which is required to repay the mortgage on schedule. Since both the term of the mortgage and the mortgage rate are fixed, the mortgage payment is determined by the outstanding mortgage and the age of the mortgage according to the following formula:

$$Q(M, a, t) = \frac{M}{1 + r_M} \cdot \frac{\kappa_a}{1 - (1 + r_M)^{\tau}}$$

where

$$\kappa_1 = \frac{r_M}{1 - (1 + r_M)^{\tau}}$$

$$\kappa_a = \begin{cases} \frac{\kappa_{a-1}}{1 + (1 - \kappa_{a-1})} & a = 2, \ldots, \tau \\ 0 & a > \tau \end{cases}$$

$$\tau = \min[\tau^s, T - t - a]$$

where the fixed term of the mortgage $\tau$ is either equal to the standard term $\tau^s$ or the remaining life time at origination in case that is shorter. Equation (26) states that consumption is equal to remaining cash-on-hand after mortgage payment $Q$, maintenance costs $\psi_M$ and liquid savings $S_t$ have been made. The only choice variable in this situation is hence the amount of liquid savings $S_t$. Next period the agent will enter with the same house but a lower mortgage (equation (28)) which is one period older.

If the agent decides to refinance his mortgage, he faces the following problem:

$$V_{t}^{ref}(X_t, \bar{H}, \bar{M}, \bar{Y}_t) = \max_{S_t, M_t} (1 + \lambda) u(C_t, \mu H) - \lambda T_t^{house}(X_t, \bar{H}, M, a, \bar{Y}_t)$$

$$+ \beta \cdot \mathbb{E} \left[ V_{t+1}^{house}(X_{t+1}, \bar{H}, M_{t+1}, 1, \bar{Y}_{t+1}) \right]$$

s.t. $\quad C_t = X_t - \psi_M P_t^H \bar{H} + (1 - \delta_M)M_t - \bar{M} - S_t$

$$\quad M_t \leq \phi_v \cdot P_t^H \bar{H}$$

$$\quad M_t \leq \phi_y \cdot \bar{Y}_t$$

$$\quad X_{t+1} = S_t(1 + r_S) + Y_{t+1}$$

$$\quad M_{t+1} = M_t(1 + r_M)$$

He has to choose the optimal balance of a new mortgage and liquid savings based on his state variables cash-on-hand $X_t$, the house size he owns $\bar{H}$, the old mortgage balance outstanding $\bar{M}$ and his permanent income $\bar{Y}_t$. He repays his existing mortgage and takes out a new one subject to transaction costs (see equation (34)). As in the case when he buys a house, the new mortgage balance has to satisfy both LTV and LTI constraints (equations (35) and (36)). Next period, he will enter with the same house but a new mortgage which will be one period old. Note that the agent does not have to take out a new mortgage if he decides to refinance. Instead, he can choose to repay his mortgage and not take out a new one.\(^{10}\)

\(^{10}\)This is equivalent to taking out a new mortgage with zero balance.
The third possibility of a home owner is to sell his house. Houses are illiquid assets which cannot be sold immediately. Instead, the agent has to decide to sell the house in the current period, but the transaction only takes place during the transition from the current period to the next. This implies that in the current period, the agent still has to pay maintenance costs and to make the mortgage payment required to repay the mortgage on schedule. Next period, he will enter without a house but with his cash-on-hand increased by the proceeds from selling the house. He will be able to buy another house immediately. In particular, if he wants to upsize or downsize he can do that by deciding to sell now and by buying the desired house size next period. In detail, the problem of an agent who sells his house is the following:

\[
V_t^{sell}(X_t, \bar{H}_t,M_t,a_t,\bar{Y}_t) = \max_{S_t} (1 + \lambda) u(C_t, \mu \bar{H}) - \lambda T_t^{house}(X_t, \bar{H}, M_t, a, \bar{Y}_t) + \beta \cdot E \left[ V_{t+1}^{nohl}(X_{t+1}, \bar{Y}_{t+1}) \right]
\]

s.t. \( C_t = X_t - \psi_M \bar{H}_t - Q(M_t, a, t) - S_t \)

\( X_{t+1} = S_t(1 + r_S) + Y_{t+1} + (1 - \delta_S) P_{t+1}^{H} \bar{H} - (M_t - Q(M_t, a, t))(1 + r_M) \)

The choice to introduce the delay in selling but not in buying is deliberate. It implies that buying a house is associated with the potential temptation to buy a too expensive house while home equity is illiquid and cannot be spent immediately. In reality, the purchase of a house is not instantaneous. However, people start planning and dreaming about how to alter or decorate the house the moment they come to the viewing. Their utility is thus affected early on in the purchasing process. In contrast, sellers only receive the proceeds from the sale at the end of this process. There is hence a significant amount of time between the decision to sell and being able to actually spent the money you obtain by selling. This is captured by the delay in the optimization problem of a seller.

The last option of a home owner is to default on his mortgage. In this case there are five consequences. First, he immediately loses his house and hence has to rent in this period. Second, his mortgage balance is immediately set to zero. Third, he suffers from the stigma of defaulting which reduces his utility in the period of default. Fourth, he will be excluded from the housing market for a random number of periods. Lastly, if he had positive home equity in the house prior to default, he will receive the proceeds from the house sale next period if there is anything left after the mortgage has been repaid. However, since the sales price of a foreclosed home is typically lower than for a normal sale, the transaction costs will be higher in case of default than in case of selling...
The optimization problem of a defaulting household looks as follows:

\[
V_t^{\text{def}}(X_t, \bar{H}, M_t, \bar{Y}_t) = \max_{S_t, H_t} (1 + \lambda) u((1 - \eta)C_t, (1 - \eta)H_t) - \lambda T_t^{\text{house}}(X_t, \bar{H}, M_t, a, \bar{Y}_t) + \beta \left( (1 - \omega)\mathbb{E}\left[V_{t+1}^{\text{ex}}(X_{t+1}, \bar{Y}_{t+1})\right] + \omega \mathbb{E}\left[V_{t+1}^{\text{noh}}(X_{t+1}, \bar{Y}_{t+1})\right]\right)
\]

s.t. \quad C_t = X_t - P_t^R \cdot H_t - S_t \quad (42)
\]

where \( \eta \) is the stigma effect which reduces the utility agents receive from consumption in the period of default. Equation (42) states that the agent will reenter the housing market only with probability \( \omega \).\(^{11}\) With probability \( (1 - \omega) \), the agent will be excluded and hence does not have the option to buy a house:

\[
V_t^{\text{ex}}(X_t, \bar{Y}_t) = \max_{S_t, H_t} (1 + \lambda) u(C_t, H_t) - \lambda T_t^{\text{ex}}(X_t, \bar{Y}_t) + \beta \left( (1 - \omega)\mathbb{E}\left[V_{t+1}^{\text{ex}}(X_{t+1}, \bar{Y}_{t+1})\right] + \omega \mathbb{E}\left[V_{t+1}^{\text{noh}}(X_{t+1}, \bar{Y}_{t+1})\right]\right)
\]

s.t. \quad C_t = X_t - P_t^R \cdot H_t - S_t \quad (45)
\]

