Home Equity Withdrawal in Retirement

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Abstract

We document in the data and study theoretically the patterns of home equity withdrawal among retirees. Using the American Housing Survey, Health and Retirement Study, and the Survey of Consumer Finances, we show that as home equity has become more accessible over time, retirees have been increasingly relying on home equity borrowing, with increasing preference for relatively new and flexible instruments like home equity lines of credit and reverse mortgages, and that this upward trend continued even as house prices began to decline and the rest of the population contracted their borrowing against equity. Simultaneously, we document that the cost of living for retirees has been increasing, due to factors such as rising healthcare costs. One goal is to understand the driving forces behind home equity borrowing trends, and their welfare implications. More broadly, we are also interested in their macroeconomic and policy implications. We present a dynamic stochastic partial-equilibrium overlapping-generations model that captures and analyzes these trends in the data given the liberalization of financial markets in the last 25 years and increasing costs of living.

1 Introduction

The last three decades witnessed a substantial increase in household indebtedness in the U.S. For example, total household debt relative to GDP increased from 52% in 1980 to 100% in the first quarter of 2009. Together with the consistent increase in the number of consumer bankruptcies, and the spike in the number of foreclosures in the ongoing recession, there is a concern that the increased indebtedness might be associated with a negative welfare effect on the U.S. households. Moreover, the increased indebtedness might have significant negative macroeconomic consequences through a lower saving rate.

As we will show, the increased indebtedness is also evident among older households, the majority of whom are retirees. This is particularly alarming because the proportion of older households is expected to increase, both due to the general trend of aging, and due to the retirement of the baby boomers in the near future, and because there is a concern about the sustainability of the current social security system. It is obvious that the ongoing changes in the saving and borrowing behavior of older households will affect any discussion concerning changes in the design of the social security system, as well as other relevant policy debates.

In terms of the composition of the debt, although the amount of all kinds of debt – secured and unsecured – increased over the last three decades, the increase in household mortgage debt has been the most striking. The proportion of home mortgages relative to GDP more than doubled from 33% in 1980 to 74% in the first quarter of 2009. The proportion of home mortgages in the total debt is 74% now, compared with 64% in 1980.

Moreover, as we will show, among home mortgages, home equity lines of credit (HELOCs) are the fastest growing instrument. Among older households, not only HELOCs, but also reverse mortgage loans (RMLs) are gaining popularity rapidly, even though the absolute amount of reverse mortgages is still relatively small. An additional striking fact is that even as across the population, the pace of borrowing has contracted recently in light of falling house prices, retirees appear to have bucked that trend and continue to increase borrowing against HELOCs and RMLs. We believe that these trends warrant careful consideration, yet to date, we do not have a model to study implications of increased use of these new instruments; this is a gap we hope to fill with this paper. (See below for related literature review).

This paper provides two contributions, one on the empirical side and the other on the theoretical side. First, we document the increased use of the newer mortgage instruments among older households, primarily using the Health and Retirement Survey (HRS). HRS is a biennial longitudinal data set and has rich information on household characteristics and detailed financial assets and liabilities, in particular on housing and collateralized loans. Therefore, the HRS allows us to study the household decision with respect to different types of secured borrowing in great detail. Second, we develop a model of retirees which features the choice of instruments for home equity borrowing. In particular, we focus on how households choose between more traditional, relatively inflexible mortgage instruments, and more recent and more flexible line of credit. Moreover, the HRS contains rich data on health situations and medical expenditures of households. Consistent with what is often argued, we will document that the out-of-pocket medical expenditures are on a

rising trend. We will later use our model to show how much increasing medical expenditure risk may contribute to increased households' indebtedness and to their choice of debt instruments.

We model the household decision regarding the mortgage choice using two kinds of models. First, we start by investigating the optimal decision of a representative home owner household in a simplified version of the model. We are interested in understanding how the saving and borrowing decisions of retired households change when the set of available mortgage instruments change from the conventional and relatively inflexible mortgages to a set that includes both the traditional mortgages and the newer more flexible lines of credit. The model highlights the key trade-offs regarding the secured debt instrument choice. We find that when HELOCs become available in the economy, older agents switch to HELOCs readily, in situations where they run out of financial assets or are hit by large medical expense shocks, because HELOCs provide the required degree of flexibility given increasing probability of death. We also find that HELOCs allow agents to stay in their homes more often, whereas in the economy without HELOCs, some agents, given large financial medical shocks, choose to default, given high transactions costs of alternative loans. We also compute the size of the welfare gain from having the newer lines of credit instruments, and find it to be sizable; also, agents in poor health have larger welfare gains than agents in better health.

Then we move on to construct a full version of the model. The full version features a more involved set of financial decisions of the retires households, and rich heterogeneity across households. We plan to use the model to study four things. First, we will try to disentangle which trends - e.g. housing prices and rising medical costs - have contributed to driving retired households into deeper debt. Second, we will study the welfare gain stemming from the development of a richer set of mortgage instruments. Third, we will study how households' saving and borrowing behavior is affected by changing house price. We are particularly interested in the case that reflects recent events in the housing market, where the trend of the house price is reversed from a positive to a negative growth. Do households suffer more or less in the environment with a richer set of mortgage choices? Fourth, we will study policy implications of having a richer set of mortgage instruments; for example, we want to investigate how the debate over social security reform might be affected by these recent developments. Since the development in the mortgage markets affects how households insure against survival risk and medical risk, our model will have important implications with respect to the optimal design of the social security system.

Both we and Yogo (2009) are interested in deepening the understanding of financial decisions of retired households in the presence of the medical expenditure risk. The difference is that Yogo (2009) focuses on the portfolio choice decision between risky and riskless financial assets and housing asset, together with endogenous health expenditures, while our focus is on the choice of different types of home equity borrowing.

Our paper is an addition to the recently developing literature on the optimal mortgage decision. In innovative work, Chambers et al. (2009b) construct a general equilibrium model with a focus on the optimal choice between conventional fixed-rate mortgages and newer mortgages with alternative repayment schedules, and study macroeconomic implications of having different types of mortgages available for households. However, unlike this paper, they focus on different types

of mortgage loans with differences in downpayment ratios and repayment terms; we instead consider and focus on newer equity instruments, and bring out the differences in flexibility between them and traditional mortgages. Campbell and Cocco (2003) investigate the optimal choice for home buyers between conventional fixed-rate mortgages (FRM) and more recent adjustable-rate mortgages (ARM).

Our paper is also an addition to the recently growing macroeconomic literature with housing. Davis and Heathcote (2005) study a business cycle model of housing. Díaz and Luengo-Prado (forthcoming) investigate the implications of explicitly considering housing in explaining the observed large wealth inequality in the U.S. Chambers et al. (2009a) examine various elements which contribute the rise in homeownership rates in the U.S. and find that introduction of new mortgage instruments which allow lower downpayment at the time of purchase has a sizable effect on homeownership rate. Ortalo-Magné and Rady (2006) study the impact of income shocks and credit constraint for business cycle dynamics of the housing market.

The paper is organized as follows. Section 2 describes the development and institutional details of different types of home equity loans available today. Section 3 presents data analysis from the HRS and the SCF, as well as the American Housing Survey (AHS). We will develop two versions of the model. In Section 4, we develop what we call the *simplified model*. The model is a stripped-down version of the full model developed later, but is useful in analyzing different aspects of the decision of a homeowner regarding home equity borrowing. In Section 5, we discuss the calibration of the simplified model. We implement our analysis with the simplified model in Section 6. In Section 7, we develop the *full model*. This model analyzes not only decisions of home owners, but also features the decision of whether to be a homeowner or a renter, as well as more complex saving and borrowing decisions. We begin to calibrate the model in Section 8. This analysis is currently in progress. Section 10 concludes.

2 Institutional Details

2.1 Traditional Options for Equity Borrowing

In post-war United States, traditional ways for home owners of collateralized (secured) borrowing have included mortgage loans against the home, with a possibility of refinancing to change interest rate terms of the loan or to take out additional lump-sum loans (so-called cash-out refinance). A related and similar option was a home equity loan (HEL), a lump-sum loan that would not involve refinancing but would be secured by the equity in the house. For any household, but particularly for older and equity-rich ones, another option would be to downsize: sell the current house and buy a smaller one with the proceeds. Thus the new house is owned outright and the difference in prices would provide a one-time cash injection. The extreme case of downsizing is to sell the house and become a renter.

A traditional (first) mortgage is a lump-sum loan from a bank. Typically, a first mortgage is a way of financing the purchase of the house to begin with. These are often fixed-rate loans, although

more recently adjustable-rate options became available.[1] To pay the loan off, the household makes regular monthly payments starting immediately after the loan is acquired. At the beginning, one repays mostly interest, while toward the end payments go more toward the principal. This means that the household only starts building equity some years into the life of the loan. A typical first mortgage is a 30-year loan. Interest payments on these loans are tax-deductible. The uses of traditional mortgages are generally restricted.

The mortgage can be refinanced, subject to the same eligibility criteria as the ones needed to get the mortgage initially. Typically, there are income, asset, and credit criteria that have to be met in order for the household to be able to refinance. Refinancing allows the owner to change the terms and generally lower the payments on the mortgage due to a lower interest rate. In addition, some households are able to "cash out" while refinancing (or even as the main goal of the refinance) - that is, to take a one-time cash loan that is added to the amount of the new mortgage - if they have equity built up in the home. Transaction costs of refinancing can add up to 3-6% of the outstanding principal; in addition, the amortization process is restarted - with a newly refinanced mortgage, more of the initial payments go toward the interest than the principal, so that equity is accumulated more slowly. This may be a drawback for older equity-rich households.

Next, a household can take out a second mortgage with similar terms as the first mortgage, though a typical term is 15 years. Very similar to a second mortgage is a home equity loan (HEL). This is again a lump-sum loan, typically given for a term of 10-15 years. These also tend to be fixed-rate loans, and like mortgages, carry regular monthly payments. However, interest rates on these can be higher than on a traditional mortgage. One difference between a traditional mortgage and a HEL is that the uses of HEL money are not restricted, while for a mortgage they often are.

2.2 Recent Developments in Equity Borrowing

In recent years, two additional instruments became available. For all households with equity, a home equity line of credit (HELOC) allows an open credit line that can be borrowed against any time and in any amount up to a ceiling. For households of age 62 and older, a reverse mortgage loan (RML) allows the household to borrow against equity with the debt repayed only when the homeowner moves out of the house. HELOC's have existed from the mid-1980's, and the reverse mortgage option became available with legislation in 1989. However, the real rise in their popularity only occurred in recent years, as we will describe below.[2]

Unlike mortgages, cash-out refinancing and home equity loans, HELOC's are flexible lines of credit.

[1] In our model, we do not consider an environment with changing interest rates, and thus there is no difference between fixed- and adjustable-rate loans. Campbell and Cocco (2003) analyze the optimal choice between fixed- and adjustable-rate mortgages. Chambers et al. (2009b) analyze the newer types of mortgages with alternative repayment schedule.

[2] The first notable increase in the use of HELOC's occurred with the change in taxation legislation in the late 1980's when interest on non-secured debt became non-tax deductible. The uptake of RML's remained very slow well into the 1990's; for example, as of 2007, two-thirds of all RML's issued were issued in 2005-2007 according to Redfoot et al. (2007). We discuss this more later.

They are opened against available equity, following credit and income checks. These lines grant access to 70-100% of home equity (a typical line is at about 70%), and no interest is paid until a withdrawal, by writing a check or receiving a cash transfer, is made. Once one withdrawal from the line is made, the loan begins to accrue interest and requires a monthly payment involving at least the interest. If there is no balance on the line, no interest is paid. The interest rates on these loans are adjustable rates, and they adjust at quarterly frequency. However, these rates are low relative to other forms of credit lines – e.g. credit cards. In comparison with other forms of collateralized borrowing, on the other hand, interest rates on HELOC's tend to be higher than mortgage rates in times of high interest rates (i.e. the Fed Funds rate), but below mortgage rates in low-interest periods. For example, in 2001, the average reported interest rate in the SCF on a HELOC was 8.5%, while on a mortgage it was about 7.6%, and about 7% on a home equity loan. In 2007, HELOC rates were also at a premium relative to other collateralized borrowing. In 2004, instead, a period of low interest rates, HELOC rates were at 4.6%, and mortgage rates at 6.3%. There is no evidence in the data of a difference in interest rate terms for retirees versus non-retirees; moreover, over the period that we will be looking at, policy interest rates stayed relatively high, suggesting that HELOC interest rates would have generally been higher than mortgage rates. HELOC rates have a regulated range. The lines of credit have relatively low startup costs that are frequently waived, especially if a HELOC is taken out simultaneously with refinancing. HELOC's have a limited draw period, typically of 10 or 15 years, and repayments are made as long as something is owed on the line. At the end of the draw period, the rest of the loan has to be repayed - either right away, or over some repayment period, e.g. 10 years. HELOC's can be renewable, in which case at the end of the first draw period, the line could be extended.

