TIME PREFERENCES AND MORTGAGE CHOICE

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ABSTRACT

Mortgage choice and management are both decisions with important consequences for the consumer, lenders, and the state of the economy more generally. Mortgage decisions are also prototypical of consumer financial choices that that involve a stream of expenditures and consumption occurring across time. We focus on using heterogeneity in time preferences, particularly a present bias, to explain a sequence of decisions concerning mortgages, the selection of a mortgage that may lead to having negative equity, and the decision to abandon a mortgage.

We employ an analytic model, a nationally-representative sample of US households, and a survey of mortgaged households augmented by zip-code level house price and banking data. All three suggest that consumers with greater present bias and discounting are more likely to choose mortgages that minimize up-front costs. We also show an interesting reversal: Present bias decreases homeowners' willingness to abandon a mortgage, but higher discounting increases that willingness. Our results suggest that a two-parameter model of time preferences is helpful for understanding how homeowners make mortgage decisions.

Keywords: Time preferences, mortgage choice, mortgage defaults, individual differences

INTRODUCTION

Selecting a mortgage is the largest and most complicated financial choice made by most consumers (Campbell and Cocco 2003). Not only is it a major determinant of consumer outcomes, but it is also one of the largest components of consumer debt in the US economy ($10.5 trillion, Tufano, 2009). Consumers' decisions in choosing and managing these obligations has had important effects on the US and world economy (Rubio 2011).

While there has been significant economic research on mortgages, mortgages have received little attention in marketing (but see Lee and Hogarth (1999) who examine the understanding of interest rates). However, besides the practical importance of mortgage decisions, as mortgages involve costs and benefits that occur over significant time periods, they are a useful setting for examining the effect of time preferences on choice, a topic of importance to many consumer decision problems. Time preferences describe individuals' tradeoffs between costs and benefits which occur now and in the future. Mortgage choices typically involve large amounts of money over significant time commitments—borrowing 4 times the annual income of a household to be repaid over 30 years is commonplace (Zillow 2014).

Most economic analysis of mortgage choice employs a standard intertemporal maximization model, assuming that households select mortgages to optimize their expected lifetime consumption, discounting future events exponentially. In other words the importance of future outcomes is decreased by a constant proportion for each period of time delay (Campbell and Cocco 2003). In such accounts the standard practice in inter-temporal welfare analyses is to assume that those rates are (i) the same across households, and (ii) the same for all time horizons (Harrison, Lau and Williams 2002). Similar assumptions are made in studying dynamic choice

in marketing using structural models (see Yao et al. 2012 for a discussion).

While such accounts have been useful, we explore a different approach to understanding mortgage choices that changes both assumptions. First, in line with a growing literature in economics and psychology we are interested in how people *differ* in discounting the future, or their personal discount rates (Anderson et al 2008; Becker and Mulligan 1997; Zauberman et al 2009). We suggest that this individual difference variable that may help us understand mortgage behavior. Second, we examine a framework that allows the discount rate to vary over time in both our analytical and empirical analysis, employing models consistent with evidence that discount rates decrease over time (Frederick, Loewenstein and O'Donoghue 2002, Loewenstein and Thaler 1989). Thus, we apply a model with two components of *individual* time preference: first, the long-term exponential discount rate used in standard models, but varying across individuals. Second, we model present bias, reflecting an individual's tendency to overvalue immediate outcomes (Laibson 1997; Phelps and Pollak 1968).

Non-constant discount rates have an important implication: Decision-makers can exhibit intertemporal preference reversals, making choices they later regret (Hoch and Loewenstein 1991). This suggests it might be useful to look at mortgage choices as a sequence of decisions. We simplify the continuing sequence of mortgage decisions by classifying them into two categories: The first is the initial *mortgage choice* choosing among types of offerings, the amount mortgaged, and interest rate structure. The second is *mortgage management*, consisting of the ongoing decisions such as whether to make early, on-time or late payments, to secure further financing through second mortgages or home-equity loans, or terminate the mortgage by refinancing or by abandoning a mortgage entirely. If time preferences change over time, a mortgage holder might regret the consequences of their previous mortgage choice. This can

occur because factors like changes in housing prices, or income, but our focus on changing discount rates suggests such dissatisfaction might also occur because of changing time preferences over the life of the mortgage. In this paper, we study the effect of time preferences across both initial mortgage choice and subsequent mortgage management, but focus on two choices: the initial mortgage selection and the decision to abandon a mortgage following a negative housing shock, a decision known colloquially as walking away.

As a preview, we explore three major changes to the way we think about mortgage behavior. First, we examine how systematic individual differences affect the initial choices of mortgages. Our model suggests that these differences will affect mortgage choice and we examine this relationship using a large national survey of a representative sample of households that contains questions about time and risk preferences. Second, this model of time preferences suggests partitioning these individual differences into two components: long-term discounting and present bias, which we show to have, at times, opposing effects on choice. We examine these effects on mortgage choice by conducting a survey that uses an adaptive estimation of these two distinct components of time preference. We also gathered self-reports about various mortgage behaviors, supplementing this data with administrative data about prices for houses and bank policies. Finally, since mortgage choice and management are dependent decisions we examine, using both our survey and an analytical model, the role of time preferences in mortgage choice and abandonment. The next section outlines recent developments in behavioral time preferences in more detail.

INDIVIDUAL DISCOUNT RATES, PRESENT BIAS AND MORTGAGE CHOICE AND MANAGEMENT

Individual Differences in Discount Rates

Starting with the classic work of Mischel, Ebbesen and Zeiss (1972), work in both psychology and economics has shown that differences in discounting is associated with a wide range of life-altering choices. Personal discount rates correlate with many life outcomes including smoking, body-mass index, savings towards retirement, and credit card debt (Chabris et al. 2008; Reimers et al. 2009). One recent paper reports that refusing an immediate outcome in a single item at age 13 was associated with a number of life outcomes: 0.20 standard deviations higher GPA, 5.3% greater likelihood to complete college, and when measured three decades later, an 11% increase in wages, 15% fewer days of unemployment, and 0.9% lower likelihood of death before 50, even when controlling for parental income, education, and other socioeconomic factors (Golsteyn, Grönqvist and Lindahl 2013).

Along with these long-term longitudinal results, there is recent cross sectional work in economics linking experimentally elicited time preferences with real-world credit (Meier and Sprenger 2011) and savings (Ashraf, Karlan and Yin 2006; Sutter, Rutzler and Trautmann 2013; Tanaka, Camerer and Nguyen 2010). This suggests that in the domain of mortgage choice and maintenance, examining time preferences may be useful.

Present Bias and Long-Term Discounting

Historically, most work looking at time preference and mortgage choice has used a standard Discounted Utility model. In this model, choice options are represented as (x, t), meaning a reward x that is consumed at time t, or t periods (e.g., days or years) from now. In Discounted Utility, $U(x,t)=v(x)d(t)$, and assumes that the discount function, $d(t)$, is exponential.

In contrast, empirical findings suggest that discount rates change over time: While most

respondents prefer, say \$60 now over \$64 in 4 weeks, many prefer the \$64 in 6 weeks over \$60 in 2 weeks. Note that the only change in these two choice sets is the addition of 2 weeks to all delays, and suggesting that the immediately available outcome, the \$60 now in the first choice is weighted more heavily relative to the \$60 in the second. To model this *present bias*, a quasi-hyperbolic time discount function (QTD, Angeletos et al. 2001; Benhabib, Bisin and Schotter 2010; Laibson 1997; O'Donoghue and Rabin 2001) places more weight on the initial period through the utility function:

$$U(x,t) = v(x)d(t), \text{where } d(t) = \begin{cases} 1 & \text{for } t = 0 \\ \beta\delta^t & \text{for } t > 0 \end{cases}. \quad (1)$$

For $\beta < 1$, the discount function devalues all future events (where t>0) by single fraction relative to the present, a measure of present bias. The discount fraction, δ, corresponds to the individual's long-term (exponential) discount rate which devalues outcomes more when they are further in the future. We acknowledge other advances in understanding time preferences beyond the QTD model, such as invoking fixed costs in lieu of present bias (Benhabib et al. 2010) and that the "present" may refer to the earliest point in time rather than strictly "now" (Read 2001). Future research may address these other functional forms, but we will show that merely adding the additional parameter produces interesting theoretical and empirical insights.

The QTD model makes a strong prediction: Things that are attractive now, because of present bias, may be regretted later. Conversely, consumers may also regret future costs that they now willingly embrace (Kirby and Herrnstein 1995). This can be detrimental to consumers in many ways. Opportunistic firms could exploit consumers' QTD preferences by initially pricing low and inflicting heavy switching costs or back-loaded fees (DellaVigna and Malmendier 2004), a pattern enabled through popular alternative mortgage contract arrangements. Similarly, theoretical analysis suggests that given QTD preferences in the credit

market, present-biased consumers suffer welfare losses by over-borrowing and enthusiastically adopting credit arrangements that are inexpensive in the short-run but inflict expensive default penalties following inevitable repayment delays (Heidhues and Koszegi 2010; Zauberman 2003).

MODEL AND HYPOTHESES

We develop an analytical model of mortgage choice and maintenance, presented in Web Appendix A, and provide an intuition for our results by contrasting one mortgage contract, the "2 and 28" mortgage (Mayer, Pence and Sherlund 2009) to the traditional 30 year fixed rate mortgage. The 2 and 28 is an adjustable mortgage with an initial 2 year low rate (for example, 7.25 percent) followed by a 28-year adjustable rate that becomes much higher at the end of the 2-year initial period (for example 11.81 percent) set according to the London Interbank Borrowing Rate (LIBOR) (Johnson and Mayer 2011). These mortgages are termed back-loaded because they are more attractive in the short term but not the long term (DellaVigna and Malmendier 2004). Similar back-loaded mortgage instruments that move debt to later periods include home refinancing to recover equity and interest-only adjustable-rate mortgages. In contrast, mortgages such as a 30 year fixed contract are front-loaded because they typically require a significant down-payment and because the subsequent payments do not increase. In our model, back-loaded mortgages like the 2/28 should be particularly appealing to more present-biased individuals because they are more willing to trade lower upfront costs in return for greater later costs.

Our model also predicts that individuals who relatively have greater long term discounting are more likely to favor back-loaded mortgages. This is explained by a QTD model because, for homeowners who discount the future, back-loading involves smaller payments in

the early, heavily weighted periods (i.e. the first two years) and larger payments in the later periods (years 3-30).

