Too Poor to Retire? House Prices and Retirement☆

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Abstract

This paper finds that the cyclical movements in housing prices and stock prices can explain the puzzling countercyclical old-age labor force participation during the recent recessions in the US. The retirement probability of home/stock owners drops when housing/stock price unexpectedly declines. A calibrated incomplete-market life-cycle partial-equilibrium model with housing consumption and endogenous retirement is able to reproduce the retirement and consumption patterns in the data. The paper quantifies three channels (resizing effect, bequest motive, and collateral borrowing) through which housing prices can affect retirement. It also highlights the endogenous retirement as a self-insurance tool for the old homeowners against housing price risks.

Keywords: housing wealth effect, endogenous retirement, self-insurance
JEL: E21, E24, J26

1. Introduction

In the United States, the unemployment rate is countercyclical and the employment-population rate is procyclical for households aged 16-64, which are among the stylized facts about business cycles. The labor-force participation rate (LFPR, hereafter) is also procyclical for most working-age population. However, the LFPR for households aged 55-64 is countercyclical over the last two decades.

Table 1 displays the time-series correlation between the HP-filtered LFPR and selected business cycles indicators by age groups. First, the LFPR for young people is highly procyclical, which is consistent with the findings in the literature, e.g., Rios-Rull [1], Gomme et al. [2], Jaimovich and Siu [3]; second, the LFPR for households aged 55-64

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Table 1: The Cyclical Labor Force Participation Rate By Age Groups

Period 1995-2011	16-24	25-34	35-44	45-54	55-64	65+
corr(LFPR,unemployment rate[a])	-.52***	-.46***	-.18***	-.15**	.23***	-.05
corr(LFPR,employment-population rate)	.65***	.62***	.39***	.31***	-.13*	.08
corr(LFPR,S&P500)	.26***	.35***	.15**	.19***	-.40***	-.11
corr(LFPR,Case-Shiller 10-MSA[b])	.11	-.05	-.19***	-.15**	-.21***	-.15**
Period 1948-2011	**16-24**	**25-34**	**35-44**	**45-54**	**55-64**	**65+**
corr(LFPR,unemployment rate)	-.36***	-.27***	-.13***	-.12***	.04	-.06*
corr(LFPR,employment-population rate)	.60***	.46 ***	.33***	.31***	.09**	.23***
corr(LFPR,S&P500)	.13***	.15***	-.04	.02	-.13***	.00
corr(LFPR,Case-Shiller 10-MSA)	.16***	.01	-.10*	-.02	-.10*	-.02

[a] The labor-force participation rate is from BLS data seasonally adjusted series LNS11324887, LNS11300089, LNS11300091, LNS11300093, LNU01300095, and LNU01300097. The unemployment rate for 16 years and over is from LNS14000000. The employment-population rate for 16 years and over is from LNS12300000.

[b] The S&P500 and Case-Shiller 10-MSA composite index are in logarithm value and deflated by monthly CPI index. All monthly series are HP-filtered with smoothing parameter 129,600, as recommended by Ravn and Uhlig [5]. The Case-Shiller 10-MSA composite index is available since 1987. *** (**) [*] significant at the 1(5)[10]% level.

is positively correlated with the aggregate unemployment rate during 1995-2011. The correlation remains positive but insignificant over the longer period 1948-2011; third, the LFPR for households aged 55-64 is negatively correlated with asset prices. The above patterns hold for both males and females. As shown in Figure 1, the HP-filtered LFPR for this near-retirement age group increases by more than .5 percent above the long-term trend in the two recent recessions and the retirement rate drops by the similar magnitude.[1]

The countercyclical LFPR for households aged 55-64 is puzzling because job hunters could postpone entering the job market and the unemployed may stop searching for new jobs when labor market is tight, both of which decrease the LFPR. However, the wealth loss and income loss associated with the recession can increase LFPR due to the wealth effect on labor supply. If the counteracting force is strong enough, then LFPR will spike in the recession. This is most likely to be true for the near-retirement age group because they have accumulated lifetime wealth, which will be used to finance consumption and health expenditure in the later life. Moreover, the U.S. households are gradually shifting their portfolios towards riskier assets because of the recent development in the financial market, e.g., the increasing participation rate in the defined contribution plan and the boom in home ownerships from mid-1990s.[2] Therefore, the near-retirement households

[1] The Retirement Rate (not the Retirement Hazard Rate), defined as the proportion of retired households in the total population, is computed by the author using monthly CPS data 1976-2011. All series are HP-filtered 12-month moving average using smoothing parameter 129,600. Daly et al. [4] also documents the abnormal increase in the LFPR for households aged 55-64 in the two recent recessions.

[2] Most increase in DC plans takes place within private sectors. Costo [6] documents that the coverage of DC plans in private sectors has outpaced the coverage of DB plans since 1992. The difference between the two coverage rates is 20 percent at year 2005. Chambers et al. [7] shows the surge in the home ownerships after 1994.

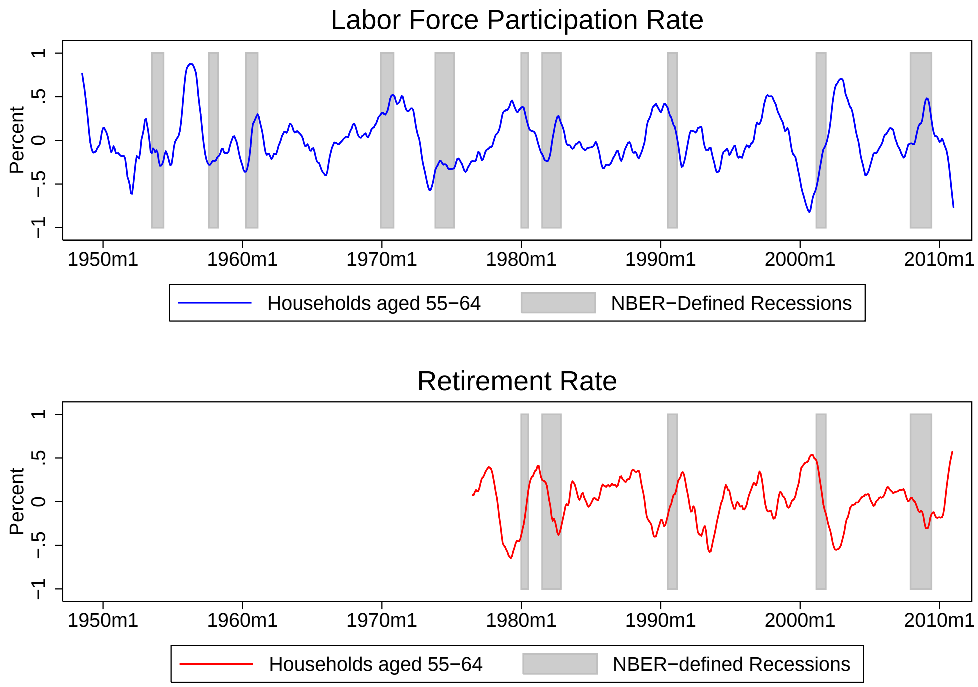

Figure 1: HP-filtered Labor Force Participation and Retirement Rate 1948-2011

are faced with great volatility in total wealth if the portfolios are heavily concentrated in housing assets and stocks.[3] One way for them to insure against asset price risks is to adjust labor along both extensive margin and intensive margin. It often takes the form of altering retirement planning, as most old households withdraw completely from labor market when they retire (Prescott et al. [9]).

This paper is going to answer the following questions. What is the impact of asset price shocks on the probability of retirement and on non-durable consumption? Is the standard incomplete-market life-cycle model with housing consumption and endogenous retirement able to quantify such wealth effect? How effective is the endogenous retirement as a self-insurance tool in cushioning housing price risks?

The first contribution of the paper is to estimate the asset price effect on retirement and consumption for the near-retirement households using the most updated data from Health and Retirement Survey (HRS) and the Current Population Survey (CPS). By

[3]During last 20 years, the annualized returns to stocks and housing asset have been varying from -20 percent to 50 percent. The median households whose age is now between 57-62 hold 22.3 percent of their total net worth (including social security wealth) in housing market, 9.2 percent in stocks market at year 2006 (Gustman et al. [8]). Since then, both stocks market and housing market have been declining by 30 percent, which is equal to 10 percent of their total wealth, nearly $53,700 in 2006 dollars. The loss is even larger than the median household income, which is $50,233 in 2007 according to the U.S. Census Bureau.

running both panel and cross-sectional regressions, I find that a 10 percent decline in local housing price will reduce the mean retirement probability for home owners by 1.2-1.4 percent and their non-durable consumption by 2.9 percent. The same percentage decline in stock price will reduce the mean retirement probability for stock owners by .7 percent and their non-durable consumption by 1.8 percent.