Overall, a home owner will choose the option which leads to the highest value:

\[
V_t^{\text{house}}(X_t, \bar{H}, M_t, a, \bar{Y}_t) = \max_{H_t} \left[ V_t^{\text{repay}}(X_t, \bar{H}, M_t, a, \bar{Y}_t), V_t^{\text{ref}}(X_t, \bar{H}, M_t, \bar{Y}_t), V_t^{\text{sell}}(X_t, \bar{H}, M_t, a, \bar{Y}_t), V_t^{\text{def}}(X_t, \bar{H}, M_t, \bar{Y}_t) \right] \quad (49)
\]

**Temptation of a Home Owner** As in the case of a renter it is important to identify the most tempting option \( T_t^{\text{house}}(X_t, \bar{H}, M_t, a, \bar{Y}_t) \) in the choice set of a home owner. There are 3 candidates for the most tempting option. First, it could be most tempting to default on the mortgage. In this case the home owner immediately loses his house and suffers from a stigma effect, but can use all cash-on-hand for consumption and renting a house:

\[
T_t^{\text{def}}(X_t, \bar{Y}_t) = \max_{H_t} u\left( (1 - \eta)(X_t - P_t^R \cdot \bar{H}_t), (1 - \eta)\bar{H}_t \right) \quad (50)
\]

\(^{11}\)In reality, bankruptcy flags are removed from the credit report after a fixed number of years. I choose to model the process of being able to reenter the housing market as stochastic for computational tractability. However, when calibrating the model the probability of reentering will be chosen so that the average number of years with a bankruptcy flag corresponds to U.S. regulations.
Second, it could be most tempting to keep the house, make the mortgage payment and pay maintenance costs, and spend all remaining cash-on-hand on current consumption:  

$$T_t^{\text{repay}}(X_t, H, M_t, a, Y_t) = u(X_t - \psi_M P_t^H H - Q(M_t, a, t), \bar{H})$$  \hspace{1cm} (51)$$

How tempting this second option is relative to the first is strongly affected by the size of the required mortgage payment relative to the size of the house. Default will be tempting if the mortgage payment is too large relative to the instantaneous utility the agent receives from his house. If the agent wants to use the house and mortgage as a commitment device, he needs to ensure that default is not tempting. This effectively leads to an upper bound for the size of the mortgage relative to the house size, i.e., for the LTV ratio.

However, there is a third candidate for the most tempting option: It can be most tempting to keep the house, extract as much home equity as possible by refinancing and spend all resulting cash-on-hand on current consumption:

$$T_t^{\text{ref}}(X_t, H, \bar{M}, Y_t) = \max_{\tilde{M}_t} u(\tilde{C}_t, \mu \bar{H})$$  \hspace{1cm} (52)$$

subject to

$$\tilde{C}_t = X_t - \psi_M P_t^H H + (1 - \delta_M) \tilde{M}_t - \bar{M}$$  \hspace{1cm} (53)$$

$$\tilde{M}_t \leq \phi_v \cdot P_t^H H$$  \hspace{1cm} (54)$$

$$\tilde{M}_t \leq \phi_y \cdot Y_t$$  \hspace{1cm} (55)$$

This option is more tempting the more home equity there is to extract, which reduces the commitment effect of houses and mortgages. The overall temptation that a home owner faces is given by the maximum of the three options:

$$T_t^{\text{house}}(X_t, H, M_t, a, Y_t) = \max \left[ T_t^{\text{def}}(X_t, Y_t), T_t^{\text{repay}}(X_t, H, M_t, a, Y_t), T_t^{\text{ref}}(X_t, H, \bar{M}, Y_t) \right]$$  \hspace{1cm} (56)$$

2 Self Control and Housing and Mortgage Choice

In this section I describe the effects of temptation and self control on the housing and mortgage choice. First, I describe the parameterization of the model. Second, I show that in the calibrated model self control has economically sizable effects on the housing and mortgage choice and that these effects are in line with the empirical correlations. Third, I analyze how an increase in the minimum down payment requirement or the restriction of the prepayment option affects the behavior and welfare of agents with different degrees of self control.

Table 1 contains all parameter values used in the benchmark model. They are annual values.

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12Note that in case of selling the highest possible current utility is the same as in case of repaying since the agent still owns the house in the current period.
Table 1: Parameter Values in Benchmark Model

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preferences</td>
<td></td>
<td></td>
</tr>
<tr>
<td>risk aversion</td>
<td>$\sigma$</td>
<td>2</td>
</tr>
<tr>
<td>discount rate</td>
<td>$\rho$</td>
<td>0.06</td>
</tr>
<tr>
<td>stigma effect</td>
<td>$\eta$</td>
<td>0.2</td>
</tr>
<tr>
<td>ownership benefit</td>
<td>$\mu$</td>
<td>1.0075</td>
</tr>
<tr>
<td>weight of housing services</td>
<td>$\theta$</td>
<td>0.20</td>
</tr>
<tr>
<td>degrees of self control</td>
<td>$\lambda$</td>
<td>${0, 0.04, 0.08, 0.12}$</td>
</tr>
<tr>
<td>shares of self control types</td>
<td></td>
<td>${0.25, 0.5, 0.2, 0.05}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HRS 2010</td>
</tr>
<tr>
<td>Market Environment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>risk free rate</td>
<td>$r_S$</td>
<td>0.018</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1-year Treasury Constant Maturity</td>
</tr>
<tr>
<td>mortgage rate</td>
<td>$r_m$</td>
<td>0.033</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30-year Convent. Mortgage rate</td>
</tr>
<tr>
<td>house price growth rate</td>
<td>$r_H$</td>
<td>0.016</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All trans. house price index (FHFA)</td>
</tr>
<tr>
<td>rental price - to - house price ratio</td>
<td>$\frac{P^R}{P^H}$</td>
<td>0.045</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Davis, Lehnert and Martin (2008)</td>
</tr>
<tr>
<td>maintenance cost of housing</td>
<td>$\psi_M$</td>
<td>0.021</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kaplan and Violante (2014)</td>
</tr>
<tr>
<td>transaction costs when buying</td>
<td>$\delta_B$</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hsieh and Moretti (2003)</td>
</tr>
<tr>
<td>transaction costs when selling</td>
<td>$\delta_S$</td>
<td>0.06</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hsieh and Moretti (2003)</td>
</tr>
<tr>
<td>transaction costs for mortgage</td>
<td>$\delta_M$</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Berndt, Hollifield and Sandas (2012)</td>
</tr>
<tr>
<td>transaction costs when defaulting</td>
<td>$\delta_D$</td>
<td>0.27</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Campbell, Giglio and Pathak (2011)</td>
</tr>
<tr>
<td>expected years of exclusion</td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>income process</td>
<td></td>
<td>Fair Credit Reporting Act</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cocco, Gomes and Maenhout (2005)</td>
</tr>
<tr>
<td>maximum LTV</td>
<td>$\phi_v$</td>
<td>0.965</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FHA requirement</td>
</tr>
<tr>
<td>maximum LTI</td>
<td>$f(\phi_y)$</td>
<td>0.43</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FHA requirement</td>
</tr>
</tbody>
</table>

which correspond to the model period of 1 year. The analysis starts at age 20 for agents without college degree and at age 23 for agents with college degree. All agents retire at age 65 and live until age 80.