Our model contrasts QTD time preferences to a standard baseline model that considers mortgage choice as an optimization problem conducted across the lifespan, with expectations of consumption and wealth. For example, Campbell and Cocco (2003) model the choice between a fixed rate and an adjustable mortgage for households (indexed by *j*) that maximize an objective function capturing the expected lifetime flow of discounted consumption:

$$E_{t=0}\left[\sum_{t=0}^{T}\delta^{t}\frac{C_{jt}^{1-\sigma}}{1-\sigma}+\delta^{T+1}\frac{W_{j,T+1}^{1-\sigma}}{1-\sigma}\right], \quad (2)$$

subject to household *j*'s income constraints, an exponential long-term discount rate (δ), a coefficient of relative risk aversion (σ), expected consumption amount *(C)* in each time period (*t)*, and terminal real wealth (*W*).[i] These are summed over *T* time periods representing the expected lifetime of the individual. Campbell and Cocco (2011) model mortgage default using a similar model. With exponential discounting and constant relative risk aversion, this functional form is typical of standard economic life-cycle models for savings and investing in general, and of mortgage choice in particular.

Time Preferences and Mortgage Choice

Our alternative model allows agents to vary in impatience (see Equation W3a and W3b in Web Appendix A) and to have preferences for the payments themselves rather than merely the implications of payment timing on consumption. This builds on evidence that people possess preferences for payment timing that are not explained by the effect payment has on lifetime consumption (Prelec and Loewsenstein 1998). Homeowner preferences for payment timing and impatience together yield our first hypothesis.

Hypothesis 1: Impatient agents (low β and δ) are more likely to choose mortgages that

enable them to delay payments than patient agents. For example, agents with $\beta < 1$ or $\delta < 1$ will back-load mortgages more willingly than agents with $\beta = \delta \approx 1$.

Time Preferences and Subsequent Mortgage Management

For mortgage maintenance, the picture is different. Homeowners who have chosen back-loaded mortgages have less home equity at any given point in time and are the first to owe more than the value of the house (become underwater) following negative home price shocks

If present-biased and exponential discounters have more back-loaded mortgages, at any given point in time they owe more on their mortgages than patient homeowners. For constant home values, this translates to lower home equity for impatient homeowners. If a negative housing shock erodes property values, impatient homeowners will see their home value fall below their mortgage debt before patient homeowners do. This logic is stated formally in the second section of Web Appendix A, and summarized by Hypothesis 2.

Hypothesis 2: The mortgages selected by impatient agents (low β and δ) are more likely to be underwater following negative housing market shocks.

Time Preferences and Strategic Default

Present bias and discounting have opposing implications for strategic default once underwater. Our model suggests present-biased people are less likely to say they will walk away from their underwater properties. The intuition behind this argument is that more present-biased people will overweight the immediate costs of moving such as finding a rental, removing children from schools, etc. In contrast, our model suggests that homeowners who discount strongly over the long term are more willing to default because they ignore the distant prospect of fully owning the home, a result consistent with past literature (Meier and Sprenger 2011).

Homeowners who discount more over the long term tend to favor defaulting because

defaulting involves the loss of the residual value of the home after mortgage payments have been made, a prospect that matters less when the distant future is discounted heavily (Meier and Sprenger 2011). In contrast, under quasihyperbolic models of time preferences (DellaVigna and Malmendier 2004, 2006; Laibson 1997), present-biased individuals overweigh immediate consequences relative to future consequences. In the decision about whether to default, present-biased homeowners find staying in the home to be more attractive because they overweight negative immediate term consequences (such as social stigma and experiencing negative affective reactions of the loss of one's home) and underweight positive medium-term consequences of moving (such as reduced housing payments) and long-term consequences (such as loss of the residual value of the home. Consequently, our model suggests that present bias and discounting will have opposing effects with strategic default, an intuition that we state formally in Web Appendix A equations W4-W8 and summarize as Hypothesis 3.

Hypothesis 3: Homeowners who discount the future over the long-term more (low δ) are more likely to default on their mortgages while present-biased homeowners (low β) are less likely to default.

We test these three central hypotheses through two studies. The first uses a nationally syndicated survey that includes a basic measure of time preferences and allows us to test whether impatient homeowners select mortgages with delayed payment plans (Hypothesis 1). The second uses a more sophisticated measure examining both present bias and long-term discounting and looks at both mortgage choice and intents to abandon a mortgage (Hypothesis 2 and 3). We close by examining the implications of the results for both lenders and public policy.

STUDY 1: DOES IMPATIENCE LEAD TO CHOOSING BACK-LOADED MORTGAGES?

Our first analysis tests the relationship between time preferences and mortgage choice in a nationally representative survey sample. We added a measure of overall impatience to a large commercial survey of a nationally-representative sample of US households to examine if impatient homeowners were more likely to select back-loaded mortgages. In particular, we looked at two indicators of back-loading mortgage payments, namely, having an adjustable-rate mortgage and having mortgages that allow interest-only payments that do not reduce the total outstanding mortgage debt. Both of these forms of mortgage back-loading are fairly common: according to the nationally representative sample we analyze, data 13% of mortgaged US homeowners have adjustable-rate mortgages and 18% have or had interest-only loans. Consistent with Hypothesis 1, we found more mortgage back-loading among impatient homeowners.

Method

Strategic Business Insights' (SBI) MacroMonitor is nationally-representative[ii] survey of US households' financial decisions and included in 2010 at our request, a time preference elicitation similar to measures widely used in economics (where it is called a price list) and psychology (where it is termed a titrator). Given limitations on administrative time, this item does not decompose time preferences into present bias and long-term discount rates but it does allow the estimation of each respondent's yearly discount fraction based on his or her hypothetical choices between $100 today and an increasing series sums ($110, $125, $150, $175, $200, $225) in twelve months. Since in our model present bias and long-term discount rates have the similar effects on mortgage choice, we can test this hypothesis using this single compound parameter. We estimated each respondent's yearly discount fraction based on the rate

corresponding with the midpoint between the smallest delayed payment accepted and largest delayed payment rejected.

The SBI data set also asked about homeowners' mortgage characteristics, including whether the loan had an adjustable or fixed interest rate, whether it had an interest-only period, the initial amount borrowed, the current amount owed on the mortgage and the length of the mortgages and many other financial characteristics. We first validated whether loans with adjustable-rate mortgages were more back-loaded than fixed-rate mortgages. We then ran a series of survey-weighted logistic regressions to assess the relationship between the impatience estimate and the two indications of back-loading, that is, having adjustable-rate mortgages and interest-only mortgages.

As a robustness check we added a series of controls to the analysis of the SBI data. First, we controlled for loss aversion, also measured using a similar titrator as that used for time preferences (Fehr and Goette 2007). Second, we controlled for demographic factors including income, marital status, gender, age and education, as well as the year in which the home was purchased. Third, we controlled for measures of liquidity including checking account balance, savings account balance and credit card balance, each as a fraction of income, along with net worth. Finally, we simultaneously controlled for all of these factors.

Results

Our data allow us to test if impatient households were more likely to have back-loaded mortgages, in support of Hypothesis 1. To test this hypothesis, we ran logistic regressions on the probability of choosing a back-loaded mortgage. Consistent with Hypothesis 1, impatience is associated with an increase in probability. Table 1 shows results from a series of logistic regressions relating impatience with adjustable-rate mortgages using the survey sampling

weights. Across regressions, for each 10% decrease in the discount fraction (i.e. increase in impatience), the likelihood of having an adjustable rate mortgage increases by roughly 15%. This result is largely consistent across models with controls including measures of income and education, measures of credit card debt, checking account balances and savings balances and net-worth. These predictors are not significant, suggesting that differences in borrowing ability do not affect the choice of an adjustable rate loan in our sample, once the effects of time preferences are included in the model. Loss aversion, age, and gender also have no effect. Including fixed effects for purchase year does not change the effect of impatience, suggesting that the effect of impatience is unrelated to changes in the characteristics of mortgage buyers across time. The only significant variable is the marital status: Married couples are more likely to choose a fixed rate mortgage.

Table 2 shows a similar analysis relating impatience with interest-only mortgages. The results for discount rate are similar: For each 10% decrease in the discount rate (i.e. increase in impatience), the likelihood of having an interest only loan increases by roughly 15% across specifications. This effect survives the inclusion of identical controls of the adjustable-rate mortgage analysis. However, several controls now predict the choice of such a mortgage, including being younger, male, and having more credit-card debt.

We verified that adjustable and interest only mortgages represent back-loaded contracts by examining other characteristics and repayment status of these two mortgage types, relative to fixed rate mortgages. As expected, adjustable rate mortgages involve borrowing more initially ($M_{adjustable}$ = \$233,583 versus M_{fixed} = \$174,913; $F(1, 2012) = 39.16$, $p < 0.0001$), owing more currently ($M_{adjustable}$ = \$206,043 versus M_{fixed} = \$147,123; $F(1, 1990) = 42.19$, $p < 0.0001$), and having a smaller fraction of the initial amount borrowed paid off ($M_{adjustable} = 0.16$ versus M_{fixed} =

0.19; $F(1, 1983) = 4.14$, $p = 0.04$). The two mortgage types had the same duration ($M_{adjustable}$ = 24.4 years versus $M_{fixed} = 24.7$; $F(1, 2059) = 0.24$, $p = 0.63$) and had the same average origination date ($M_{adjustable} = 2003.4$ versus $M_{fixed} = 2003.9$; $F(1, 2055) = 1.84$, $p = 0.18$). Similarly, interest-only mortgages also involve borrowing more initially involve borrowing more initially ($M_{interest\text{-}only}$ = \$252,833 versus $M_{principal\text{-}paying}$ = \$181,409; $F(1, 1487) = 49.11$, $p < 0.0001$), owing more currently ($M_{interest\text{-}only}$ = \$229,350 versus $M_{principal\text{-}paying}$ = \$153,002; $F(1, 1472) = 58.30$, $p < 0.0001$), and having a smaller fraction of the initial amount borrowed paid off ($M_{interest\text{-}only} = 0.15$ versus $M_{principal\text{-}paying} = 0.19$; $F(1, 1468) = 3.60$, $p = 0.058$). Interest-only and principal-paying mortgages had the same duration ($M_{interest\text{-}only}$ = 25.6 years versus $M_{principal\text{-}paying}$ = 24.8; $F(1, 1518) = 1.72$, $p = 0.19$) and the same average origination date ($M_{interest\text{-}only} = 2004.5$ versus $M_{principal\text{-}paying} = 2004.1$; $F(1, 1513) = 1.17$, $p = 0.28$). Thus, while both interest-only and adjustable-rate mortgages are back-loaded, they are of similar duration (and vintage) as fixed rate mortgages.