The second contribution of the paper is to demonstrate that a calibrated incomplete-market life-cycle model, in which households choose housing consumption and the timing of retirement subject to income risk, housing price risk, and mortality risk, can replicate the retirement and consumption patterns found in the empirical regressions.

In this paper, I explore three channels through which housing prices can affect the timing of retirement. The first one is the resizing effect. Housing plays a dual role here, i.e., the consumption good and the investment tool. First, it provides housing services flows, which can substitute for non-durable consumption. Empirical studies find that the elasticity of substitution between housing and non-durable consumption is close to one. (See Fernandez-Villaverde and Krueger [10] for a list of references). Hence, households want to adjust housing size in response to housing prices even with additional transaction cost.[4] Second, housing also serves as an investment tool because of its durability.[5] The realized capital gains or losses due to fluctuating prices and house resizing will affect the reservation wage and the probability of retirement.

The second channel is the warm-glow bequest motive.[6] Even for households with the same total net worth and income risk, different levels of housing prices change the incentive to work by altering the amount of accidental or intentional bequest. Given that most households leave bequest and housing wealth accounts for the largest fraction of non-pension wealth for the median old households, it is important to quantify this channel as well.

The third channel is the collateral borrowing. Housing not only provides services flows, but also serves as the most important collateral for households. Housing price fluctuations will change households' borrowing limit. In the period of housing boom, households may apply for the home equity line of credit or refinance their mortgages to take advantage of high collateral value.[7] When housing bubble bursts, collateral borrowing constraint limits the extent of self-insurance. This provides one extra incentive

[4]For example, households purchase bigger house when housing price is low and downsize the house when price is high

[5] There have been debates on whether housing, like other liquid assets, is being used by old households to finance consumption because of its transaction cost. In the U.S., home ownership rate over life-cycle increases until age 60s, remains stable until age 70s, and declines significantly afterwards (Yang [11]). The adjustment to housing can take place along intensive margin as well. Banks et al. [12] finds that U.S. households downsize their houses in terms of reductions in the number of rooms per dwelling and the value of the home, keeping the home ownership rate unaltered. Hryshko et al. [13] finds evidence for housing asset is used a risk-sharing tools for consumption.

[6]Nardi [14] finds that introducing bequest motive can explain the high concentration of wealth and large amounts of wealth held by the richest households during very old age in the data.

[7]According to Survey of Consumer Finance 2007, nearly 50 percent of households age 50-59 have refinanced their first lien mortgages on primary residence. In the Survey of Consumer Finance 1998, this proportion is only 34 percent. The total combined volume of Case-out and 2nd Mortgages/Home equity line of credit have increased from only 21.7 billion in 1995 to 346 billion in 2006 when the housing price peaked. After that, it drops to only 130.9 billion in 2008 when the housing market goes down dramatically. It is also possible for old people aged above 62 to use reverse mortgage to cash out their home value, i.e., households don't have to pay back the loan until they die or move out of the house.

to change the timing of retirement for the old.

The last contribution of the paper is to quantify the effectiveness of endogenous retirement in cushioning housing price risks. It finds that in response to an unexpected housing price decline, the drops in non-durable consumption for the home owners aged 55-64 with the ability to adjust retirement is 14 percent smaller than the drops in the case with exogenous retirement.

Early literature about wealth effect focus on its impact on households non-durable consumption.[8] Recent studies by Case et al. [19] and Campbell and Cocco [20] look at one important component of household wealth, the housing asset.[9] They find that consumption of old homeowners are most responsive to housing prices. However, these studies ignore the endogenous retirement, which turns out be an important way of self-insurance against housing price risks for the near-retirement age households according to my research.

A growing literature is trying to estimate the wealth effect on labor supply and retirement, most of which are empirical studies. Early researches use household level data to estimate the stock market boom on the retirement decision. These studies confirm the anecdotal story that bear market force old households to stay in the labor force.[10] However, the findings about housing wealth effect on retirement are mixed. Farnham and Sevak [25] finds that a 10 percent increase in housing wealth will reduce the expected retirement age by 3.5 months to 5 months. Coile and Levine [26] finds no evidence that old workers respond to fluctuating housing market. More recently, French and Benson [27] argues that the overall labor force participation rate would be 0.7 percentage points lower were it not for the declines in the values of stocks and houses over the 2006-2010 period. In this paper, I will complement the literature by looking at the evidence of wealth effect on both retirement and non-durable consumption *jointly* using panel data from Health and Retirement Study.

In terms of contributions to structural models, most previous papers emphasize the

[8] Holtz-Eakin et al. [15] and Imbens et al. [16] use exogenous wealth variations, such as inheritances or lottery winnings, to identify the wealth effect on consumption. The virtue of this method is to avoid the endogeneity problem of wealth accumulation. Other studies, including Parker [17] and Juster et al. [18], estimate the marginal propensity to spend out of household wealth using micro survey data. Estimates by those authors range between 3 percent and 8 percent.

[9] Case et al. [19] use aggregate data to find a 10 percent increase in housing wealth increases aggregate consumption by 0.4 percent for the US and roughly 1.1 percent for international panel. Meanwhile, they find only insignificant effect of rising financial wealth on aggregate consumption. Using the UK households data, Campbell and Cocco [20] investigate the response of household consumption to house price by constructing a pseudo panel. They find the largest effect of house prices on consumption for old home owners and smallest effect for young renters. In their benchmark regression, a 1 percent increase in housing value increase the non-durable consumption of the old homeowner by around 1.22 percent, which accounts for 8 percent of the increase in housing value.

[10] Cheng and French [21] show that the run-up in the stock market in 1990s, which has brought greater than $50,000 gains to more than 15 percent of individuals aged 55 and above, decreases the participation rate for people older than 50 by 3.2 percent. Sevak [22] exploit the Health and retirement study data to find an increase of $50,000 wealth shock will lead to a 1.9 percent increase in retirement probability among individuals aged between 55 and 60. Coronado and Perozek [23] uses the same data set and finds that households who held corporate equity immediately prior to the bull market of the 1990s retired 7 months earlier than other respondents on average. Gustman et al. [8] finds that recent stock market decline lead the early boomers to postpone retirement by 1.5 months on average. Chai et al. [24] build up a structural model with stocks and endogenously labor supply to study the effect of stock price crisis on households consumption and retirement.

role of social security, private pension, health insurance, earning shocks, and taxation in determining retirement, e.g., French [28], Ljungqvist and Sargent [29], and Prescott et al. [9]. From a different perspective, this paper analyzes the impact of wealth changes on retirement. My structural model is close to studies by Bottazzi et al. [30], Farhi and Panageas [31], Yogo [32], Imrohoroglu and Kitao [33], and Hryshko et al. [13]. However, none of these authors look at the effect of housing prices on retirement.

The rest of the paper is organized as follows. Section 2 describes the data sets, estimation strategy, and show empirical evidence of housing wealth effect on retirement. Section 3 presents an incomplete-market life-cycle model with housing and endogenous retirement. I use the structural model to perform some counterfactual experiments. Section 4 concludes.

2. Empirical Evidence

2.1. Data

The empirical part is based on two US household survey data: the Health and Retirement Study (HRS) and the Current Population Survey (CPS). The HRS is a national, biennial panel survey of individuals over age 50 and their spouses. It includes detailed information about demographics, income, wealth, health status, job status and history, and pension plans etc. In this paper, I use the RAND [34] version of HRS data 1992-2008. The CPS is a monthly U.S. household survey conducted jointly by the U.S. Census Bureau and the Bureau of Labor Statistics from 1940s. It contains labor force status, wages, hours, and detailed geographic and demographic information. I use the basic CPS data 1989-2011 from NBER.

