Housing, Mortgages, and Self Control*

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Abstract

Using a quantitative theoretical framework this paper analyzes how problems of self control influence housing and mortgage decisions. The results show that people with stronger problems of self control are less likely to become home owners, even though houses serve as commitment for saving. The paper then investigates the welfare effects of regulating mortgage products if people differ in their degree of self control. Higher down payment requirements and restrictions on prepayment turn out to be beneficial to people with sufficiently strong problems of self control, even though these policies further restrict access to the commitment device. *(JEL: D91,E21)*

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

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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 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.

The paper shows 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 starts by documenting in a correlation study that signs of poor self control are correlated with housing and mortgage outcomes. In the main part of the paper I formalize this notion in a quantitative life-cycle model with housing and mortgages where I explicitly model households to have problems of self control. The model is calibrated to the US economy allowing for heterogeneity in the degree of self control. I then use the model 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 diffucult.

In the correlation study, based on data from the Health and Retirement Study, I find that smoking and being obese is correlated with a stronger self-assessed problem of self control. At the same time, in data from the Panel Study of Income Dynamics I find that smoking and being obese is correlated with a lower likelihood of owning a house, lower house values and higher loan-to-value ratios. After controlling for income, health and other demographic variables these effects are large, comparable in size with the effects of only having a high school degree instead of a college degree. These correlations may explain policy makers' concern about irrationality in the context of housing and mortgage decisions. Though they don't constitute causal evidence, they are qualitatively in line with the effects of self control I later find in the theoretical model.

To formalize the effects of self control on the housing and mortgage choice this paper builds a structural life-cycle model with housing and mortgages. 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. 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. All these results are qualitatively consistent with the correlations found in the data.

These effects of self control on the behavior 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. This area has been the subject of great interest since the crisis in the housing and mortgage market. Studies which focus on life-cycle considerations include Campbell and Cocco (forthcoming), Chambers, Garriga and Schlagenhauf (2009), and Attanasio et al. (2012).[1] My model extends the housing and mortgage literature by analyzing how self control affects these choices. In two recent papers, Ghent (2015) and Kovacs (2015) also consider a model of housing with agents who have self control problems. Ghent (2015) compares equilibria of economies in which all agents have standard preferences with those in which agents discount the future quasi-hyperbolically (Laibson, 1997). Kovacs (2015) focuses on estimating the average degree of self control on micro data. The current paper has a different goal: It starts from evidence on heterogeneity of preferences in household survey data. It then emphasizes the differential welfare effect of regulation in the mortgage market on agents with and without self control problems. In addition, in contrast to the earlier literature, this paper allows for continuous choices of both house size and mortgage size, as well as for the margin of renting vs. owning, two features that are important for the

[1]There is also an important stream of literature emphasizing the macroeconomic effects of the housing and mortgage market. Studies in this area include, for example, Barlevy and Fisher (2011), Chatterjee and Eyigungor (2015), Chen, Michaux and Roussanov (2013), Corbae and Quintin (2015) and Iacoviello and Pavan (2013).

quantitative results.

The second stream of literature that this paper directly relates to is the analysis of self control in other household decisions. Temptation and self control were found to play a role in various contexts, for example in the choice of gym contracts (DellaVigna and Malmendier, 2006), for credit card debt (Meier and Sprenger, 2010; Kuchler, 2013) and in the workplace (Kaur, Kremer and Mullainathan, forthcoming).[2] Moreover, Laibson, Repetto and Tobacman (2007) and Nakajima (2015) study effects of self control on credit card debt in a life-cycle model, 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. Finally, Ameriks et al. (2007) find survey evidence that problems of self control are correlated with wealth accumulation.

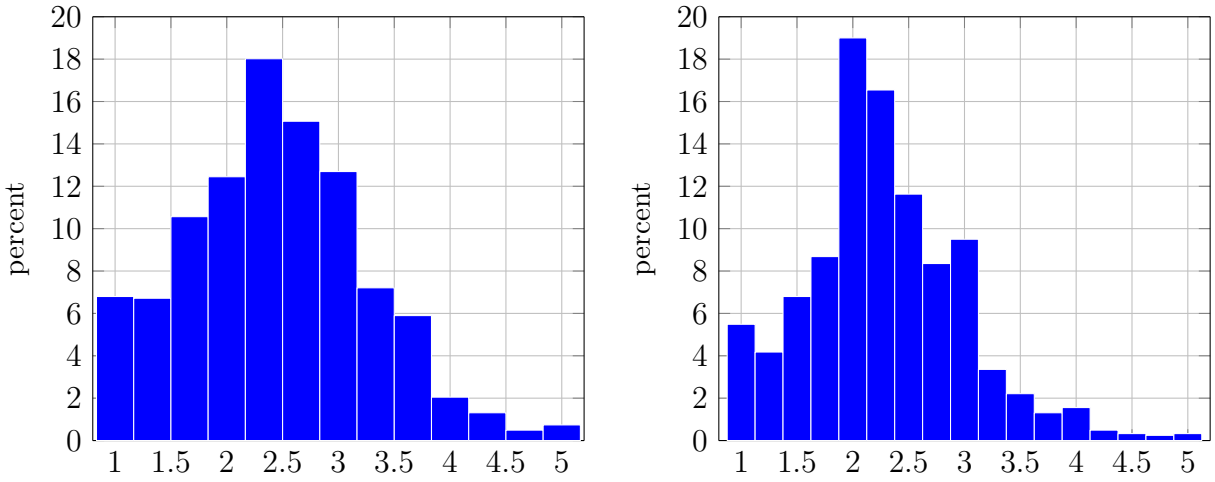
The remainder of this paper is organized as follows. Section 2 documents that showing signs of poor self control empirically is correlated with housing and mortgage portfolios. Section 3 describes the structural model which is used to analyze how self control affects the housing and mortgage choice. Section 4 shows the results of the calibrated model and analyzes how two policies of financial regulation affect the choices and welfare of agents with different degrees of self control. Section 5 concludes.

1 Signs of Self Control in the data

This section shows that behavioral patterns which can be thought of as signs of poor self control are correlated with a household's financial portfolio, in particular its housing and mortgage positions. The Health and Retirement Study (HRS) contains a test module in its 2010 wave that asks about a person's self control. This gives an explicit measure of self control in the cross-section. However, housing and mortgage choices are typically made in the first part of working life while the sample in the HRS is representative for the population close

[2]DellaVigna (2009) gives an overview over field experiments concerning behavioral aspects in household decisions.

Figure 1: Distribution of Self Control Measures in HRS



(a) problem of self control (general)

(b) problem of self control (financial)

Source: Health and Retirement Study (HRS), wave 2010, module 5 "Personality", and own caluculations

to or already in retirement. It is therefore not possible to directly analyze the relationship between self control and housing and mortgage choice in this data set. To address this, I link the degree of self control to observable behavior which is typically associated with lack of self control. These behavioral indicators are in turn present in the Panel Study of Income Dynamics (PSID) which provides data on the housing and mortgage positions of households over the whole life cycle. I use PSID data to show that there is unexplained variation in the housing and mortgage positions that is systematically correlated with behavior that is in turn correlated with poor self control. Note that at no point in this empirical analysis do I identify causal effects. Instead, the findings in this section motivate the structural analysis in the rest of paper where I build a life-cycle model and explicitly model the problem of self control and its effects on housing and mortgage choices.