Reverse mortgages, also known as HECM loans (Home Equity Conversion Mortgage), are different from HELOC's in several important ways, though they have some overlap. Only households of age 62 and above are eligible for reverse mortgages, and there are no credit or income criteria for RML borrowing. The amount of equity accessible through these is typically smaller than that accessible through HELOC's, because RML's have very large starting and subsequent interest costs. For example, AARP estimates the cost to be at least 10% of available equity, not including interest costs (Redfoot et al. (2007)), and with interest, the cost can run up to as much as 30% of available equity. Payments from RML's can be made via a line of credit (80% of borrowers choose this option), as regular monthly payments or a single lump-sum payment, or combination of a LOC and lump-sum loan(s). A distinguishing feature of these loans is that no monthly payments on the loan are made, and no payments at all, until the homeowner leaves the house or dies. Interest accrues on the debt for the life of the loan. However, unlike HELOC's, RML's are non-recourse loans: the total amount of repayment is capped at the current value of the house. Thus if the house value goes down, negative equity is not an issue for the debtor or the heirs. Interest rates on these loans are adjustable on a monthly basis; historically, they have been a bit lower than HELOC rates.

In choosing between different types of home equity borrowing, households have to trade off transactions costs of opening the loan, interest rate costs, and different levels of flexibility associated with the various types of loans. Below, we document the trends that show how these tradeoffs play out in older households' choices in the data. We will then focus on these differences in loan terms

in our theoretical model(s).

3 Data

For the analysis presented here, we mainly use two surveys. The Health and Retirement Study (HRS) is a biennial longitudinal survey of households of age 50 and above available between 1992 and 2006. Because of sampling issues (the 1992 wave does not include respondents above 70 years of age), we begin our analysis in 1994. We use the entire sample of retirees present in the survey. Periodically, the sample is re-balanced to make up for attrition by adding new relatively young respondents. We use the RAND version of the raw HRS files, which have been streamlined across the years.

The HRS has detailed information about household assets and debts, which we use extensively. The HRS also has extensive information on respondents' health and health expenditures, which we will also use, as well as detailed information on their income. However, some types of household borrowing are not distinguished in sufficient detail - for example, it is impossible to say with certainty when a household cashes out during refinancing. To offset this difficulty, we also use the Survey of Consumer Finances (SCF), which is a triennial survey going back to the early 1980's. The SCF provides more detail on each available type of equity borrowing. It is a cross-sectional survey, but allows us to study how borrowing behavior changes over time. Also, the HRS currently stops in 2006, while for the SCF, we have the 2007 wave, which allows us a first glimpse into the data after the housing market collapsed. Neither survey distinguishes reverse mortgage loans from HELOC's. We are thus at most able to analyze total HELOC borrowing, which we assume includes a lot of RML borrowers, since the majority take their payments in the form of a line of credit.

Just in order to document the aggregate trend in the takeup of RMLs, we also turn to the American Housing Survey (AHS), which does not have a lot of detail on the micro level, but allows us to document the share of home owners who borrow against reverse mortgages over time, which grants a significant insight into this notable recent trend.

3.1 Summary

The focus of our data analysis is to document the changes over time of retirees' borrowing behavior, especially as it pertains to secured borrowing. Below we present evidence for the following facts in the data:

1. Over the period that we can study given our data, 1994-2006/7, retirees have found themselves increasingly in debt, and this debt is mostly in the form of loans against their house. We observe this increase along both the extensive and intensive margins: more retirees have debt over time, and the mean amount of debt per capita increases over time.

2. Since the late 1990's, there has been a shift in retirees' secured debt toward more flexible forms of borrowing. A key role in this trend has been played by home equity lines of credit (HELOCs), and the trend again repeats along both the extensive and intensive margins. In addition, reverse mortgage loans (RMLs), although they are still a very small portion of the overall loans, have also seen a dramatic increase in use in recent years.

3. The trend of increase in the use of HELOCs and RMLs by the retired households has continued even after housing prices began to fall and the non-retiree population has decreased their borrowing against HELOCs.

These trends motivate our study of retirees' choices with respect to home equity borrowing. Before we can address the larger implications of these changes, we have to understand the reasons behind them. We look for factors that may have contributed to possible increased popularity of equity borrowing generally among retirees, and of HELOC borrowing specifically. One obvious contributing factor is the fact that retirees' equity has been increasing over time with the pace of the increase in the house prices. However, the last point above suggests that more than just house prices is behind retirees' increased use of HELOCs. The following additional possible contributing factors also stand out:

1. Costs of living have been increasing rapidly for retirees, due in large part to increasing medical costs.

2. We see some evidence that retirees may have been, in recent years, substituting away from financial savings and using home equity instead of those savings. However, this is observationally equivalent to the situation where higher costs of living are driving retirees to deplete their financial savings and forcing them to use equity loans and lines of credit following that depletion; the two possibilities are hard to distinguish.

3. HELOCs are replacing, to some extent, traditional (less flexible) methods of equity borrowing, but the increase in HELOC borrowing, along the extensive margin, is greater than any matching decrease in more traditional types of loans.

4. It is possible that HELOCs and RMLs are getting cheaper over time. Although this fact is difficult to document conclusively, this may be one reason why these instruments were not significantly used in the 1980's (early 1980's for HELOCs) and early 1990's, despite the fact that they were available then.

In what follows, we present some evidence for each of the above points.

3.2 Details

By aggregating our HRS data, we can study the aggregate patterns of borrowing among retirees over time. On the most aggregate level, we find that the total amounts of outstanding secured

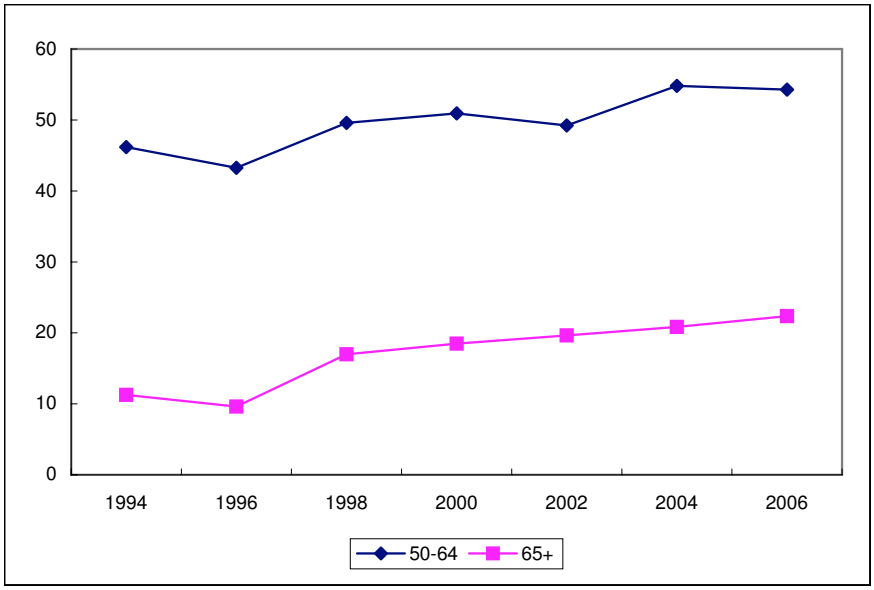


Figure 1: Percent of Households with Positive Secured Debt, by Age. Source: HRS

and unsecured debt have increased among retirees over time (1994-2006), but that the run-up in secured debt in this period has far outpaced that of unsecured debt, thus suggesting that home equity borrowing deserves specific attention. To be more specific, the total amount of unsecured debt outstanding among retirees tripled over the period, from $26 billion in 1994 to $75 billion in 2004, and came down to $67 billion in 2006. Instead, the total amount of secured debt outstanding grew sevenfold over the period, from $124 billion in 1994 to $868 billion in 2006.

Figures 1 and 2 show the share of older households, by age, that had positive secured debt, and the amount, per capita, of secured debt over time. These figures show that the increase in secured debt among older households has taken place both along the extensive and intensive margins, and moreover, the increasing trend was observed uniformly across age groups. Moreover, from looking at the 50-59 age group in the second graph, we see that over time, households *entered* retirement with increasing amounts of secured debt.

Figure 3 shows that the trend in HELOC debt has been a sizeable part of the overall increase in secured debt. Moreover, Figure 4 shows that retirees over time have shown an increasing preference for HELOCs over traditional mortgages, as the share of HELOCs in total secured debt has increased, while mortgages' share has decreased. HELOCs and traditional mortgages together account for nearly all of secured debt. Mortgages' share decreased from 94% to 79% of total secured debt between 1994 and 2006, while HELOCs' increased from 2.8% in 1994 to 14.2% in 2006.

Figures 5 and 6 analyze the trend in HELOCs along the extensive and intensive margins, and show a sizeable increase in both. The share of retired households with HELOCs has increased from 3% to 8% between 1996 and 2006. At the intensive margin, the median per-capita amount owed on a HELOC has seen a moderate increase; however, the mean has been increasing strongly over time,

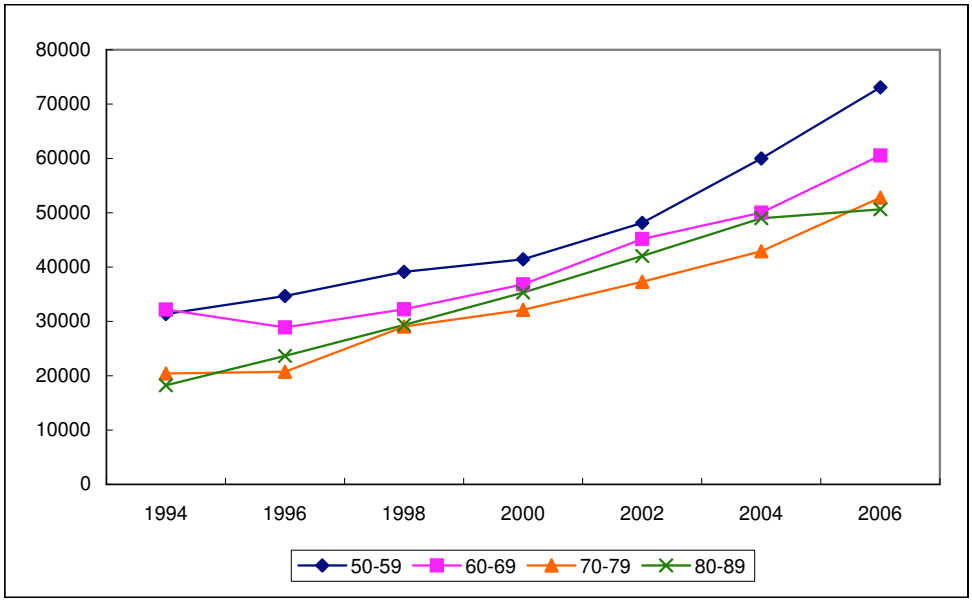


Figure 2: Average per-Capita Amount of Secured Debt, by Age. Source: HRS

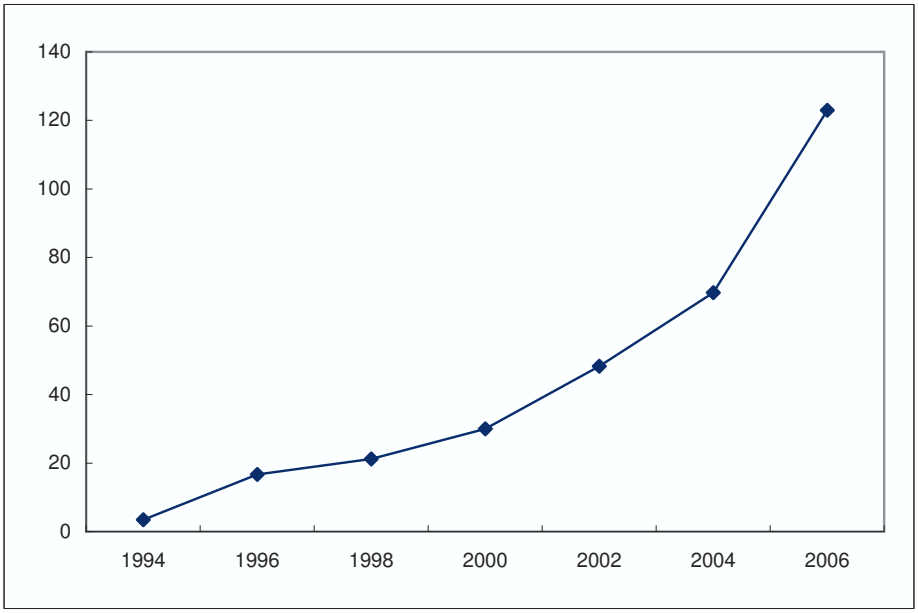


Figure 3: Aggregate HELOC Debt, Billions Dollars, Households 65+. Source: HRS

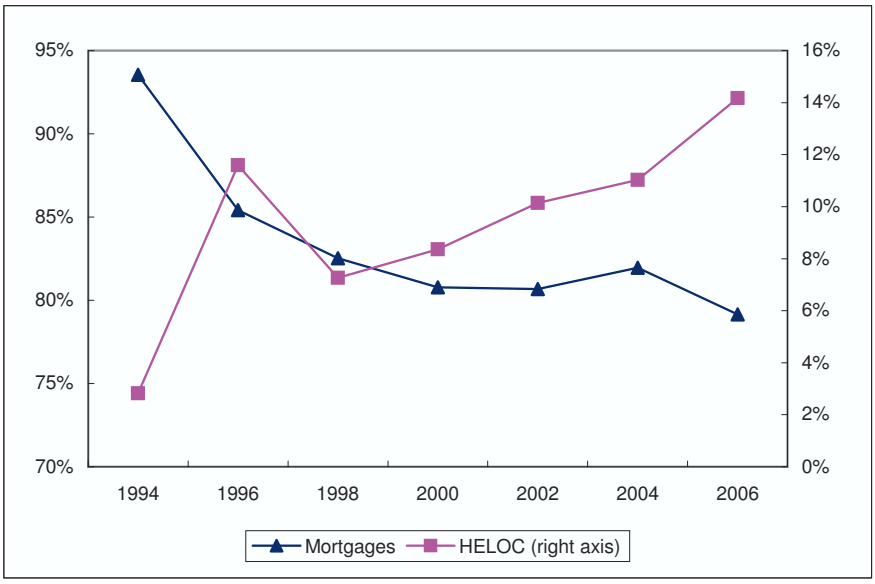


Figure 4: Mortgage and HELOC Debt as Percent of Total Secured Debt, Households 65+. Source: HRS

from around $20,000 to over $40,000 in nominal terms.