**Market Environment** The risk free rate is set equal to the average 1-year Treasury Constant Maturity rate over the period 1972-2006, adjusted for inflation using the Consumer Price Index (CPI). I model 30-year fixed rate mortgages ($\tau^s = 30$) and set the mortgage rate equal the average real rate on 30-year conventional fixed rate mortgages in the same time period. For the house price growth I compute the mean growth rate in the All Transactions House Price Index for the United States in the same time period, adjusted for inflation. Davis, Lehnert and Martin (2008) find that the average rent-price-ratio is between 0.04 – 0.05 using data from the Decennial Census of Housing. I therefore set $P^R$ equal to 0.045.

For the transaction costs when buying or selling a house I refer to Hsieh and Moretti (2003).
who find that the commission charged by real estate agents is 6% of the sales price. I assume that these costs are fully paid by the seller and set $\delta_B = 0$ and $\delta_S = 0.06$. Campbell, Giglio and Pathak (2011) further study the discount that applies when a house is sold after foreclosure and find that the sales price is 27% lower on average than the price for a normal sale. I hence set $\delta_D = 0.27$.

For the transaction costs of taking out a mortgage I turn to two studies: Berndt, Hollifield and Sandas (2012) report the mean fee paid to the mortgage broker to be 3.1% of the principal amount for subprime mortgages during the period 1997 - 2006. Woodward and Hall (2012) find a similar number in their sample of FHA insured mortgages in 2001. I therefore set $\delta_M = 0.03$.

The LTV and LTI restrictions are crucial for the mortgage choices in the model. To set their benchmark values I turn to official regulations in the US. For home buyers to be eligible for FHA insurance, they have to at least invest 3.5% of own funds into the purchase (US Department of Housing and Urban Development, 2011). I use this value as the minimum down payment requirement, i.e., I set the maximum LTV ratio to $\phi_v = 0.965$. Furthermore, for home buyers to qualify for FHA insurance, the FHA requires a mortgage payment-to-income-ratio of at most 31% and the ratio of total obligations-to-income not to be higher than 43%. Since mortgage debt is the only debt in my model, I choose to set the maximum LTI constraint in accordance with the latter number. Lastly, if a house is foreclosed by law this event will remain on the credit report of the home owner for 7 years (Federal Trade Comission, 2011). I therefore set the probability of leaving the exclusion state such that on average the agent is excluded for 7 years.

**Preference Parameters** The only preference parameter which can be set exogenously is the weight of housing services in the utility function ($\theta$). Due to the functional form of the felicity function, I know that for a standard agent, the weight will be equal to the optimal expenditure share on housing. Piazzesi, Schneider and Tuzel (2007) estimate this expenditure share on data from the Consumer Expenditure Survey. I therefore set $\theta$ equal to their estimate of 0.2.

Heterogeneity in self control is at the core of the present paper. To calibrate the model I therefore have to determine both the population shares of self control types as well as the levels of $\lambda$ for each type. To determine appropriate group sizes, I turn to data from the Health and Retirement Study (HRS) which asked interviewees in its 2010 wave to assess their own problem of self control. Figure 1 shows the distribution of self control in the sample where 1 indicates “no problem of self control” and 5 indicates a “strong problem of self control”. While the measure in the HRS cannot speak to the level of $\lambda$, I use the distribution to construct population shares. Approximately 25% of individuals answer the questions in a way that suggests no problem of self control at all (< 2), around 50% of people answer in a way that indicates a small problem (≥ 2 and < 3), around 20% of individuals fall in the range ≥ 3 and < 4 which I allocate to a medium sized problem and the last 5% of people have measures ≥ 4 which I attribute to a large problem.

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13See appendix A for the exact survey questions and construction of the measure of self control.
Assuming that the first group does not have any problem of self control at all \((\lambda = 0)\) this leaves the levels of the remaining three types to be determined in the calibration.

To the best of my knowledge there is no established way of choosing the self control parameter \(\lambda\) or a consensus about plausible values. The values obtained in the present calibration are \(\lambda = 0.04, 0.08, 0.12\). There are two papers which structurally estimate the degree of self control: \(\hat{\lambda}\) obtains an estimate of 0.2 for the degree of self control based on an Euler Equation approach in the context of housing, while Bucciol (2012) estimates \(\lambda = 0.05\) in a model of liquid vs illiquid investments. The values obtained in this paper are hence well within their range. Moreover, to get a sense for the plausibility of the values I follow Krusell, Kuruscu and Smith (2009) who determine the consequences of temptation and self control by two hypothetical welfare considerations. For each value of \(\lambda\) I compute how much better off the agent would be if 1) he was relieved of his costs of self control but could not alter his choices and 2) he was relieved of his costs of self control and could also alter his choices. I express both hypothetical welfare increases in terms of consumption equivalent, i.e., the percentage increase in consumption and housing services in each period that would make a self control agent as well off as if he was in situation 1) or 2). I report both consumption equivalents in the results of the model to get a sense for the magnitude of the problem. This ensures that the chosen values are not too extreme to be of empirical relevance.

The remaining preference parameters are also determined through calibration: the risk aversion parameter \((\sigma)\), the discount rate \((\rho)\), the home ownership premium \((\mu)\), and the stigma effect \((\eta)\). The parameter values are calibrated so that the simulated median house value and median loan-to-value ratio for three different age groups \((\text{age} < 35, 35 \leq \text{age} < 50, 50 \leq \text{age} < 65)\) as well as the ownership rate are as close to their empirical counterparts as possible. The parameters obtained for risk aversion and for the discount rate are \(\sigma = 2\) and \(\rho = 0.06\), respectively. Both values are.
Table 2: Fit of the model

<table>
<thead>
<tr>
<th>Ownership</th>
<th>Median House Value (owners)</th>
<th>Median LTV (owners)</th>
<th>Ownership rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 35</td>
<td>90</td>
<td>0.76</td>
<td>0.66</td>
</tr>
<tr>
<td>35 - 50</td>
<td>106</td>
<td>0.56</td>
<td></td>
</tr>
<tr>
<td>50 - 65</td>
<td>104</td>
<td>0.24</td>
<td></td>
</tr>
<tr>
<td></td>
<td>92</td>
<td>0.73</td>
<td>0.64</td>
</tr>
<tr>
<td></td>
<td>104</td>
<td>0.64</td>
<td></td>
</tr>
<tr>
<td></td>
<td>111</td>
<td>0.33</td>
<td></td>
</tr>
</tbody>
</table>

Note: The table compares the targeted data moments and their model equivalents. Data moments have been constructed using data from the Survey of Consumer Finances (SCF), waves 1989-2010.

within the range commonly used in and estimated for life cycle models (see, e.g., Gourinchas and Parker, 2002). Moreover, the parameter value for the ownership benefit is $\mu = 1.0075$ and for the stigma effect $\eta = 0.20$.

**Model Fit** Table 2 shows how the benchmark model fits the targeted data moments. The model matches the median house values well. In addition to the targeted moments, figure 2(a) also compares the interquartile ranges between the model simulation and the data. Even though it was not targeted, the interquartile range turns out to be well approximated. This is particularly striking since the model does not exogenously impose any size restriction on the choice of house size in the households optimization problem. Table 2 and figure 2(b) further show the fit of the LTV ratio. The model matches the median LTV for the young age group very well while the median values for the middle and old age group are slightly higher than in the data. At the same time, the interquartile range for the oldest age group fits the interquartile range of empirical LTV ratios well. This is true even though this measure was not targeted and households can choose their LTV ratio freely below the maximum LTV ratio of 96.5%.