1.1 Self Control and Behavioral Patterns

The Health and Retirement Study is a panel data set that focuses on individuals who are close to or already in retirement. It consists of an abundance of health measures, personality questions as well as wealth and income information. In particular, wave 2010 contains a

module that specifically asks the participants to assess their self control. There are questions about four specific dimensions of self control (financial, food, exercise, and interpersonal) as well as self control in general. Since the housing and mortgage decision is mostly a financial one, I focus on financial and on general self control. Regarding general self control, the interviewee is asked to assess how much the following statements resemble him on a scale from 1 to 5 (1: "Very much like me", 5: "Not like me at all"):

I wish I had more self-discipline.

I am good at resisting temptation.

Sometimes I can't stop myself from doing something, even if I know it's wrong.

To assess financial self control, the interwiewee is 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 general self control and financial self control, respectively. Figure 1 shows the distribution of the two measures, where a higher value corresponds to a stronger problem of self control.[3]

To gain further insight into these measures of self control, I relate them to behavioral indicators which are typically associated with a lack of self control: smoking and being overweight. Since the sample in the HRS consists of people who are mostly in retirement, only few individuals still smoke. For the smoking behavior, I therefore construct a dummy variable which indicates if a person has ever smoked. The characteristic of being overweight is measured according to a person's Body Mass Index (BMI), a commonly employed measure

[3]See appendix A.1 for details about the sample selection.

Table 1: Behavioral Indicators in HRS

	%
Smoking	
never smoked	44.31
has smoked / smokes	55.69
BMI	
normal	31.20
overweight	37.51
obese	31.29

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

Table 2: Conditional Correlations in HRS

	(1) general self control	(2) financial impulsivity
ever smoked	0.131***	0.113***
	(0.048)	(0.041)
BMI		
overweight	0.111*	0.153***
	(0.057)	(0.049)
obese	0.203***	0.203***
	(0.060)	(0.051)
Observations	1221	1221
R^2	0.042	0.073

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

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

Note: Conditional correlations of the self control measures with behavioral indicators in the HRS sample, obtained by OLS with additional control variables: age, marital status, race, education, retirement status, and income. A higher measure of self control refers to worse self control.

of body shape which relates a person's weight to his height.[4] Table 1 shows the distribution of these behavioral indicators in the sample.

Table 2 shows that exhibiting these types of behavior is positively correlated with reporting a problem of self control. Note that these correlations are obtained after controlling for standard demographic characteristics such as age, marital status, race, education, retirement

[4]The exact formular is BMI = mass(kg) / height(m)^2. According to the U.S. Department of Health & Human Services, a person is classified as underweight for a BMI < 18.5, normal for for a $18.5 \leq$ BMI < 25, overweight for $25 \leq$ BMI < 30, and obese for BMI ≥ 30. I use the same classification.

Table 3: Behavioral Indicators in PSID

	all obs %	home owners %
Smoking		
don't smoke	73.66	76.83
smoke	26.34	23.17
BMI		
normal	20.75	19.33
overweight	46.91	48.19
obese	32.33	32.48
Self-assessed Health		
excellent	16.75	16.13
very good	31.61	31.84
good	35.26	35.72
fair	12.27	12.13
poor	4.10	4.17
Observations	2901	2374

Source: Panel Study of Income Dynamics (PSID), wave 2005, and own calculations

status, and income. In the next subsection I will thus relate these behavioral patterns, which can be thought of as signs of poor self control, to financial variables of interest.

1.2 Behavioral Patterns vs. Housing and Mortgage Outcomes

The behavioral indicators which I have shown to be correlated with poor self-assessed self control in the HRS are also available in the Panel Study of Income Dynamics (PSID). In particular, since wave 1999 information about smoking as well as height and weight have been added to the survey. In order to use as recent data as possible while avoiding the huge disruptions in the housing market in later years I therefore use wave 2005 to construct the sample.[5] Since the sample composition in the PSID is different to the HRS I redefine the smoking indicator to account for the younger sample. In particular, it is set to one if a

[5]As a robustness check I conduct my analyses also on all waves 1999-2007. Appendix A.2 contains a detailed description of the sample selection and variable definition, and the online appendix details the robustness checks.

Table 4: Financial Variables in PSID

	all obs		home owners	
	mean	std.dev.	mean	std.dev.
net worth	372	1249	434	1363
house value	188	231	230	236
income	76	105	83	114
ownership rate	0.82			
illiquid share	0.82	0.22	0.85	0.18
LTV	0.43	0.33	0.43	0.33
Observations	2901		2374	

Source: Panel Study of Income Dynamics (PSID), wave 2005, and own calculations

Note: The table shows descriptive statistics for the financial variables. Net worth, house value and income are in Tsd. US$.

person currently smokes. Table 3 and table 4 show the distribution of the indicators and descriptive statistics for financial variables of interest, respectively. Note that these statistics are calculated on the household level and a household is classified as exhibiting a particular behavior if at least one of the partners (head or spouse) exhibits the behavior.[6]

All the behavioral indicators are health related and poor health can be expected to affect current and future health expenditures as well as human capital. To eliminate this channel I control for self-assessed health status in the regression. Since I also control for income I hence control for all health related effects that have already materialized. I cannot exclude, however, that there might still be remaining effects on *expected* health expenditures and future income. As before, I control for standard demographics.

Table 5 shows how the behavioral signs of poor self control relate to overall net worth, the share of illiquid assets in net worth, the likelihood of being a home owner, the value of owner-occupied housing and the loan-to-value ratio (LTV). People who show signs of poor self control have on average less overall net worth. At the same time, they have a higher share

[6]Robustness checks show that the results are robust to controlling for intensity of behavior within the household.

Table 5: Conditional Correlations in PSID

	(1) log(net worth)	(2) illiquid share	(3) owner	(4) log(house value)	(5) LTV
smoke	−0.384***	0.001	−0.059***	−0.183***	0.016
	(0.061)	(0.010)	(0.016)	(0.036)	(0.014)
BMI					
overweight	0.016	0.014	0.014	−0.032	0.018
	(0.063)	(0.012)	(0.017)	(0.038)	(0.015)
obese	−0.306***	0.035***	0.006	−0.123***	0.078***
	(0.073)	(0.012)	(0.019)	(0.043)	(0.016)
log(income)	0.852***	−0.012	0.089***	0.549***	0.044***
	(0.049)	(0.008)	(0.011)	(0.027)	(0.010)
Health					
very good	−0.068	−0.008	−0.004	−0.032	0.016
	(0.070)	(0.013)	(0.020)	(0.039)	(0.017)
good	−0.217***	0.001	−0.012	−0.077*	0.037**
	(0.073)	(0.013)	(0.020)	(0.041)	(0.017)
fair	−0.521***	−0.001	−0.035	−0.212***	0.059***
	(0.099)	(0.017)	(0.026)	(0.058)	(0.023)
poor	−0.121	0.008	−0.008	−0.043	−0.002
	(0.141)	(0.025)	(0.040)	(0.088)	(0.032)
Obs	2901	2901	2901	2374	2374
R^2	0.483	0.080	0.260	0.349	0.362

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

Source: Panel Study of Income Dynamics (PSID), wave 2005, and own calculations

Note: Conditional correlations of financial variables with behavioral indicators in the PSID sample, obtained by OLS with additional control variables: age, marital status, race, education, and family size.

of illiquid assets in their portfolio. These findings are in line with the findings of Ameriks et al. (2007) who use data from their own survey. In the current sample it is possible to further look at portfolio composition, in particular the housing and mortgage positions. It can be seen that people who smoke are less likely to be home owners. If they are home owners they on average have houses with lower value. Moreover, being obese is correlated with having a higher LTV. Note that these effects are large. In particular, they are of the same magnitude as the effect of having only a high school degree instead of a college degree (not reported in the table).