--- Insert Tables 1 and 2 around here ---

Discussion

Together, these results show strong support for Hypothesis 1, demonstrating that impatient homeowners are more likely to have back-loaded mortgages. In particular, impatient homeowners are more likely to have adjustable-rate mortgages and to have or have had interest-only loans. Both of these results are robust to the inclusion of several controls. In addition, we note that the current status of the back-loaded mortgages is consistent with Hypothesis 2: Because they owe more on their housing than those with fixed rate mortgages, they would be more vulnerable to a decrease in housing prices and more likely to have negative equity in such an event.

While the use of a large-scale representative sample is a strength of this data, these surveys allow limited time for responses, requiring an abbreviated measure of time preferences. In Study 2 we are able to use a more sophisticated estimation of time preference assessing both long-term discounting and present bias. Study 2 attempts to replicate Study 1's findings relating time preferences to mortgage choices, extend the results to both present bias and personal discount factors and examines mortgage management. To do this we turn from an existing survey to a custom survey augmented with administrative data.

STUDY 2: HOW DO TIME PREFERENCES AFFECT MORTGAGE CHOICE AND MANAGEMENT?

Study 2 combined measures time preferences and mortgage management with market-level real estate variables provided by commercial sources. While the sample is not nationally representative, Study 2 does allow for the inclusion of a larger set of measured potential controls including risk attitude, financial literacy, social contagion, and moral beliefs. Our survey also decomposes time preferences into present bias and long-term discounting, allowing us to test our third hypothesis. Additionally, we analyzed the results using a series of structural equations in order to independently test the effects of time preferences on negative home equity (Hypothesis 2) and strategic default (Hypothesis 3).

Survey

We administered an Internet survey to 244 mortgaged US homeowners, of which 120 were underwater and 124 had positive equity, between April 15, 2010 and May 2, 2010. The survey took roughly 40 minutes to complete on average. These individuals were drawn from a

panel of research volunteers maintained by Columbia's Center for Decision Sciences. Using a screening questionnaire embedded in other unrelated studies administered to roughly 2,000 people, we identified 750 potential participants who owned a home in the United States and had a nonzero mortgage debt. We invited five hundred to participate in this study. Because having negative equity was an event of particular interest and underrepresented in the population, we oversampled this category to create a roughly even split of underwater and non-underwater homeowners.[iii]

Homeowners answered a series of questions about themselves, their home and their financial status. As described in more detail in Web Appendix B, to control for several alternate explanations we collected information about individual differences in evaluation of prospects, present-biased time preferences, participants' debt literacy, and cognitive reasoning. Participants were compensated $12 for their time, plus 1 in 100 participants were given outcomes up to $150 depending on their choices in the risk and time preference elicitation tasks making these incentive-compatible.

After orienting participants to the common concepts and terminology surrounding mortgage maintenance choices, participants were presented with two clear, if simplified, options: (1) to allow the bank to foreclose on the house and move into a rental unit, or (2) continue to make mortgage payments and stay in their current home. Through an adaptive titrator we elicited willingness to default as the amount of home would need to lose in value for the respondent to walk away from the mortgage, which we term the "walk-away value."

We then asked a number of questions characterizing the respondent's financial situation, their mortgage and demographic characteristics. We administered Lusardi and Tufano's three-item debt literacy scale (2009) and Frederick's three-item cognitive reflection task (2005). At

the end of the survey we estimated quasi-hyperbolic time discounting (QTD) parameters (present bias and long-term discounting, respectively measured as 1-β *and 1-*δ*)* and cumulative prospect theory parameters (CPT), (probability distortion, loss aversion and diminishing sensitivity, measured as α, λ, σ) through two adaptive, incentive-compatible questionnaires developed and discussed by Toubia et al. (2013).

While self-reports may have weakness relative to administrative data, survey data allows us to directly assess individual-level characteristics such as time preferences and financial knowledge, as well as to forward-looking outcomes such as intentions to walk away from a mortgage.[iv] Further, we can use zip-code estimates based on administrative data to both validate the self-reports and to serve as additional controls. We use two sources of zip-code level data. The first, provided by Zillow.com, includes current median home price for each zip code, the median home price when the home was purchased and price at the peak of the housing market. Zillow prices have been widely used by real estate economists (e.g. Mian and Sufi 2009), and we validated our self-reported home prices against the zip-code level home prices obtained from Zillow.com to find that the measures correlate 0.47. Secondly, to further control for the local market environment we supplemented the self-reports with zip-code level foreclosure and shortsale rates, obtained by BlackBox Logic LLC. The resulting data set combining self-reports, individual traits and market-level statistics allowed us to evaluate the relationship between time preferences and mortgage choices while controlling for a number of individual and market-level factors.

Results

We organize our results as follows: First we present basic statistics for the measures and examine the validity of the self-report measures. After discussing our analysis strategy, we

examine Hypothesis 1, the relationship between time preferences and mortgage choices. We then examine the relationship between time preferences and the mortgage management choices, as reflected both in the equity position of the home (Hypothesis 2) and homeowners' willingness to walk away from an underwater mortgage (Hypothesis 3). In this analysis we control for value and risk, cognitive abilities and knowledge, and various demographic and market-level variables. Finally, we examine of alternative variable specifications, and discuss alternative explanations of the results.

Descriptive statistics and validation. Table 3 provides descriptive statistics (mean and standard deviations) characterizing the sample and their home equity and debt choices.[v] Homeowners owed, on average, $228,904 on homes worth $277,507. The current value of the homes is a net loss from home purchase prices which averaged $315,246, on which the homeowners initially borrowed $286,906. The statistics are separated for each group of measures by mortgage equity status. People classified as underwater owe, on average, more than $14,368 on their home than its current value, or are approximately 5.3 percent underwater. In contrast, positive equity homeowners' homes are valued at $110,474 (38%) more than their debt. We find time preference, value, and risk parameters are comparable to prior studies using different, non-adaptive techniques and different samples (See Toubia et al. (2013) for a more extensive discussion). To compare our sample with the larger population of US homeowners, we compared our respondents to the representative sample of US households from Study 1. We compared the characteristics of our sample to those from the SBI sample that carry mortgage debt. Table 3 suggests that our sample is reasonably similar to the nationally representative sample. The two have similar home values, but the SBI respondents have smaller mortgages, have owned their homes longer, are older, and less educated.

We next examined the validity of the self-reports of underwater status. While it might be preferable to employ archival data for some measures, they are not always preferable. First, homeowners' choices are based on their perceptions of their home values and contract terms, which often do not match reality (Bucks and Pence, 2008; Henriques 2013). Second, our measures of underwater status seem both reliable and valid. During the prequalification survey and again during the main survey, subjects were asked to assess whether they owed more in mortgage debt than the current market value of their home. Sixty percent of respondents gave exactly the same rating on a 5-point scale, and the two ratings had a 0.76 correlation (Cronbach's alpha=0.865). We averaged these ratings for our measure.[vi]

--- Insert Table 3 around here ---

Mortgage choice and time preferences. We replicate the results from Study 1 in support of Hypothesis 1, the direct effect of time preferences upon mortgage choice. This suggests that mortgage-related decisions involving the acceleration of benefits and the delay of costs will be associated with time preference. We find that there is a relationship between time preferences, but particularly present bias, which is associated with several different back-loading measures, as shown in Table 4. In the selection of the original mortgage, homeowners with stronger present bias are more likely to have borrowed a larger portion of the cost of their home (p=0.001) and are more likely to have an adjustable mortgage (p=0.006). More present bias is also associated with a greater likelihood of having a second mortgage on the home (p=0.034), and with spending a larger fraction of income paying the mortgage (p=0.035). In contrast, long-term discounting (delta) is generally unrelated to these mortgage choices (ps > 0.15). These preliminary results emphasize the potential importance of partitioning time preferences and are consistent with the idea that present bias plays a large role the results of study 1.

--- Insert Table 4 around here ---

Estimation. We next turn to testing the effect of time preferences on multiple interrelated aspects of mortgage maintenance, in particular, negative home equity (Hypothesis 2) and strategic default (Hypothesis 3). These two decisions are financially interdependent. For example, someone who borrows more in an initial mortgage increases the payments that they must make regularly, increases their risk that their home may be worth less than the amount owed, and may be more willing to default on their loan which has less equity. We want to test the relationship is between the two components of time preferences and underwater status and the decision to strategically default on the mortgage. The estimation challenge is that underwater status is related to home equity position which should be a strong predictor of mortgage abandonment. Since home equity status influences willingness to walk away, we estimate two simultaneous equations using the three-stage least squares procedure developed by Zellner and Thiel (1962).[vii] The reduced-form equations characterizing the mortgage choices leading to underwater status and willingness to walk away for individual *i*, are:

(3) $$underwater_i = \beta_0 + \beta_{u1} * beta_i + \beta_{u2} * delta_i + \varepsilon_{ui}$$

(4) $$walkaway_i = \beta_0 + \beta_{w1} * beta_i + \beta_{w2} * delta_i + \beta_{w3} * posequity_i + \beta_{w4} * negequity_i + \varepsilon_{wi}$$

In other words, an individual homeowner's underwater status, $underwater_i$, is a function of present bias (β_i) and long-term discounting (δ_i), while the homeowner's willingness to walk away is a function of their time preferences and their degree of positive or negative equity. Note that $posequity_i$ and $negequity_i$ are expanded forms of $undewater_i$, focusing respectively on the amount of home value in excess of, or shortfall relative to mortgage debt. Consequently, error terms ε_{wi} and ε_{ui} are correlated, and as ε_{ui} influences $underwater_i$, under

simple OLS regression, $posequity_i$ and $negequity_i$ are not independent of ε_{wi}. Since OLS regression would produce biased estimates, we estimate the equations simultaneously through 3SLS. Analysis with OLS regressions revealed similar relationships between time preferences and all our outcome measures.

Under our simplest model, we simultaneously estimate the relationships between the individual time preferences (β_i and δ_i) and the endogenous mortgage factors, $underwater_i$ and $walkaway_i$. Because there are at least as many exogenous factors as endogenous factors being estimated, $underwater_i$ and $walkaway_i$ are identifiable.

The remaining analyses control for local real estate fluctuations and liquidity constraints. We add to equation 3 the fractional change in local housing prices from Zillow and the fraction of the household's income spent on the mortgage (mortgage burden). Equation 4 includes local real estate foreclosure and short sale trends and mortgage burden. Model 2 also includes mortgage year fixed effects intercepts to test for changes in bank lending policy and Model 3 considers debt literacy as a precursor to underwater status as well as social and moral considerations in the decision to walk away. Model 4 examines the potential confounding effects of risk preferences in each equation, as reflected in the Prospect theory parameters, probability sensitivity, diminishing value sensitivity and loss aversion, while Model 5 controls for employment security and cognitive reasoning in each equation, plus expectations about and confidence in the local housing market.