In order to exploit the time variation in housing price across different regions and time variation in stock price, I use the housing price index for 9 census divisions (CDs) from Federal Housing Finance Agency and S&P/Case-Shiller housing price index for 20 metropolitan statistical areas (MSAs).[11]

2.2. Identification

To understand why wealth effect may cause a puzzling the countercyclical old-age labor supply, it is better to look at the negative correlation between housing prices and unemployment rate first. Figure 2 confirms this negative correlation at MSA level. It plots the 1-year changes in the log Case-Shiller housing price against the 1-year changes in the levels of unemployment rate for 20 MSAs in 2008.[12] The fitted regression has R-squared .53 and a coefficient -.113, which is significant at 1 percent level. It means that 1 percentage point increase in the unemployment rate is associated with 11.3 percent

[11] Both indices are based on repeat transactions on the same physical property units in order to control for differences in the quality of the houses comprising the sample used for statistical estimation. The Case-Shiller housing price index is more volatile than FHFA housing price index. The census divisions are East North Central, East South Central, Middle Atlantic, Mountain, New England, Pacific, South Atlantic, West North Central, and West South Central. See Table A.9 in the appendix for detailed definitions of 20 MSAs

[12] The 1-year difference is defined as the median value of 12-month changes in housing price, unemployment rate, or retirement rate for 20 MSAs in 2008. The Retirement Rate (not the Retirement Hazard Rate), defined as the proportion of retired households in the total population.

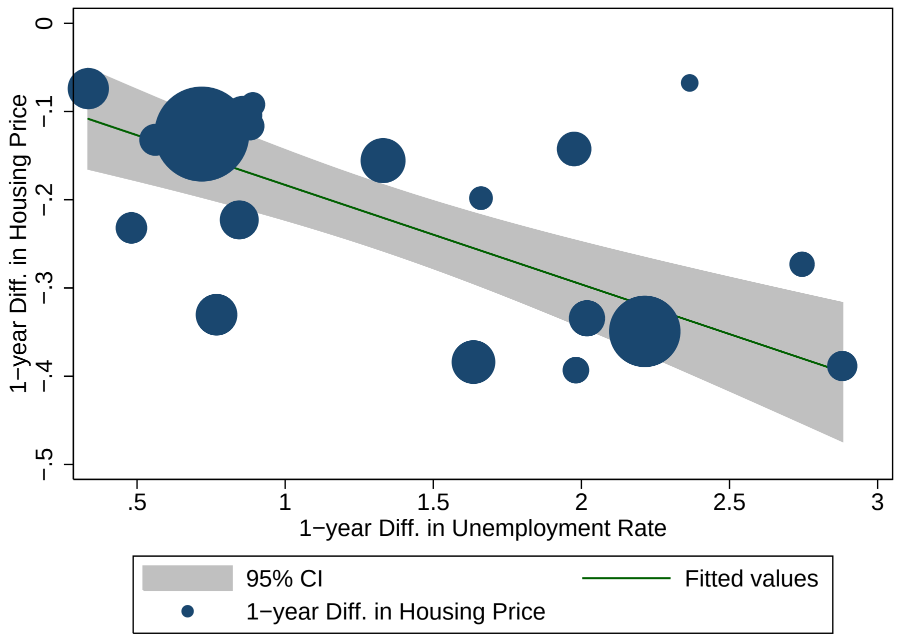

Figure 2: Housing Price Changes and Unemployment Rate for 20 MSAs in 2008

drop in housing price level in 2008. Therefore, the increased retirement rate due to the high unemployment rate in the recession has to be weighted against the wealth loss associated with housing prices. If the latter dominates, then we shall expect a surge in the retirement rate instead of a decline.

The identification strategy is in the same spirit as a difference-in-difference estimator. The idea is to use both the time and geographic variations in housing prices, as well as different responses of home owners and renters to housing prices. As an example, Figure 3 and 4 illustrate where the identification of housing wealth effect comes from. Figure 3 first plots the median value of 1-year changes in HP-filtered retirement rate for home owners aged 55-64 against the median value of 1-year changes in log Case-Shiller price index. The positive slop implies that the drops in the retirement rate across different MSAs is proportional to the drops in local housing price. Here I exploit the geographic variations is housing prices to identify the housing wealth effect on retirement.[13]

Combing the left panel of Figure 3 with Figure 2 helps to understand the right panel of Figure 3, which plots the changes in the retirement rate against the 1-year changes in the unemployment rate. The negative slop suggests that retirement probability drops more in the region where the increase in the unemployment rate is higher.[14] Therefore, the countercyclical labor supply for the near-retirement group is not due to some unobserved regional-specific time-invariant factors. Is housing price risk is the underlying reason

[13]The coefficient of this univariate OLS regression is 7.75, with p-value .036 and R squared .22.
[14]The coefficient of this univariate OLS regression is -.84, with p-value .08 and R squared .13.

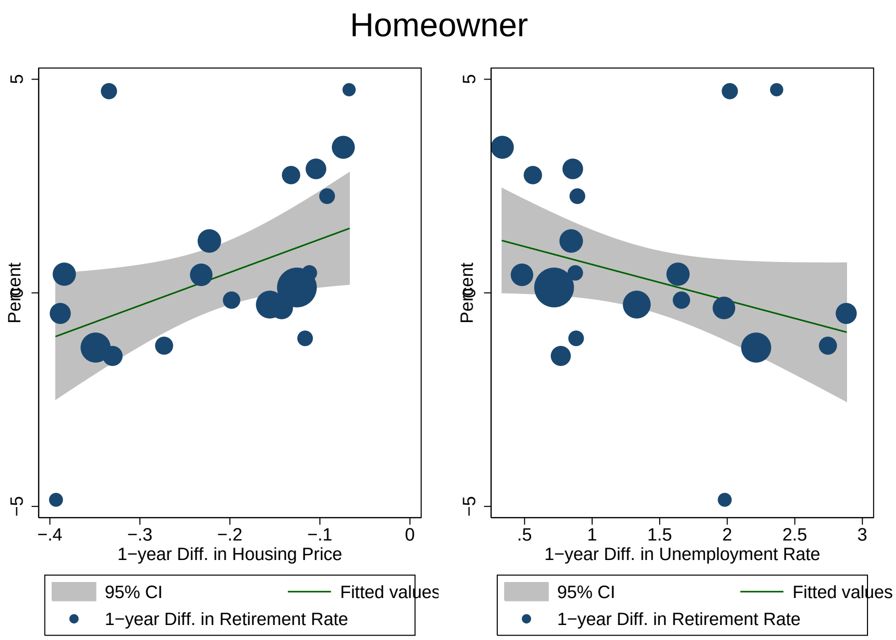

Figure 3: Changes in Retirement Rate for Homeowners aged 55-64 in 20 MSAs in 2008

for this countercyclical labor supply? One can gain some insights from looking at the renters' behavior.

Figure 4 plots the similar graph for the renters. First, the retirement rate doesn't response to the housing price. The slope is negative but not significantly different from zero. Second, the retirement rate of renters is positively correlated with unemployment rate.[15] This suggests that I can exploit the different responses of homeowners and renters to separate the effect of labor market conditions from the effect of housing prices on retirement. The same argument applies to the identification of stock wealth effect, where I can make use of the time variation in stock prices and different responses of stock and non-stock owners to stock prices. Therefore, I include the interaction term between home ownership and housing price index in the explanatory variables in the regression. Similarly, I also include the interaction term between stock ownership and stock price index in the explanatory variables to identify stock wealth effect.

Many empirical studies on retirement treat it as a binary decision problem (Sevak [22], Farnham and Sevak [25], Coile and Levine [35, 26]), where households choose to retire if the discounted future value of being a retiree is larger than the value of being a worker.[16] Since the value for each individual is unobservable, the regression model

[15]The univariate regression has a coefficient 1.25 with p-value .07 and R-squared .08.