I conclude that there are unobserved determinants of housing and mortgage positions that explain a considerable portion of the variation in these variables. These unobserved variables are correlated with behavior that is in turn correlated with lack of self control. In the remainder of the paper I therefore build a structural model to explicitly analyze the effects of self control on the housing and mortgage choice.

2 Structural Life-Cycle Model

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 I model costs of self control and show what the main driving forces are in this preference specification. Second, I describe the life-cycle model of housing and mortgages.

2.1 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 paper, agents receive utility from nondurable consumption C and housing services H. The detailed functional form of the per period utility is as follows[7]:

$$U(C_t, H_t) = u(C_t, H_t) + \lambda \cdot \big(u(C_t, H_t) - T(B_t)\big) \tag{1}$$

$$\text{where } T(B_t) = \max_{\{\tilde{C}_t, \tilde{H}_t\} \in B_t} u(\tilde{C}_t, \tilde{H}_t) \tag{2}$$

It can be seen that 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

[7]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 λ.

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 λ governs how severe the temptation is. This is the central parameter to this specification of DSC preferences. If λ is equal to zero the self control term drops out and per period utility simplifies to standard preferences without problems of self control. As λ 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:

$$\begin{aligned} V(X_t) &= \max_{C_t \in B_t} U(C_t) + \beta \cdot V(X_{t+1}) \\ &= \max_{C_t \in B_t} u(C_t) + \lambda \cdot \big(u(C_t) - T(B_t)\big) + \beta \cdot V(X_{t+1}) \end{aligned} \tag{3}$$

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:

$$-(1+\lambda)\frac{\partial u(C_t)}{\partial S_t} = \beta \cdot \left[\frac{\partial u(C_{t+1})}{\partial S_t} + \lambda \cdot \left(\frac{\partial u(C_{t+1})}{\partial S_t} - \frac{\partial T(B_{t+1})}{\partial S_t}\right)\right] \tag{4}$$

From equation (4) we see 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 effectively more impatient.[8] This effect is what I refer to as *impatience effect*.

[8] An equivalent way of expressing this effect would be to divide the equation by $(1+\lambda)$ so that the effective

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*.[9] 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.

2.2 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.[10] 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 assets,

discount factor would be $\beta/(1+\lambda) \leq \beta$.

[9]This effect arises since agents are sophisticated in the sense that they fully anticipate their problem of self control in the future.

[10]Throughout the paper I will use the terms *agent* and *household* interchangebly since I abstract from inter-household optimization.

houses, serve two purposes. On the one hand, agents receive utility from consuming housing services. The felicity function has the following form:

$$u(C, \mu H) = \frac{\left(C^{1-\theta}(\mu H)^{\theta}\right)^{1-\sigma}}{1-\sigma} \tag{5}$$

where μ 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 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:

$$Y_{it} = \bar{Y}_{it} \cdot V_{it} \tag{6}$$

$$\bar{Y}_{it} = G_t \cdot \bar{Y}_{it-1} \cdot N_{it} \ , \qquad t = 1 \ ... \ T^R \tag{7}$$

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.[11] During retirement

[11] Note that in this model, period t is equivalent to a specific age of the household since all households start their life in period $t = 1$.

there is no income uncertainty and the agents receive a fraction ς of their permanent income in the last working life period:

$$Y_{it} = \varsigma \cdot \bar{Y}_{iT^R} \ , \qquad t = T^R + 1 \ ... \ T \tag{8}$$

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.

2.2.1 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[12]:

$$V_t^{rent}(X_t, \bar{Y}_t) \ = \ \max_{S_t, H_t} \ (1+\lambda) \ u(C_t, H_t) - \lambda \ T_t^{noh}(X_t, \bar{Y}_t) + \beta \cdot \mathsf{E}\left[V_{t+1}^{noh}(X_{t+1}, \bar{Y}_{t+1})\right] \tag{9}$$

$$\text{s.t.} \qquad C_t = X_t - S_t - P_t^R \cdot H_t \tag{10}$$

$$X_{t+1} = S_t(1 + r_S) + Y_{t+1} \tag{11}$$

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 faces who enters the period without a house. Equation (10) determines the implied nondurable consumption C_t where P_t^R 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.

[12] To simplify notation I drop the subscript i for all subsequent optimization problems.

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

$$V_t^{buy}(X_t, \bar{Y}_t) = \max_{S_t, \bar{H}, M_t} \; (1+\lambda)\; u(C_t, \mu\bar{H}) - \lambda\; T_t^{noh}(X_t, \bar{Y}_t) + \beta \cdot \mathsf{E}\left[V_{t+1}^{house}(X_{t+1}, \bar{H}, M_{t+1}, 1, \bar{Y}_{t+1})\right] \tag{12}$$

$$\text{s.t.} \qquad C_t = X_t - (1+\delta_B) \cdot P_t^H \bar{H} + (1-\delta_M) \cdot M_t - S_t \tag{13}$$

$$M_t \leq \phi_v \cdot P_t^H \bar{H} \tag{14}$$

$$M_t \leq \phi_y \cdot \bar{Y}_t \tag{15}$$

$$X_{t+1} = S_t(1+r_S) + Y_{t+1} \tag{16}$$

$$M_{t+1} = M_t(1+r_M) \tag{17}$$

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 (δ_B) and on the mortgage (δ_M). Equations (14) and (15) represent the restrictions on the mortgage size: The ratio of mortgage to house value cannot exceed the fraction ϕ_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 ϕ_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:

$$V_t^{noh}(X_t, \bar{Y}_t) = \max\left\{V_t^{rent}(X_t, \bar{Y}_t), V_t^{buy}(X_t, \bar{Y}_t)\right\} \tag{18}$$

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 $T_t^{noh}(X_t, \bar{Y}_t)$ 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.

$$T_t^{rent}(X_t, \bar{Y}_t) = \max_{\tilde{H}_t} \quad u(X_t - P^R \cdot \tilde{H}_t, \tilde{H}_t) \tag{19}$$

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.

$$T_t^{buy}(X_t, \bar{Y}_t) = \max_{\tilde{H}, \tilde{M}_t} \quad u(\tilde{C}_t, \mu\tilde{H}) \tag{20}$$

$$\text{s.t.} \qquad \tilde{C}_t = X_t - (1 + \delta_B) \cdot P_t^H \tilde{H} + (1 - \delta_M) \cdot \tilde{M}_t \tag{21}$$

$$\tilde{M}_t \leq \phi_v \cdot P_t^H \tilde{H} \tag{22}$$

$$\tilde{M}_t \leq \phi_y \cdot \bar{Y}_t \tag{23}$$

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:

$$T_t^{noh}(X_t, \bar{Y}_t) = \max \left\{ T_t^{rent}(X_t, \bar{Y}_t), T_t^{buy}(X_t, \bar{Y}_t) \right\} \tag{24}$$

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.