Underwater status and time preferences. Table 5 presents the results of our three-stage least-squares analyses of underwater status with various controls. Consistent with Hypothesis 2, Model 1 indicates that homeowners with strong present bias (lower β) or who underweight outcomes in future time periods (lower δ) are more underwater. Models 2-5 suggest this result

persists after accounting for the effects of several descriptors of individuals' economic condition, knowledge and skill, and other preferences as well as market-level events. In the following regressions, all continuous covariates are mean-centered.

--- Insert Table 5 around here ---

Model 2 and those that follow add two controls. The first, based on data provided by Zillow.com, employs a variable representing zip code-specific real estate market change in price since the property's peak estimated value. This controls for the possibility that the observed time preference effects are the result of the choice of the houses or neighborhood. As expected, this has a significant effect on being underwater. Similarly, entering the proportion of income servicing the mortgage (based upon the respondent's answers to income and mortgage payment questions) is a significant predictor of being underwater, with those devoting more of their income to servicing the mortgage more likely to be underwater. This controls for the liquidity of the household. It might be that households that are strapped for cash become present-biased or that time preferences influence other financial choices that constrain the range of mortgage choices available to the household. However, both present bias and long-term discounting remain significant in the presence of these controls, suggesting that time preferences matter independent of real estate choice and financial demands of the mortgage. Additionally, this model includes fixed effects for each purchase year, which rules out a possible confounding by mortgage year in the relationship between time preferences and underwater status.

Model 3 controls for knowledge about debt, a variable shown to predict the cost of credit card borrowing (Lusardi and Tufano 2009) but which is insignificant in this context. Model 4 adds the three prospect-theory variables to Model 2 and shows that loss aversion, diminishing sensitivity, and probability distortion do not relate to being underwater. Finally Model 5 controls

for a questionnaire-based measure of the ability to suppress impulsive answers, the Cognitive Reflection Task (CRT), and for self-reported employment security to control for optimism in future income. None of these controls are related to being underwater. The CRT result is particularly important, since CRT is associated with discounting in other studies (Frederick 2005).

Together, these analyses suggest that: 1) both measures of time preference predict mortgage management choices leading to underwater status: More present bias and greater impatience are associated with being underwater; 2) this result is likely not driven by the other variables related to the real estate and constraints that may be affected by or affect intertemporal discounting; and 3) the finding is robust after controlling for non-linearity in probabilities and value, and loss aversion, and for differences in abilities, optimism and knowledge.

Walking away and time preferences. The second part of our simultaneous estimation explores the factors that explain underwater homeowners' willingness to walk away from paying their mortgage. Respondents reported the price they believed that their home could be sold for in the current housing conditions.[viii] We then asked subjects to report whether they would continue to pay their mortgage given that their home value declined from this value. In this context, willingness to walk away is the size of the further change in the resale price of the home, a negative amount, necessary for the homeowners to stop paying the mortgage. Hence when this measure has a slightly negative value, a homeowner is quite willing to walk away. A more negative value corresponds with a greater willingness to stay. Thus this measure increases with willingness to walk away.

Recall that Hypothesis 3 suggested that more present-biased individuals would be less likely to walk away because the immediate costs of walking away loom large, while individuals

who discount the future more over the long-term would be more likely to walk away because the mortgage payments are weighed heavily. Table 6 summarizes five versions of the simultaneous estimation that demonstrate that present bias and long-term discounting have opposite relationships with walking way intentions. These are again robust to the determinants of individual-level Prospect theory parameters, and relevant demographic, economic, and market-level controls.

-- Insert Table 6 around here –

All models estimate separate coefficients for positive and negative equity, since we note that negative equity alters the financial consequences of foreclosure, and consequently homeowners might be more willing to walk away from an underwater home. Model 1 reports these coefficients as well as coefficients for present bias and long-term discounting. In this specification, present bias and heavy discounting of future periods have opposite effects on willingness to walk away in response to negative housing price shocks. Present bias is associated with greater willingness to stay in a home that is further underwater (p=0.026), while the discount fraction is associated with greater willingness to walk away (p=0.023). This predicted relationship in the opposite direction occurs despite the positive (.54) correlation between the two components of time preference and reflects the advantages of staying in the immediate term (e.g. avoiding social stigma, moving costs and realization of the unfortunate financial position). While sizable, this correlation allows the estimation of separate effects for the two components of time preference. As might be expected, the slight tendency for present bias and long-term discounting to have opposite effects on walking away is increased when the effect is jointly estimated, as in the first regression.

Model 2 and those that follow add two controls. First, based on data from BlackBox, the

model controls for market-level factors outside the control of the homeowners, namely, the proportion of the zip code's houses that are currently in short sale, and the fraction in foreclosure. Second, it controls for financial constraints by including the proportion of the homeowner's income servicing the mortgage. Notably, our results suggest that homeowners are more likely to continue paying in zip codes with more foreclosures, and more likely to walk away in zip codes with more short sales. Finally, Model 2 also includes mortgage year controls, suggesting that the intention to walk away is not driven by when the home and mortgage were selected. However, the effects of present bias and long-term time discounting remain significant and largely unchanged.

Model 3 adds a measure of the perceived morality of walking away and a measure of the social distance between the homeowner and someone who has strategically defaulted to capture social contagion (Guiso, Sapienza and Zingales 2010; White 2010). Neither variable is significantly related to intention to walk away. Model 4 included, instead, the individual-level prospect-theory parameters. This revealed a marginal and unexpected result that more loss-averse people are marginally more likely to walk away, but the effects of present bias and long-term time discounting on walk-away intentions are largely unchanged.

Finally, Model 5 assesses an alternate explanation that overconfidence in the local housing market discourages walking away future income similarly to how overconfidence in future income may encourage excessive borrowing. Browning and Tobacman (2007) note that choices motivated by time preferences can at times be indistinguishable from optimism about future income and income smoothing by time-consistent homeowners. This account would predict that employment security, and expectations about and confidence in the local housing market, which are negatively related to walking away, would fully account for the effect of time

preferences on walking away. We find that controlling for these factors[ix], along with the unrelated Cognitive Reflection Task, both present bias and discounting remain significant predictors of walking away.

In sum, our results suggest that time preferences, in addition to being linked to underwater status, are linked with willingness to walk away from one's mortgage. Unlike with underwater status, present bias and long-term discounting have opposing relationships with walking away, despite a high positive correlation between present bias and long-term time discounting. These results are not explained by the local housing environment, liquidity constraints, components of risk aversion, cognitive reasoning ability, debt literacy, overconfidence, nor other demographic controls.

Robustness Checks and Alternative Explanations

We have shown that the results seem to be robust in the presence of several controls. In this section we test the robustness of our results by discussing three additional potential concerns. First, we test alternate specifications of present bias, accounting for skewness in present bias. Second, we explore whether bankers' changes in bank loan approval policies explain our results. Third, we test another alternate account, namely, that time preferences affected liquidity constraints rather than the mortgage choices directly. Together, these additional tests increase confidence in our proposed account that time preferences are an important driver of mortgage and mortgage maintenance choices.

Alternate specifications of present bias and underwater status. Because present bias (1-β) is skewed, we specified a median split around β=0.94, a 75%-25% split around β=0.86 and a logit transformation. For each, we estimated the models in Table 5, and found directionally and statistically similar results. The only exception is the median split, which shows somewhat less

significant results as expected given the split loses information.

We also replicated Table 6's results relating time preferences and strategic default, restricting analysis to the sample's underwater homeowners. Despite the restricted sample size (110), we replicated the directionally opposing relationships. This suggests that the observed relationships between time preferences and strategic default is likely not because our sample included both homeowners with positive and negative home equity.

Changing bank policy as alternate explanation. We tested whether the relationship between intertemporal preferences and underwater mortgages is observed because banks approved loans less prudently in the years immediately preceding the housing market peak and made loans to people with different time preferences. We regressed years since purchase on intertemporal preference parameters and found no relationship. Additionally, as year effects might differentially impact households who mortgaged under different policy regimes, Model 2 of Tables 5 and 6 includes yearly fixed effects. While it did increase the model fit significantly, it did not substantially change the relationships between time preferences and having an underwater mortgage, or with willingness to walk away. This suggests that while there is year-to-year variation in mortgage balance and intent to strategic default, these effects are independent of time preferences.

Time preferences, liquidity and mortgage choice. Finally, as presented in Web Appendix C we tested whether liquidity constraints confound or explain the observed relationship between intertemporal preferences and default. We tested this by estimating a version of the models which included liquidity constraints as an endogenous factor. We found, in each case, that the observed relationships between time preferences, home equity and default persist in the presence of and are not explained by the relationship between time preferences and liquidity constraints.

DISCUSSION

Summary

Mortgage choice and management are both decisions with important consequences for the consumer, lenders, and the state of the economy more generally. Mortgage decisions are also prototypical of many consumer financial choices that that involve a stream of expenditures and consumption occurring across time. In this paper we focus on using heterogeneity in time preferences, particularly a present bias, to explain a sequence of decisions concerning mortgages, the selection of a mortgage that may lead to having negative equity, and the decision to abandon a mortgage. Our results suggest that a two-parameter model of time preferences is helpful for understanding how homeowners make mortgage decisions.

In mortgage choice we find that consumers with stronger present bias are more likely to have borrowed a larger portion of the cost of their home, are more likely to have an adjustable-interest-rate mortgage, and are more likely to have a second mortgage on the home. In addition, consumers who weight immediate outcomes more heavily or are more present-biased are more likely to be "underwater" with their mortgages. Similarly, those who discount the future more over the long-term are also more likely to be underwater. Furthermore, the findings do not appear to be driven by the "reverse" effect of underwater status on intertemporal discounting, nor by changes in the stringency of mortgage standards. Finally, the importance of modeling present bias and discount rate for future incomes separately is illustrated by our analysis of walking away from a mortgage. Here present bias and discount rates work, as predicted, in opposite directions. Because the costs of abandoning a mortgage are mostly in the near term, present-

biased households are more likely to continue paying a mortgage, even when there is negative equity. In contrast, more discounting of the future, beyond the present (i.e., exponential/long-term discounting), was associated with a greater willingness to walk away.

The findings are robust to the inclusion of several controls for preferences including consumer differences in probability weighting, sensitivity to value changes, and loss aversion. In addition, the findings are robust to other individual differences in debt literacy, cognitive reasoning, liquidity constraints, and demographic factors.

Caveats and Future Research

Our initial efforts to understand mortgage decisions using a more complex two-part view of time preferences are just a beginning, and our conclusions should be interpreted with several caveats in mind. In this section we discuss the implications of treating time preferences as trait-like and other caveats related to the assumptions particular to QTD time preferences.