[16]Instead of looking at wealth effect on the unconditional retirement, the survival analysis method generally investigates wealth effect on the conditional retirement rate. Retirement can be defined as "failure" using the terminology of survival analysis. One important assumption of this method is that

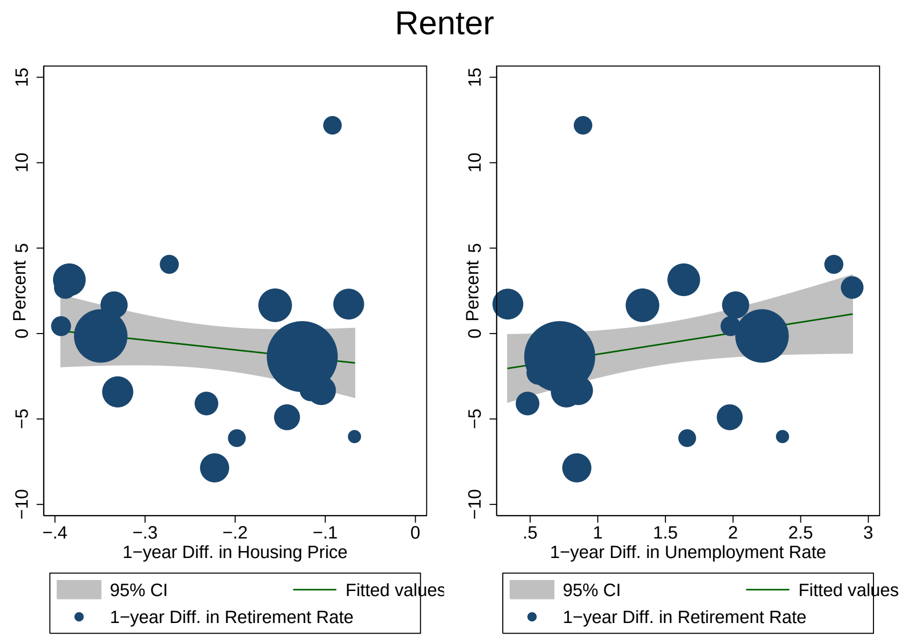

Figure 4: Changes in Retirement Rate for Renters aged 55-64 in 20 MSAs in 2008

simply assumes that the underlying value function can be written as a linear combination of observable variables. Under different assumptions about distribution of error terms, the problem can be formulated as binary choice model, e.g., Logit, Probit, or linear probability model.

In this paper, I estimate the linear probability model for both HRS and CPS data. There are some seasons for me to like this specification. First, my focus in the empirical part is to estimate the average wealth effect and make sure that theoretical predictions from the structural model introduced later is consistent with the empirical data. Then I can use the structural model to study the heterogenous responses for households with different age and wealth level. Second, the linear probability model does not suffer from incidental parameters problem for the fixed effect model with binary explanatory variable. Moreover, the interpretation of marginal effect is more straightforward than the conditional Logit model, in which the marginal effect is conditional on the sum of outcome.[17] Therefore, I will continue with the linear probability model keeping the mind that the usual disadvantage of linear probability model, such the heteroscedasticity and

retirement is an irreversible action. Since HRS is a panel data, this assumption can be checked by looking at the transition of same individual over time. The the two-year transition probability from retirement to non-retirement status is 7.5 percent to 10.8 percent, depending on different definition of retirement. Obviously, this magnitude cannot be attributed to pure measurement errors only. Therefore, I choose not to follow the survival analysis literature in this paper.

[17] It is also relatively easier to address possible endogenous regressors problem (either continuous or discrete) using instrumental variables. See Angrist [36]

unbounded prediction.

2.3. HRS Data

The analyzed sample consists of respondents aged between 50 and 70 during 1992-2008. I exclude their spouses to avoid the strategic working arrangement or any implicit risk-sharing within the households. The sample includes the entire five cohorts in HRS, that is the initial HRS cohort, the AHEAD (Assets and Health Dynamics Among the Oldest Old) cohort, the CODA (Children of Depression) cohort, the War Baby cohort, and the early Baby Boomer Cohort. The average number of households in a single wave is around 10,000.

The probability of retirement given X_t^i can be written as follows:

$$\Pr(Retire_t^i = 1|\mathbf{X}_t^i) = \alpha^i + \beta_t^T \mathbf{X}_t^i + \epsilon_t^i \tag{1}$$

Where $Retire_t^i$ equals 1 if the respondent i is retired at time t and 0 otherwise.

In the Rand HRS data, the labor force status is divided into seven states: work full time, work part time, unemployed, partly retired, fully retired, disabled, not in the labor force. Here, I define retirement as a combination of three status: partly retired, full retired, and not in the labor force (excluding the disabled). The average retirement rate for respondents aged 50-70 is 48 percent. There is a second definition of retirement, the self-reported retirement. I also use the second definition as robustness check. The results are given by Table A.10 in the appendix.

$\mathbf{X}_t^i$ is a vector of observable variables, which include the respondent's labor earnings last year, the interaction term between home ownership dummy and housing price index, the interaction term between stock ownership dummy and stocks price index, social demographic and geographical variables, the self-reported health status, a full set of dummies for census divisions and age, and whether the respondent is covered by government-provided or employer-covered health insurance plan. α^i is the individual unobserved characteristic, which remain constant over time but may be correlated with observable variables $\mathbf{X}_t^i$.

In HRS, questions about the respondents and their spouses' labor earnings are retrospective. According to the definition of RAND [34], the respondent' labor earnings is the sum of his/her wage income, bonuses, overtime pay, commissions, tips, 2nd job or military reserve earnings, professional practice, and trade income. For simplicity, I treat the labor earnings as income from the year previous to the survey year.[18] The labor earning is deflated by the annual CPI index.

The home ownership dummy is an indicator of *renter*. It equals 0 if the respondent reports a positive gross value of his/her primary residence. It equals 1 if the value of primary residence is zero. Similarly, the stock ownership dummy is an indicator of *non-stock owner*. It equals 0 if the respondent has any stocks, mutual funds, investment

[18] Generally, Wave 1 questions ask about 1991 income, Wave 2H asks about 1993 income, and Wave 2A and from Wave 3 forward, about income last calendar year, based on the Financial Respondent's interview year. In Waves 2A, 3H, 4, and 5 forward not all interviews are completely conducted in the same year.

Table 2: Regression Results for the HRS data

Dependent Variable: Retirement	(1)	(2)	(3)
	All	All	Home Owners
Housing Price^{BP}	.11**	.14***	.14***
	(2.2)	(2.7)	(2.6)
Renter	-2.4e-3	-2.0e-3	—
	(−.30)	(−.30)	
Renter×Housing Price^{BP}	-.064	-.065	—
	(−.47)	(−.48)	
Stock Price^{BP}	.046***	.073***	.080***
	(2.8)	(3.5)	(3.3)
Non-Stock Owner	8.6e-3**	9.0e-3**	.012**
	(1.8)	(2.1)	(2.5)
Non-Stock Owner×Stock Price^{BP}	-.13***	-.13***	-.083***
	(−5.2)	(−5.3)	(−2.9)
Lagged Labor Earnings (1000$ in 1998)	-1.4e-3***	-1.4e-3***	-1.2e-3***
	(−3.1)	(−3.1)	(−2.6)
Self-employed	-.22***	-.22***	-.20***
	(−21)	(−21)	(−16)
Health Status	6.1e-3***	6.0e-3***	7.5e-3***
	(2.9)	(2.9)	(3.0)
Government Provided Health Insurance	.089***	.089***	.084***
	(13)	(13)	(10)
Employer Provided Health Insurance	-.18***	-.19***	-.18***
	(−31)	(−31)	(−26)
Unemployment Rate^{BP}	—	7.2e-3**	9.0e-3**
		(2.2)	(2.3)
Census Divisions and Age Dummies	Yes	Yes	Yes
Overall R^2	.33	.33	.36
Number of Observations	85,685	85,685	56,445
Number of Households	19,635	19,635	12,837

trusts, individual retirement account, or defined contribution plan on any previous job.[19] It is a binary variable, which equals 1 if households own any form of stocks. I drop the observations for which either home value or stock value is missing. For households with respondent aged between 50 and 70, the weighted average stock ownership and home ownership is 46 percent and 83 percent respectively.

I use the monthly housing price index from Federal Housing Finance Agency for 9 census divisions. The index is based on sales price data, rather than appraisal data. The stock prices are from S&P500 index. In the main results, I include the yearly average of BP-filtered log monthly price index.[20] All indices are deflated using CPI index. As a robustness check, I also report regression results in Table A.10 using the yearly average of HP-filtered log monthly price index and the 1-year changes in the yearly average of log price index.[21]

Table 2 shows the estimates of fixed effect model only, where the unobserved heterogeneity is assumed to be correlated with other explanatory variables. The t-statistics are given in the parenthesis and standard errors are clustered at household level. The Breusch and Pagan Lagrangian multiplier test for random effects reject the absence of individual effect. The Hausman specification test for all specifications gives p-value less than 1 percent. Therefore, the null hypothesis that there is no significant difference between the random effect model and fixed effect model is rejected, and the fixed effect model gives consistent estimates while the random effect model does not.

The main effect of housing price is .11 in the specification 1. Remember that the reference group here is the home owners. Therefore, it means 10 percent increase in housing price above the trend is associated with 1.1 percent increase in the retirement probability. The renter dummy is insignificant, suggesting there is no significant difference in retirement probability between the home owner and the renter after controlling for the unobserved fixed effect. The net effect of housing price on the renters' retirement probability is the sum of main effect and the interaction effect, which is .46 percent ($.11 - .064 = .046$). Although positive, this effect is insignificant, with p-value .721.