Finally, we document the overall trend among the elderly in borrowing against reverse mortgage loans, using data taking from the American Housing Survey (AHS). Figure 7 shows the dramatic increase in the use of RMLs by retirees, especially starting in 2001. Although to date still less than 1% of all eligible-age home owners have reverse mortgages, there has been strong growth in that market, and it remained remarkably strong even as home prices began to decline in 2006.

Our interest then is in understanding what drives these trends in HELOCs relative to other methods of secured borrowing. Obviously one correlated trend is the increase in house prices between the mid-1990's and 2006. In what follows, we explore a few additional features of HELOC borrowing among retirees in an attempt to understand whether other factors may also contribute to the surge in HELOC borrowing. Figure 8 breaks down HELOC borrowing by retirement status of households in the SCF, going back to 1989. As expected, the general trend for both groups is an increase in HELOC borrowing. A striking fact that emerges, however, is that non-retired households have all contracted their HELOC borrowing between 2004 and 2007, when house prices have first begun to contract. Retired households instead have all continued to increase their borrowing. This suggests that more than just the housing price trend may be affecting retirees' behavior.

Figure 9 provides further supporting evidence for this fact. Here we break down the median household-level amount of home equity (home value net of secured debt) by retirement status. Interestingly, despite the aggregate trend in house prices which have begun their descent after the summer of 2006, for non-retirees, the trend in home equity continued upward, perhaps reflecting the fact that over the period 2004-2006, house prices grew more than they fell in the 2006-2007 period. However, what is notable is that the pace of equity increase for non-retirees has been

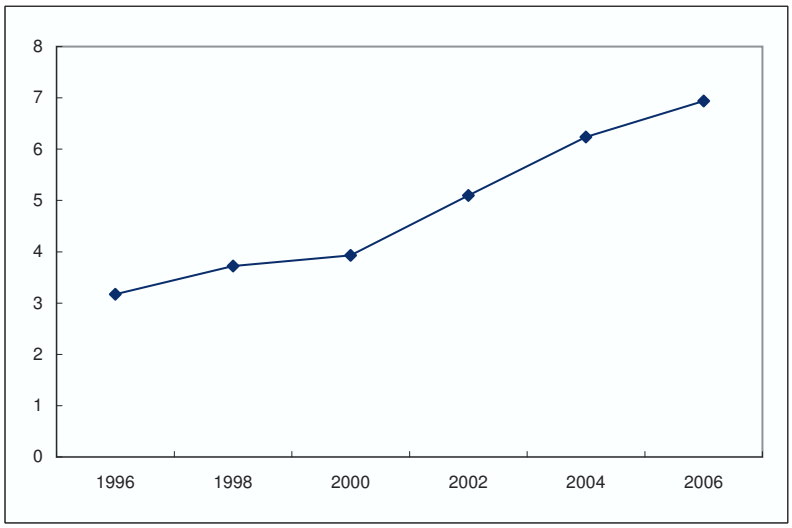


Figure 5: Percent of Households Age 65+ Using HELOCs. Source: HRS

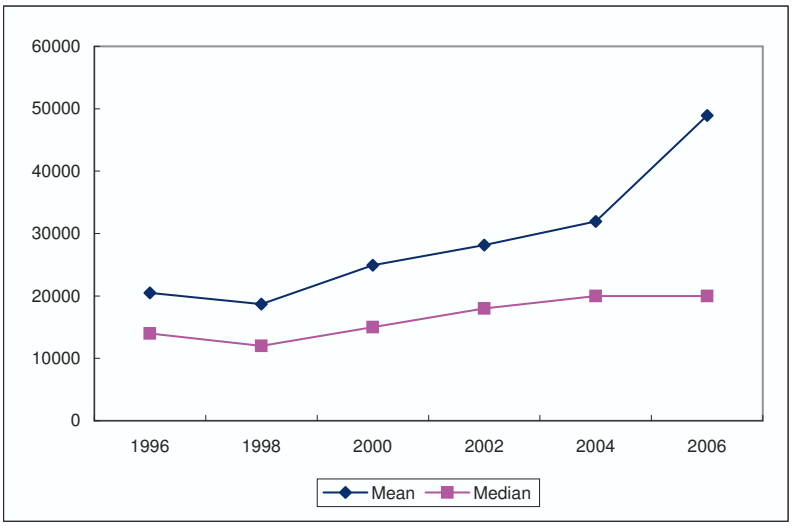


Figure 6: HELOC Amount Owed per Capita, Age 65+, Conditional on Having HELOC. Source: HRS

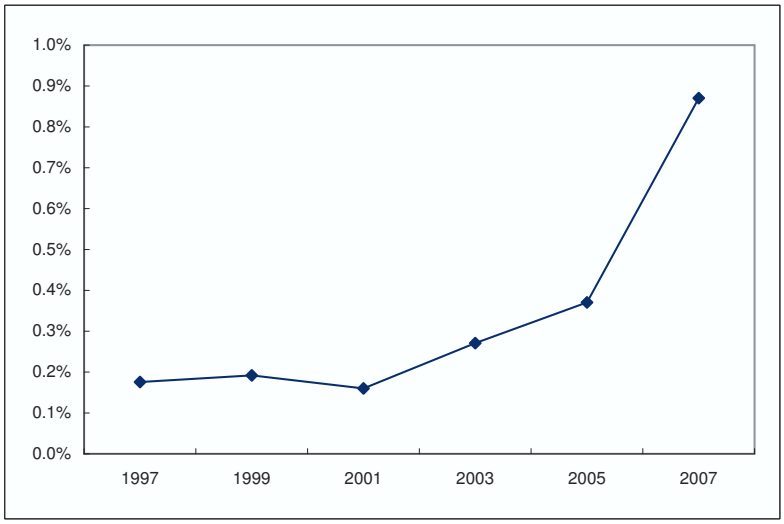


Figure 7: Percent of Home Owners 65+ with Reverse Mortgages. Source: AHS

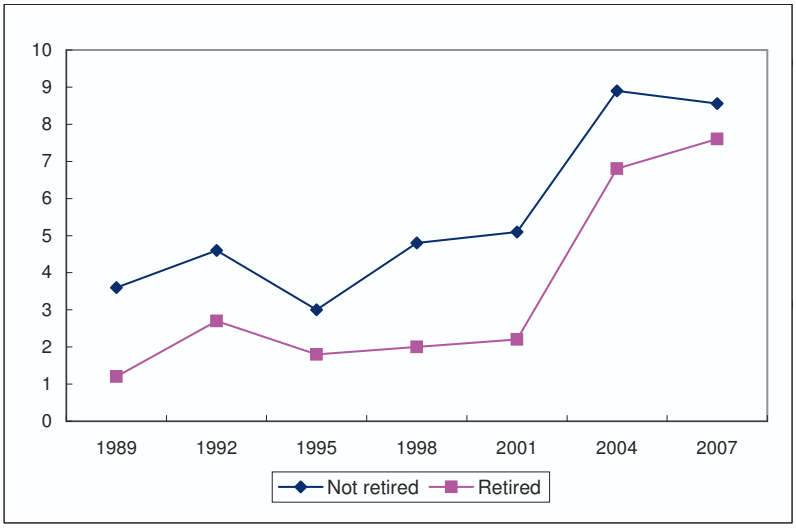


Figure 8: Percent of Households Borrowing against HELOCs by Retirement Status. Source: SCF

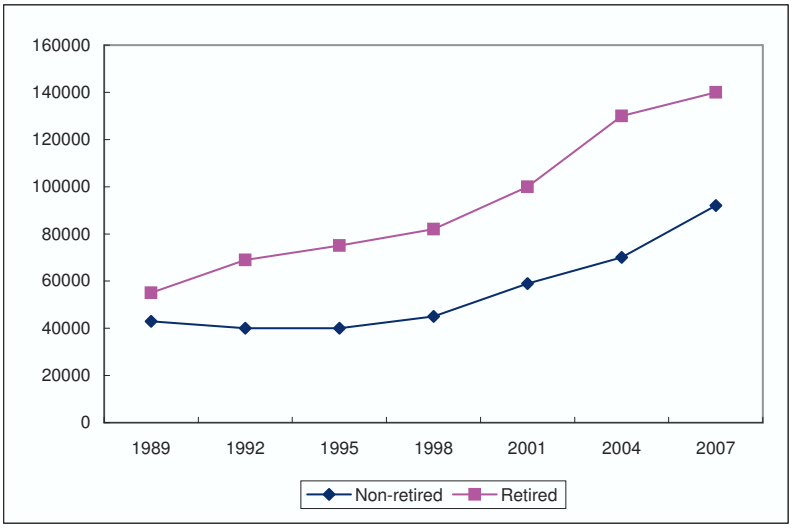


Figure 9: Median Home Equity by Retirement Status. Source: SCF

greater than for retirees. That is, retirees increased their HELOC borrowing as their home equity growth flattened, while non-retirees faced the opposite situation.

Below we explore additional possible contributing factors. The first one may be that retirees face increasing costs of living over time. An obvious factor that would contribute disproportionately to the decision-making of older households is medical costs. Figure 10 presents median individual out-of-pocket medical costs, in per-capita terms and deflated by the GDP deflator. The trend is clear: median costs have been rising, particularly severely for households in their 70's and above. The increase is also pronounced for those in their 60's, although the slope is flatter, and this is repeated if we look at the group in their 50's (not pictured). That is, the older old have experienced a particularly dramatic increase in medical expenses which may have translated into a greater need for liquidity during retirement in the period under consideration. There is a slight drop-off in medical expenses in the last wave of the HRS, perhaps reflecting the policies of the Bush administration aimed at reducing the cost of prescriptions for seniors, but the general trend is a plausible driving factor for the increase in HELOC borrowing.

Two, it may be possible that retirees have saved less in other (non-housing) assets over time, and replaced financial assets with additional borrowing against equity. However, this is difficult to distinguish in the data from the scenario that ties to the medical cost argument above: if medical costs are rising, we may see retirees running down their financial assets faster over time, and thus being forced to turn to HELOCs or other equity borrowing methods more often. Figures 11 and 12 show median per-capita gross and net, respectively, non-housing financial assets over time. On the one hand, that trend shows an overall increase in the assets throughout the period in question, as HELOCs were becoming popular; on the other hand, there is a steady flattening and decrease in financial assets among retirees in exactly the period, from 2001 on, when HELOCs became especially popular. This provides evidence that possibly supports some degree of substitution between financial saving and equity borrowing; however, the trend may also correlate with increasing costs

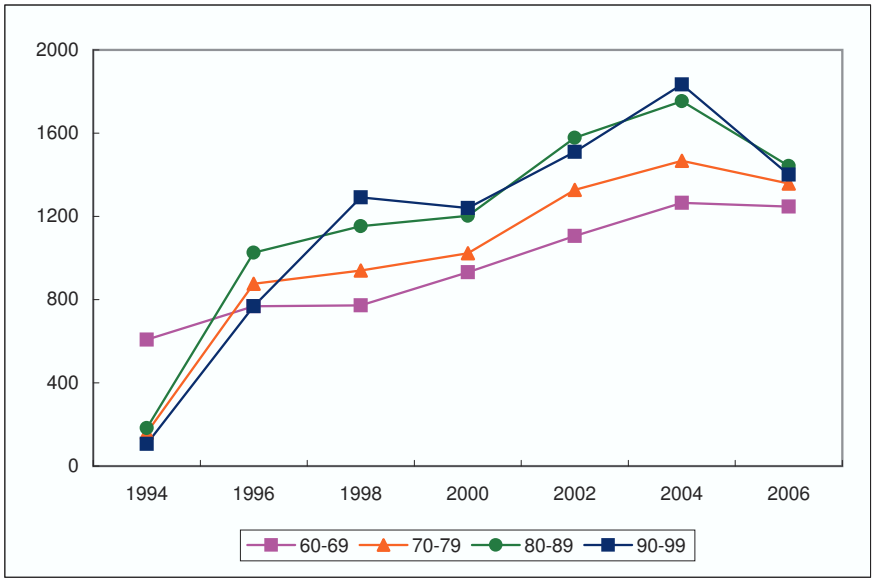


Figure 10: Median Real Individual Out of Pocket Medical Expenses, by Age. Source: HRS

of living.[3]

The final possibility that we are able to quantify is that HELOCs are becoming more popular because they are substituting more traditional and less flexible forms of equity borrowing. Chief among these in popularity in the data is cashout refinancing. Figure 13 shows the trends in cashout refinancing by retirement status. We see that some degree of substitution may have been happening for retirees throughout the 1998-2007 period; for non-retirees, this is not the case, since cashout refinancing is increasing together with HELOC borrowing. However, this comparison is not pure: in many cases, households refinance in order to improve their interest rate terms on the mortgage, something that taking a HELOC does not allow. Moreover, retirees increased their HELOC borrowing at a much faster pace than the decline in cashouts, suggesting that even if substitution is present, it is far from capturing the whole story.