Lastly, it is important to mention that there are no defaults in equilibrium. This is because there is no house price risk so that people are never underwater with their mortgage. They can thus always sell their house before they would be forced to default. The only other occasion where defaults could occur is in the period immediately after mortgage origination before the household has started repayment. However, due to the costs of defaulting, in particular being excluded from purchasing another house in the near future and the stigma effect, such defaults do not occur either. Nevertheless, it is important to allow for the possibility to default in the presence of self control.

---

14 The data moments were computed from the Survey of Consumer Finances (SCF), waves 1989-2010. The weights in the SCF are designed to correct for non-response while in the Panel Study of Income Dynamics (PSID), on which the estimates of the income process are based, there is no such correction. Since non-response is more common for wealthier households, wealthy households are typically underrepresented in the PSID. In order to reconcile the income process from the PSID with wealth data from the SCF I hence follow Heathcote, Perri and Violante (2010) and adjust the SCF sample to match the wealth distribution in the PSID by dropping the wealthiest 1.47% of weighted observations (17.6% of unweighted observations) in each wave. See appendix B for details about the model solution and simulation.
preferences. The reason is that even if people never actually default, default is still in their choice set. This implies that the option to default will affect the temptation that people face even if they do not choose to give in to this temptation. Default will be particularly tempting if the burden of the mortgage payment is very high relative to the utility the agents obtain from their house. The option to default hence has a disciplining effect on how large a mortgage people optimally choose.

2.1 Results of the Benchmark Model

Figure 3 shows the policy functions for households with high school education at age 32 who enter the period as a renter. The graph shows how much these households save and which LTV ratio they choose as a function of cash-on-hand. Policy functions for the four different degrees of self control are plotted for comparison. Figure 3(a) shows the optimal level of overall savings, i.e., the sum of liquid savings and down payment in case the household purchases a house. Overall savings decrease with the problem of self control. Moreover, for each degree of self control, there is a particular level of cash-on-hand at which overall savings increase substantially. This is the threshold level of cash-on-hand above which the households purchase a house (and makes a down payment) and below which they remain renters. The figure shows that the stronger the problem of self control, the higher is this threshold for purchasing a house. Note also that even though savings are always lower for stronger problems of self control, this difference is particularly pronounced in the region between the thresholds, i.e., where agents with lower self control costs already purchase

---

15The model is solved in normalized terms, i.e., all level variables are normalized by permanent income. The graph hence depicts both overall savings and cash-on-hand in normalized terms.
Figure 3: Policy Functions in the Benchmark Model

Note: Policy Functions of high school graduate at age 32 who enters the period as a renter in the benchmark model. The figure plots (a) overall savings (= liquid savings + down payment if applicable) and (b) LTV as a function of cash-on-hand. Overall savings and cash-on-hand are normalized by permanent income.

Figure 3(b) depicts the optimal LTV ratio when buying a house. The optimal leverage increases with problems of self control. Making a down payment is more costly for households with costs of self control and they hence optimally postpone payment into the future.

While the policy functions are important for understanding the effects of self control, simulation results show the economic relevance of the effects. Table 3, panel A shows the quantitative effects of the problem of self control in the benchmark model. The first two columns refer to the welfare effect of self control problems described above, namely how much better off an agent would be if he was relieved of costs of self control but couldn’t change his behavior (CE1) and if he could also revise his behavior (CE2). For the large costs of self-control ($\lambda = 0.12$), for example, the welfare increase if the agent was relieved of his problems of self control would be equivalent to an increase in consumption and housing services of 1.99% in each period. If he was allowed to revise his choices his welfare would increase by an equivalent of 3.47%. While these welfare effects of self control are sizable, they are not unreasonably large.

Columns 3-7 give the effects of self control on the simulated behavior of the households relative to the behavior of the standard agent. These effects have been constructed by simulating the model separately for each degree of self control. First, I simulate 10,000 households assuming that all households are standard agents ($\lambda = 0$). I report the average behavior over the life cycle in the first row. Then I take the same households (same initial wealth, same income shocks) and simulate them again where the only difference is that now all households have either $\lambda = 0.04$, $\lambda = 0.08$, or...
Table 3: Effects of self control in simulation

<table>
<thead>
<tr>
<th>Welfare Costs of Self Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE1</td>
</tr>
<tr>
<td>(1)</td>
</tr>
<tr>
<td>Effects of Self Control on Behavior</td>
</tr>
<tr>
<td>net worth</td>
</tr>
<tr>
<td>(all)</td>
</tr>
<tr>
<td>(3)</td>
</tr>
<tr>
<td>Welfare Effect of Policy</td>
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<td>(8)</td>
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</table>

Panel A: Benchmark Model

<table>
<thead>
<tr>
<th>λ</th>
<th>CE1</th>
<th>CE2</th>
<th>net worth</th>
<th>owner-ship rate</th>
<th>home equity share</th>
<th>house value</th>
<th>LTV</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>67.04</td>
<td>0.75</td>
<td>0.81</td>
<td>122.67</td>
<td>0.46</td>
<td></td>
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</tr>
<tr>
<td>0.04</td>
<td>1.22</td>
<td>1.34</td>
<td>-0.23</td>
<td>-0.08</td>
<td>-0.00</td>
<td>-0.01</td>
<td>0.06</td>
</tr>
<tr>
<td>0.08</td>
<td>2.00</td>
<td>2.52</td>
<td>-0.45</td>
<td>-0.21</td>
<td>-0.02</td>
<td>-0.03</td>
<td>0.14</td>
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<tr>
<td>0.12</td>
<td>1.99</td>
<td>3.47</td>
<td>-0.69</td>
<td>-0.50</td>
<td>-0.05</td>
<td>-0.07</td>
<td>0.23</td>
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</table>

Panel B: Down Payment ≥ 20%

<table>
<thead>
<tr>
<th>λ</th>
<th>CE1</th>
<th>CE2</th>
<th>net worth</th>
<th>owner-ship rate</th>
<th>home equity share</th>
<th>house value</th>
<th>LTV</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>66.52</td>
<td>0.70</td>
<td>0.85</td>
<td>122.70</td>
<td>0.41</td>
<td>-0.06</td>
<td></td>
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<tr>
<td>0.04</td>
<td>1.13</td>
<td>1.22</td>
<td>-0.22</td>
<td>-0.05</td>
<td>0.00</td>
<td>-0.01</td>
<td>0.06</td>
</tr>
<tr>
<td>0.08</td>
<td>1.91</td>
<td>2.30</td>
<td>-0.41</td>
<td>-0.14</td>
<td>0.00</td>
<td>-0.03</td>
<td>0.13</td>
</tr>
<tr>
<td>0.12</td>
<td>2.15</td>
<td>3.23</td>
<td>-0.60</td>
<td>-0.31</td>
<td>-0.01</td>
<td>-0.05</td>
<td>0.21</td>
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</table>

Panel C: No Refinancing

<table>
<thead>
<tr>
<th>λ</th>
<th>CE1</th>
<th>CE2</th>
<th>net worth</th>
<th>owner-ship rate</th>
<th>home equity share</th>
<th>house value</th>
<th>LTV</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>64.46</td>
<td>0.68</td>
<td>0.71</td>
<td>122.32</td>
<td>0.49</td>
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<tr>
<td>0.04</td>
<td>0.99</td>
<td>1.09</td>
<td>-0.19</td>
<td>-0.08</td>
<td>0.07</td>
<td>-0.03</td>
<td>-0.03</td>
</tr>
<tr>
<td>0.08</td>
<td>1.67</td>
<td>2.04</td>
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<td>-0.16</td>
<td>0.12</td>
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<tr>
<td>0.12</td>
<td>2.00</td>
<td>2.84</td>
<td>-0.51</td>
<td>-0.29</td>
<td>0.14</td>
<td>-0.09</td>
<td>-0.06</td>
</tr>
</tbody>
</table>