The main effect of stock price is .046 in the specification 2. The reference group for the stock wealth effect is the stock owners. It means 10 percent increase in stock price above the trend is associated with .46 percent increase in the retirement probability. The net effect of stock price on non-stock owners is -.084 ($-.13 + .046 = .084$). The effect is significantly different from zero. This suggests that the stock price is correlated with the economic fundamentals which also affect non-stock owners' willingness to work.

In order to control for the economic prospective, I include the census-division specific aggregate unemployment rate in specification 2. Again, I apply the bass-passing filter

[19] Here I simply assume that all assets in the individual retirement account and defined contribution plan are invested in the stocks market. In HRS, the information on the type of pension plan is missing if the respondent is already retired. I define the retiree's pension plan status according to the information during the previous wave of survey when he/she is still working.

[20] In order to take out both the long term trend in price and too high frequency movement in the price index, I use a Baxter-King band-pass filter with parameters 18 and 96 to preserve the components of the cycle with frequency between 1.5 and 8 years. For the housing price data, the earliest monthly repeated sales data for 9 census divisions is available from 1991m1. I choose the lead-lag length of the filter to be 36, as recommended by Baxter and King [37]. This forces me to drop the 1992 wave of HRS because the BP-filtered housing price index is only available from 1993.

[21] The HP-filtered log monthly price index are using smoothing parameter 129,600, as recommended by Ravn and Uhlig [5]

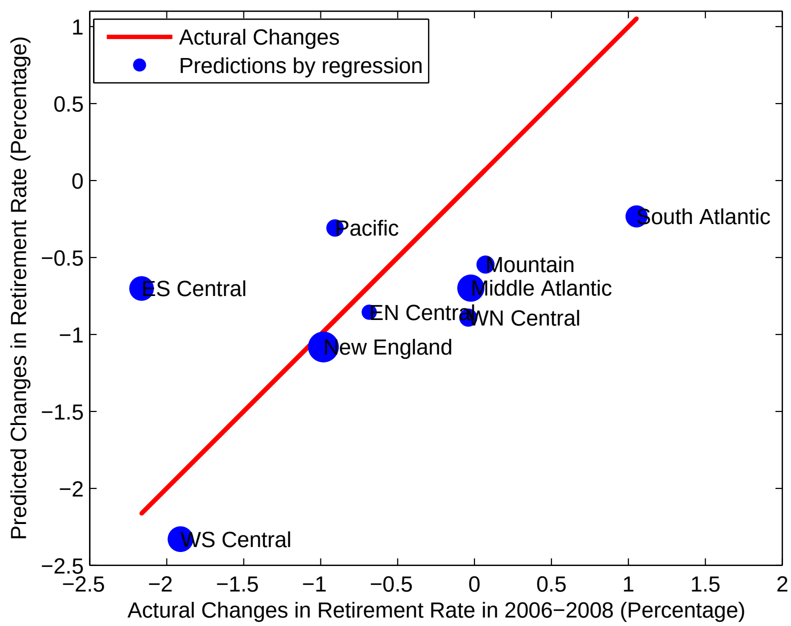

Figure 5: Predictions About the Housing Crisis 2006-2008

to take out the long term trend from the unemployment rate. The coefficient before unemployment rate is .0072, which means 1 percentage point rise in unemployment rate above the long-term trend is associated with .72 percent increase in the retirement rate. This is consistent with the idea that tight labor market tends to increases the retirement probability of the old households.

There are some concerns about the endogeneity of home ownerships and stock ownerships, e.g., some unobserved individual characteristic that accounts for both the ownerships and retirement decisions. However, as long as these unobserved characteristics is not time varying, the fixed effect model takes care of it. The specification 3 looks at subsample of home owners who haven't change their ownerships within the sample period and who haven't moved across census divisions. The results from home owners sub-sample give the same estimate about housing wealth effect and a little bit higher stock wealth effect on retirement than the full sample. This suggests that these results are to some degree robust to the selection of home owners.

How large is this wealth effect? The mean gross house value of primary residence in 2006 for the sample of home owners aged between 50 and 70 is 272,833 dollars. The mean asset value of stocks (without taking into account of defined contribution plans) for the stock owners aged 50 and 70 is 175,684 dollars, which is only 60 percent of housing asset. From 2006 to 2008, the Band-Pass filtered housing price in the West South Central region drops more than 15 percent below the long-term trend, nearly 40,900 dollars. Meanwhile, the unemployment rate for the Pacific region increases by 0.5 percentage point above the trend. According to the point estimate of specification 3, the average retirement probability for home owners should drop as large as 2.1 percent ($.15 \times 1.4 - .5 \times .009$).

Now I can evaluate model's prediction on aggregate retirement rate by comparing it with empirical data. I first compute the 2-year changes in retirement rate for home owners aged 50-70 in 9 census divisions. Then I plot the model predicted changes in retirement rate against the actual changes in Figure 5. If the model can perfectly predict the changes, all the dots will lie on the 45 degree line (the solid line). I take the 2-year changes in bp-filtered housing prices in each census division and multiply them by the housing wealth effect coefficient .14 from the regression. I will name these results as predicted changes in retirement rate. It can be seen from the graph that the regression gets pretty good prediction for most census divisions, expect for the East South Central and South Atlantic. The R-squared is .40, which suggests that the predictions can account for 40 percent of variations in regional retirement rate for home owners by using the housing price variation alone. The retirement rate in those two regions drops less than the regression predicts which may be due to the rising unemployment rate or demographics changes in the two regions.

There are other determinants of retirement, which are also interesting to look at. The coefficient before lagged labor earnings last year is negative, which is not surprising since labor earnings is the opportunity cost of retirement. It means that 10,000 dollars (in 1998 dollars) increase in households annual labor earnings will reduce the retirement probability in the subsequent year by 1.4 percent.

Health status is also an important factor. The health index ranges from 1 to 5, with the most excellent health status indexed by 1. For one extra level increase in health indicator, the retirement probability increases by 0.6 percent in the fixed effect model. For a person with most excellent health, his retirement probability is 2.4 percent smaller than the person with poorest health. The coverage of health insurance also plays an important role in households' retirement planning. The retirement probability of the worker covered by employer provided health insurance plans is 19 percent smaller than their non-insured counterparts. On the other hand, government provided health insurance, like Medicare and Medicaid, increases respondent's retirement probability. This is partly because Medicaid is only available for those aged above 65.

2.4. CPS data

In this section, I use the monthly CPS data from Jan 1989 to Dec 2010 to confirm my previous findings with HRS.[22] The whole sample consists of householders aged between 50 and 70 from Jan 1989 to December 2010. Some periods in the sample (1995M5, 1995M6, 1995M7) are dropped because of the missing geographic information. The advantage of this data set is the large sample size. The data set contains detailed geographic information on the monthly basis, which allows me to investigate the wealth effect from local housing price changes. I focus on the sub-sample of households who are living in the 20 largest metropolitan statistics areas (MSAs), for which the Case-Shiller housing price index is available. However, the drawback of the data is its cross sectional structure. Therefore, I cannot control the unobserved individual characteristics using fixed effect

[22] This is mainly because the monthly housing price index for different MSAs is only available from 1987. What's more, the housing tenure question was not asked in the CPS before 1982.

model. Moreover, it doesn't contain any information on stock ownerships or pension plans. Hence, I can use only some proxy for stock ownerships. The new regression model is written as follows:

$$\Pr(Retire_t^i = 1|\mathbf{X}_t^i) = \alpha + \beta_t^T \mathbf{X}_t^i + \epsilon_t^i \tag{2}$$

The binary variable $Retire_t^i$ equals 1 if individual i retires at time t. After 1994, the redesign of CPS questionnaire lists the retirement status as a separate item in CPS labor force status. Before 1994, retirement cannot be identified using the labor force status alone. I combine the labor force status with the major labor activity last week (item 19) to identify the retirement status. I define a person to be retired if and only if her major activity last week is reported as retirement and her labor force status in CPS is coded as being "not in the labor force". The difference in the sample design creates a level difference between the two periods. I include a regime dummy for the post-1994 period in the regression to control for this change. All observations are weighted by their final sampling weights in the regression.

$\mathbf{X}_t^i$ contains the interaction term between home ownership dummy and housing price index and a set of demographic and geographic variables, such as gender, race, marital status, number of persons in the family, and a set of dummies for each age, MSA, and month interviewed in the sample.