To summarize, we see dramatic increases in equity borrowing among retirees, and retirees appear to increasingly prefer loans such as HELOCs and RMLs to more traditional forms of borrowing, despite the interest premium on these. Moreover, these increases in HELOC and RML borrowing continue as house prices have started to fall and as aggregate secured borrowing began to contract. We have listed some possible factors that drive these trends, which we eventually want to investigate to understand which have played a part in the changes that we observe. We are also ultimately concerned with macroeconomic and policy implications of these changes. Thus we will construct a model that can capture the main trends that we have observed over time among retirees. We proceed in steps. Before we can do macroeconomic analysis, we analyze the financial decisions of a household that begins and ends its life as a retired homeowner. We want to inves-

[3] Indeed we find in the data a correlation of dramatic financial losses with medical shocks, and in turn, a correlation between financial losses and equity withdrawals, particularly against HELOCs.

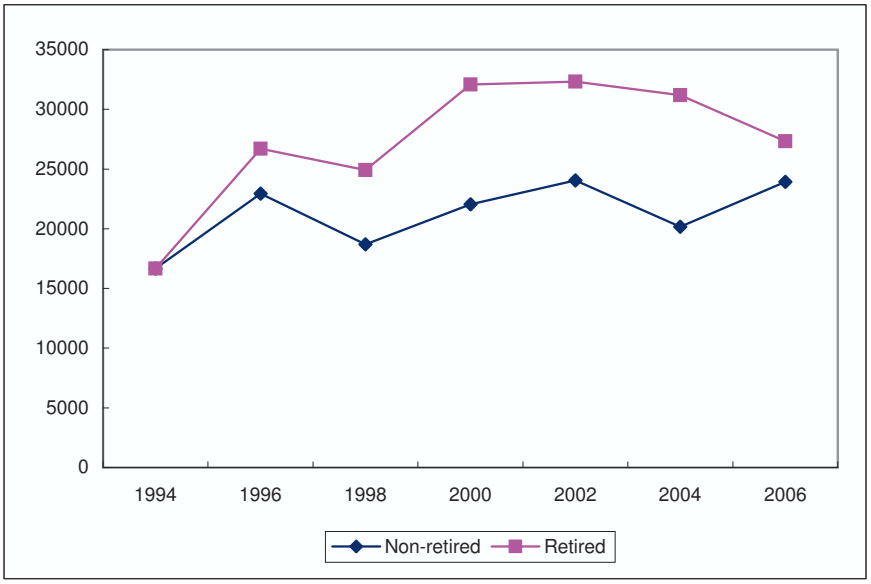


Figure 11: Median Gross Real Per-Capita Financial Asset Holdings. Source: HRS.

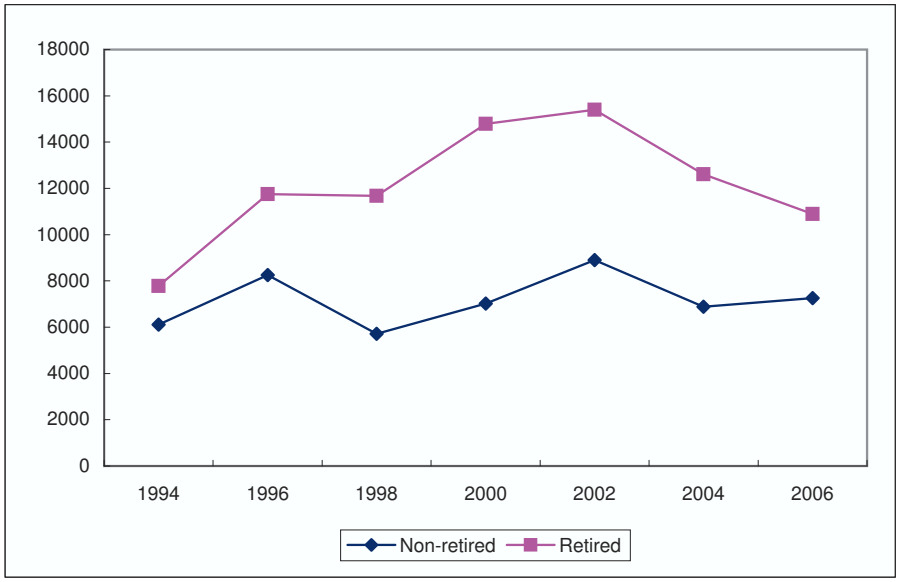


Figure 12: Median Net Real Per-Capita Financial Asset Holdings. Source: HRS.

Figure 13: Percent Households using Cashout Refinancing, by Retirement Status. Source: SCF.

tigate how the introduction of HELOCs/RMLs into the market would affect retirees' choices with respect to equity borrowing methods, and how well our model can capture the basic tradeoffs that we observe in the data. In this model, we treat HELOCs and RMLs as one instrument, abstracting from certain differences in up-front costs and repayment schedules, but capturing an increased degree of flexibility that both instruments offer. After that, we expand the model to also study the decisions to own a home or move.

4 Simplified Model

We model consumption, housing, and home equity borrowing choices in retirement. The novel feature of our model is that we model explicitly a variety of ways to finance consumption after retirement, in particular, a variety of mortgage instruments. Yogo (2009) develops a related model of consumption, housing, health expenditures, and portfolio choices in retirement. While Yogo (2009) focuses on the portfolio decision between risky and riskless assets, our focus is on the choice of instruments for home equity borrowing.

We develop what we call the *simplified model* in this section. We use the simplified model to illustrate the main features of the optimal decision problem associated with the home equity borrowing in retirement. Later we develop the *full model*. We use the full model to study the macroeconomic implications of the recent developments in the mortgage market, but the key intuitions that we obtain with the simplified model are carried over to the full model.

The simplified model has a single agent. We focus on the optimal decision of this representative agent. In order to focus on the decision regarding the choice of home equity borrowing, we abstract

from the decision regarding the size of the house as well as the tenure decision (the decision of whether own or rent). The agent is endowed with a house, and remains the owner of the same house throughout her lifetime, unless the agent cannot pay the out-of-pocket medical expenses and default on her bills. After a default, she remains a renter. These restrictions will be removed in the full model.

Like the full model, we consider different environments where different kinds of mortgage instruments are available. In particular, we compare two cases here. First is the model economy where only conventional mortgage loans are available, with the option of refinancing. The agent can borrow using the conventional fixed-maturity mortgage loan, and can refinance the mortgage. In the other environment, the agent has an access to HELOCs, in addition to the conventional mortgage loans. We use the simplified model to analyze how the agent's decision regarding home equity borrowing changes depending on the available mortgage instruments.

4.1 Preferences

This is a model of decision making in retirement. There is a single agent who is a retiree. An agent is *born* at age $i = 1$ and potentially lives up to age I. There is a probability of earlier death, details of which are given later, together with health status. An agent maximizes the following time-separable utility function:

$$\mathbb{E}\sum_{i=1}^{I}\beta^{i-1}\left[\prod_{j=1}^{i}\mathbb{1}_{m_j\neq 0}u(c_i,h_i,o_i)+\prod_{j=1}^{i}\mathbb{1}_{m_j=0}w(q_i)\right] \tag{1}$$

where β is the time discount factor, m_j represents the health status of the agent, $u(.,.,.)$ is the period utility function, c_i is non-housing consumption, h_i is housing consumption, o_i is housing tenure status, $w(.)$ is the period utility function associated with a bequest, and q_i is the one-time bequest upon death. If an agents dies at age j, q_j takes a positive value (if the agent leaves a positive amount of assets behind), and $q_i = 0\ \forall i \neq j$. o_i can take value of either 0 (renter) or 1 (homeowner). Having o_i in the utility function potentially helps us capture intangible benefits of owning a house rather than renting. $\mathbb{1}$ is an indicator function and $m_j = 0$ means the agent is dead in age j. Together $\mathbb{1}_{m_j\neq 0}$ takes value 1 is an agent is alive in age j, and value 0 otherwise.

4.2 Health Status and Medical Expenditures

$m \in \{0, 1, 2, ..., M\}$ represents the health status of an agent. $m = 0$ indicates that the agent is dead. A strictly positive m indicates that the agent is alive, with varying degree of health condition. $m = 0$ is an absorbing state, i.e., $m_j = 0$ for $\forall j \geq i$ if $m_i = 0$. We assume that m follows a first order Markov process. We use $\pi^m_{i,m,m'}$ as the transition probability from a health state m to m', for an agent of age i. Because of the way we include the death state in the health status, the transition probability $\pi^m_{i,m,m'}$ also includes the survival probability of agents. In particular,

the survival probability for an agent of age i and current health status m can be represented as $\sum_{m \neq 0} \pi^{m}_{i,m,m'}$.

An agent is hit by medical expenditure shocks $x \geq 0$ each period. x is drawn from a cumulative density function $F_{i,m}(x)$. Notice that the distribution of x depends on both age of the agent (i) as well as the agent's current health status (m). We assume that the shock is uninsurable; the medical expenditure shock corresponds to the out-of-pocket expenses in the data.

4.3 Income

As a retiree, an agent is entitled to receive pension income b each period. We assume b is constant over time. b can take different values for different agents in the full model, but assumed to be constant over the years for each agent.

4.4 Housing

An agent gains utility by living in a housing h and enjoying services generated from it. Housing can be owned ($o = 1$) or rented ($o = 0$). The house price is denoted by p^h. The rent of a house is denoted as r^h. If renting, an agent has to pay $r^h h$ each period as long as she is renting. There is no period-by-period cost for homeowners.

Moving from a house to another incurs non-convex adjustment costs. We assume that the moving costs are proportional to the size of the house. In particular, costs of moving-in are $\psi^0 h$ for renters, and $\psi^1 h$ for homeowners. Costs of moving-out are $\xi^0 h$ for renters, and $\xi^1 h$ for homeowners. Although we will not use the moving costs in the Simplified model as we abstract from moving decision, we describe the general environment which can be applied to the full model as well.

As we already discussed in Section 4.1, an agent might gain different utility depending on whether she owns the house or she rents it, even though the size of the house is the same. This difference in utility depending on the tenure status enables us meant to capture intangible benefits of owning rather than renting.

For the simplified model, the agent does not have a tenure choice; the agent is born as a homeowner and stays a homeowner unless she is forced to leave the house when she defaults. Moreover, the agent cannot move to a house of a different size. These restrictions are removed in the full model, where agents have the active tenure decision as well as the decision regarding the size of the house.

4.5 Financial Markets

An agent can either save, at interest rate r^s, or borrow. We consider only loans collateralized by house value; there is no unsecured credit in the model. Naturally, renters can only save but cannot

borrow.

The set of different types of mortgage loans available to agents is exogenously given. In particular, we focus our attention on two contrasting types of loans against the value of the house that capture most of the options available in the data: (i) conventional mortgage loans with lump-sum cash withdrawal and fixed long-term repayment schedule - these capture first and second mortgages, and HEL's; and (ii) home equity lines of credit (HELOCs), with periods of flexible cash withdrawal and a lump-sum repayment at the end of the term of the loan, which in a stylized manner capture HELOCs and RMLs in the model. In one of the model economies that we consider, we allow only conventional mortgage loans with an option to refinance. We use this model economy to capture the time before the development of the new mortgage instruments. In the other model economy we pose, agents have both types of instruments available.