Time preferences as state or trait? One recurring concern in this research is the direction of causality: Diminished resources may change respondents' time preferences. While we control for financial circumstances in many of our estimation procedures, and while the ability to control against immediate temptations seems to have a stable component over periods of at least a decade (Eigsti et al. 2006), future research should still examine the relationship between trait-like time preferences and short-term changes in circumstances.

A trait-like view is further supported by work in decision neuroscience pointing to systematic differences in activation of specific regions, notably the ventral striatum (Kable and Glimcher 2007). However these parameters might also be seen as convenient summaries of more complex cognitive processes because they reflect constructed as well as revealed values. The constructive component is consistent with the observation that discount rates differ across

quantities (Chapman 1996), and that discount rates differ markedly across response modes such as decisions to accelerate or delay consumption (Loewenstein 1988; Weber et al. 2007), or have other context dependent components.

Such a constructive process view suggests possible interventions, particularly combined with the observation that present bias has different roles in mortgage choice and in walking away. In particular, individuals seem to be making decisions that, when viewed jointly, may be problematic. In the first case, overweighting short-term benefits leads them to make mortgage choices that put them at great risk of being underwater and perhaps foreclosure. In the second, they are unlikely to walk away from that mortgage, despite the economic incentives to do so. Both decisions might benefit from the suggestion that decision-makers "frame the future first," by framing intertemporal choices as decisions in an accelerate frame (Weber et al. 2007). This intervention might help this at-risk group to avoid bad mortgages in the first place, and to walk away if warranted.

Sophistication, mental accounting and "now." Traditional economic models assume long-term discounting and integration over all future time periods. In contrast, our approach assumes that consumers may treat periods more separately. This is consistent with the notion made popular by the term "mental accounting" (Thaler 1999; Thaler and Johnson 1990), suggesting that not all expenditures are considered together. It is also consistent with the idea that consumers bracket transactions narrowly (Read, Loewenstein and Rabin 1999). However, more research is needed to understand the representation used by consumers when faced with these choices. Similarly, our analysis makes significant use of non-monetary costs such as moving and search costs, and emotional attachment to the neighborhood. We do not, however, explicitly measure these. We measure preferences for money over time and elements of risk

taking but do not measure preferences over other non-monetary costs. Each of these could be addressed by future research.

Our analysis assumes that homeowners are unsophisticated and do not anticipate their future impatience as discussed by O'Donoghue and Rabin (2001) and others. In other words, our analysis supposes that homeowners are, in this context, naive in their time preferences. While our results are consistent with models of consumers who tend to repay more slowly than they expect, such as in Heidhues and Koszegi (2010), future work might consider the mortgage choices given varying levels of homeowner sophistication.

The opposing effects of present bias. One intriguing result of our model, supported in Study 2, is that present bias tends to lead to the choice of an inferior mortgage but also to leads to staying in this state. This suggests that present bias hurts for two reasons: People make bad choices and do not abandon them. A similar logic and empirical results exist in the job search literature (DellaVigna and Paserman 2005). This result is quite interesting, but also serves to limit the kinds of alternative explanations that can account for the current data. For example, simple third variable explanations, like differences in liquidity cannot easily explain the opposite relationships of present bias and long-term discounting with willingness to walk away. This account is also not supported in the supplementary analysis with endogenous liquidity. Broadly, one might be concerned that a third factor drives mortgage choices and incidentally correlates with both present bias and long-term discounting. While this possibility is not completely ruled out, such an account must account for not just the main effect of time preferences, but for these distinctive reversals. More generally, the current results draw attention to the reasons why modeling both present bias and discount fractions separately might be important.

Policy Implications

Focusing on more behaviorally informed models and individual differences may be important for three reasons: first, misunderstanding time preferences may have contributed to the recent crisis in home mortgages by encouraging consumers to become more highly leveraged in a single sector of the economy and thus more exposed to negative housing market shocks. Second, understanding time preferences may help design successful interventions by structuring incentives most likely to appeal to underwater homeowners considering whether to default on their mortgage contracts. Third, understanding time preferences can shed light on all household financial choices that involve streams of expenditures and consumption over time such as retirement savings, wealth decumulation and others. In that sense, mortgage choice is a useful context to understand the implications of time preferences across a wide range of consumer financial decisions.

A decade ago, subprime mortgages like the 2/28 mortgage seemed to offer a promising route to home ownership to those unable to qualify for traditional mortgage financing. From the lender's perspective, back-loaded mortgages such as the 2/28 loan were thought to appeal to only those who are willing or able to improve their credit ratings. The argument in standard economics is that after two years of making payments and with their improved credit score, these more trustworthy borrowers would refinance into better loans. Thus 2/28 mortgages were seen as a tool that allowed consumers to repair or establish their credit, and lenders were seen as protected against adverse selection because only potential prime borrowers would select this mortgage (Mayer, Pence and Sherlund 2009). Of course, this is not how the back-loaded mortgages functioned. The promising alternatives such as 2/28 mortgages have turned out to be a nightmare, for both lenders and homeowners.

While unscrupulous or overly optimistic borrowers and lenders played a role in the

mortgage crisis, we suggest that behavioral models of time preferences may also help explain the choices made by consumers and mistaken judgments made by banks. Going forward, both lenders and government are concerned with how to prevent mortgage default. One consulting firm has recently marketed a product to banks to convince homeowners not to walk away by offering money when the mortgage is paid off (Loan Value Group 2010; RHReward.com 2010). If our analysis is correct that underwater homeowners have both greater present bias and a tendency to discount the future, this intervention is misguided, since they are the people *least* likely to be persuaded by distant payoffs. A more effective strategy, our research suggests, is a small immediate payoff when each payment is made.

Additionally, our analysis suggests that there are strong practical applications of the time preference elicitation procedure developed by Toubia et al. (2013). For example, the tool can be applied in marketing contexts to segment customers and target customers based on time preferences. Given this new source of information, marketers and policymakers could design financial products and market interventions with intertemporal incentive structures based on a better understanding of time preferences provided by the elicitation method.

To conclude, our analysis of mortgage choice and maintenance suggests principles that can be applied to many consumer decisions that, in economics, would be the province of life-cycle models. These decisions include balancing savings and retirement across the lifetime, the choice to rent or to own, and the decision to insure against longevity risk through annuities, as well as mortgage choice. Our results suggest that ideas that are central to marketing, individual differences and market segmentation tools, particularly when applied to the behavioral economic concepts of present bias and personal discount rates, would help us understand a broad range of consumer financial decisions.

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FOOTNOTES

[i] Campbell and Cocco refer to δ and σ as β and γ, respectively, but the variables are labeled differently here for consistency with notation from prospect theory and quasi-hyperbolic discounting.

[ii] SBI's MacroMonitor survey is, in turn, validated through the Survey of Consumer Finances and the Flow of Funds report by the US Federal Reserve's Board as well as internal wave-to-wave validation

[iii] Though we cannot directly assess how oversampling underwater homeowners affected the results of Study 2, we note that the oversampling process was blind to our hypotheses, rendering the sample a reasonably arbitrary domain to test the hypotheses.

[iv] Consumer finance studies increasingly utilize survey data (Graham and Harvey 2001). Since the current level of negative equity has no recent equivalent, attempts to understand the consequences of the crisis using only econometric analysis of administrative data must wait years.

[v] For more information, Web Appendix D contains descriptions, sources and levels of all variables, as well as a correlation matrix of the main variables of interest.

[vi] The subjective home valuations correlated 0.47 with Zillow's zip-code level median home prices, and the measures were not significantly different (difference = $2,382, two-tailed $t(166)=0.1366$, $p=0.89$). This suggests the subjective measures are relatively accurate and unbiased.

[vii] Independent OLS estimations are not appropriate as the residual from equation 3 is a significant predictor when inserted into equation 4 ($p<0.03$). The 3SLS estimates are not materially different from seemingly unrelated regression under this system of equations.

[viii] The subjective home valuations correlated 0.47 with Zillow's zip-code level median home prices, and the measures were not significantly different (difference = $2,382, two-tailed $t(166)=0.1366$, $p=0.89$). This suggests the subjective measures are relatively accurate and unbiased.

TABLES

Table 1. Impatience and Adjustable-Rate Mortgage Choice

	(1)	(2)	(3)	(4)	(5)
1-Year Impatience (1-βδ)	1.76** (0.67)	1.54* (0.65)	1.48* (0.71)	1.76* (0.68)	1.24† (0.68)
Loss Aversion		0.027 (0.03)			0.03 (0.03)
Income ($100,000s)			0.00 (0.16)		0.06 (0.17)
Married			0.50* (0.26)		0.56* (0.26)
Gender (1=male)			-0.18 (0.23)		-0.08 (0.24)
Age			-0.00 (0.01)		-0.01 (0.01)
Has bachelor's degree			-0.33 (0.29)		-0.32 (0.28)
Has graduate degree			0.13 (0.29)		0.13 (0.29)
Credit card debt to income				-0.26 (0.64)	-0.12 (0.40)
Checking account balance to income				-0.52 (0.72)	-0.14 (0.38)
Savings account balance to income				0.09 (0.31)	0.43 (0.33)
Net Worth ($m)				0.00 (0.08)	-0.01 (0.12)
Intercept	-1.92*** (0.11)	-1.94*** (0.11)	Purchase Year Fixed Effects	-1.92*** (0.11)	Purchase Year Fixed Effects
N	1992	1982	1821	1992	1813
Pseudo R-sq	0.01	0.01	0.09	0.01	0.09

Note: Survey-weighted logistic regression, continuous measures centered.

*** p<0.001; ** p<0.01; * p<0.05; † p<0.10.

Table 2. Impatience and Interest-Only Mortgages

	(1)	(2)	(3)	(4)	(5)
1-Year Impatience (1-βδ)	1.45** (0.53)	1.39* (0.56)	1.48* (0.59)	1.54** (0.54)	1.58** (0.60)
Loss Aversion		-0.02 (0.03)			-0.01 (0.03)
Income ($100,000s)			-0.03 (0.16)		-0.15 (.17)
Married			-0.18 (0.23)		-0.22 (0.23)
Gender (1=male)			0.42† (0.22)		0.41† (0.22)
Age			-0.02* (0.01)		-0.02* (0.01)
Has bachelor's degree			-0.35 (0.26)		-0.34 (0.26)
Has graduate degree			0.34 (0.29)		0.35 (0.28)
Credit card debt to income				-2.33** (0.88)	-2.46* (1.01)
Checking account balance to income				-0.54 (0.69)	-0.35 (0.63)
Savings account balance to income				-0.37 (0.40)	-0.22 (0.38)
Net Worth ($m)				-0.01 (0.07)	0.08 (0.07)
Intercept	-1.49*** (0.10)	-1.51*** (0.11)	Purchase Year Fixed Effects	-1.54*** (0.10)	Purchase Year Fixed Effects
N	1679	1673	1564	1679	1560
Pseudo R-sq	0.01	0.04	0.08	0.02	0.09

Note: Survey-weighted logistic regression, continuous measure centered.