In the monthly CPS, there is a question about the household income each month, which is recorded as categorical variable. I simply impute the value of household income using the cell mean and include this variable in the regression.[23]

Home ownership dummy is an indicator of the *renter*. It equals 0 if the respondent owns the residence. It equals 1 if the respondent is a renter. I use the interaction term between home ownership and MSA-specific Case-Shiller housing price index to identify the housing wealth effect. The identification of stock wealth effect is more difficult in the CPS because there is no question about stock ownerships. Following Coile and Levine [26], I proxy the stock ownerships using *college degree*. I include the interaction term between the non-college group and S&P500 index to see whether stocks price affect this education group in a different way. If the stocks wealth effect does exist, we will expect to see a significant and negative coefficient before the interaction term, given that there is high correlation between education attainment and stock ownerships.[24]

I include the BP-filtered monthly logarithm Case-Shiller housing price index and S&P500 stock price index in the regression.[25] Table A.11 in the appendix also provides the regression results using 12-month difference and hp-filtered price index. All price indices are deflated by the monthly CPI.

Table 3 shows the regression results for the CPS data from pooled OLS regression. The t-statistics are given in the parenthesis and standard errors are clustered at MSA

[23] In the monthly CPS, only those who are going to leave the sample, i.e., the ongoing rotation group, are asked detailed question about individual earnings. This group accounts for less than 25 percent of the whole sample. I choose not use the subgroup because it would reduce the sample size in some MSA to very little observations.

[24] For example, 77 percent of household heads with college degree own stocks in 2006 according to HRS data. Only 20.1 percent of household heads with high school degree own stocks.

[25] The band-passing filter uses parameters 18 and 96 to preserve the components of the cycle with frequency between 1.5 and 8 years. The lead-lag length of the filter is set to be 36.

Table 3: Regression Results for the CPS data

Dependent Variable: Retirement	(1)	(2)	(3)
	All	All	Home Owners
MSA Housing Price^{BP}	.14***	.12**	.090*
	(3.9)	(2.3)	(1.7)
Renter	-.062***	-.063***	—
	(−23)	(−17)	
Renter×MSA Housing Price^{BP}	-.11*	-.14	—
	(−1.8)	(−1.50)	
Stock Price^{BP}	.15***	7.4e-3	4.4e-3
	(3.2)	(.23)	(.13)
No College Degree	.025***	.014***	.015***
	(8.7)	(3.5)	(3.5)
No College Degree×Stock Price^{BP}	-.20***	-.013	4.2e-3
	(−4.0)	(−.38)	(.12)
Lagged Family Income (1000$ in 1998)	-1.4e-3***	-1.4e-3***	-1.5e-3***
	(−36)	(−26)	(−24)
Self-employed	-.17***	-.16***	-.16***
	(−77)	(−52)	(−50)
Number of persons	-9.4e-3***	-8.9e-3***	-7.2e-3***
	(−13)	(−8.9)	(−5.9)
MSA Unemployment Rate^{BP}	—	7.80e-4	-1.0e-3
		(.32)	(−.36)
Race, Marital Status, Gender, Age dummies	Yes	Yes	Yes
Year ≥1994, Month-in-sample, MSA Dummies	Yes	Yes	Yes
R^2	0.33	0.34	0.33
Number of Observations	522,560	463,846	382,305

level. The main effect of housing price is .14 in the specification 1. The reference group here is home owners. It means 10 percent increase in housing price above the trend will increase the retirement probability for home owners by 1.4 percent. The renter dummy is significant at 1 percent level. It says the renters are 6.2 percent less likely to retire than homeowners. The net effect of housing price on renter is .03, with p-value .62.

The main effect of stock price is .15. The reference group here is householders with college degree. It suggests the retirement probability of college education group is highly correlated with stock price movement. The net effect of stock price on non-college group is -.05, which is also significantly different from zero at 1 percent level.

As mentioned before, I include the MSA-specific unemployment rate for households aged above 16 in specification 2 in order to control for the economic prospective. Again, I apply the bass-passing filter to take out the long term trend from the unemployment rate. After controlling the MSA-specific unemployment rate, the main effect of stock price is no longer significant, but the main effect of housing price declines only by .02.

Specification 3 restricts the sample to home owners only. The housing wealth effect on home owners changes significantly. It suggests that some unobserved individual characteristics that account for both the home ownerships and retirement decisions are not controlled because of the cross-sectional structure of the model. One need to be more cautious in interpreting the housing wealth effect estimated from CPS data.

The coefficient before family income is almost identical to the one estimated from HRS regression. It says that 10,000 dollars (in 1998 dollars) increase in households income will reduce the retirement probability of householder by 1.4 percent. The impact of self-employment on retirement is also similar. The self-employed households are 17 percent less likely to retire than wage and salary workers.

3. The Frictionless Benchmark Model

So far I have provided the evidence of housing wealth effect on retirement. In the following section, I am going to set up a structural model that is suitable for answering the following questions. First, what are the channels through which house prices can affect consumption and retirement? Second, how effectively can endogenous retirement cushion housing price risks as a self-insurance tool?

The natural starting point to answer these questions is the incomplete-market life-cycle model, with extensions to allow for housing consumption and retirement decesion. I will first use the model to quantify the effect of house prices on retirement through three channels. Then I compare the housing wealth effect on non-durable consumption in the benchmark model with a second economy where households cannot schedule their retirement. By doing this, I am able to quantify the role of endogenous retirement in self-insurance against housing price risks.

3.1. Demographics

The model economy is inhabited by J overlapping generations. Each generation consists of one unit measure of households. Households have a uncertain life span. They enter the labor market at age 1 and live up to the maximum age J. The conditional survival probability from age j to $j+1$ is s_j.

As the model abstracts from population growth, the fraction of newborns at the stationary distribution of population is

$$\mu_1 = \frac{1}{1 + \sum_{j=1}^{J-1} \pi_j} \tag{3}$$

where $\pi_j \equiv \prod_{i=1}^{j} s_i$ is the unconditional survival probability for age j. The fraction of age j cohort is determined recursively by

$$\mu_{j+1} = s_j \mu_j \tag{4}$$

3.2. Preferences and Endowments

Each household is endowed with one unit of labor endowment. Labor supply is inelastic. The household provides one unit of labor when at work and zero when retired. The indivisibility assumption is justified by the facts that most variations in aggregate hours are attributed to extensive margin rather than intensive margin, especially for the near-retirement households (See Prescott et al. [9]). A more relaxed assumption could be that old households can only look for a part-time job after retirement that pay much less than the full-time job before the retirement. Following Farhi and Panageas [31], I assume retirement is an irreversible choice. Therefore, the model solves a discrete version of the optimal stopping problem.

Labor income is risky. Let j^r be the endogenous retirement age. The stochastic process for the before-tax wage is assumed to be

$$\ln w_j = e_j + z_j + \epsilon_j \tag{5}$$

$$z_j = \rho_z z_{j-1} + \eta_j \tag{6}$$

for all $j = 1, \ldots, j^r - 1$. It consists of three parts. e_j is the deterministic age-specific labor efficiency unit. η_j is the persistent shock to wage and ϵ_j is the transitory shock to wage. Both shocks are independently and identically normally distributed with mean 0 and variance σ_η^2, σ_ϵ^2 respectively. Households pay the payroll tax τ when at work. Labor income after tax is

$$y_j = (1 - \tau)\, w_j \tag{7}$$

The model also abstracts from home-production. After retirement, households with age qualified for social security are able to collect constant retirement benefit b each year.[26]

$$y_j = b \tag{8}$$

for all $j = j^r, \ldots, J$.

Households derive utility from non-durable consumption goods c_j , housing services h_{j+1}, and leisure n_j. Moreover, they have bequest motive denoted as u^B. n_j is a binary variable, which equals 1 if households remain in the labor force and 0 if they are retired. The household's utility function can be written as

$$E_0 \sum_{j=1}^{J} \beta^j \left[\pi_j u\left(c_j, h_{j+1}, n_j\right) + \left(\pi_j - \pi_{j+1}\right) u^B\right] \tag{9}$$

where u^B is the bequest utility which is a function of the state variables.