2.2.2 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.[13] If he decides to keep his house and keep repaying his mortgage then he has to solve the following optimization problem:

$$V_t^{repay}(X_t, \bar{H}, M_t, a, \bar{Y}_t) = \max_{S_t} \; (1+\lambda) \; u(C_t, \mu\bar{H}) - \lambda \; T_t^{house}(X_t, \bar{H}, M_t, a, \bar{Y}_t) + \beta \cdot \mathsf{E}\left[V_{t+1}^{house}(X_{t+1}, \bar{H}, M_{t+1}, a+1, \bar{Y}_{t+1})\right] \tag{25}$$

$$\text{s.t.} \qquad C_t = X_t - Q(M_t, a, t) - \psi_M P_t^H \bar{H} - S_t \tag{26}$$

$$X_{t+1} = S_t(1 + r_S) + Y_{t+1} \tag{27}$$

$$M_{t+1} = (M_t - Q(M_t, a, t))(1 + r_M) \tag{28}$$

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 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:

$$Q(M, a, t) = \frac{M}{1 + r_M} \cdot \kappa_a \; , \qquad a \geq 1 \tag{29}$$

$$\text{where} \qquad \kappa_1 = \frac{r_M}{1 - (1 + r_M)^{-\tau}} \tag{30}$$

$$\kappa_a = \begin{cases} \frac{\kappa_{a-1}}{1 + r_M - \kappa_{a-1}} & a = 2, ...\tau \\ 0 & a > \tau \end{cases} \tag{31}$$

$$\tau = \min\left[\tau^s, T - t - a\right] \tag{32}$$

where the fixed term of the mortgage τ is either equal to the standard term τ^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 ψ_M and

[13] 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.

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:

$$V_t^{ref}(X_t, \bar{H}, \bar{M}, \bar{Y}_t) = \max_{S_t, M_t} (1+\lambda)\ u(C_t, \mu\bar{H}) - \lambda\ T_t^{house}(X_t, \bar{H}, \bar{M}, a, \bar{Y}_t) + \beta \cdot \mathsf{E}\left[V_{t+1}^{house}(X_{t+1}, \bar{H}, M_{t+1}, 1, \bar{Y}_{t+1})\right] \tag{33}$$

$$\text{s.t.} \qquad C_t = X_t - \psi_M P_t^H \bar{H} + (1-\delta_M) M_t - \bar{M} - S_t \tag{34}$$

$$M_t \leq \phi_v \cdot P_t^H \bar{H} \tag{35}$$

$$M_t \leq \phi_y \cdot \bar{Y}_t \tag{36}$$

$$X_{t+1} = S_t(1+r_S) + Y_{t+1} \tag{37}$$

$$M_{t+1} = M_t(1+r_M) \tag{38}$$

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.[14]

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

[14]This is equivalent to taking out a new mortgage with zero balance.

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:

$$V_t^{sell}(X_t, \bar{H}, M_t, a, \bar{Y}_t) = \max_{S_t} \ (1+\lambda)\ u(C_t, \mu\bar{H}) - \lambda\ T_t^{house}(X_t, \bar{H}, M_t, a, \bar{Y}_t) + \beta \cdot \mathsf{E}\left[V_{t+1}^{noh}(X_{t+1}, \bar{Y}_{t+1})\right] \tag{39}$$

$$\text{s.t.} \qquad C_t = X_t - \psi_M P_t^H \bar{H} - Q(M_t, a, t) - S_t \tag{40}$$

$$X_{t+1} = \ S_t(1+r_S) + Y_{t+1} + (1-\delta_S)P_{t+1}^H \bar{H} - (M_t - Q(M_t, a, t))(1+r_M) \tag{41}$$

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 ($\delta_D > \delta_S$). The optimization problem of a defaulting household looks as follows:

$$V_t^{def}(X_t, \bar{H}, M_t, \bar{Y}_t) = \max_{S_t, H_t} \ (1+\lambda)\ u\big((1-\eta)C_t, (1-\eta)H_t\big) - \lambda\ T_t^{house}(X_t, \bar{H}, M_t, a, \bar{Y}_t) + \beta\left((1-\omega)\mathsf{E}\left[V_{t+1}^{ex}(X_{t+1}, \bar{Y}_{t+1})\right] + \omega\mathsf{E}\left[V_{t+1}^{noh}(X_{t+1}, \bar{Y}_{t+1})\right]\right) \tag{42}$$

$$\text{s.t.} \qquad C_t = X_t - P_t^R \cdot H_t - S_t \tag{43}$$

$$X_{t+1} = S_t(1+r_S) + Y_{t+1} + \max\left[0, (1-\delta_D)P_{t+1}^H \bar{H} - M_t(1+r_M)\right] \tag{44}$$

where η is the stigma effect which reduces the utility agents receive from consumption in the

period of default. From equation (42) it can be seen that the agent will reenter the housing market only with probability ω. With probability $(1-\omega)$, the agent will be excluded and hence does not have the option to buy a house:

$$V_t^{ex}(X_t, \bar{Y}_t) = \max_{S_t, H_t} \; (1+\lambda)\; u(C_t, H_t) - \lambda\; T_t^{ex}(X_t, \bar{Y}_t) + \beta\left((1-\omega)\mathsf{E}\left[V_{t+1}^{ex}(X_{t+1}, \bar{Y}_{t+1})\right] + \omega\mathsf{E}\left[V_{t+1}^{noh}(X_{t+1}, \bar{Y}_{t+1})\right]\right) \tag{45}$$

$$\text{s.t.} \qquad C_t = X_t - P_t^R \cdot H_t - S_t \tag{46}$$

$$X_{t+1} = S_t(1+r_S) + Y_{t+1} \tag{47}$$

$$T_t^{ex}(X_t, \bar{Y}_t) = \max_{\tilde{H}_t} \; u(X_t - P^R \cdot \tilde{H}_t, \tilde{H}_t) \tag{48}$$

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

$$V_t^{house}(X_t, \bar{H}, M_t, a, \bar{Y}_t) = \max\Big[V_t^{repay}(X_t, \bar{H}, M_t, a, \bar{Y}_t),\; V_t^{ref}(X_t, \bar{H}, M_t, \bar{Y}_t), V_t^{sell}(X_t, \bar{H}, M_t, a, \bar{Y}_t),\; V_t^{def}(X_t, \bar{H}, M_t, \bar{Y}_t)\Big] \tag{49}$$

Temptation of a Home Owner As in the case of a renter it is important to identify the most tempting option $T_t^{house}(X_t, \bar{H}, M_t, a, \bar{Y}_t)$ 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:

$$T_t^{def}(X_t, \bar{Y}_t) = \max_{\tilde{H}_t} \; u\big((1-\eta)(X_t - P^R \cdot \tilde{H}_t), (1-\eta)\tilde{H}_t\big) \tag{50}$$

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[15]:

$$T_t^{repay}(X_t, \bar{H}, M_t, a, \bar{Y}_t) = u\big(X_t - \psi_M P_t^H \bar{H} - Q(M_t, a, t), \bar{H}\big) \tag{51}$$

[15]Note 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.