*** p<0.001; ** p<0.01; * p<0.05; † p<0.10.

Table 3. Descriptive Statistics, by Home Equity and Comparable Values of a National Sample.

Mean St. Dev.	Total Sample (n=244)	Under Water (n=120)	Positive Equity (n=124)	SBI Respondents with Mortgage Debt**
A. Demographics				
Age	39.8 (10.8)	37.8 (8.38)	41.7 (12.5)	50.6 (13.5)
% Male	0.34 (0.47)	0.37 (0.48)	0.31 (0.47)	0.47 (0.50)
% White	0.82 (0.39)	0.78 (0.42)	0.85 (0.35)	0.78 (0.41)
% With Bachelor's Degree	0.67 (0.47)	0.64 (0.48)	0.70 (0.46)	0.43 (0.50)
% With Graduate Education	0.27 (0.45)	0.32 (0.47)	0.23 (0.42)	0.16 (0.37)
B. Real Estate Characteristics				
Current Home Value	$277,507 (219,586)	$268,806 (221,719)	$285,916 (218,111)	$250,216 (213,790)
Current Mortgage Owed	228,904 (227,651)	283,750 (272,237)	175,441 (157,171)	130,594 (121,766)
Home Purchase Price	$315,246 (376,536)	$335,917 (372,531)	$295,242 (380,807)	
Initial Mortgage Size	$286,906 (463,218)	$326,042 (479,440)	$249,032 (445,623)	$161,049 (128,719)
Amount Paid To Date (Home Cost – Curr. Debt)*	$54,053 (291,112)	$21,509 (126,364)	$85,777 (250,177)	
Percent of Home Cost Borrowed Initially	89.7% (26.7%)	95.0% (28.2%)	84.6% (24.2%)	
Percent of Mortgages With an Adjustable Rate	18.0% (38.5%)	20.0% (40.2%)	16.1% (36.9%)	13.1% (33.7%)
Percent With a Second Mortgage	33.6% (47.3%)	41.7% (49.5%)	25.8% (43.9%)	13.9% (34.6%)
Share of Income Servicing Mortgage	23.0% (14.5%)	23.8% (14.2%)	22.3% (14.8%)	21.2% (17.3%)
Years Since Purchase	7.77 (5.55)	7.09 (4.75)	8.43 (6.18)	11.27 (10.26)

C. Time Discounting and Prospect Theory Risk Parameters				
Beta: lower values suggest more present bias	0.88 (0.15)	0.84 (0.18)	0.91 (0.10)	
Delta: lower values suggest more Discounting	0.43 (0.27)	0.37 (0.27)	0.49 (0.25)	
Lambda: Higher values mean more loss aversion	2.26 (1.06)	2.24 (1.10)	2.28 (1.02)	
Alpha: Prob. Weighting	0.74 (0.29)	0.73 (0.29)	0.76 (0.29)	
Sigma: Lower values mean more risk aversion/diminishing sensitivity	0.64 (0.28)	0.64 (0.29)	0.65 (0.27)	
D. Knowledge / Cognitive Resources				
Cognitive Reasoning (CRT) Scale	1.14 (1.08)	1.13 (1.09)	1.15 (1.08)	
Debt Literacy	0.39 (0.22)	0.37 (0.22)	0.42 (0.22)	

* Does not equal difference between means of home cost and current debt due to 9 missing values for current debt.

** Variables with no equivalent in the SBI data set are shaded gray.

Table 4. Antecedents to Negative Home Equity and Intertemporal Preferences

	% of Home Cost Borrowed (regression)	**Mortgage Type (Fixed Rate=0, Adjustable Rate=1) (logit)**	**Second Mortgage (logit)**	**Share of Income Servicing Mortgage (regression)**
Present Bias (1-β)	0.429*** (0.129)	2.995** (1.097)	2.260* (1.066)	0.151* (0.071)
Long-Term Discounting (1-δ)	-0.038 (0.072)	0.287 (0.758)	0.813 (0.608)	-0.052 (0.040)
Constant (Mean Value)	0.897*** (0.017)	-1.583*** (0.175)	-0.707*** (0.140)	0.230*** (0.009)
Adjusted/Pseudo R^2	0.043	0.050	0.041	0.011
Resid. Std. Error	0.261	0.375	0.460	0.144
Observations	244	244	244	239

Note: beta, delta centered. *** p<0.001; ** p<0.01; * p<0.05; † p<0.10

Table 5. Which Homeowners Are Underwater?

	Model 1	Model 2	Model 3	Model 4	Model 5
Present Bias (1-β)	2.23** (0.85)	1.87* (0.81)	1.98* (0.84)	1.85* (0.83)	1.75* (0.84)
Long-Term Discounting (1-δ)	0.79* (0.40)	0.95* (0.40)	0.80* (0.40)	0.91* (0.40)	0.91* (0.40)
Frac. Change in Local Housing Prices Since Peak / Purchase		-2.60*** (0.55)	-2.08*** (0.56)	-1.95*** (0.56)	-2.14*** (0.56)
Frac. Income Servicing Mortgage		1.43* (0.64)	1.40* (0.64)	1.27* (0.64)	1.40* (0.64)
Debt Literacy			-0.53 (0.42)		
Loss Aversion (λ)				0.04 (0.11)	
Diminishing Sens. (σ)				-0.34 (0.44)	
Prob. Distortion (α)				0.10 (0.32)	
Employment Security					0.09 (0.08)
CRT Scale					-0.06 (0.08)
Constant	0.10 (0.09)	Purchase Year Fixed Effects	0.11 (0.09)	0.18* (0.09)	0.03 (0.11)
R-sq	0.0921	0.2573	0.1667	0.1562	0.1679
N	226	215	215	206	215

Note: Dependent measure is self-assessment of underwater status, ranging from -2 to 2, with higher values corresponding to more negative equity. Each column contains 3SLS regression coefficients simultaneously estimated with walk-away model, with standard errors in parentheses. *** $p<0.001$; ** $p<0.01$; * $p<0.05$; † $p<0.10$.

Table 6. Time Preferences and Strategic Default

	Model 1	Model 2	Model 3	Model 4	Model 5
Present Bias (1-β)	-180,204* (81,194)	-185,343* (75,254)	-162,615* (76,798)	-150,569* (74,590)	-143,239† (76,563)
Long-Term Discounting (1-δ)	86,346* (38,038)	85,272* (36,725)	100,714** (36,323)	104,328** (36,136)	96,011** (36,435)
Degree of Positive Equity	-28,724* (13,586)	-13,871 (13,014)	-17,820 (13,093)	-12,330 (13,165)	-18,032 (13,244)
Degree of Negative Equity	21,012 (13,573)	13,822 (12,692)	17,185 (13,101)	20,877† (227,821)	18,330 (13,158)
Proportion Local Homes in Foreclosure		-54,861* (26,076)	-50,173† (26,513)	-52,004* (26,042)	-49,235† (26,313)
Proportion Local Homes in Short Sale		651,776** (228,100)	595,851** (234,613)	550,977* (227,821)	647,538** (233,512)
Proportion Income Servicing Mortgage		-41,399 (59,415)	-62,556 (59415)	-49,073 (57,672)	-69,360 (59,153)
Social Connection to Strategic Defaulters			9,269 (35,715)		
Morality of Strategic Default			-12,730 (23,133)		
Loss Aversion (λ)				16,016† (9,787)	
Diminishing Sens. (σ)				-21.277 (38,627)	
Prob. Distortion (α)				-37,674 (38,627)	
Employment Security					-13,841* (6,954)
CRT Scale					1,281 (7,446)
Expectations about Local Housing Market Changes over 3 Years					-16,118 (69,788)
Confidence in Housing Market Assessment					-11,392 (7,187)
Constant	-143,932*** (17,219)	Purchase Year Fixed Effects	-146,575*** (16,394)	-151,480*** (16,110)	-136,163*** (18,053)
R-sq	0.0957	0.2203	0.1373	0.1643	0.1599
N	226	215	215	206	215

Note: Dependent measure is how much home value loss is sufficient to induce strategic default, with higher (less negative) values indicating greater willingness to strategically default. Each column contains 3SLS regression coefficients simultaneously estimated with underwater model, with standard errors in parentheses. *** p<0.001; ** p<0.01; * p<0.05; † p<0.10.

WEB APPENDIX A: A SIMPLE MODEL MOTIVATING PREDICTIONS ABOUT TIME PREFERENCES AND MORTGAGE CHOICES

Time Preferences and Underwater Mortgages

Consider a simple discrete 3-period model in which a prospective homeowner (agent) with quasihyperbolic time preferences characterized by present bias (low β) and long-term discounting (low δ), where $\beta , \delta \in [0,1]$ is deciding between two mortgages that are each repaid over two time periods beyond the present (Period 0). The agent can choose to make a larger payment in the present (a "front-loaded mortgage") or during Period 1 and Period 2 (a "back-loaded mortgage"). Following Campbell and Cocco (2003), we assume that future consumption events are separable in utility, and assume no ex post inflation uncertainty and risk neutrality. We model only consumers who are naïve to the consequences of their time preferences. We represent preferences for each option can be with the following utility functions:

(W1a) $$U(Front\ Loaded\ Mortgage) = -P_f - \beta\delta f - \beta\delta^2 f$$

(W1b) $$U(Back\ Loaded\ Mortgage) = -P_b - \beta\delta b - \beta\delta^2 b$$

Here P_f and P_b are the initial costs of the two mortgages and f and b reflect their periodic payments, with $P_f, P_b, f, b \in [0,\infty)$. Since, by definition the front-loaded mortgage has a larger initial payment than the latter, $P_f > P_b$. This leaves a greater loan balance for the back-loaded mortgage, so $b > f$. This setup can be thought of as capturing the decision to put more money down or to pay a larger monthly mortgage payment, analogous to the choice between a standard 30-year mortgage and a 2/28 loan. While this model illustrates how time preferences motivate mortgage choices with two periods beyond the present, the logic holds when homeowners pay f and b over any number of periods.

The agent will choose the front-loaded mortgage if U(Front) ≥U(back). This suggests the boundary $P_f{}^*$ such that, as shown in the below diagram, the agent would select the front-loaded mortgage for all values if $P_f < P_f{}^*$ and the back-loaded mortgage if $P_f > P_f{}^*$. In other words, higher $P_f{}^*$ values correspond with a greater willingness to pay for front-loaded mortgages instead of back-loaded mortgages.