First, conventional mortgage loans are modeled as follows. An agent can borrow up to a fixed fraction λ^c of the value of her house $p^h h$. Using d as the initial amount borrowed, the mortgage borrowing restriction can be represented as follows:

$$d \leq \lambda^c p^h h \tag{2}$$

We can interpret λ^c as the upper bound of the loan-to-value ratio, or $1 - \lambda^c$ as the downpayment requirement ratio, which is the minimum, represented as a fraction of house value, that an agent has to pay at the time of purchase. The closing cost of mortgage loans is $\kappa^c d$, which is the fraction κ^c of the initial loan amount d. The borrower pays interest r^c for the remaining balance of her loan each period. The term of repayment is K^c periods. We denote the repayment schedule using $\{\mu_k^c\}_{k=1}^K$; when an agent borrows d, the borrower repays $d\mu_K^c$ in the first period, $d\mu_{K-1}^c$ in the second period,..., and $d\mu_1^c$ in the K-th (last) period. We also use $\{\nu_k^c\}_{k=1}^K$ to denote the remaining balance of a conventional mortgage loan. Formally:

$$\nu_k^c = \sum_{j=1}^{k} \mu_j^c \tag{3}$$

It is easy to see that $\nu_K^c = \sum_{j=1}^K \mu_j^c = 1$ and $\nu_1^c = \mu_1^c$. In each period, a borrower who borrows the amount d and has k period of repayment pays $r^c \nu_k^c d + \mu_k^c d$. Following the most popular type of repayment plan, we set $\{\mu_k^c\}_{k=1}^K$ such that the payment associated with a conventional mortgage loan is constant over time. Under this particular repayment plan, it is easy to show the following:

$$\mu_k^c = \frac{r^c(1+r^c)^{K-k}}{(1+r^c)^K - 1} \tag{4}$$

With $\{\mu_k^c\}_{k=1}^K$ characterized as above, $\{\nu_k^c\}_{k=1}^K$ can be computed easily from $\{\mu_k^c\}_{k=1}^K$.

A borrower can prepay the existing mortgage loan. The cost of prepayment is the fixed proportion κ^p of the remaining loan amount. In addition, a borrower can take a new loan to replace the original loan. The combination of prepayment and replacing is basically the refinancing. The closing cost of the new mortgage loan is the fraction κ^f of the new loan balance. When the

borrower refinances, the repayment schedule is reset with the term K^c, with the new loan amount $dp^h h$. The refinancing option can be used either for taking out more of the home equity (cashout refinancing), or for repaying faster than the original repayment schedule.

Second, an agent can buy an option to borrow flexibly for a fixed period of time, up to a given fraction of the house value. This option captures the HELOC in a stylized manner. The price of this option is κ^ℓ of the house value. Once an agent purchases the option, the agent can draw up to a fixed fraction λ^ℓ of the house value for K^ℓ periods. Each period, as long as the agent has a positive balance, the agent has to pay interest at the rate of r^ℓ for the balance. After K^ℓ periods, the loan becomes due and the borrower is required to repay the total loan amount outstanding. If the borrower moves out of the house, or dies, the loan instantly becomes due.

Considering that the closing cost of HELOC is frequently waived, we assume $\kappa^\ell = 0$. Somewhat surprisingly, this assumption helps simplifying the problem greatly. When there is no closing cost and the repayment is flexible, whether an agent has an open HELOC account not important; an agent can open up a new HELOC account if necessary. Consequently, we do not keep track of the term of HELOCs. Moreover, if we assume that the interest rate charged to the HELOC balance is higher than the saving interest rate, which is a reasonable assumption, it is not optimal to borrow against a HELOC when there is a positive amount of savings. Therefore, borrowing against a HELOC can be understood as a negative amount of saving.

Finally, as we discussed in Section 2, 80% of the borrowers of Reverse Mortgage Loans choose the line of credit option. Therefore, we can interpret RMLs as a special form of a HELOC, where the loan becomes due when either the borrower moves out of the house, or the borrower dies. Since HELOCs are costlessly rolled over in our model, we do not need to distinguish between borrowing against a HELOC and an RML with line of credit option, although we thus abstract from the closing costs of RMLs, which are typically much higher than HELOC costs. Still, since we cannot distinguish HELOCs from RMLs in our micro data, we think aggregating the two in this way in the model is reasonable.

4.6 Default

Since agents in the model are hit by out-of-pocket expenditure shocks, there is a positive probability that an agent cannot consume a strictly positive amount if the agent pays a medical expenditure in full. Therefore, we allow a possibility of default. If an agent defaults, the agent loses all of her asset and debt, including the housing. Notice we are assuming no homestead exemption. Consequently, the agent becomes a renter in the next period. Moreover, we assume that a fixed fraction τ of her income is garnished. Following the Chapter 7 bankruptcy law in the U.S., there is no garnishment of the future income of the defaulting agent.

4.7 Agent's Problem

We formulate the agent's problem recursively. An agent's individual type can be summarized by $(i, m, x, b, o, a, h, d, k)$, where i is the age, m is the health status, x is the current medical expenditure, b is the social security benefits received each period. o is the housing tenure status ($o = 0$ implies a renter and $o = 1$ implies a homeowner), a is the amount of savings or borrowing under HELOC, h is the size of housing, d is the initial size of the mortgage debt, and k is the remaining periods of mortgage repayment. Naturally, when either an agent is a renter, an agent did not take a mortgage loan when purchasing a house, or an agent finished repaying her mortgage loan, $d = 0$ and $k = 0$.

We will use the model under two different environments with respect to the available mortgage instruments. In particular, the two environments differ by whether or not HELOCs are available. Since borrowing against a HELOC is captured as a negative a, the model economy without HELOC is characterized by $\underline{a} = 0$. On the other hand, the model economy where agents can borrow with HELOC is characterized by $\underline{a} = \underline{a}(h, d, k)$. The borrowing limit for HELOC depends on (h, d, k) because agents can borrow up to a fixed fraction of the house value, using the combination of the conventional mortgage loans and borrowing under HELOC.

In order to save space, we use the following notation in the recursive formulation of the problem of renters and homeowners below:

$$\underline{a} = \begin{cases} -(\lambda^{\ell} p^{h} h - \nu^{c}_{k-1} d') & \text{for model with HELOC} \\ 0 & \text{for model without HELOC} \end{cases} \tag{5}$$

$$r = \begin{cases} r^{s} & \text{if } a \geq 0 \\ r^{\ell} & \text{if } a < 0 \end{cases} \tag{6}$$

In an economy with HELOCs, the agent can borrow up to the fixed fraction of the house value $\lambda^{\ell} p^{h} h$ net of the remaining balance of the conventional mortgage loan $\nu^{c}_{k-1} d'$. In other words, when HELOCs are available, the agent can borrow up to a fraction λ^{ℓ} of the house value, using a combination of conventional mortgage loans and HELOCs. Interest associated with a is the saving rate r^{s} if the agent is saving and not using HELOC, and is the borrowing interest rate associated with HELOC (r^{ℓ}) if the agent is not saving but borrowing under HELOC.

4.7.1 Homeowner's Problem

The representative agent is *born* at age one as a homeowner, with a house of size h and asset a. The agent receives a constant income b each period. If an agent is a homeowner, the agent can either (i) stay in the same house and keep repaying the mortgage debt if there is any, (ii) stay in the same house but refinance the mortgage, or (iii) default and become a renter. We assume that renting is an absorbing state. This is a reasonable assumption as very small number of retirees change their tenure status from renting to owning. Remember there is no active tenure decision nor decision of moving to a house of different size in the simplified model.

The problem of a homeowner can be formalized as follows:

$$V(i,m,x,b,1,a,h,d,k) = \max\{V_{\text{stay}}, V_{\text{refi}}, V_{\text{def}}\} \tag{7}$$

where V_{stay}, V_{refi}, and V_{def} are conditional values corresponding to the three choices listed above.

Value conditional on staying at the same owned house is as follows:

$$V_{\text{stay}}(i,m,x,b,1,a,h,d,k) = \max_{c\geq 0, a'\geq \underline{a}} \{u(c,h,1) + \beta EV(i,m,b,1,a',h,d',k')\} \tag{8}$$

subject to:

$$c + a' + x + \mu_k^c d + r^c \nu_k^c d = (1+r)a + b \tag{9}$$

$$k' = \begin{cases} k-1 & \text{if } k > 0 \\ 0 & \text{if } k = 0 \end{cases} \tag{10}$$

$$d' = \begin{cases} d & \text{if } k > 0 \\ 0 & \text{if } k = 0 \end{cases} \tag{11}$$

$\mu_k^c d$ is the repayment of the principal of the mortgage loan when the agent has k more repayment periods. $r^c \nu_k^c d$ is the interest payment for the remaining balance of the debt. k keeps decreasing until the loan is completely repaid ($k = 0$). d keeps record of the initial balance as long as there is an outstanding balance, and becomes zero once the loan is completely repaid.

EV is short-hand notation for the expected value with respect to the health shock (including early death shock) and the medical expenditure shock. Formally, EV is defined as follows:

$$EV(i,m,b,o,a,h,d,k) = \sum_{m'=1}^{M} \pi_{i,m,m'}^{m} \int_{x'} V(i+1,m',x',b,o,a,h,d,k) dF_{i+1,m'}(x') + \pi_{i+1,m,0}^{m} W(o,a,h,d,k) \tag{12}$$

where $W(o,a,h,d,k)$ is the value associated with giving bequest. We assume that, upon death, all the assets and debts are consolidated and there is a one time bequest, from which a dying agent gains utility. Formally:

$$W(o,a,h,d,k) = w(q) \tag{13}$$

where

$$q = \begin{cases} a & \text{if } o = 0 \text{ (renter)} \\ a + h - \nu_k^c d & \text{if } o = 1 \text{ (homeowner)} \end{cases} \tag{14}$$

Notice that only the remaining balance of the conventional mortgage loan is subtracted from the value of the house when all the assets and debt are consolidated. This is because a HELOC is modeled as a negative a.

Value conditional on refinancing is:

$$V_{\text{refi}}(i,m,x,b,1,a,h,d,k) = \max_{c\geq 0, a'\geq \underline{a}, d'\geq 0} \{u(c,h,1) + \beta EV(i,m,b,1,a',h,d',k')\} \tag{15}$$

subject to:

$$c + a' + x + (1 + r^c + \kappa^p)v_k^c d + \kappa^f d' = (1+r)a + b + d' \tag{16}$$

$$k' = \begin{cases} K^c & \text{if } d' > 0 \\ 0 & \text{if } d' = 0 \end{cases} \tag{17}$$

When the agent decides to refinance, the total remaining balance of the old loan ($v_k^c d$) becomes due, together with the interest rate for the current period (r^c) and prepayment cost (κ^p). $\kappa^f d'$ is the closing cost associated with the newly taken loan of amount d'. The remaining term of the mortgage loan (k') is reset at K^c if the agent obtains a new loan and set at zero if the agent just prepays without obtaining a new loan. The part of the agent's problem associated with HELOC is the same as in the problem of the staying agent.

Value conditional on defaulting is defined as follows:

$$V_{\text{def}}(i,m,x,b,1,a,h,d,k) = \max_{c\geq 0, a'\geq \underline{a}} \{u(c,h,1) + \beta EV(i,m,b,0,a',h,0,0)\} \tag{18}$$

subject to:

$$c + a' = (1-\tau)b \tag{19}$$

$$\tag{20}$$

Notice that the agent can default on the medical expenditure x, but loses house h and whatever the savings that she has. Moreover, a fraction τ of the income b is garnished. In the next period, the agent will be a renter. Since we have only one size for the house, the agents rents a house of size h.

4.7.2 Renter's Problem

If the agent is a renter, the agent can either (i) keep renting the same house, or (ii) default. Notice that there is no tenure decision, as we assume that renting is an absorbing state. Also notice that we abstract from the decision regarding moving to another rental property with different size.

The problem of a renter can be formalized as follows:

$$V(i,m,x,b,0,a,h,0,0) = \max\{V_{\text{stay}}, V_{\text{def}}\} \tag{21}$$

where V_{stay}, and V_{def} are conditional values corresponding to the two choices listed above.

Value conditional on staying at the same rental property is as follows:

$$V_{\text{stay}}(i,m,x,b,0,a,h,0,0) = \max_{c\geq 0, a'\geq 0} \{u(c,h,0) + \beta EV(i,m,b,0,a',h,0,0)\} \tag{22}$$

subject to:

$$c + a' + x + r^h h = (1 + r^s)a + b \tag{23}$$

Asset position for the next period a' is nonnegative because we do not allow unsecured borrowing, and the agent cannot use a HELOC.

Finally, value conditional on defaulting is defined as follows:

$$V_{\text{def}}(i, m, x, b, 0, a, h, 0, 0) = \max_{c \geq 0, a' \geq \underline{a}} \{u(c, h, 0) + \beta EV(i, m, b, 0, a', h, 0, 0)\} \tag{24}$$

subject to:

$$c + a' = (1 - \tau)b \tag{25}$$

$$\tag{26}$$

The problem is basically the same as the homeowner's, because defaulters become a renter.