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:

$$T_t^{ref}(X_t, \bar{H}, \bar{M}, \bar{Y}_t) = \max_{\tilde{M}_t} \quad u(\tilde{C}_t, \mu\bar{H}) \tag{52}$$

$$\text{s.t.} \qquad \tilde{C}_t = X_t - \psi_M P_t^H \bar{H} + (1-\delta_M)\tilde{M}_t - \bar{M} \tag{53}$$

$$\tilde{M}_t \leq \phi_v \cdot P_t^H \bar{H} \tag{54}$$

$$\tilde{M}_t \leq \phi_y \cdot \bar{Y}_t \tag{55}$$

This option is more tempting the more home equity there is to extract, which reduces the commitment effect of houses and mortgages. In particular, the disciplining effect of default on the LTV ratio will be less relevant. The overall temptation that a home owner faces is given by the maximum of the three options:

$$T_t^{house}(X_t, \bar{H}, M_t, a, \bar{Y}_t) = \max \Big[T_t^{def}(X_t, \bar{Y}_t),\ T_t^{repay}(X_t, \bar{H}, M_t, a, \bar{Y}_t), \\ T_t^{ref}(X_t, \bar{H}, M_t, \bar{Y}_t) \Big] \tag{56}$$

3 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

Table 6: Parameter Values in Benchmark Model

Parameter		Value	Source
Preferences			
risk aversion	σ	2	
discount rate	ρ	0.06	
stigma effect	η	0.2	
ownership benefit	μ	1.0075	
weight of housing services	θ	0.20	Piazzesi, Schneider and Tuzel (2007)
degrees of self control	λ	$\{0, 0.04, 0.08, 0.12\}$	
shares of self control types		$\{0.25, 0.5, 0.2, 0.05\}$	HRS 2010
Market Environment			
risk free rate	r_S	0.018	1-year Treasury Constant Maturity
mortgage rate	r_m	0.033	30-year Convent. Mortgage rate
house price growth rate	r_H	0.016	All trans. house price index (FHFA)
rental price - to - house price ratio	$\frac{P_t^R}{P_t^H}$	0.045	Davis, Lehnert and Martin (2008)
maintenance cost of housing	ψ_M	0.021	Kaplan and Violante (2014)
transaction costs when buying	δ_B	0	Hsieh and Moretti (2003)
transaction costs when selling	δ_S	0.06	Hsieh and Moretti (2003)
transaction costs for mortgage	δ_M	0.03	Berndt, Hollifield and Sandas (2012)
transaction costs when defaulting	δ_D	0.27	Campbell, Giglio and Pathak (2011)
expected years of exclusion		7	Fair Credit Reporting Act
income process			Cocco, Gomes and Maenhout (2005)
minimum down payment	ϕ_v	0.035	FHA requirement
max mortgage payment to income		0.43	FHA requirement

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 6 contains all parameter values used in the benchmark model. THey are annual values 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. 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 (θ). 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 θ equal to their estimate of 0.2.

To the best of my knowledge there is no established way of choosing the self control parameter λ or a consensus about plausible values. To calibrate the model I therefore assume that there are four types of agents in the population and set the population share of the four types according to the distribution of the self control measures in the HRS data.[16] The values for the four self control types obtained in the calibration are $\lambda = 0, 0.04, 0.08, 0.12$. There are two papers which structurally estimate the degree of self control: Kovacs (2015) obtains an estimate of 0.15 for the degree of self control in the housing context, while Bucciol (2012) estimates $\lambda = 0.05$ in a model of liquid vs illiquid investments. The values obained in this paper are hence well within their range. Moreover, to get an impression 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 λ 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 feeling 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

[16] See appendix B for how the the population shares were determined.

Table 7: Fit of the model

	age $<$ 35			35 $\leq$ age $<$ 50			50 $\leq$ age $<$ 65		
	p25	p50	p75	p25	p50	p75	p25	p50	p75
House Value (owners)									
data	62	90	136	71	106	169	66	104	171
model full	71	92	126	75	104	147	72	111	169
model standard	70	90	118	77	106	147	75	114	173
LTV (owners)									
data	0.56	0.76	0.89	0.31	0.56	0.76	0.01	0.24	0.53
model full	0.55	0.73	0.81	0.50	0.64	0.74	0.08	0.33	0.50
model standard	0.66	0.77	0.84	0.45	0.62	0.73	0.01	0.21	0.40
Ownership rate									
data		0.46			0.71			0.81	
model full		0.13			0.75			0.94	
model standard		0.22			0.92			1.00	
Net worth									
data	1	9	46	7	49	164	29	111	493
model full	1	4	10	16	37	65	46	76	122
model standard	2	6	15	29	49	79	60	91	142

aversion parameter (σ), the discount rate (ρ), the home ownership premium (μ), and the stigma effect (η). The parameter values are calibrated so that the simulated median life cycle profiles of house value, loan-to-value ratio and net worth 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 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 7 shows the fit of the benchmark model. It compares the median and the interquartile range of house value, LTV ratio and net worth, as well as the ownership rate in the simulation with the corresponding data moments in the Survey of Consumer Finances

(SCF), waves 1989-2010.[17] Moreover, it compares the performance of the full model with a model that doesn't allow for problems of self control.

The model fits the distribution of house values and the distribution of LTV ratios well. Note that in the calibration only the median levels for the different age groups were targeted, not the entire distribution. Nevertheless, the model matches the interquartile ranges in both variables well throughout the life-cycle. The ownership rate, however, is matched less well over the life cycle. It fits well for the middle age group but is too low early in life and too high for the older age group. This very low ownership rate early in life is an undesirable feature that is common to models with a fixed maximum LTV ratio (see Abbott (2013)). It can also be seen that the model without heterogeneity in self control has a significantly worse fit in the ownership rate since it overpredicts the ownership rate both for the the middle and the oldest age group. The model is able to match the lower part of the empirical net worth distribution but is not able to represent its thick right tail.

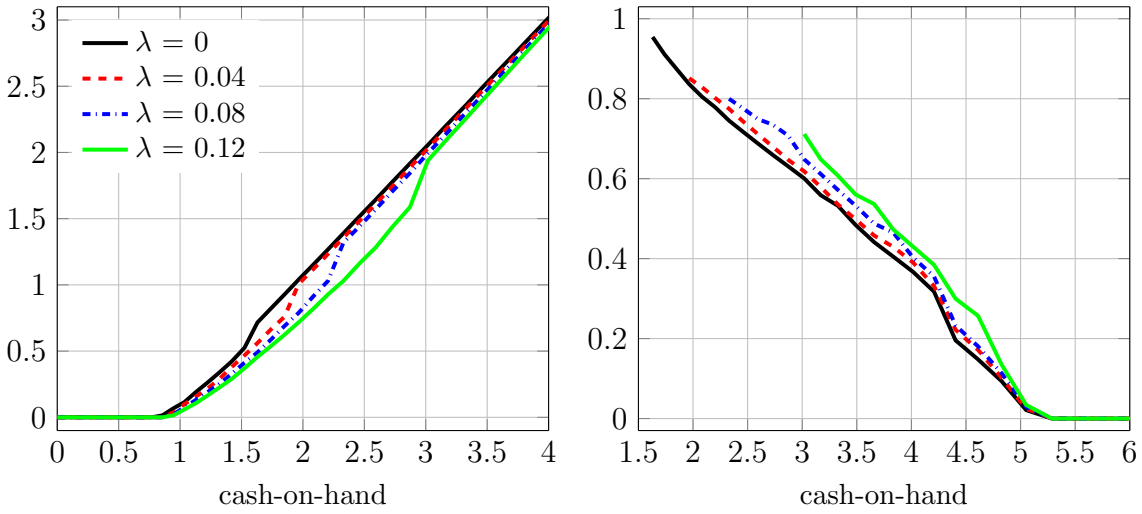
Lastly, it is important to mention that there are no defaults in equilibrium. This is because there is no house price risk so that people are never underwater with their mortgage. They can thus always sell their house before they would be forced to default. Nevertheless, it is important to allow for the possibility to default since default can be tempting if the burden of the mortgage payment is very high. The option to default hence has a disciplining effect on how large a mortgage people optimally choose.