P_b $P_f{}^*$ ∞
|----------|----------) P_f
{Pick Front} {Pick Back}

Accordingly, by combining equation W1a and W1b for when $U(Front) = U(Back)$ and rearranging:

(W2) $$P_f{}^* = P_b + \beta\delta(b - f) + \beta\delta^2(b - f)$$

Recall that we are interested in understanding how willingness to pay for up-front mortgages changes based on time preferences. Consequently, we take the partial derivatives of $P_f{}^*$ relative to β and δ:

(W3a) $$\frac{\partial P_f{}^*}{\partial \beta} = (\delta + \delta^2)(b - f)$$

(W3b) $$\frac{\partial P_f{}^*}{\partial \delta} = (\beta + 2\beta\delta)(b - f)$$

Since $b > f$, agents are more willing to purchase front-loaded mortgages (i.e. higher $P_f{}^*$) when they are present-unbiased (i.e. higher β) and patient over the long term (i.e. higher δ). Hence, this model predicts Hypothesis 1.

Hypothesis 1: Impatient agents (low β and δ) are more likely to choose mortgages that enable them to delay payments than patient agents. For example, agents with $\beta < 1$ or $\delta < 1$ will back-load mortgages more willingly than agents with $\beta = \delta \approx 1$.

Time Preferences and Negative Home Equity

A homeowner is underwater if his or her total debts exceed the market value of the home. Hence a homeowner can become underwater either having more debt or having a lower home market value. As home values fall, homeowners who selected a back-loaded mortgage become underwater before homeowners with otherwise equivalent homes carrying front-loaded mortgages.

More formally, suppose the subsequent home's market value, $M \in [0, \infty]$, is discovered only after the down payment is made. At this time, a homeowner with the front-loaded mortgage will owe $2f$ in mortgage debt, while the one with a back-loaded mortgage will owe $2b$. As $b > f$, the homeowner with the back-loaded mortgage will owe more in mortgage debt than the homeowner with the front-loaded mortgage. If $2f > M$, the front-loaded mortgage holder is underwater. Since the back-loaded mortgage holder owes more, the back-loaded mortgage holder must also be underwater. In contrast, if $2b > M$, while the back-loaded mortgage holder is underwater, one cannot conclude that the front-loaded mortgage holder is underwater as there exists an $f < b$ such that $2f < M < 2b$. In other words, an underwater back-loaded mortgage is a necessary, but not sufficient, condition for the front-loaded mortgage to be underwater. Building on Hypothesis 1, as more impatient homeowners repay their mortgages more slowly through back-loaded mortgages, more impatient homeowners will get underwater before front-loaded mortgages. Thus a housing market shocks causes impatient homeowners to become underwater before those with less remaining debt. This leads to Hypothesis 2:

Hypothesis 2: The mortgages selected by impatient agents (low β and δ) are more likely to be underwater following negative housing market shocks.

Time Preferences and Strategic Default

A similar logic provides insights into the strategic default decision, though selecting and maintaining a mortgage has one notable structural difference. Defaulting on a mortgage involves additional immediate monetary and non-monetary costs associated with finding a rental unit, and moving. In some cases homeowners will lose valued neighbors or their children would need to change schools. There are also near-term social stigma and moral concerns that discourage homeowners from defaulting (Foote, Gerardi and Willen 2008). To default, a homeowner must perceive the longer-term savings from paying rent instead of mortgage payments as more significant than both the immediate costs of moving and the distant prospect of eventually living in the home rent-free.

We illustrate the contrasting predictions of present bias and impatience for strategic default, by modeling a homeowner with quasihyperbolic time preferences who decides whether to move or walk away. This homeowner values staying in her home and continuing to make mortgage payments (m) as described by the following utility function:

(W4) $$U(stay) = -m - \beta\delta m + \beta\delta^2 M,$$

Here *m* is the mortgage payment, *M* is the expected residual home value after mortgage payments are complete, and β and δ again reflect time preferences. These four values are all assumed to be positive, finite values, and we also assume that borrowing against future home equity is not available. Similarly, walking away is given by the following utility function:

(W5) $$U(walk) = -s - r - \beta\delta r + \beta\delta^2 * 0$$

Similarly, *r* is the periodic rent payment, *s* is the short-term cost of moving including both physical costs associated with changing residences and social stigma of defaulting. The homeowner will walk away if U(walk)≥U(stay) and stay if U(stay)≥U(walk) and hence there is a residual home value *M** whereby the homeowner is indifferent between moving and staying.

High values of *M** correspond with greater willingness to *walk*, since there is a smaller range of residual home values where the homeowner finds it worthwhile to continue to pay the mortgage. In other words, a higher *M** corresponds with more strategic defaulting.

More specifically, M* can be characterized by combining equations W4 and W5:

(W6) $$M^* = \frac{m-s-r}{\beta\delta^2} + \frac{m-r}{\delta}$$

Taking partial derivatives shows that differences in time preferences, β and δ, influence the threshold value M* and hence, willingness to walk away.

(W7) $$\frac{\partial M^*}{\partial \beta} = \frac{-m+s+r}{\beta^2\delta^2}$$

$$\frac{\partial M^*}{\partial \delta} = \frac{-2*(m-s-r)}{\beta\delta^3} - \frac{m-r}{\delta^2}$$

More present-unbiased people (i.e. higher β) are more willing to walk away (higher *M**) if equation $\frac{\partial M^*}{\partial \beta} > 0$. This occurs if $s + r > m$. In other words, more present-biased people are more willing to stay in an underwater home if the present-term costs associated with moving (including rent) exceed the periodic mortgage cost. More long-term impatient people (i.e. lower δ) are more willing to walk (higher M*) if $\frac{\partial M^*}{\partial \delta} < 0$. This occurs if $\beta\delta > 2(\frac{s}{m-r} - 1)$. Hence there exists a range of time preferences where we observe a "*β*-*δ* reversal" if equation W8 holds:

(W8) $$\frac{s}{1+\frac{\beta\delta}{2}} < m - r < s.$$

In other words, present bias and long-term discounting have opposite relationships with walking away provided that the periodic savings from walking away (*m*-*r*) meets two conditions. First, present-biased homeowners are more likely to stay if the net present savings are positive, namely, if the short-term costs of moving exceed the periodic walkaway savings (i.e. *m*-*r*<*s*).

On the other hand, homeowners who long-term discount more are more likely to walk away if the periodic default savings exceeds a fraction of the short-term cost of moving (i.e. $\frac{s}{1+\frac{\beta\delta}{2}} < m - r$). While the lower bound on periodic walkaway savings increases with both present bias and long-term discounting, both of conditions are met by range of periodic walkaway savings unless $\beta = \delta = 0$. This leads to the final hypothesis.

Hypothesis 3: Homeowners who discount the future more over the long-term (low δ) are more likely to default on their mortgages while present-biased homeowners (low β) are less likely to default.

This analysis suggests that, considered in the abstract, individual differences in time preferences can play a role in mortgage choice and abandonment. There are clearly other factors that contribute to these decisions. Other factors can add to our ability to predict mortgage decisions, and to the extent that they covary with time preferences, could provide alternative explanations for our predicted results, a prospect that is tested empirically in the two studies of this paper.

WEB APPENDIX B: ADDITIONAL STUDY 2 DETAILS

Participants began by reading a passage orienting them to concepts and terminology commonly available through mainstream media sources about a particular mortgage maintenance choice, namely, whether to walk away from an underwater mortgages. To identify the relationship between time preferences and mortgage maintenance choices for underwater homes, we posed a choice between two clear, if simplified, options: (1) moving into a rental unit in their area and allowing the bank to foreclose on the house, or (2) staying in their current house and continuing mortgage payments.

We elicited willingness to default as the "walk-away value," the dollar amount to which the home would need to fall for a given respondent to walk away from the mortgage. These values were elicited through an adaptive titrator, which asked a series of binary questions about whether the respondent would stay or walk away if their home's market value changed to a specific value determined by prior responses. The titrator was calibrated to each subject's current home market value (as reported at the outset of the survey), and the range of possible walk-away values was considered to be between 0 and 120 percent of their current home value (see Guiso, Sapienza and Zingales 2010 for a similar measure). In each round, subjects responded with whether they would move out and stop paying their mortgage at that home value. After each round, if they indicated a willingness to stay (default) at a particular home value, the ceiling (floor) walk-away value was reduced (increased) by 42% of the range of values. This process repeated until it achieved sufficient specificity, which occurred when the range of

potential values was reduced to below 5% of their current home market value.[1]

Respondents then answered a series of questions about their financial position and demographic factors, including, age, gender, marital status, number of children, and education. Financial factors included employment status, income, monthly mortgage payment, years since the home was purchased, current mortgage debt, the initial cost of the home, and their self-assessment of their home equity status. Income and monthly mortgage payment were combined to produce the share of income servicing the mortgage. While some researchers have expressed concerns that individuals cannot recall mortgage details (Bucks and Pence 2008), we find that respondents' assessment of their home equity and debt were largely internally consistent with their other responses in the survey and correlate strongly with zip code-level averages obtained from Zillow.com. This data contained average home sale prices at the zip code level both in the year the home was bought (for years since 2000) and around the time of the survey. Mean zip code-level home prices correlated 0.47 with respondents' self-reported home prices. To further ensure data integrity, we dropped data from a limited number of observations that provided wildly inconsistent answers to our two housing equity questions. Additionally, we administered the three-item debt literacy scale and financial competency self-assessment of Lusardi and Tufano (2009) and a three-item cognitive reflection task (Frederick 2005) and asked additional

[1] The range constricted by 42% each round to ensure efficient convergence to an individual-level walk-away price estimate while permitting response uncertainty. We verified the adaptively elicited value by directly asking respondents their walkaway price. The measures correlated 0.99.

questions characterizing their mortgage type including whether it has a fixed or adjustable interest rate and if they have a second mortgage.

At the end of the survey, we used two adaptive incentive compatible tools to estimate individual-level parameters for quasi-hyperbolic time discounting (QTD) (Laibson 1997) (β, δ) and cumulative prospect theory (CPT) (α, λ, σ) (Prelec 1998; Tversky and Kahnemann 1991). To estimate quasi-hyperbolic discounting parameters, subjects chose from 20 pairs of possible payments at different points in time, one of which sometimes included the present day. Present bias (β) and long-term discounting (δ) were estimated with each time period corresponding to a year, so a payment delayed one year is diminished by the discount fraction $\beta*\delta$, and a one-week delay induces a discount fraction $\beta * (\delta\text{^}(\frac{1}{52}))$. We compared the fit of the QTD model to both a hyperbolic and an exponential model to respondents' choices, finding the QTD model was significantly superior. Similarly, to estimate CPT parameters $\{\alpha, \lambda, \sigma\}$, we displayed 16 pairs of two outcome mixed gambles and asked respondents to indicate their choice. For a full discussion of this adaptive, method and its Bayesian estimation procedure, including validity checks of the estimation of discounting and prospect-theory parameters, see Toubia et al. (2013). One in one hundred participants were randomly selected to receive the outcome of one of their choices.