4.8 Prices

The price of non-housing consumption goods is normalized to one. There are four prices in the model: p^h, r^s, r^c, and r^ℓ. We assume that prices are exogenously given. For now, we further assume that prices are constant over time.

5 Simplified model: Calibration

Since the Health and Retirement Survey is biennial, we set one model period as two years. We give detailed description of our calibration of the simplified model. Table 1 summarizes the calibrated parameter values for both the simplified model and the full model.

5.1 Preferences

We use the following standard constant relative risk aversion (CRRA) utility function. We use Cobb-Douglas aggregator between consumption of non-housing goods and that of housing services:

$$u(c, h, o) = \frac{(c^\eta (\omega_o h)^{1-\eta})^{1-\sigma}}{1 - \sigma} \tag{27}$$

ω_i is one for renters ($o = 0$) and is $1 + \overline{\omega}$ for homeowners ($o = 1$). A strictly positive $\overline{\omega}$ captures intangible benefits of owning rather than renting.

Table 1: Summary of Calibration

Parameter	Value (Simplified)	Value (Full)	Description
β	0.9600[1]	TBD	Discount factor.
σ	1.5000	1.5000	Coefficient of relative risk aversion.
η	Not Used	TBD	Aggregation between housing & non-housing consumption.
γ	1.0000	TBD	Strength of warm-glow bequest motive.
ω	0.0000	TBD	Intangible benefits associated with homeownership.
$\pi^m_{i,m,m'}$	See Text	See Text	Transition matrix of health status.
$\pi^x_{i,m,x}$	See Text	See Text	Distribution of medical expenditure shocks.
$x_{i,m,x}$	See Text	See Text	Possible realizations of medical expenditure shocks.
b	11000[1]	See Text	Median income of retirees.
h	71000	See Text	Median house value of retirees at age 65.
a_1	44000	See Text	Median financial asset of retirees at age 65.
d_1	56800	See Text	80% of the house value.
k	10[1]	See Text	10 more years of mortgage amortization.
p^h	1.0000	1.0000	House price. Normalized.
r^h	0.0400[1]	0.0400[1]	Rental cost. Equal to saving interest rate.
ψ^0	Not Used	0.0000	Move-in cost rental property.
ψ^1	Not Used	0.0250	Move-in cost owned property.
ξ^0	Not Used	0.0000	Move-out cost rental property.
ξ^1	Not Used	0.0700	Move-out cost owned property.
τ	0.2500	0.2500	Income garnishment rate.
r^s	0.0400[1]	0.0400[1]	Saving interest rate.
r^c	0.0400[1]	0.0400[1]	Conventional mortgage interest rate.
r^ℓ	0.0500[1]	0.0500[1]	HELOC interest rate.
λ^c	0.8000	0.8000	Maximum LTV ratio for conventional mortgage loans.
λ^ℓ	0.8000	0.8000	Maximum LTV ratio for HELOC.
κ^c	0.0500	0.0500	Closing cost for conventional mortgage loans.
κ^p	0.0100	0.0100	Prepayment cost for conventional mortgage loans.
κ^f	0.0500	0.0500	Refinancing cost for conventional mortgage loans.
κ^ℓ	0.0000	0.0000	Closing cost for HELOC.
K^c	30[1]	30[1]	Term of conventional mortgage loans.

[1] Annualized.

The utility function for bequests is also assumed to be of CRRA type:

$$w(q) = \gamma \frac{q^{1-\sigma}}{1-\sigma} \tag{28}$$

where $\gamma > 0$ determines the strength of *warm-glow* bequest motive.

In the simplified model, we set the coefficient of relative risk aversion (σ) to be 1.5. β is set such that the discount factor is equal to the saving interest rate, implying $\beta = 0.96$ annually. ω is set at zero, because there is no active tenure decision in the simplified model. γ is calibrated to be 1.0 since $\gamma = 1.0$ generates the amount of bequests roughly consistent with data. η does not play any role in the simplified model as there is only one house size.

5.2 Health Status and Medical Expenditures

We use the HRS and its longitudinal dimension in order to calibrate the transition matrices for health status as well as the medical expense shock process.

As mentioned above, the matrices for health status transition, $\pi^m_{i,m,m'}$, are conditioned on age. Thus, we will have as many health transition matrices as we have age groups. To compute these transitions, in order to insure that we have large enough groups from which to compute the probabilities, we aggregate individuals into 10-year age bins, so that we condition the transition matrices on being in the 60's, 70's, 80's, etc. Thus, in the model, households of five different model ages at a time will have the same transition matrix for health.

We classify all individuals in the HRS according to their self-reported health status. In the data, individuals choose from one of five options to describe their current health: excellent, very good, good, fair, and poor. We aggregate these categories into three groups: excellent/very good, good, fair/poor. To this, we add death as the fourth health-status state. We then compute, in every pair of consecutive waves of the HRS (from 1994 to 2006, giving us seven pairs), the numbers of individuals in each age bin who have transitioned between each health state into any of the three health states in the following wave, as well as those who transitioned from any health state into death. Finally, we average the matrices across waves, to produce one set of transition matrices for each age group. The resulting matrices are given in table 2.

In order to calibrate the distribution of medical expense shocks, we look at self-reported out-of-pocket medical expenses of individuals in the HRS. Again, we compute these distributions by age group and health status. In each wave of the HRS, conditional on age group and each of the health status bins (not including death), we compute the mean and standard deviation of the log of out-of-pocket medical expenses, which we deflate by the GDP deflator to take out the influence of inflation. While we documented above that real medical out-of-pocket expenses have been dramatically rising over time, for this simplified model we assume that the distribution is constant over time, and thus once again, we average the distributions across the waves. The resulting means and standard deviations of the log of medical costs are given in table 3.

Once we obtain the mean and standard deviation of the log-normal distribution of out-of-pocket medical expenditures, together with the distinct probability of having zero expenditures, we approximate the distribution using a finite number of possible realizations. In particular, we choose $N_x = 4$ grids for the discretization. The distribution of x conditional on the current age and health status (i, m) can be represented by $\{x_{i,m,j}\}_{j=1}^{N_x}$ and $\{\pi^x_{i,m,j}\}_{j=1}^{N_x}$, where the former is the set of possible realizations, and the latter is the probability assigned to each point. We set $x_{i,m,1} = 0$ and

Table 2: Health State Transition Matrices

Age		0 (death)	1 (excellent)	2 (good)	3 (poor)
60-69	0	100.0	0.0	0.0	0.0
	1	1.15	71.59	21.92	5.36
	2	2.20	25.15	51.95	20.70
	3	8.78	6.27	19.47	65.48
70-79	0	100.0	0.0	0.0	0.0
	1	3.17	62.26	25.52	9.05
	2	6.01	22.29	46.48	25.22
	3	15.75	5.30	16.94	62.01
80-89	0	100.0	0.0	0.0	0.0
	1	9.37	49.11	26.55	14.98
	2	13.46	18.89	37.79	29.86
	3	27.82	5.18	13.64	53.36
90-99	0	100.0	0.0	0.0	0.0
	1	26.37	35.06	20.88	17.69
	2	31.61	16.03	25.28	27.08
	3	46.73	4.63	12.04	36.60

Table 3: Health Expense Shock Distributions

Age		1 (exc.)	2 (good)	3 (poor)
60-69	mean	6.69	7.03	7.40
	st.dev.	1.37	1.39	1.49
	$\mathbb{P}(x=0)$	0.10	0.10	0.16
70-79	mean	6.68	6.96	7.27
	st.dev.	1.39	1.34	1.42
	$\mathbb{P}(x=0)$	0.10	0.10	0.13
80-89	mean	6.83	7.05	7.34
	st.dev.	1.39	1.37	1.39
	$\mathbb{P}(x=0)$	0.11	0.10	0.11
90-99	mean	6.86	7.24	7.35
	st.dev.	1.50	1.41	1.49
	$\mathbb{P}(x=0)$	0.16	0.15	0.15

$\pi^x_{i,m,1}$, which is the probability of receiving $x = 0$ conditional on (i, m), as the numbers we obtain from HRS. The remaining $\{x_{i,m,j}\}_{j=1}^{N_x}$ and $\{\pi^x_{i,m,j}\}_{j=1}^{N_x}$ are pinned down by discretizing a (log-)normal distribution.

5.3 Income

The representative agent receives $b = 11,000$ dollars each period. This is the across-waves average of the median non-financial income in HRS. The median non-financial income includes social security benefits (retirement and disability), employer pension or annuity income, and other government transfers. The age profiles of both median and mean of the non-financial income are relatively flat in the HRS sample, justifying the use of constant b.

5.4 Housing

Price of housing p^h is set at unity. The rent is set at the same rate as the saving interest rate, which is 4% annually (8% in the model). The moving costs are not used in the simplified model, since there is no active moving decision.

5.5 Financial Markets

Saving interest rate r^s is set at annual 4% (8% per model period). Notice that the return is intended to capture the average return of all financial assets, including pensions and other retirement assets.

λ^c is set at 0.8, which means that homeowners can take up to 80% of the value of their housing using their primary mortgages. This is consistent with the average loan-to-value ratio of conventional mortgage loans in the data, which is always around 80%. Closing cost parameter κ^c is set at 5%, which is in the middle of distribution of closing cost in the data. The interest rate r^c is set at 4% annually (8% per model period), which is same as the saving interest rate. Although the historical average of the premium of the conventional mortgage loans over 30-year treasury bonds is around 1%, we take into account the tax benefit of mortgage interest payment deduction. The term of the conventional mortgage loans is set at 30 years (15 periods in the model). About three quarters of the primary mortgage loans have 30-year maturity in 2007, according to the American Housing Survey (AHS).

Prepayment cost parameter κ^p is set at 1%. The prepayment cost varies, but typically is not as high as the closing cost of conventional mortgages. Refinancing cost parameter κ^f is set at the same as the closing cost of the conventional mortgage loans (5% of the loan amount).

The characteristics of HELOCs vary quite substantially. The maximum loan to value ratio, λ^ℓ, is set at 0.8, as many HELOCs have the limit between 0.7 and 0.9 of the house value. Since the closing cost of HELOCs is waived frequently, we set $\kappa^\ell = 0$. As we discussed, $\kappa^\ell = 0$ helps simplifying the solution of the model substantially. One notable characteristics of HELOCs is that HELOCs often have adjustable interest rate, which contrasts with the conventional mortgage loans which usually have fixed interest rate. In addition, typically, HELOCs have various kinds of additional costs, for example, *points* charged to the balance, account maintenance cost, etc. In order to capture these additional cost, we set r^ℓ, interest rate for HELOC balance, as 5% per year (10% in model period), which is 1% above the rate for conventional mortgage loans.

5.6 Default

The income garnishment rate upon default (τ) is set at 0.25 (25%), which is the limit imposed by the Federal government.

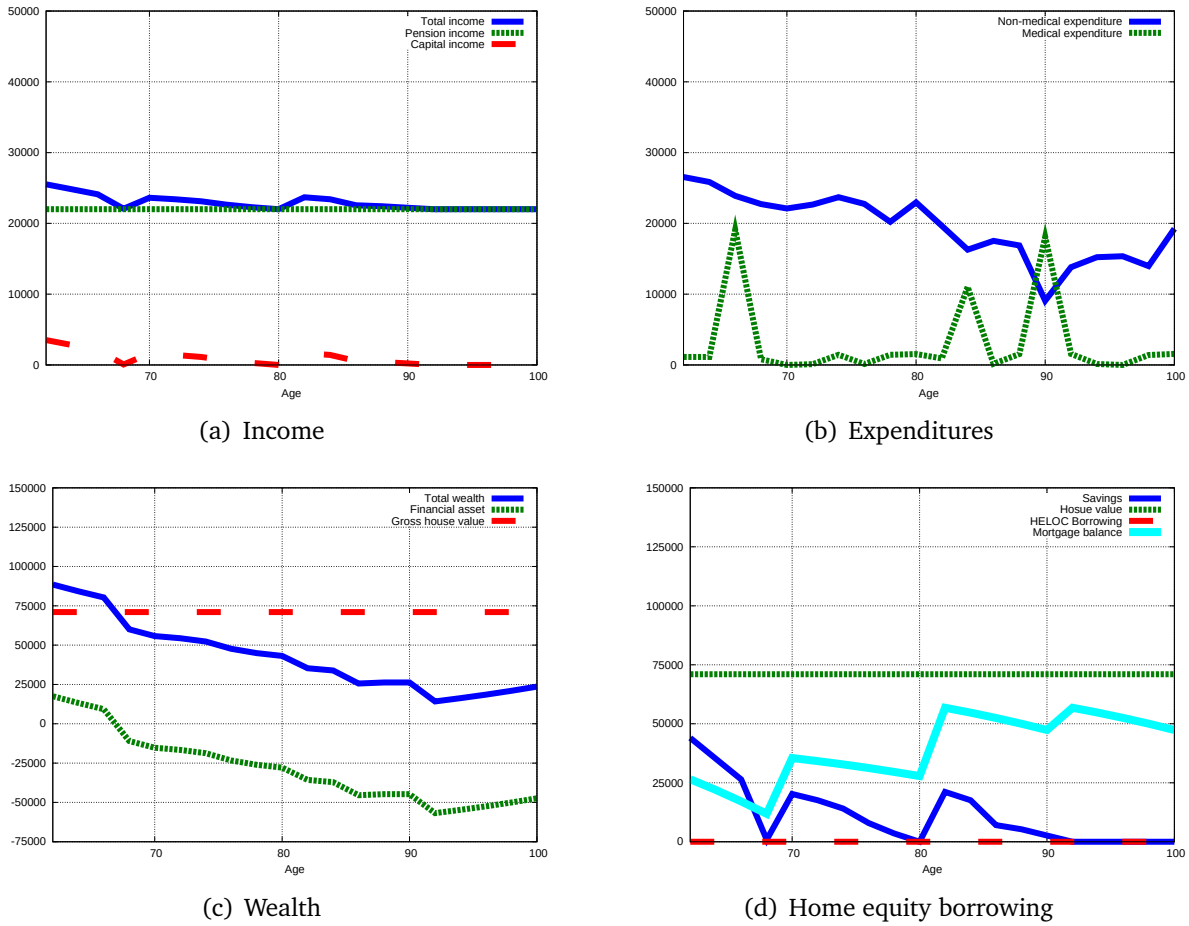
5.7 Endowment

We assume that the representative agent is born as a homeowner. The value of the house is taken from HRS. We use the time average of the median value of the house owned by 65 years old retirees in HRS sample, \$ $71,000$, as h. Similarly, initial a is set at \$ $44,000$. The representative agent starts out having taken out a conventional mortgage loan of 80% of the house value. We assume that she had repaid for 20 years already by the time of retirement, and has to repay 10 more years.