3.1 Results of the Benchmark Model

Figure 2 shows the policy functions for a households with high school education at age 32 which enters the period as a renter. The figure plots the policy functions for different degrees of self control against normalized cash-on-hand. Figure 2(a) shows the optimal level of overall

[17]The weights in the SCF are designed to correct for non-response while in the 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 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.

Figure 2: Policy Functions in the Benchmark Model



(a) overall savings (b) LTV

Note: Policy Functions of high school graduate at age 32 who enters the period as a renter in the benchmark model.

savings, i.e. the sum of liquid savings and down payment. It can be seen that the overall savings decrease with the problem of self control. Moreover, the stronger the problem of self control, the higher is the threshold for purchasing a house. At this threshold overall savings jump up as the household makes a down payment. 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 a house while agents with stronger problems keep renting. Figure 2(b) depicts the optimal LTV ratio when buying a house. We see that 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 8, 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

Table 8: Effects of self control in simulation

	Welfare Costs of Self Control		Effects of Self Control on Behavior					Welfare Effect of Policy
	CE1	CE2	net worth (all)	owner-ship rate	home equity share (owners)	house value (owners)	LTV (owners)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Benchmark Model								
$\lambda = 0$			67.04	0.75	0.81	122.67	0.46	
$\lambda = 0.04$	1.22	1.34	-0.23	-0.08	-0.00	-0.01	0.06	
$\lambda = 0.08$	2.00	2.52	-0.45	-0.21	-0.02	-0.03	0.14	
$\lambda = 0.12$	1.99	3.47	-0.69	-0.50	-0.05	-0.07	0.23	
Panel B: Down Payment $\geq 20\%$								
$\lambda = 0$			66.52	0.70	0.85	122.70	0.41	-0.06
$\lambda = 0.04$	1.13	1.22	-0.22	-0.05	0.00	-0.01	0.06	0.05
$\lambda = 0.08$	1.91	2.30	-0.41	-0.14	0.00	-0.03	0.13	0.14
$\lambda = 0.12$	2.15	3.23	-0.60	-0.31	-0.01	-0.05	0.21	0.18
Panel C: No Refinancing								
$\lambda = 0$			64.46	0.68	0.71	122.32	0.49	-0.31
$\lambda = 0.04$	0.99	1.09	-0.19	-0.08	0.07	-0.03	-0.03	-0.07
$\lambda = 0.08$	1.67	2.04	-0.34	-0.16	0.12	-0.06	-0.05	0.15
$\lambda = 0.12$	2.00	2.84	-0.51	-0.29	0.14	-0.09	-0.06	0.29

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 $\lambda = 0$ give the average behavior over the working life for households without costs of self control, the values for $\lambda > 0$ give the mean difference in individual behavior if degree of self control is changed from $\lambda = 0$ (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

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

From column 3 we can see that the overall net worth decreases with the degree of the self control problem. For example, agents with low costs of self control ($\lambda = 0.04$) have on average 23% less net worth than standard agents. For households with large costs ($\lambda = 0.12$) this effect increases to a reduction in net worth of almost 70%. We hence see that the differences in optimal savings that we saw in the policy functions translate into substantial differences in average net worth.

Next, in column 4 we see that 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, we see from table 8, column 5 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

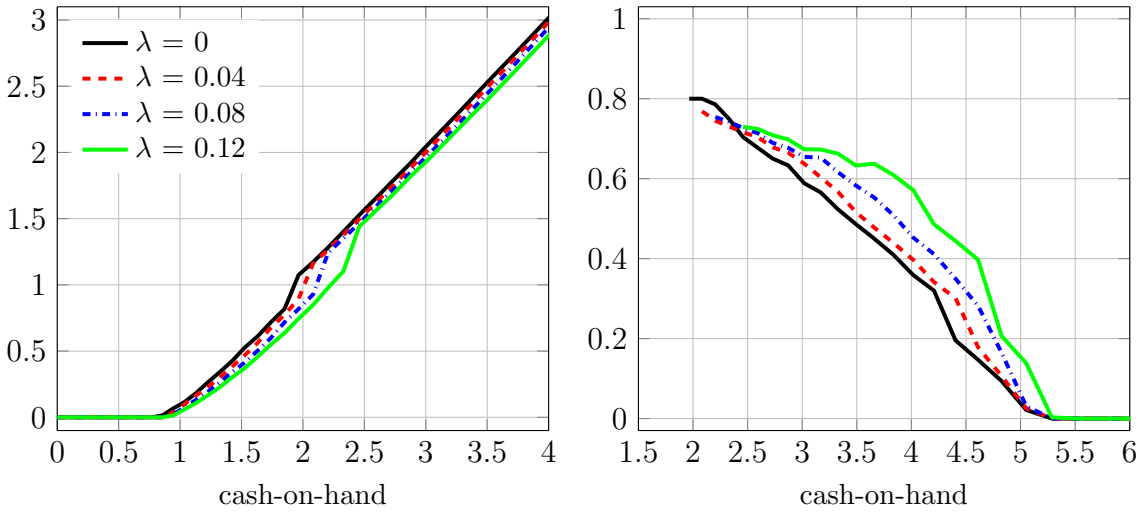
than saving in liquid assets so that the anticipation effect is only very small. The impatience effect, however, leads to higher optimal LTV ratios and hence to lower home equity.

Columns 6 and 7 refer to the effects of self control on the housing and mortgage portfolio. We see that the house value is 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.

3.2 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 3: Policy Functions with Increased Down Payment



(a) overall savings (b) LTV

Note: Policy Functions of high school graduate at age 32 who enters the period as a renter in the model with 20% down payment.

Figure 3 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.

Looking at the optimal choice of LTV ratio we first of all see 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

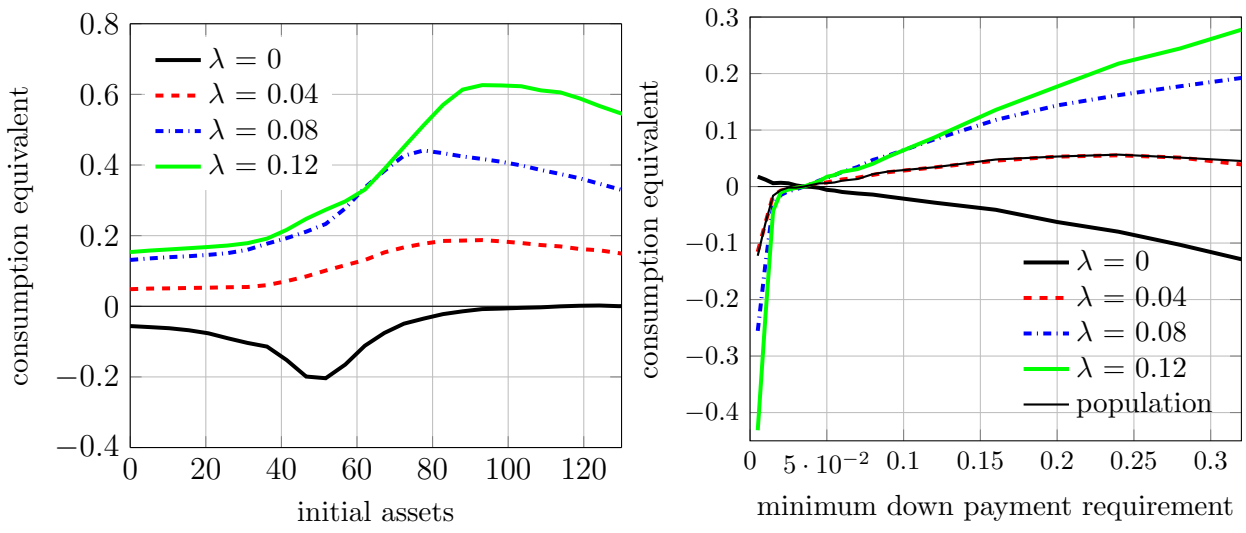
problems of self control. The reason is that choosing a higher LTV implies that there is less home equity in the house above the minimum required level. Hence, the amount that agents will be able to extract by refinancing in the following years is lower which reduces the temptation that agents will face. This effect is stronger the stronger the problem of self control so that the optimal LTV is increasing in costs of self control.