3.3. Assets Market

There is no annuity market in the model. The only financial asset is the risk free bond with gross interest rate R. The only risky asset in the economy is the housing. The housing price follows a AR(1) process

$$\ln p_j = \rho_p \ln p_{j-1} + \zeta_j \tag{10}$$

where ζ_j is independently and identically distributed with mean 0 and variance σ_ζ^2. Housing depreciates at a rate of δ_h, which also includes the maintenance cost. Housing asset is fully divisible. In the benchmark model, I assume that the adjustment to housing size does not incur any transaction cost. Therefore, all households choose to become home owners.[27]

Housing not only provides services flows for housing consumption, but also serves as collateral. Households can only borrow using housing as collateral. The down-payment

[26] Alternatively, the retirement benefit can be modeled as households receive payment which is a fraction of their average pre-retirement labor income. This will increase the computation burden dramatically by keeping track of whole history of labor income shocks.

[27] Without transaction cost, rental price will be a fraction of housing price. Given the same riskiness of rental housing and owner-occupied housing and the collateral value of owner-occupied housing, all households will choose to own a house rather than to rent.

ratio is λ, i.e., the households can borrow up to $1-\lambda$ fraction of total housing value. For simplicity, the loan rate is assumed to be the same as interest rate. Households can adjust the credit balance without any cost. I rule out default on mortgage in the model, which implies that households have to pay back their debt when borrowing constraint is binding.

3.4. Households' Problem

Households are heterogeneous in dimensions $\Theta_j = \{x_j, z_j, \epsilon_j, p_j, j\}$, which denote total wealth at the beginning of period j, persistent income shock, transitory income shock, housing price, and age respectively.[28]

The timing of the economy is the following. At the beginning of period, households are endowed with total net worth at given housing price level. After income shocks are randomly drawn, households decide whether to work or not. If they work, they receive labor income and pay taxes. If they retire, they receive retirement benefit if their age is qualified. Then households choose the housing size, the amount of non-durable consumption goods and savings. At the end of period, households receive interest from financial asset. Then the mortality risk and housing price next period are revealed. If one dies, the amount of financial asset and housing asset are left as bequest. If one survives, he starts the next period with new net worth and housing price level.

Let V^W be the value function of the not-yet retired households (households who have not yet retired and have the option to work or retire this period). Let V^R be the value function of the retired households. The dynamic programming problem for households can be formulated recursively as follows:

Before the retirement, households solve the problem

$$V^W(\Theta_j) = \max_{n_j \in \{0,1\}} \left\{ \begin{array}{c} (1-n_j) \max\limits_{c_j, h_{j+1}} \left\{ u(c_j, h_{j+1}, n_j) + \beta E_j \left[s_j V^R(\Theta_{j+1}) + (1-s_j) u^B(\Theta_{j+1}) \right] \right\} \\ +n_j \max\limits_{c_j, h_{j+1}} \left\{ u(c_j, h_{j+1}, n_j) + \beta E_j \left[s_j V^W(\Theta_{j+1}) + (1-s_j) u^B(\Theta_{j+1}) \right] \right\} \end{array} \right\} \tag{11}$$

subject to

$$x_{j+1} = R(x_j + y_j - c_j - p_j h_{j+1}) + p_{j+1} h_{j+1}(1-\delta_h) \tag{12}$$

$$x_j + y_j - c_j \geq \lambda p_j h_{j+1} \tag{13}$$

$$c_j > 0 \tag{14}$$

$$h_{j+1} > 0 \tag{15}$$

$$x_{j+1} > 0 \tag{16}$$

where n_j is a binary variable for retirement/work decision. Equation (12) is the budget constraint for the working households who enter the age j with total net worth x_j.

[28] The no-transaction-cost assumption enables me to reduce "savings" and "housing stocks" into one state variable, the total net worth.

(13) is the borrowing constraint, which means the net worth at the end of this period cannot be larger than λ fraction of current housing value. (16) is the bequest constraint. Note that because of housing price risk next period, the borrowing constraint (13) does not necessarily imply that households cannot leave negative bequest. The endogenous retirement age j^r is defined as

$$j^r \equiv \min \{ j \mid n_j = 0, 1 \leq j \leq J \} \tag{17}$$

Once become retired, the households cannot choose to go back to work. The household's value function is given by

$$V^R(\Theta_j) = \max_{c_j, h_{j+1}} \left\{ u(c_j, h_{j+1}, 0) + \beta E_j \left[s_j V^R(\Theta_{j+1}) + (1 - s_j) u^B(\Theta_{j+1}) \right] \right\} \tag{18}$$

subject to the same constraints (12), (13), (14), (15) and (16).

3.5. Characterization of Partial Equilibrium

When the borrowing constraint is not binding, the first order optimality conditions for c_j and h_{j+1} can be partly characterized by Euler equations:[29]

$$u_c(j) = \beta s_j R E_j [u_c(j+1)] + \beta (1 - s_j) R E_j \left[u_x^B(j+1) \right] \tag{19}$$

$$\begin{aligned} u_h(j) = {} & \beta s_j E_j [u_c(j+1)(R p_j - (1 - \delta_h) p_{j+1})] \\ & + \beta (1 - s_j) E_j \left[u_x^B(j+1)(R p_j - (1 - \delta_h) p_{j+1}) \right] \end{aligned} \tag{20}$$

where $u_c(j)$ stands for $u_c(c_j, h_{j+1}, n_j)$ and $u_h(j)$ stands for $u_h(c_j, h_{j+1}, n_j)$.

From (19), one can see that decrease in the consumption today will also increase the marginal utility from leaving a bequest, weighted by the probability of death. If $s_j = 1$, there is no uncertain life span and (19) becomes the standard consumption Euler equation.

Equation (20) is the housing Euler equation (no arbitrage condition for housing). It says the user cost of owner-occupied housing is the sum of foregone consumption and bequest next period.

When borrowing constraint is binding, the only first order condition becomes

$$\begin{aligned} u_h(j) = {} & \beta (1 - s_j) E_j \left[u_x^B(j+1)((1 - \lambda) R p_j - (1 - \delta_h) p_{j+1}) \right] + u_c(j) \lambda p_j \\ & + \beta s_j E_j [u_c(j+1)((1 - \lambda) R p_j - (1 - \delta_h) p_{j+1})] \end{aligned} \tag{21}$$

and the optimal consumption is determined by

$$c_j = x_j + y_j - \lambda p_j h_{j+1} \tag{22}$$

Now the user cost of housing has an additional component $u_c(j) \lambda p_j$, which corresponds to the cost of binding constraint on current consumption. This cost is positively correlated with down-payment ratio. When there is no borrowing constraint,i.e., $\lambda = 0$, then we go back to the equation (20).

---

[29] The retirement decision is a binary variable, therefore, the intra-temporal optimality condition for n_j doesn't exit. The policy function for labor is determined by comparing the continuation value for a worker and a retiree.

Table 4: Households Asset Portfolios By Age Group

Variables[a]	50	55	60	65	70	75	80	85
Real Asset[b]	291.3	356.8	364.8	291.1	297.9	270.9	176.6	159.5
Net worth[c]	489.5	570.6	680.8	582.8	571.7	487.7	342.6	295.2
Real/Net worth(%)	59.4	59.7	52.7	49.2	51.0	54.6	51.7	55.1
Normalized Net worth[d]	6.80	7.93	9.46	8.10	7.94	6.78	4.76	4.10

[a] Data is from Survey of Consumer Finance 1998. All statistics are mean value weighted by the sampling weight. Asset values are in 1998 thousand dollars. Age group i, i=50,55,60,65,70,75,80, include households aged i-2 to i+2. Age Group 85 include households older than 83

[b] The real asset is defined as total non-financial asset (including vehicles, primary residence, secondary residence, net equity in non-residential real estate, businesses, and Other misc. nonfinancial assets) minus debt secured by primary residence (mortgages, home equity loans, and debt secured by other residential property.

[c] The total net worth is the sum of real asset and financial asset. Financial asset include all types of transaction account, certificates of deposit, directly held pooled investment funds , savings bonds, directly held stocks, directly held bonds, cash value of whole life insurance, other managed assets, quasi-liquid retirement accounts, and other financial assets less any other lines of credit, credit card balances after last payment, installment loans , and other debt

[d] The total net worth is normalized by the before-tax average wage and salaries of working households at age 50, which is 70,567 in 1998 dollars

3.6. Algorithm

I solve the life-cycle model backwards from the end of life cycle. I combine the Newton-Raphson method with Simulated Annealing to solve the nonlinear system of Euler equations. Due the discrete nature of retirement problem, value functions have to be stored for each possible choice combination. The conditional expectation is computed by Gaussian Quadrature. I approximate the stochastic process for housing price and persistent income shocks with a 7-state Markov Chain using Rouwen-Hurst's method summarized in Kopecky and Suen [38]. The transitory income shock is simply approximated by 2-state Markov Chain.