6 Simplified model: Results

First, we will compare how decisions of the representative agent are affected by the difference in the set of available mortgage instruments. In particular, we compare model economies with and without HELOCs. For facilitate the comparison, we pick one agent with one particular history of shocks.

Figure 14 exhibits the lifecycle of a sample agent, between age 62 (initial age) and 100. We choose the agent who turns out to live until age 100, though many agents do not survive until age 100. Panel (a) shows the income. The total income (blue line) is the sum of the pension income (green line) and the financial income (red line). The agent earns a positive financial income only when the agent has a positive amount of savings. Panel (b) shows the consumption expenditures. The green line shows the out-of-pocket medical expenses, which are shocks for agents in the model. The blue line shows the non-medical non-housing consumption expenditures. It is decreasing over time, because the increasing probability of death over the lifecycle has the effect of increasing discount rate over the lifecycle. Lifecycle profile of consumption expenditures is mostly smooth, except for a period when the agent is hit by a large medical expenditure shock (age 90). Panel (c) shows the total wealth (blue line), which consists of the housing asset (red line) and the financial asset (green line). Financial asset consists of the savings and mortgage debt. There is no borrowing under HELOC in the current example. The agent starts with a net positive wealth position at age 62, but quickly falls into a net negative wealth position by refinancing her mortgage debt repeatedly. The last Panel (d) shows how the agent uses the mortgage loans. The green line represents the house value. The green line represents the savings. And the light blue line shows the amount of conventional mortgage debt balance. As we can see in Panel (d), the agent refinances three times, which is represented by the three spikes in Panel (d). For the first two times the agent refinances when the savings run out (when the blue line hits the bottom). In the last time, the agent refinances when she cannot cover the medical expenditure with her savings. Since



(a) Income

(b) Expenditures

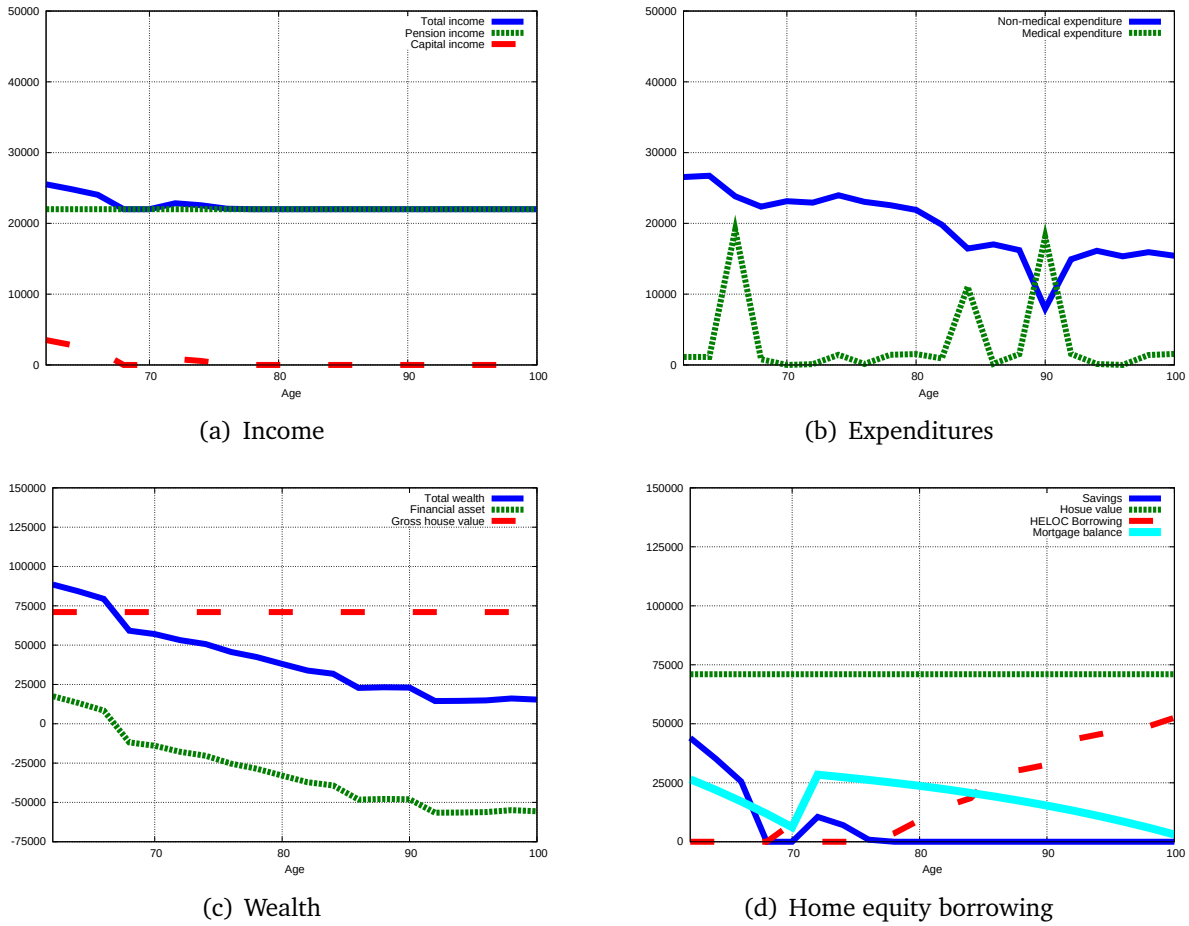
(c) Wealth

(d) Home equity borrowing

Figure 14: Simplified model - Without HELOCs

refinancing incurs non-convex costs, refinancing occurs infrequently, and in a lumpy manner; she wants to minimize the number of times she refinances. On the other hand, the agent typically does not borrow up to the maximum amount (80% of the house value in the current setup) because non-convex cost of refinancing is increasing with the amount of new debt. It is easy to understand that this particular cost structure potentially hurts the ability of the agent to achieve the desirable consumption path which could be achieved in the absence of these frictions.

Figure 15 exhibits the same lifecycle profiles but in the economy with HELOCs. Apart from Panel (d), the figures are similar; the agent keeps borrowing against the home equity to finance consumption in retirement. The interesting difference can be seen in Panel (d). The red line, which stayed at zero in Figure 14, shows the amount of borrowing against a HELOC. Since agents use HELOCs only when the savings run out, the red line takes a positive value only when the blue line (saving) hits zero. Like in the previous case, the agent refinances early in her retirement life (age 70), but after that, the agent keeps repaying the conventional mortgage debt. Note that the light blue line keeps decreasing smoothly, which shows that the agent repays according to the standard amortization schedule. After age 78, the agent exclusively uses HELOCs to finance consumption



(a) Income

(b) Expenditures

(c) Wealth

(d) Home equity borrowing

Figure 15: Simplified model - With HELOCs

after retirement. Why does the agent refinance once and uses the HELOC after that? In the early period in retirement, the risk of refinancing, that is, taking a costly lump-sum loan, and dying shortly after, before benefiting from refinancing rather than borrowing under HELOC, is relatively small, although it also depends on the health status (this agent turns out to have a good health status at age 70). In the later part of her life, the risk that she refinances and cannot take advantage of it is too large, so she exclusively uses borrowing against the relatively costless and flexible HELOC when she runs out of savings or encounters a medical expense shock.

To put it more generally, the benefit of using refinancing rather than borrowing against a HELOC is the lower interest rate. But because of the non-convex cost, the borrower naturally takes a larger amount of debt than necessary immediately. This can be costly if the agent dies soon after taking mortgage loans. On the other hand, although borrowing against a HELOC incurs a higher interest rate, the borrower can use it in more flexible manner.

How about the implications on aggregate debt? There are two possible and opposing effects. First, when HELOCs are available, agents can avoid over-borrowing; with HELOC, agents can borrow exactly the amount needed instead of borrowing for both current and future needs. This logic

Table 4: Welfare implications of HELOC

Initial health status	$\mathbb{E}V$[1] (No HELOC)	$\mathbb{E}V$[1] (With HELOC)	Consumption equivalence[2]
Good	−0.09557	−0.09521	+0.76%
Normal	−0.09239	−0.09202	+0.79%
Poor	−0.08365	−0.08330	+0.84%

[1] $\mathbb{E}V$ denotes the expected lifetime utility.
[2] Measured by the percentage change in flow consumption.

implies that the availability of HELOCs may actually *reduce* overall indebtedness. On the other hand, the high cost of refinancing might prevent some agents from borrowing in an economy without HELOCs. In this case, availability of HELOCs could increase indebtedness. We will use the full model later to quantitatively compare these different and opposing effects on aggregate debt.

Since the model with HELOCs has all the financial instruments available in the economy without HELOC, there is a welfare gain from this extra financial instrument. How large is it? Table 4 exhibits the expected welfare gain of the representative agent, conditional on the initial health status. The gain is represented as the percentage increase in the flow consumption, i.e., percentage increase of consumption in every period and node to make the lifetime utility in a model without HELOCs equal to that in the model with HELOCs. For agents of any initial health status, the expected welfare gain of having an option of borrowing under HELOCs is about 0.8% of flow consumption at the initial age (which is calibrated to be age 62), and increases slightly as health status deteriorates - agents in poor health experience a larger welfare gain from more flexible borrowing options. Overall, the welfare gains are sizable.

Finally, the simulations of the simplified model indicates that agents default and become renters less often when HELOCs are available. For example, among the agents who turn out to live until 100 (the last age in the model), 35% of agents default once and become renters in the model without HELOCs, while the proportion is 30% in the model with HELOCs. When HELOCs are unavailable, in some occasions, especially when the agents receive a large medical bill, agents find it optimal to default rather than to pay a large fixed cost and refinance. When HELOCs are available, agents under the same circumstances choose to borrow against the HELOC rather than default. This property seems to indicate that, in the full model where agents can actively choose whether to own or to rent, HELOCs might help agents to keep their house. This is interesting because the AARP reports that some of the users of RMLs that they interview point out that a benefit of having an RML is that it allows them to stay in their house.

7 Full Model

Since the environment of the full-model is virtually the same as the simplified model, we skip the description of the environment and immediately start describing the problem of agents. There are three key differences between the simplified model and the full model. First, the full model is used to study the macroeconomic implications of mortgage market development. Therefore, the economy is populated by heterogenous agents. There are both ex-ante (initial asset, house, debt, and health status) and ex-post (evolution of health status, and medical expenditure shocks) heterogeneity. Second, agents can choose to be renters or homeowners. Third, both renters and homeowners can move to a house of different size. These features make the full model richer than the simplified model, but the basic intuition that we obtained from the simplified model will be still valid.

7.1 Agent's Problem

We formulate the agent's problem recursively. For ease of understanding, we formulate separately the problem of homeowners and renters. An agent's individual type can be summarized by $(i, m, x, b, o, a, h, d, k)$, where i is the age, m is the health status, x is the current medical expenditure, b is the social security benefits received each period. o is the housing tenure status ($o = 0$ implies a renter and $o = 1$ implies a homeowner), a is the amount of savings or borrowing under HELOC, h is the size of housing, d is the initial size of the mortgage debt, and k is the remaining periods of mortgage repayment. Naturally, when either an agent is a renter, an agent did not take a mortgage loan when purchasing a house, or an agent finished repaying her mortgage loan, $d = 0$ and $k = 0$.