Table 8, 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.

In columns 6 and 7 we see 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 we see the effects 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

Figure 4: Welfare Effect of a Change in Minimum Down Payment Requirement



(a) 20% down payment requirement

(b) various requirements

Note: Welfare effect of a change in minimum down payment from 3.5% to 20% (panel a) and various down payments (panel b).

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 loss in flexibility.

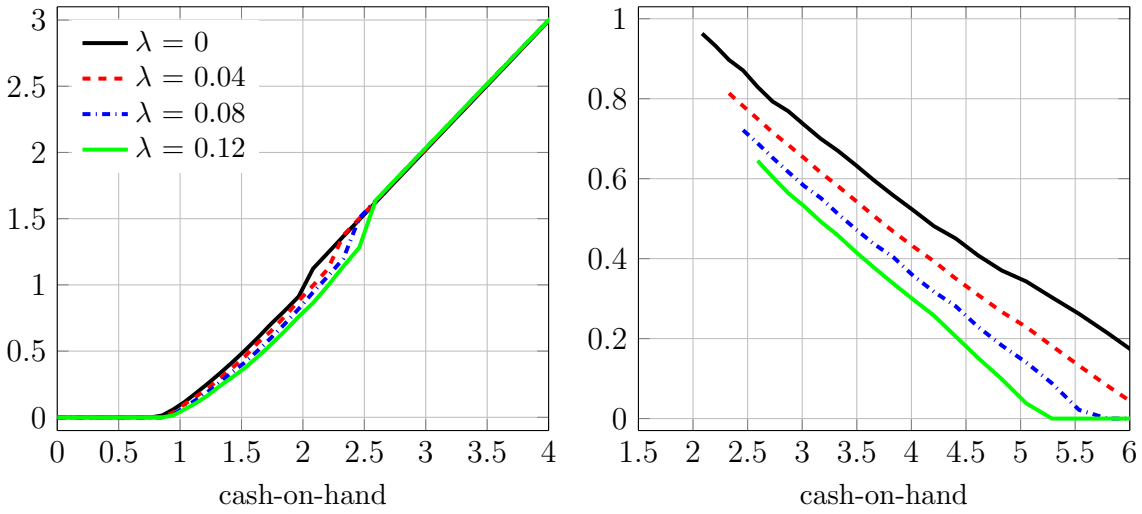
Figure 4(a) breaks down the welfare effect of the increase in minimum down payment against the level of assets agents hold at the beginning of their working life. We see that there is heterogeneity in the welfare consequences between different asset levels. For the standard agent the policy is more welfare 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 from 3.5% to 20%, figure 4(b) computes the consumption equivalent for several down payment requirements, varying from 0.005% to 32%. We see that 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.

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%.

Figure 5: Policy Functions without Option to Refinance



(a) overall savings (b) LTV

Note: Policy Functions of high school graduate at age 32 who enters the period as a renter in the model without refinancing.

3.3 Possibility to Refinance

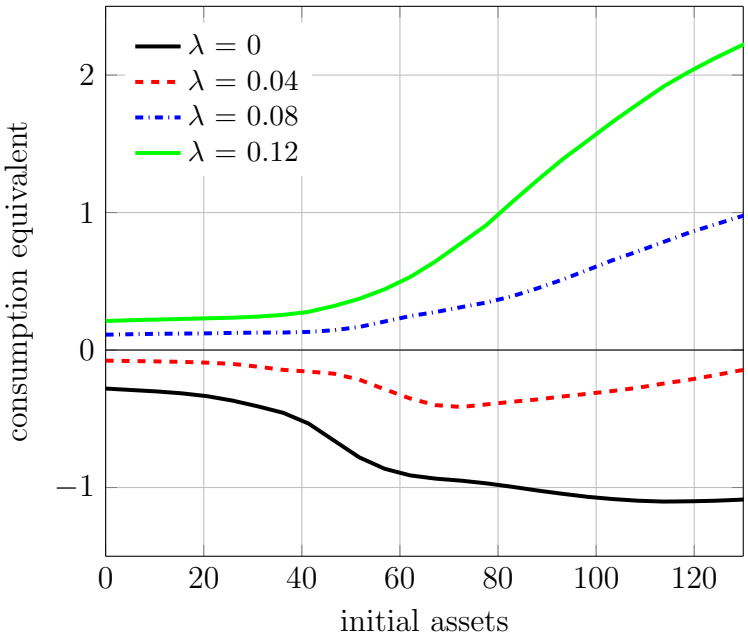
The second policy experiment is to remove the possibility to prepay and hence to refinance mortgages. In this case home equity becomes truly illiquid since it can only be accessed by selling the house which takes time. For standard agents the effect of this change is again unambiguous. Their choice set 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 isn't 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 5 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 8, panel C shows the economic relevance of these effects in the simulation. First, we see in column 4 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, we see in column 8 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, we also see that 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

Figure 6: Welfare Effect of Possibility to Refinance



Note: Welfare effect of removing the possibility to refinance.

control are better off by an equivalent of 0.29% life-time consumption. Figure 6 depicts these welfare effects for different levels of initial assets at the beginning of working life. We see that 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.

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.

To summarize, I find that making home equity less easily accessible increases the welfare of people with sufficiently strong problems of self control and this effect is stronger for wealthier households. However, I also find that even if houses are a powerful commitment device, having a problem of self control still prevents a large share of people from accumulating enough savings to purchase a house and thus to get access to the commitment device.

4 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 extend 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 first step in this direction. However, it leaves open a number of questions which I think are important to address in future research. For example, it would be interesting to analyze general equilibrium effects as they surely must be taken into account in a full welfare analysis. It would also be interesting to allow for the presence of another illiquid asset as this would change the value of houses as commitment vehicles. Finally, I have considered a particular departure from standard preferences and at the very least it would be worthwhile to consider quasi-hyperbolic discounting (Laibson, 1997) as an alternative.

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A Details about Empirical Analysis

A.1 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. I obtain the data from this module and merge it to the RAND HRS data set which is a user-friendly version of the HRS provided by the RAND Center for the Study of Aging. The "Personality" module was answered by 1251 individuals. Of these individuals 18 are classified as underweight according to their BMI. Due to the small size of this subsample I choose to drop those observations. Moreover, I drop another 12 observations because of missing data on some of the variables in my analysis. This leaves a sample of 1221 individuals.