Definitions: Welfare Costs of Self Control: CE1: How much better off would you be if you were relieved of your self control problem but were not allowed to change your choices; CE2: How much better off would you be if you were relieved of your self control problem and could change your choices; both CE1 and CE2 expressed in terms of each period’s percentage increase in consumption of nondurable goods and housing services; Effects of Self Control on Behavior: the values for λ = 0 give the average behavior over the working life for households without costs of self control, the values for λ > 0 give the mean difference in individual behavior if degree of self control is changed from λ = 0 (standard agent) to the respective degree of self control (in percent), all else equal; Welfare Effect of Policy: Welfare consequences of policies in terms of consumption equivalent, i.e., percentage change in consumption of nondurable goods and housing services in each period (without changing the costs of self control) that would make the agent as well off in the benchmark model as under the implemented policy.

λ = 0.12. Columns 3-7 show the mean individual percentage difference between these simulations and the one for standard agents.

Column 3 shows that the overall net worth decreases with the degree of the self control problem. For example, agents with low costs of self control (λ = 0.04) have on average 23% less net worth than standard agents. For households with large costs (λ = 0.12) this effect increases to a reduction in net worth of almost 70%. The differences in optimal savings in the policy functions hence translate into substantial differences in average net worth.
Table 4: Empirical Conditional Correlations

<table>
<thead>
<tr>
<th></th>
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<th>(2)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>log(net worth)</td>
<td>owner</td>
<td>log(house value)</td>
<td>LTV</td>
<td>problem of self control</td>
</tr>
<tr>
<td>smoker</td>
<td>−0.520**</td>
<td>−0.076***</td>
<td>−0.235***</td>
<td>−0.004</td>
<td>0.102**</td>
</tr>
<tr>
<td></td>
<td>(0.238)</td>
<td>(0.016)</td>
<td>(0.043)</td>
<td>(0.015)</td>
<td>(0.041)</td>
</tr>
<tr>
<td>obese</td>
<td>−0.848***</td>
<td>−0.024*</td>
<td>−0.139***</td>
<td>0.070***</td>
<td>0.112**</td>
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<tr>
<td></td>
<td>(0.224)</td>
<td>(0.014)</td>
<td>(0.035)</td>
<td>(0.013)</td>
<td>(0.043)</td>
</tr>
</tbody>
</table>

Data Set          | PSID | PSID | PSID | PSID | HRS |
Observations       | 3507 | 3507 | 2602 | 2602 | 1229 |
R²                | 0.210 | 0.310 | 0.280 | 0.372 | 0.077 |

* p < 0.1, ** p < 0.05, *** p < 0.01. Standard errors in parentheses.

Source: Columns 1-4: Panel Study of Income Dynamics (PSID); column 5: Health and Retirement Study (HRS); and own calculations.

Note: Conditional correlations of financial portfolio variables and the self control measure with smoking and being obese, obtained by OLS with additional control variables: Columns 1-4 (PSID): quadratic term in age, marital status, race, education, family size, health status and log(income); Column 5 (HRS): quadratic term in age, gender, marital status, race, education, retirement status and log(income).

Next, in column 4 the ownership rate decreases with the problem of self control. The average home ownership rate over all age groups decreases by 8% for low costs of self control and by 50% for large costs. These quantitatively large effects are a combination of the higher threshold for purchase and lower savings which make any threshold harder to reach. For some households this means that they never become home owners, while others become home owners at a later age.

Furthermore, column 5 shows that home owners with costs of self control have up to 5% less home equity relative to their overall net worth. The reason is that home equity is not very illiquid in this setting since it can be immediately accessed, albeit subject to transaction costs. Saving in home equity is hence hardly less costly in terms of self control than saving in liquid assets so that the anticipation effect is only very small. The impatience effect, however, leads to higher optimal LTV ratios and hence to lower home equity.

Columns 6 and 7 refer to the effects of self control on the housing and mortgage portfolio. House values are on average between 1% and 7% lower for agents with costs of self control than for standard agents. Furthermore, agents with problems of self control have between 6% - 23% higher LTV ratios. This is both driven by the fact that the optimal LTV ratio is higher for a given level of wealth and by the fact that agents with problems of self control only reach their threshold for purchasing a house later in life. This latter effect reinforces the first one since the LTV ratio is highest right after a mortgage is taken out.

How do these results compare to financial portfolios in micro data? Table 4 shows conditional correlations of overall net worth, home ownership, house value and LTV ratio with indicators for...
being a smoker or being obese in the Panel Study of Income Dynamics (PSID).\textsuperscript{16} These correlations do not constitute a test of the model. Nevertheless, it is reassuring that the empirical correlations of the financial portfolio variables with smoking and being obese are qualitatively in line with the predictions of the model. While smokers and the obese are likely to differ along many dimensions from other households (not all of which can be controlled for), column 5 shows that they are more likely to report a stronger problem of self control in the HRS module discussed earlier. The correlations in micro data are hence consistent with the causal effects predicted by the benchmark model.

2.2 Increase in Minimum Down Payment Restriction

The first policy experiment is to increase the minimum down payment restriction from its benchmark value of 3.5\% to 20\%. For a standard agent this has only one consequence: it reduces his choice set. A standard agent can hence never be better off due to this restriction. On the contrary, for agents who suffer from costs of self control this is not the only effect. Restricting the choice set also reduces the temptation they face. With a very low minimum down payment requirement they could afford to buy a large house with a small down payment which is tempting. Resisting this temptation is costly. If the minimum down payment is increased, the temptation that they face is reduced in each period that they consider buying a house or want to up- or downsize. Moreover, since the LTV restriction also directly affects the share of home equity that can be extracted by refinancing, increasing the minimum down payment requirement also reduces the temptation to extract home equity. This strengthens the commitment effect of the house. Agents with problems of self control hence have both positive and negative welfare consequences of a minimum down payment restriction. Ex ante it is not clear if the agents will be better or worse off. I will now first show how the policy changes the effects of self control on the behavior. Afterwards, I will discuss the welfare consequences of the policy.

Figure 4 shows the policy functions for the same type of agent as we analyzed in the benchmark model. The first observation is that the difference in thresholds for purchasing a house is smaller. This is both because standard agents now have a higher threshold (they are required to make higher down payments) and because agents with high costs of self control have lower thresholds. The latter effect is due to the increased commitment effect of buying a house. 20\% of the house value can now be saved without incurring any costs of self control. Due to the anticipation effect this makes purchasing a house more attractive for agents with problems of self control. Moreover, since most of the differences in overall savings occur in the region where agents with lower costs of self control already buy a house while agents with higher costs keep renting, the fact that the purchasing thresholds are now closer to each other translates into smaller differences in overall savings.