Control Variables: Risk, Differences in Ability/Knowledge, and Financial Status

Risk attitude has a central role in standard models of mortgage and real-estate choices (Campbell and Cocco 2003, 2011; Genovese and Mayer 2001), so assessment of individual attitudes toward risk could be potentially helpful in understanding mortgage selection and management. It has also been argued that the observed high levels of discounting may be related to high levels of risk aversion (Andersen et al. 2008) so this allows us to control for the degree

of risk aversion in looking at the effects of time preferences. We use a standard cumulative prospect-theory framework and the probability-weighting function proposed by Prelec (1998) with a set of adaptively generated options. Value for a choice option is described by three parameters $\{\alpha, \sigma, \lambda\}$, which capture, respectively, the distortion (nonlinear sensitivity) of the probabilities, the curvature (sensitivity) of the value function corresponding to the usual parameter for risk aversion, and loss aversion.

We also build on recent work to model potential cognitive, knowledge and economic effects. We use measures of cognitive reflection (Frederick 2005) to assess cognitive ability on a 0-3 scale. Since Lusardi and Tufano (2009), Fernandes, Lynch and Netemeyer (2014) and others have documented large differences in financial and debt literacy and related them with financial decision quality, we also control for preexisting domain knowledge using Lusardi and Tufano's 2009 debt literacy scale, which we scale on a 0-1 range. Finally, as mortgage choices are influenced by economic status such as income and credit, which could be affected by time preferences, we control for these variables when relating time preferences with mortgage choice and abandonment.

Market-Level Variables

In addition to individual characteristics, market-level outcomes affect mortgage choices and management decisions. For example, the current house price and initial purchase price determine the current equity in the house. We use two sources of data to control for market-level shocks. The first, provided by Zillow.com, estimates of the current median home price, the price when the home was purchased, and its price at the peak of the market at the level of each homeowner's zip code. To control for the effect of the policies of current mortgage holders, we obtained from BlackBox Logic LLC the percentage of homes that are currently being foreclosed

and the percentage that are involved in short sales. BlackBox tracks 90% of privately securitized US mortgages originated between 2000 and 2009. For both data sets, there were occasions (respectively, 25 and 7 percent) when zip code data were not available. In these cases, we substituted available state-level data, which correlated highly with zip code-level data.[2]

[2] Correlations between state- and zip code-level data were, respectively, 0.59 for Zillow.com data, 0.78 for BlackBox foreclosure data, and 0.51 for BlackBox short sale data. Our analysis excludes a few subjects who provided invalid zip codes.

WEB APPENDIX C: LIQUIDITY CONSTRAINTS, INTERTEMPORAL PREFERENCES AND MORTGAGE CHOICES

In this section we further explore the relationship between liquidity constraints, intertemporal preferences and mortgage choices. There are two alternate explanations involving liquidity constraints that compete with our hypothesis that intertemporal preferences directly influence mortgage choices and defaulting behaviors. One possibility is that our measurements of intertemporal preferences expressed by participants are conflated with their preexisting liquidity constraints. Another possibility is that intertemporal preferences could influence choices that affect liquidity, and then facing these constraints, intertemporal preferences do not further influence mortgage choices. We test both of these competing hypotheses through a final series of simultaneous regressions that explore the relationship between intertemporal preferences, liquidity and walking away.

In particular, we assessed whether liquidity confounds or mediates the relationship between intertemporal preferences and walking away by adding fraction of income servicing mortgage (inverse liquidity) as an additional endogenous factor to Models 2-5. In each case, in addition to estimating the relationship between intertemporal preferences and underwater homeownership (equation 3) as well as with walking away (equation 4), we also simultaneously estimated the relationship between intertemporal preferences and income servicing mortgage (inverse liquidity), equation W9:

(W9) $$mort\_pmt\_to\_income_i = \beta_0 + \beta_{l1} * beta_i + \beta_{l2} * delta_i + \varepsilon_{li}$$

We added to this the appropriate covariates predicting income servicing mortgage in each model. In the modified models (Models 2a-5a), underwater mortgages and walking away were

as specified in Models 2-5, and income servicing mortgage was an endogeneously determined function of present bias and long-term discounting, along with (Model 2a) purchase year fixed effects, (Model 3a) debt literacy, (Model 4a) prospect theory parameters, and (Model 5a) employment security, and cognitive reasoning.

In each model, we find that liquidity constraints do not account for the relationship between intertemporal preferences and walking away. After accounting for endogenously determined income servicing mortgage (inverse liquidity) the relationship between present bias, long-term discounting underwater status and walking away are unchanged, in significance and magnitude, from relationships when liquidity is assumed to be exogeneous. The fraction of income servicing mortgage is not significant in predicting walking away, though the direction of its coefficient indicates that increasing liquidity corresponds with increased willingness to default. Income servicing mortgage, in general, increases with present bias and decreases with long-term discounting (all ps < 0.10), except in model 3a, which accounts for debt literacy. In other words, liquidity decreases with present bias and increases with long-term discounting. Since willingness to walk away increases with liquidity, the relationship between time preferences and liquidity is directionally consistent with the relationship between time preferences and walking away. The relationship between intertemporal preferences and walking away is unchanged after accounting for the effect of liquidity.

WEB APPENDIX D: DESCRIPTIVE STATISTICS FROM SURVEY OF MORTGAGED HOMEOWNERS, CORRELATION BETWEEN KEY VARIABLES AND HISTOGRAMS OF TIME PREFERENCES

Web Appendix Table 1. Variable Descriptions from Survey of Mortgaged Homeowners

Variable	Description	Source	Level	Mean	St. Dev.
(DV) Underwater	Self-assessment of home equity status. Ranges from -2 to 2; 2 is most underwater. Average of two measures.	Prequal. and Main survey.	Individual	0.14	1.42
(DV) Walk-Away Value	Minimum (negative) amount home would need to change in value for mortgage abandonment. Increases with willingness to walk. Calculated based on adaptive estimation.	Main Survey; Calculated	Individual	-141,292	135,622
β	Percent of value retained when a payment is not received today. Decreases with present bias, ranges between zero and 1.	Main Survey; Calculated	Individual	0.88	0.15
δ	Percent of value retained when a payment is delayed for one year. Decreases as long-term/exponential discounting increases, ranges between zero and 1.	Main Survey; Calculated	Individual	0.43	0.27
λ	Loss aversion	Main Survey; Calculated	Individual	2.26	1.06
α	Probability Distortion	Main Survey; Calculated	Individual	0.74	0.29
σ	Diminishing Sensitivity	Main Survey; Calculated	Individual	0.64	0.28
Age	Respondent age	Main Survey	Individual	39.8	10.8
Gender	1=Male	Main Survey	Individual	0.34	0.47
Married	1= Married	Main Survey	Individual	0.82	0.38
Income	Yearly household income	Main Survey	Individual	95,539	56,007
Race	1=Caucasian	Main Survey	Individual	0.82	0.39

Has Bachelor's Degree	1= Yes	Main Survey	Individual	0.67	0.47
Has Graduate Degree	1= Yes	Main Survey	Individual	0.27	0.45
Employment Security	-2 to 2; 2 is most secure	Main Survey	Individual	0.89	1.17
Debt Literacy & Financial Competency	Combination of financial competency self-assessment and performance on debt literacy items (ranges 0 to near 1).	Main Survey	Individual	0.39	0.22
CRT	Number of Cognitive Reflection Task items correct (out of 3).	Main Survey	Individual	1.14	1.08
Morality Scale	Degree to which respondent views mortgage default in moral terms, from 6 scale items. Ranges from -1 to 1.	Main Survey	Individual	0.29	0.35
Social Connection to Strategic Defaulters	Degree of social connection to strategic defaulters. Ranges from 0 to 1, 1 is closest.	Main Survey	Individual	0.21	0.24
Initial Home Cost	Purchase price of home	Main Survey	Individual	315,246	376,536
Initial Mortgage Size	Amount initially borrowed on home	Main Survey	Individual	286,906	463,218
Adjustable Rate	1 = Mortgage has adjustible interest rate; 0= Mortgage has fixed interest rate	Main Survey	Individual	0.18	0.39
Has Second Mortgage	1 = second mortgage, 0 = no second mortgage	Main Survey	Individual	0.34	0.47
Years in Home	Years since home purchase.	Main Survey	Individual	7.77	5.55
Monthly Mortgage Payment	Amount paid in mortgage per month.	Main Survey	Individual	1,656	1,446
Share of Income Servicing Mortgage	Monthly mortgage payment * 12 / Income	Main Survey; Calculated	Individual	0.23	0.14
Current Mortgage Debt	Amount currently owed in mortgage debt.	Main Survey	Individual	228,904	227,651
Amount Paid to Date	Monthly payment * Years in Home *12	Main Survey; Calculated	Individual	54,053	201,112

Expectations About Housing Market	Fraction increase or decrease expected in home values over next three years; between -0.35 and 0.35.	Main Survey	Individual	0.00	0.12
Confidence in Housing Market Expectations	Strength of confidence in housing market expectations (-2 to 2; 2 is most confident)	Main Survey	Individual	-0.12	1.18
Avg. Change in Home Price Since Peak, for Zip Code	Percent change in average home prices, ranges from 0.66 to 0.	Zillow	Zip Code	-0.23	0.16
Foreclosures, as Percent of Zip	Homes in foreclosure, as percent of zipcode-level total.	BlackBox	Zip Code	0.41	0.33
Short Sales, as Percent of Zip	Homes in short sale, as percent of zipcode-level total.	BlackBox	Zip Code	0.04	0.04

Web Appendix Table 2: Correlation Between Primary Measures of Mortgaged Homeowners

	Under-water	Walking	*Present Bias (1-β)*	*Long-Term Disc. (1-δ)*	*Loss Aversion (λ)*	*Dim. Sens. (σ)*	*Prob. Distortion (α)*
Underwater	1.00						
Walking	0.26	1.00					
Present Bias (1-β)	0.28	-0.00	1.00				
Long-Term Discounting (1-δ)	0.25	0.15	0.54	1.00			
Loss Aversion (λ)	0.00	0.15	-0.14	-0.16	1.00		
Diminishing Sensitivity (σ)	0.04	0.09	0.17	0.19	-0.58	1.00	
Probability Distortion (α)	0.01	-0.12	0.00	-0.02	-0.20	0.08	1.00

Web Appendix Figure 1: Histograms of Intertemporal Preferences, by Home Equity Status