A.2 Panel Study of Income Dynamics (PSID)

The Panel Study of Income Dynamics (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. Regarding the health information, there have been additional changes to the questions asked since wave 2005.

Sample Selection This paper analyzes housing and mortgage decisions of households and how these decisions are affected by problems of self control. I hence want to maximize the information in the behavioral indicators which means focusing on waves 2005 and later. At the same time, there have been huge disruptions in the housing market from 2007 onwards. Since this project does not aim to explain these disruptions I use wave 2005 for the main analysis, but conduct robust checks with respect to the other waves.

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. Another small group is people with a BMI that indicates being underweight. Since this group is likely to suffer from a serious disease and not a mere problem of self control I exclude these observations. This would give a sample size of 3945 observations.

Moreover, I exclude observations with improbable or missing data. In particular, I exclude families with total income, i.e. the sum of all labor income, pensions, and all transfers, below the poverty guideline for a family of that size (228 observations).[18] I also exclude observations with reported house values below 10,000 US$ (38 observations). Furthermore, I drop observations with missing data on any of the variables in my analysis (392 observations).

Lastly, I make two additional restrictions. First, I exclude households with negative overall net worth (304 observations). The reason is that the behavior of these indebted households likely differs from the behavior of other households. Second, I exclude observations with an illiquid share outside the interval $[0, 1]$ (further 79 observations). In these cases

[18]Poverty guidelines are a federal poverty measure which is used to determine financial eligibility of federal programs. They are issued each year in the Federal Register by the Department of Health and Human Service and can be obtained from their website.

either the illiquid net worth or the liquid net worth is negative, even though the total net worth is positive. The illiquid share does therefore not purely reflect investment preferences. I conduct robustness checks with respect to these two restrictions.

The final sample therefore consists of 2904 observations, of which 2377 are home owners.

Variable Definition 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 and for the illiquid share are obtained from the supplemental wealth files. Total net worth is directly taken from these files while the illiquid share is constructed in the following way. Illiquid share is equal to the net value of all illiquid assets divided by overall net worth. Illiquid assets consist of home equity, vehicles, retirement accounts, other real estate, business and farming assets, other assets (such as life insurance) minus other debt (such as student loans). Unfortunately, the categories of other assets and other debt also include decidedly liquid assets such as bond funds and credit card debt. I therefore conduct robustness checks where I exclude these categories from illiquid assets.

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.

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.[19] 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 ≤ 22 ($23 \leq$ age ≤ 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.[20]

To obtain the simulated moments which I match to the data moments I combine households with different degrees of self control in the following way. From the distribution of the welfare measure in the HRS data set (see figure 1) I see that 25% of individuals answer the questions in a way that suggests no problem of self control at all (< 2) since to answer with "1" indicates no costs of self control. Next, I assume someone has low costs of self control if he answers at least one question below the middle category "3", i.e. his aggregate measure is ≥ 2 and < 3. This applies to about 50% of people. 20% of measures fall in the range ≥ 3 and < 4 which I allocate to medium costs. The last 5% of people have measures ≥ 4 which I label large costs. I therefore assume 25% of households are standard agents, 50% have small costs ($\lambda = 0.04$), 20% have medium costs ($\lambda = 0.08$), and 5% have large costs ($\lambda = 0.12$). The degree of self control λ and the education group are assumed to be independent.

[19] The percentages were obtained from SCF, waves 1989-2004.

[20] Fitting a distribution for each wave individually gives a range of parameter values which is similar to the estimates obtained from the pooled sample.

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Robustness Checks for Empirical Analysis

Different Years I conducted the analysis described in the main text not only on my main sample year, 2005, but on all waves 1999 - 2007. All results are robust throughout all waves. It can be seen, however, that for the earlier waves (1999 and 2001) the results are even stronger for the illiquid share (both smoking and BMI show significantly positive correlations) while the LTV results are less strong in these waves (smaller magnitude but still significant). This suggests that in the run-up to the crisis in the housing and mortgage market signs of poor self control are even more strongly correlated with higher mortgages. Higher mortgages lead ceteris paribus to higher LTVs and to lower home equity, hence to somewhat lower illiquid shares in overall net worth.

Include Indebted Households In the main analysis, households with negative total net worth and households with illiquid shares outside $[0, 1]$ were excluded. The reason for these restrictions is that households who are indebted can be expected to act systematically different to households who have positive wealth. Moreover, if the illiquid share is outside $[0, 1]$ then either liquid wealth or illiquid wealth is negative which makes the interpretation of the ratio difficult. In the main analysis I therefore excluded these observations. To see how robust the results are to these restrictions I conduct the same analysis on an extended sample which also includes indebted households and households with unconventional illiquid shares.

The results for overall net worth, house value and LTV ratio are hardly affected by this change. The results for the illiquid share, on the other hand, become less strong. This is not surprising since negative net worth implies that the illiquid share does not even have to be close to the interval $[0, 1]$ so that the meaning of this variable becomes unclear. For the ownership rate the results become somewhat mixed, since smoking is still negatively

correlated owning a house, but there is a slight positive correlation with being overweight.

Alternative Definition of Illiquid Assets The way in which PSID collects data about assets unfortunately groups both liquid and illiquid assets into the categories "other assets" (both bond funds and life insurance policies) and "other debt" (both credit card debt and student loans). If these two categories are excluded from the definition of illiquid assets many more observations have negative illiquid assets which makes the interpretation of the illiquid share difficult. This can explain why the conditional correlation between the behavioral indicators and this object becomes insignificant unless the observations with an illiquid share outside $[0, 1]$ are excluded. If they are excluded as in the main analysis, however, the correlation is again significantly positive.

Alternative Definition of Behavioral Indicators In the main analysis, behavioral indicators are dummy variables which take on the value 1 if at least one of the partners (head or spouse) exhibits a particular behavior. I conduct 3 robustness checks to see how robust the results are to the specification of the behavioral variables. First, I redefine behavioral indicators to show how many of the partners (zero, one, or both) exhibit a certain behavior. All the results are robust to this change. In fact, the strength of the correlations is increasing in the number of partners who show the behavior.

Second, I exploit the information about how many cigarettes people smoke a day and redefine the smoking indicators to show if people smoke 1-10 cigarettes or more than 10 cigarettes a day (taking the maximum value among head and spouse). The results are robust and in fact, whenever smoking is significant in the main analysis, the magnitude of the correlation is now increasing in the intensity of smoking.

Third, instead of defining being overweight or obese as indicators, I analyze directly the correlation between the financial variables and the level of BMI (the maximum among head and spouse). All the results are robust to this change.

Other Control Variables Housing and leverage decisions are very likely to depend on the possibility to obtain financial support from parents. Parents wealth can hence be expected to affect the housing and mortgage portfolio. I therefore conduct two robustness checks where I control for parents' characteristics. First, I control for parents' education. Second, I control for self assessed economic situation of one's parents (PSID asks interviewees to assess the economic situation of their family while they were growing up in categories). The results are robust to adding both sets of controls.

Aggregate factors for geographic regions, such as house prices or general wealth levels, might affect the results if behavioral patterns also vary systematically with these regions. To address this concern I also conduct the analysis with state dummies as additional controls. The results are robust to these additional controls.

Lastly, in the main analysis I control for current income. One concern might be that current income is noisy and that long-term financial decisions such as the purchase of a house are more affected by long-term income prospects. To account for this I conduct the analysis by controlling for the average income over the last 3 waves of the panel. The results are robust to this change.