\textsuperscript{16}For details about this empirical analysis see appendix C.
Figure 4: Policy Functions with Increased Down Payment

Looking at the optimal choice of LTV ratio, the first thing to note is that there are hardly any changes for standard agents compared to the case with a low down payment requirement. Their threshold for purchasing a house is higher, but conditional on purchase their LTV choice remains virtually unchanged. On the other hand, this is not the case for agents with problems of self control. The reason is that choosing a higher LTV implies that there is less home equity in the house above the minimum required level. Hence, the amount that agents will be able to extract by refinancing in the following years is lower which reduces the temptation that agents will face. This effect is stronger the stronger the problem of self control so that the optimal LTV is increasing in costs of self control.

Table 3, Panel B shows the effects of self control on the simulated behavior under the policy of 20% down payment requirement. Relative to the standard agent, agents with problems of self control on average still accumulate less net worth, but the effects are smaller than with the lower down payment requirement. The reason is that more people with problems of self control now become home owners and home owners can save 20% of their house value without costs of self control. This makes saving easier. The same logic is also reflected in the effects of self control on the home equity share. Since a substantial share of home equity is now illiquid and hence serves as commitment, the anticipation effect counteracts the impatience effect so that the net effect on the home equity share is negligible.

Columns 6 and 7 document that the effects of self control on the housing and leverage position are of comparable magnitude as in the benchmark simulation. This is despite the higher optimal
LTV ratios we saw in the policy function. The two observations can be reconciled by the fact that now the purchasing thresholds for agents with and without problems of self control are closer together. This implies that while standard agents still purchase their houses at younger ages, the age difference is now smaller. And since LTV ratios fall with time since mortgage origination, this reduces the average effect of self control on the LTV ratio.

Turning to the welfare consequences of the policy, the results are shown in column 8. The welfare effects are expressed in consumption equivalent terms, i.e., the percentage increase in consumption and housing services that would make agents in the benchmark scenario as well off as agents under the policy. The first thing we note is that the higher down payment requirement is welfare decreasing for standard agents. This is to be expected since for them the only effect of the policy is a reduction in their choice set. Agents with problems of self control, however, are better off with the higher down payment requirement by an equivalent of consumption increase of up to 0.18%. This implies that the reduction in temptation outweighs the downside of having to pay more of the purchase price upfront.\textsuperscript{17}

Figure 5(a) breaks down the welfare effect of the increase in minimum down payment against the level of assets agents hold at the beginning of their working life. There is heterogeneity in

\textsuperscript{17}This welfare gain is naturally influenced by the flexibility of the choice set, where households have several margins they can adjust in reaction to the policy change. For an analysis with less flexibility in reactions and, in fact, qualitatively different welfare results, see Ghent (2015).
the welfare consequences between different asset levels. For the standard agent the policy is more welfare decreasing for lower levels of assets. The reason is that it is now harder for the agents to buy a house and they have to postpone its purchase. For richer standard agents, however, this effect is smaller since they can afford the down payment under either down payment requirement. On the other hand, agents with problems of self control are better off with the increased down payment requirement at all asset levels. Increasing the minimum down payment requirement reduces the temptation that households face anytime they think about buying a house. For low asset levels this is the main source of benefit early in their life. Once they buy a house they benefit from the increased commitment effect of the house. This is particularly beneficial to wealthier households who benefit earlier from the commitment.

While the focus of this section has been on an increase of the down payment requirement from 3.5% to 20%, figure 5(b) computes the consumption equivalent for several down payment requirements, varying from 0.005% to 32%. Households without costs of self control are best off if the down payment requirement is as small as possible, even if the gains in welfare compared to the benchmark of 3.5% are small (up to 0.02%). At the same time, people with problems of self control are increasingly worse off if the down payment requirement is reduced. Moreover, the welfare loss of agents with costs of self control is an order of magnitude larger than the benefits of standard agents for these low levels of down payment requirements (up to -0.43%). On the other hand, higher requirements are welfare increasing for agents with problems of self control while they hurt standard agents. Note, however, that the size of welfare gains and losses are now of the same order of magnitude. The graph also depicts the average welfare consequences. Using the group sizes of self control types obtained from the HRS data and weighing everyone equally, the average welfare is highest for a down payment requirement of 23%. Furthermore, the average welfare effects are similar for requirements in the range of 15% to 25%, even though the inequality in effects becomes larger as the requirement increases.

The above welfare benefits of increasing down payment requirements have been obtained in a partial equilibrium setup that allows for a realistically flexible choice set for households. While a full general equilibrium analysis would be very interesting, it is beyond the scope of this paper. However, I conjecture that the magnitude of the partial equilibrium benefits is a lower bound for the full general equilibrium effect. Favilukis, Ludvigson and Van Nieuwerburgh (forthcoming) show that a relaxation of collateral requirements generates a boom in house prices. With higher down payment requirements - which is a tightening of collateral requirements - we can hence expect house prices to fall. If house prices are lower the amount of assets required for a down payment will be lower. This in turn will facilitate the purchase of a house without increasing the mortgage burden. The downside of increased down payment requirements, i.e., that fewer people can become home owners, will thus be ameliorated in general equilibrium. Moreover, lower LTV ratios can be expected to lead to lower mortgage rates. Financing the purchase of a house therefore becomes less expensive. This is another benefit of higher down payment requirements which has not been
internalized in the above partial equilibrium analysis.

To summarize, a down payment requirement of 20% increases the likelihood for people with problems of self control to become home owners since the house is now a stronger commitment device. However, the welfare consequences of this policy depend on the degree of the problem of self control of agents. While standard agents are worse off if the down payment requirement is increased, agents with problems of self control benefit from the restriction. These benefits are stronger for wealthier households. Moreover, the average welfare is highest for a requirement of 23%.

2.3 Possibility to Refinance

The second policy experiment is to remove the possibility to prepay and hence to refinance mortgages. In this case home equity becomes truly illiquid since it can only be accessed by selling the house which takes time. For standard agents the effect of this change is again unambiguous. Their choice set is reduced so that they can never be better off. As before, for agents with a problem of self control this is not the only effect. While they also suffer from losing the possibility to easily adjust their leverage, they at the same time benefit from the strengthened commitment effect of both the house and the mortgage. They can save in form of housing equity without ever being tempted to spend this part of net worth. Moreover, as long as default is not tempting, they can also make mortgage payments without exercising self control. Ex ante it is not clear which of these opposing welfare effects will dominate. As in the previous policy experiment I will first discuss how this policy changes the behavior of agents depending on their degree of self control. Afterwards, I will discuss the welfare consequences of the policy.

Figure 6 shows the policy functions in the same situation as in the previous scenarios. Looking at optimal overall savings, we see that for higher levels of cash-on-hand, where all agents purchase a house, the differences in overall savings are virtually non-existent. The reason is that agents with problems of self control can use their house and mortgage as a commitment device and thus eliminate almost all the temptation to spend their savings. Moreover, in order to use the mortgage as a commitment device they need to ensure that default will not be tempting. This reduces the size of optimal mortgage payment for a given house size and hence the optimal LTV ratio. Thus, in the case where the mortgage can be used as a commitment device, the LTV ratio is decreasing in the problem of self control, while it was increasing in the cases where prepayment was immediately possible.