7.1.1 Renter's Problem

A renter can either (i) stay in the same rental property, (ii) move to another rental property, or (iii) default. We assume that renting is an absorbing state; renters do not purchase and become a homeowner. This is a reasonable assumption since, among the households in the HRS sample, only about 1.3% (on average across waves) change their tenure status from renting to owning. Formally:

$$V(i, m, x, b, 0, a, h, 0, 0) = \max\{V_{\text{stay}}, V_{\text{rent}}, V_{\text{def}}\} \tag{29}$$

where V_{stay}, V_{rent}, and V_{def} are conditional values corresponding to the three choices listed above.

7.1.2 Renter: Staying

Value conditional on staying in the same rental property is:

$$V_{\text{stay}}(i, m, x, b, 0, a, h, 0, 0) = \max_{c \geq 0, a' \geq 0} \{u(c, h, 0) + \beta EV(i, m, b, 0, a', h, 0, 0)\} \tag{30}$$

subject to:

$$c + a' + x + r^h h = (1 + r^s)a + b \tag{31}$$

Saving for the next period a' is nonnegative because we do not allow unsecured borrowing, and the agent cannot use a HELOC. EV is a short-hand notation for the expected value with respect to the health shock (including early death shock) and the medical expenditure shock. Formally, EV is defined as follows:

$$EV(i, m, b, o, a, h, d, k) = \sum_{m'=1}^{M} \pi^m_{i,m,m'} \int_{x'} V(i+1, m', x', b, o, a, h, d, k) dF_{i+1,m'}(x') + \pi^m_{i+1,m,0} W(o, a, h, d, k) \tag{32}$$

where $W(o, a, h, d, k)$ is the value associated with giving bequest. We assume that, upon death, all the assets and debts are consolidated and there is a one time bequest, from which a dying agent gain utility. Formally:

$$W(o, a, h, d, k) = w(q) \tag{33}$$

where

$$q = \begin{cases} a & \text{if } o = 0 \text{ (renter)} \\ a + h - \nu^c_k d & \text{if } o = 1 \text{ (homeowner)} \end{cases} \tag{34}$$

Notice that only the remaining balance of the conventional mortgage loan is subtracted from the value of the house when all the asset and debt are consolidated. This is because HELOC is modeled as a negative a.

7.1.3 Renter: Moving to Another Rental

Value conditional on moving to another rental property is:

$$V_{\text{rent}}(i, m, x, b, 0, a, h, 0, 0) = \max_{c \geq 0, a' \geq 0, h' \geq 0} \{u(c, h, 0) + \beta EV(i, m, b, 0, a', h', 0, 0)\} \tag{35}$$

subject to:

$$c + a' + x + r^h h + \xi_0 h + \psi_0 h' = (1 + r^s)a + b \tag{36}$$

Notice that there are costs associated with moving-out of the current rental property ($\xi_0 h$) and moving-in to another ($\psi_0 h'$).

7.1.4 Renter: Defaulting

Value conditional on defaulting is:

$$V_{\text{def}}(i,m,x,b,0,a,h,0,0) = \max_{c\geq 0, a'\geq 0, h'\geq 0} \{u(c,h,0) + \beta EV(i,m,b,0,a',h',0,0)\} \tag{37}$$

subject to:

$$\begin{array}{ll} c + a' = (1-\tau)b & \text{if } h = h' \text{ (staying)} \\ c + a' + \xi_0 h + \psi_0 h' = (1-\tau)b & \text{if } h \neq h' \text{ (moving)} \end{array} \tag{38}$$

Notice that the renter who is defaulting pays for the moving cost only when she is moving to another rental property.

7.1.5 Homeowner's Problem

Before describing the problem of a homeowner, let us define the interest rate associated with a, and the constraint for saving/borrowing choice $\underline{a}$ in the same way as in the simplified model. Formally:

$$\underline{a} = \begin{cases} -(\lambda^{\ell} p^h h - v^c_{k-1} d') & \text{for model with HELOC} \\ 0 & \text{for model without HELOC} \end{cases} \tag{39}$$

$$r = \begin{cases} r^s & \text{if } a \geq 0 \\ r^{\ell} & \text{if } a < 0 \end{cases} \tag{40}$$

In the model with HELOC, agents can borrow up to the fraction λ^{ℓ} using HELOC and the conventional mortgage loan. In the model without HELOC, a only represents saving, and has to be above zero. Interest associated with a is the saving rate r^s if $a \geq 0$ and is the interest rate associated with HELOC (r^{ℓ}) if $a < 0$.

A homeowner's problem is similar to that of the renter's but slightly more involved. A homeowner can either (i) stay in the same house and keep repaying the mortgage debt if there is, (ii) stay in the same house but refinance the mortgage, (iii) purchase and move to a new house, (iv) move to a rental property, or (v) default. Formally:

$$V(i,m,x,b,1,a,h,d,k) = \max\{V_{\text{stay}}, V_{\text{refi}}, V_{\text{own}}, V_{\text{rent}}, V_{\text{def}}\} \tag{41}$$

where, again, V_{stay}, V_{refi}, V_{own}, V_{rent}, and V_{def} are conditional values corresponding to the five choices listed above.

7.1.6 Homeowner: Staying

Value conditional on staying at the same owned house is as follows:

$$V_{\text{stay}}(i,m,x,b,1,a,h,d,k) = \max_{c\geq 0, a'\geq \underline{a}} \{u(c,h,1) + \beta EV(i,m,b,1,a',h,d',k')\} \tag{42}$$

subject to:

$$c + a' + x + \mu_k^c d + r^c \nu_k^c d = (1+r)a + b \tag{43}$$

$$k' = \begin{cases} k-1 & \text{if } k > 0 \\ 0 & \text{if } k = 0 \end{cases} \tag{44}$$

$$d' = \begin{cases} d & \text{if } k > 0 \\ 0 & \text{if } k = 0 \end{cases} \tag{45}$$

$\mu_k^c d$ is the repayment of the principal of the mortgage loan when the agent has k more repayment periods. $r^c \nu_k^c d$ is the interest payment for the remaining balance of the debt. k keeps decreasing until the loan is completely repaid ($k = 0$). d keeps record of the initial balance as long as there is an outstanding balance, and becomes zero once the loan is completely repaid.

7.1.7 Homeowner: Refinancing

Value conditional on refinancing is:

$$V_{\text{refi}}(i, m, x, b, 1, a, h, d, k) = \max_{c \geq 0, a' \geq \underline{a}, d' \geq 0} \{u(c, h, 1) + \beta EV(i, m, b, 1, a', h, d', k')\} \tag{46}$$

subject to:

$$c + a' + x + (1 + r^c + \kappa^p)\nu_k^c d + \kappa^f d' = (1+r)a + b + d' \tag{47}$$

$$k' = \begin{cases} K^c & \text{if } d' > 0 \\ 0 & \text{if } d' = 0 \end{cases} \tag{48}$$

When the agent decided to refinance, the total remaining balance of the old loan ($\nu_k^c d$) becomes due, together with the interest rate for the current period (r^c) and prepayment cost (κ^p). $\kappa^f d'$ is the closing cost associated with the newly taken loan of amount d'. The remaining term of the mortgage loan (k') is reset at K^c if the agent obtains a new loan and set at zero if the agent just prepays without obtaining a new loan.

7.1.8 Owner: Purchasing a New House

Value conditional on moving to a new house is:

$$V_{\text{own}}(i, m, x, b, 1, a, h, d, k) = \max_{c \geq 0, a' \geq \underline{a}, h' \geq 0, d' \geq 0} \{u(c, h, 1) + \beta EV(i, m, b, 1, a', h', d', k')\} \tag{49}$$

subject to:

$$c + a' + x + (1 + r^c + \kappa^p)\nu_k^c d + \xi_1 h + \psi_1 h' + p^h h' + \kappa^c d' = (1+r)a + b + p^h h + d' \tag{50}$$

$$k' = \begin{cases} K^c & \text{if } d' > 0 \\ 0 & \text{if } d' = 0 \end{cases} \tag{51}$$

The budget constraint is similar to the case when the owner moves to a rental. The differences are associated with the purchase of a new house. The agents pays for the value of the house ($p^h h'$) but could simultaneously obtain a mortgage loan d'. The agent has to pay for the closing cost ($\kappa^c d'$). The remaining term of the mortgage loan is reset to K^c in case the agent takes a mortgage, and to zero if the agent does not. When the agent moves out of a house, borrowing under HELOC becomes immediately due ($a' \geq 0$), but the agent can immediately start borrowing using HELOCs using the value of the newly purchased house, net of the amount of conventionally mortgage loan taken.

7.1.9 Homeowner: Moving to a Rental

Value conditional on moving to a rental property is:

$$V_{\text{rent}}(i, m, x, b, 1, a, h, d, k) = \max_{c \geq 0, a' \geq 0, h' \geq 0} \{u(c, h, 1) + \beta EV(i, m, b, 0, a', h', 0, 0)\} \tag{52}$$

subject to:

$$c + a' + x + (1 + r^c + \kappa^p) v_k^c d + \xi_1 h + \psi_0 h' = (1 + r)a + b + p^h h \tag{53}$$

When the agent moves out of a house and becomes a renter, the remaining balance of the mortgage loan ($v_k^c d$) becomes immediately due, together with the current interest payment (r^c) and prepayment cost (κ^p). Agent then obtains the value of the house ($p^h h$). The agent also has to pay the costs of moving-out ($\xi_1 h$) and moving-in ($\psi_0 h'$). As for HELOC, when the agent moves out of the house, all the borrowing under HELOC becomes immediately due for repayment. Since HELOC is a flexible instrument, there is no prepayment cost associated with HELOC.

7.1.10 Homeowner: Defaulting

Finally, value conditional on defaulting is:

$$V_{\text{rent}}(i, m, x, b, 1, a, h, d, k) = \max_{c \geq 0, a' \geq 0, h' \geq 0} \{u(c, h, 1) + \beta EV(i, m, b, 0, a', h', 0, 0)\} \tag{54}$$

subject to:

$$c + a' + \xi_1 h + \psi_0 h' = (1 - \tau)b \tag{55}$$

Notice that the homeowner can escape from the medical expenditures, but loses asset (and debt), pays for the moving cost, and becomes a renter.

8 Full Model: Calibration

Table 1 summarizes the calibrated parameter values for both the simplified model and the full model. As can be seen in Table 1, most parameter values are shared between the two versions of the model. However, three differences are worth pointing out.

First, parameters associated with preferences are re-calibrated to match the closely-related targets in the data. Specifically, we set the coefficient of relative risk aversion (σ) to be 1.5. η is calibrated to match the proportion of aggregate housing asset in the aggregate total wealth in the data. $\overline{\omega}$ is calibrated to match the ratio of homeowners and renters among retirees. γ is calibrated to capture the average amount of bequest in the data. β is calibrated to match the average lifecycle consumption profile of retirees.

Second, since the full model features house size decision, we need to calibrate the moving cost parameters. Cost of moving in and out of rental property is assumed to be zero ($\psi^0 = 0$ and $\xi^0 = 0$). There are literatures which estimate the cost associated with moving in and out of owned properties. Grueber and Martin (2003) estimate the cost of moving-in and moving-out to be 2.5% and 7% of the value of the house, respectively. We use their estimates to set $\psi^1 = 0.025$ and $\xi^1 = 0.07$.

Third, the full model features the heterogeneity across agents. Specifically, distribution of the initial state (m, b, o, a, h, d, k) is chosen to match the corresponding distribution among recent retirees in HRS.

9 Full Model: Results

To be continued.

10 Ongoing and Future Directions

Our current work is focusing on calibrating and computing the full model and conducting the macroeconomic analysis that we detailed in the introduction. We want to know what possible processes may have caused observed increases in equity borrowing and especially in HELOCs/RMLs - along the lines of increasing house prices, increasing medical costs, substitution out of other assets, etc. We also want to analyze aggregate implications of recent developments in terms of welfare and policy implications, and we are particularly interested in the implications for retirees of trends in house prices similar to the recent housing crisis. We want to know how the recent developments in financial markets have contributed to the fallout from the crisis.

We also have three future extensions in mind. First, although we focus on the saving decision of retirees, some of our questions regarding macroeconomic implications of mortgage market developments require having the whole lifecycle in the model; this way, we could study endogenously how the retirees arrive at the asset holdings that we observe in the data. Second, we might (in the current paper) distinguish RMLs from the general HELOC to explicitly talk about RMLs, which is an instrument that is often talked about and is of interest because of its particularly strong growth in just a few recent years. Finally, one could construct a general equilibrium version of the model, to capture how different mortgage instruments are priced differently. In our model, if there is a risk

of foreclosures, different instruments naturally have different equilibrium prices. It is particularly interesting to see how the prices of different types of mortgage instruments move over the business cycle, and implications of such price changes on the business cycles, especially in recessions.

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