Table 3, panel C shows the economic relevance of these effects in the simulation. First, column 4 shows that the ownership rate for standard agents is lower in this scenario. In the presence of uninsurable income risk, the investment in a house is less attractive if home equity becomes less accessible. Moreover, agents with problems of self control are still up to 29% less likely to be a home owner. This implies that even though the house is now a stronger commitment device,
accumulating enough savings to purchase a house remains very difficult for agents with problems of self control. This remaining difference in the ownership rate also translates into only a small improvement in overall savings for agents with problems of self control. They still have up to 51% lower net worth over the life cycle. For those households who become home owners, however, their portfolio choice reflects the commitment nature of the house. The share of home equity in their overall savings is now increasing in problems of self control, while both the house size and the LTV ratio is decreasing.

Turning to the welfare effect of restricting the option to extract home equity, column 8 documents that the effects depend on the degree of self control. Unsurprisingly, standard agents are worse off under the policy since the only effect for them is the loss of flexibility. However, if the problem of self control is sufficiently strong, the gain of the commitment device outweighs the loss of flexibility. People with strong problems of self control are better off by an equivalent of 0.29% life-time consumption. Figure 7 depicts these welfare effects for different levels of initial assets at the beginning of working life. The effects become more pronounced for higher levels of wealth. This is because wealthier households are more likely to become home owners and hence to get access to the commitment device. Moreover, wealthier households want to save more so that having a commitment device becomes more important.

As in the case of changing the minimum down payment restriction, I conjecture that the welfare effects of restricting the option to prepay obtained in this partial equilibrium setup are a lower bound for the full general equilibrium effects. The reason is that limiting the option to prepay
reduces the interest rate risk that banks face. Mortgage rates incorporate this risk and can hence be expected to fall if the prepayment risk is reduced. This will make financing the purchase of a house less expensive. Moreover, as seen in the simulations above, the overall demand for housing falls if prepayment is restricted. Even though this decrease in demand will be mitigated by the fall in mortgage rates, I do not expect mortgage rates to fall enough to fully compensate risk-averse households for the loss in insurance. House prices can hence be expected to fall which again will make houses more affordable. Both of these effects have not been included in the present welfare analysis and would increase the utility of households.

While the welfare consequences are diverse between the different self control types, we can also compute the overall welfare effect of removing the prepayment option in partial equilibrium. Using the group sizes from the Health and Retirement study and weighing everyone equally leads to an aggregate decrease in welfare of an equivalent of 0.07% life-time consumption. Note, however, that if the agents could choose among a menu of mortgage contracts with and without prepayment restrictions, agents with problems of self control would optimally select into the more restrictive product. In this case people with no or low costs of self control would not be harmed while people with stronger problems of self control would benefit from being able to choose a more restrictive option. Currently, prepayment penalties are very limited in the U.S. due to restrictive mortgage regulations (see Consumer Financial Protection Bureau (2013)). However, this is not
the case everywhere. In fact, most other developed countries have mortgages with no or only limited prepayment options (see Green and Wachter (2005)). The results in this section suggest that universal rules - either for or against prepayment penalties - are not optimal. Instead, giving people the choice between mortgages with and without prepayment penalties can increase welfare.

3 Conclusion

In this paper I show that self control has sizable effects on the housing and mortgage choice and that welfare consequences of financial regulation depend on the degree of self control, with people with lower self control benefiting from less flexible mortgage contracts.

The reason that self control is an interesting topic to study in the context of housing and mortgages is that they can serve as a commitment device. The analyses in this paper reveal, however, that houses are only a weak commitment device. In all policy scenarios, the main effect of self control on the housing choice was that people are much less likely to be home owners since they cannot accumulate enough assets to afford the down payment. This turned out to be true even in the case where home equity can only be accessed through selling a house, i.e in the case where the commitment effect of the house is the strongest. I thus conclude that people who would benefit the most from the house as a commitment device are exactly the people who are the least likely to own one.

Moreover, making it easier for people to buy a house by reducing the down payment requirement in fact further decreases the welfare of people with problems of self control. The reason is that with very low equity requirements, people can buy very large houses. Even though people are aware that they cannot afford these houses in the long run, they still have to resist the temptation of the very high utility that these large houses would give them immediately. The analyses in this paper show that this increase in temptation outweighs the benefits of making it easier to become home owners.

The problem of houses as commitment device is hence the dual nature of houses: On the one hand, they are an illiquid investment and as such serve as commitment device. On the other hand, people also receive utility from their houses. This implies that increasing access to the commitment device increases temptation at the same time. Based on this result I thus conclude that houses are not an optimal commitment device. However, illiquid savings devices which are aimed at accumulating equity for a down payment, in combination with substantial down payment requirements, could improve the effectiveness of houses as commitment devices. Moreover, other commitment devices which are not linked to current utility, such as, e.g., compulsory contributions to retirement accounts, can be expected to be more effective in helping people save.

For most households, buying a house and taking out a mortgage is the most important financial decision that they have to make in their life-time. The recent history has shown that the macroeconomic consequences of failures in the housing and mortgage market can be huge. Regulation
of these markets hence plays a crucial role both for the welfare of the individual household and for the economy as a whole. I believe that it is important to understand to what extent people are influenced by behavioral biases when they make housing and mortgage decisions since this will affect the optimal regulation policies. The present paper is a step in this direction.
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A Measure of Self Control in the Health and Retirement Study (HRS)

The University of Michigan Health and Retirement Study (HRS) is a longitudinal panel study that surveys a sample representative of the US population over the age of 50. It has been running since 1992 and reinterviews the subjects every two years. Over the years, new cohorts are added to keep the sample representative. In each wave, the interview consists of the main interview as well as a set of experimental modules which vary between the waves. While all individuals answer the main questionnaire, each interviewee only answers a subset of these test modules. Wave 2010 contains a test module “Personality” that asks the subjects to assess how much self control they have. The “Personality” module was answered by 1254 individuals.

The module asked interviewees to assess their own self-control in various contexts: food, exercise, interpersonal self control, financial self control and general self control. For the purpose of this paper the questions regarding financial self control are the most relevant. People were asked to answer on a scale from 1 to 5 how often they do certain things (1: “Very often”, 5: “Never”):

- Spend too much money?
- Buy things on impulse?
- Buy things you hadn't planned to buy?
- Buy things you don't really need?

I follow the designer of the module (see Tsukayama, Duckworth and Kim, 2012), and construct averages of the answers as measures for financial self control. I reverse the ordering so that a higher level of the measure corresponds to a stronger problem of self control.

The distribution of this measure is shown in figure 1 and is used to determine the group sizes of the different self control types. Furthermore, when comparing empirical correlations with the predictions of the benchmark model, the measure of self control is used as dependent variable in an OLS regression on indicators of being a smoker and being obese (see table 4, column 5).
B  Numerical Solution and Simulation

The model solution is obtained by backwards induction over the value functions, normalized by permanent income (see Carroll, 1997). All value functions except when buying a house are solved by discretizing the state space and the control variables. The value function of buying is solved using the simplex method. Expectations are approximated by Gauss-Hermite-Quadrature and I use linear interpolation to evaluate between grid points.

To approximate the distribution of education in the population I simulate 15% of the agents with the income process for households without high school, 51% with high school, and 34% with college degree.\textsuperscript{18} The initial distribution of normalized cash-on-hand is approximated by a lognormal distribution for each education group with mean and variance parameters fitted to the net worth-to-income ratio of households with heads aged $\leq 22$ ($23 \leq \text{age} \leq 25$ for college graduates) in the SCF, waves 1989-2004. I adjust the SCF sample to match the wealth distribution of the PSID by dropping the wealthiest 1.47% of weighted observations (17.6% of unweighted observations), see Heathcote, Perri and Violante (2010). Moreover, in order to exclude outliers generated by low income I drop observations with total household non-capital income below the poverty guideline for a family of that size in the given year. Since the number of households with a head of respective education and age is very low in each wave I combine all waves when fitting the distribution.\textsuperscript{19} To obtain the simulated moments which I match to the data moments I combine education groups with self control types, assuming independence between education group and self control type. Population shares of self control types were determined based on the measure of self control in the HRS sample as described in the main text. The shares employed are equal to 25%, 50%, 20% and 5% (increasing in degree of the problem of self control).

\textsuperscript{18}The percentages were obtained from Survey of Consumer Finances (SCF), waves 1989-2004.

\textsuperscript{19}Fitting a distribution for each wave individually gives a range of parameter values which is similar to the estimates obtained from the pooled sample.
Table 4 shows conditional correlations of financial variables with indicators for smoking and for being obese. Columns 1-4 have been constructed using data from the Panel Study of Income Dynamics (PSID). The PSID is a longitudinal household survey directed by the University of Michigan that has been following families and their descendants since 1968. Until 1997 families were reinterviewed each year and since then are interviewed biannually. At the time of this change more information has been added to the survey, in particular data about the families’ assets and wealth as well as health information. To use as recent information as possible while not being affected by the huge disruptions of the housing market I focus on wave 2005.20

As is common in the literature, I exclude observations which belong to the Survey of Economic Opportunity (SEO) sample, which was added to the representative sample to increase the information on low income households. Furthermore, I restrict the sample to families with a male head. The reason is the special way in which PSID determines the head of a household. As soon as there is a male adult living in the household he is head irrespective of his income or position in the household. Hence, there are not many families with female heads and this group is a very special subsample. Since there are not enough observations for a separate analysis I choose to exclude this group. Moreover, I exclude observations missing information in the variables of interest. The final sample consists of 3507 observations, of which 2602 are home owners.

Respondents in the survey are directly asked for the value of their house as well as the principal outstanding on the first and second mortgage on that property. I use the sum of the two mortgage principles as the measure for mortgage balance. The loan-to-value ratio (LTV) is computed as mortgage balance divided by house value. The data for total net worth are obtained from the supplemental wealth files. Income is defined as the total household income, i.e., the sum of labor income (including from business or farm), pensions (including annuities and veterans’ pension) and transfer income (including alimony), for both head and spouse. Obesity is defined according to the classification of the Body-Mass-Index (BMI).21 A household is labeled as smoker or obese if at least one of the partners (head or spouse) falls into the respective category. Table 5 shows the descriptive statistics for the dependent, explanatory and control variables in the PSID sample.

Several robustness checks have been conducted. First, the results are robust to changing the wave of analysis. Second, the results hold for alternative definitions of the behavioral variables: (a) BMI as continuous variable and (b) “number of partners who are smokers (obese)” as opposed to “at least one partner is a smoker (obese)”. In fact, the magnitudes of the correlations increase with the number of partners showing the behavior. Third, I included additional controls such as the economic situation of the parents and state dummies to control for regional effects. Lastly, I

20Robustness checks have been conducted to ensure that the results are robust to the choice of wave.

21The exact formula is BMI = mass(kg) / height(m)^2. According to the U.S. Department of Health & Human Services, a person is classified as obese for BMI ≥ 30.
Table 5: Descriptive Statistics in PSID sample

<table>
<thead>
<tr>
<th></th>
<th>all obs</th>
<th>home owners</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>smoker</td>
<td>28.69</td>
<td>24.02</td>
</tr>
<tr>
<td>obese</td>
<td>32.59</td>
<td>32.78</td>
</tr>
<tr>
<td>married</td>
<td>81.04</td>
<td>89.43</td>
</tr>
<tr>
<td>black</td>
<td>5.53</td>
<td>3.80</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>high school</td>
<td>60.76</td>
<td>58.72</td>
</tr>
<tr>
<td>college</td>
<td>30.54</td>
<td>33.94</td>
</tr>
<tr>
<td>Self-assessed Health</td>
<td></td>
<td></td>
</tr>
<tr>
<td>excellent</td>
<td>16.68</td>
<td>15.91</td>
</tr>
<tr>
<td>very good</td>
<td>31.22</td>
<td>31.09</td>
</tr>
<tr>
<td>good</td>
<td>34.59</td>
<td>35.63</td>
</tr>
<tr>
<td>fair</td>
<td>12.92</td>
<td>12.87</td>
</tr>
<tr>
<td>poor</td>
<td>4.59</td>
<td>4.50</td>
</tr>
<tr>
<td>mean</td>
<td>45.42</td>
<td>48.54</td>
</tr>
<tr>
<td>std.dev.</td>
<td>15.57</td>
<td>14.91</td>
</tr>
<tr>
<td>income</td>
<td>69.17</td>
<td>79.28</td>
</tr>
<tr>
<td>std.dev.</td>
<td>98.20</td>
<td>110.55</td>
</tr>
<tr>
<td>net worth</td>
<td>314.09</td>
<td>406.13</td>
</tr>
<tr>
<td>std.dev.</td>
<td>1147.68</td>
<td>1310.94</td>
</tr>
<tr>
<td>ownership rate</td>
<td>74.19</td>
<td></td>
</tr>
<tr>
<td>house value</td>
<td></td>
<td>219.29</td>
</tr>
<tr>
<td>LTV</td>
<td>44.48</td>
<td>35.59</td>
</tr>
<tr>
<td>Observations</td>
<td>3507</td>
<td>2602</td>
</tr>
</tbody>
</table>

Source: Panel Study of Income Dynamics (PSID), wave 2005, and own calculations
Note: Income, net worth and house value are expressed in Tsd. US Dollars.

controlled for the average income over the last 6 years instead of current income. The results are robust to all these changes.

The results shown in table 4 column 5 are based on data from the HRS test module described in appendix A. The descriptive statistics for the control variables included in the regression are shown in table 6. Note that since the HRS sample is much older than the PSID sample (the HRS sample is meant to be representative of people close to or already in retirement), the indicator for smoking has been redefined to reflect this. For the analysis based on HRS data it is set to indicate whether a person has ever smoked or not.
Table 6: Descriptive Statistics in HRS sample

<table>
<thead>
<tr>
<th>%</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>has smoked / smokes</td>
<td>55.61</td>
</tr>
<tr>
<td>obese</td>
<td>30.83</td>
</tr>
<tr>
<td>male</td>
<td>36.40</td>
</tr>
<tr>
<td>married</td>
<td>60.21</td>
</tr>
<tr>
<td>high school</td>
<td>54.48</td>
</tr>
<tr>
<td>college</td>
<td>23.33</td>
</tr>
<tr>
<td>black</td>
<td>14.37</td>
</tr>
<tr>
<td>hispanic</td>
<td>8.31</td>
</tr>
<tr>
<td>retired</td>
<td>33.90</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>mean</th>
<th>std.dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>age</td>
<td>69.76</td>
</tr>
<tr>
<td>income</td>
<td>61.96</td>
</tr>
</tbody>
</table>

Observations 1239

Source: Health and Retirement Study (HRS), wave 2010, and own calculations

Note: Income is expressed in Tsd. US Dollars.