3.7. Calibration

The model economy starts at age 50 and ends at age 90. I take the initial joint distribution of total wealth and labor income for home owners at the age 50 from the 1998 Survey of Consumer Finance data (see Figure A.12).[30] Because Survey of Consumer Finance is a cross-sectional data, I cannot separate the persistent shock from transitory shock. I first randomly draw the value of persistent shocks at age 50 and attribute the residual income as transitory. Alternatively, I can randomly draw the value of transitory shocks at age 50 and treat the residual income as persistent shocks. The two methods do not change the estimate of housing wealth effect much, but affect the cross-sectional distribution of income risk over life-cycle. Using the first method will deliver a increasing cross-sectional income variance while the second one gives a slightly declining one. This is because the second method implies an initial persistent shocks that is more volatile

[30] I use the initial distribution for households aged between 48 and 52 in the data to increase the sample size. This gives me 419 households in 1998. Then I use the sampling weight to draw the simulated sample.

than the long run stationary distribution of persistent shocks from calibrated parameters in Heathcote et al. [39]. Therefore, I choose the first method in the paper.

I normalize the age specific efficiency units taken from Hansen [40] such that the average labor income at age 50 is 1. The logarithm value of efficiency unit e_j are plotted in Figure A.11. The age-specific survival probabilities are taken from the 2005 life table for white males in the United States.

The household's utility function takes the form

$$u\left(c_j, h_{j+1}, n_j\right) = \frac{\left[\left(\omega c_j^{\frac{\xi-1}{\xi}} + (1-\omega)\, h_{j+1}^{\frac{\xi-1}{\xi}}\right)^{\frac{\xi}{\xi-1}}\right]^{1-\sigma}}{1-\sigma} - \theta n_j \tag{23}$$

When n_j is a binary indicator. It equals 1 if households choose to be working. θ is the fixed cost associated with working. The higher it is, the earlier households choose to retire. Following Fernandez-Villaverde and Krueger [10], I set the elasticity of substitution between consumption and housing services ξ to be 1. The relative risk aversion parameter σ is chosen to be 2. Note that this implies that housing consumption and non-durable consumption are substitutes. The actual utility function I am using has a Cobb-Douglas form

$$u\left(c_j, h_{j+1}, n_j\right) = \frac{\left(c_j^{\omega} h_{j+1}^{(1-\omega)}\right)^{1-\sigma}}{1-\sigma} - \theta n_j \tag{24}$$

where ω determines the share of housing services in the total consumption expenditure.

Following Cocco [42], Campbell and Cocco [20], I assume the warm-glow bequest motive, which takes the following form

$$u_B\left(\Theta_j\right) = \phi \frac{x_j^{1-\sigma}}{1-\sigma} \tag{25}$$

It only depends on the total value of household's net worth. In other words, housing asset and financial asset are perfect substitutes in the bequest utility function. The other interpretation for the warm-glow bequest motive is the utility from living in the nursing home. Households can use their financial wealth or liquid their housing asset in order to pay the nursing home cost in their late life.[31] ϕ measures the bequest strength. Higher ϕ means more assets are left at the end of life.

The gross risk free interest rate is assumed to be 1.02. Nagaraja et al. [41] estimates the housing price process for 20 metropolitan areas using FHFA quarterly housing price index 1985-2004. Their model consists of a fixed time effect, a random ZIP code effect, and an autoregressive component. The autoregressive coefficients range from 0.9819 to 0.9975. The variance of persistent shocks is between 8.83e-4 to 2.5e-3 . When translate into yearly frequency, this gives $\rho_p \in [0.9295, 0.9901], \sigma_p \in [0.0592, 0.0997]$. In the benchmark model, I set the $\rho_p = 0.976$ and $\sigma_p = 0.0748$, which corresponds to the median

[31] Kopecky and Koreshkova [43] finds that 12 percent of aggregate savings is accumulated to finance and self-insure against old-age health expenses given the absence of complete public health care for the elderly, and that nursing home expenses play an important role in the savings of the wealthy and on aggregate.

Table 5: Parameters Calibrated in the Benchmark Model

Calibration inside the model				
Parameters		Value	Target Moments	Value
Discount Factor	β	0.976	Net worth of age 50-70	8.05
Consumption Weight	ω	0.805	Share of Net Real Asset of age 50-70	0.555
Bequest Strength	ϕ	22.9	Net worth of HHs older than 83	4.10
Fixed cost of working	θ	6.20	Retirement Rate of age group 65	0.778
Calibration outside the model				
Parameters		Value		
Interest Rate	R	1.02		
EIS Between c and h	ξ	1.00	Fernandez-Villaverde and Krueger [10]	
Relative Risk Aversion	σ	2.00		
Maximum Age	J	90		
Minimum Age		50		
Efficiency Unit	e_j	Figure A.11	Hansen [40]	
Persistency of Housing Price	ρ_p	0.976	Nagaraja et al. [41]	
Std. of Housing Price	σ_p	0.0748	Nagaraja et al. [41]	
Persistency of Income	ρ_z	0.973	Heathcote et al. [39]	
Std. of Persistent Shocks	σ_η	0.124	Heathcote et al. [39]	
Std. of Transitory Shocks	σ_ϵ	0.251	Heathcote et al. [39]	
Depreciation Rate	δ_h	0.005		
Down Payment Ratio	λ	0.200		
Replacement Rate	b	0.360	Pension Income of HHs older than 50	
Payroll Tax	τ	0.100	See Text	

value of estimates in 19 MSAs. The housing depreciation rate δ_h is set to be 0.005 and the housing down payment ratio λ is set to be 0.20.

The stochastic process from income risk is taken from Heathcote et al. [39]. I set the persistency of income shock $\rho_z = 0.973$, the standard variance of persistent shock $\sigma_\eta = 0.124$, and the standard variance of transitory shock $\sigma_\epsilon = 0.251$. I set replacement rate $b = 0.360$ to match the ratio of average pension income of retiree to after-tax labor income of home owners at age 50 in the HRS data. The payroll tax for social security is set to 0.10.[32]

The share of consumption in the utility function ω, the discount rate β, fixed benefit from retirement θ, and bequest strength ϕ are calibrated jointly to match the following four moments: the average share of net housing value in total net worth for householders age 50-70, the normalized net worth of households aged 50-70 , the average cumulative retirement rate of households for age group 65, the normalized net worth for households aged above 83. The wealth profile is estimated using SCF 1998 data. The cumulative retirement rate is taken from the HRS 1992-2008 data (see Table 4 for the calibration target in the benchmark model). These give $\omega = .805$, $\beta = .976$, $\theta = 6.20$, $\phi = 22.9$.

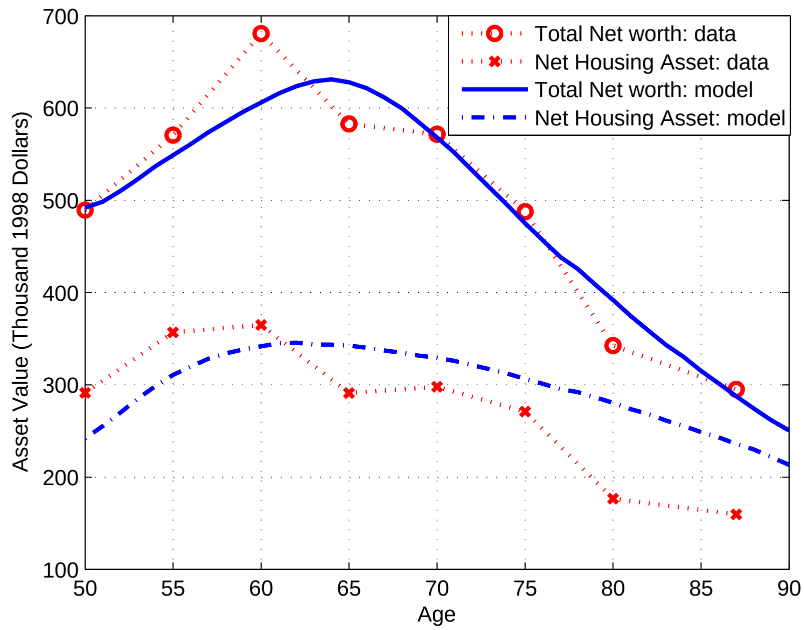

Figure 6: Life Cycle Profile of Wealth Accumulation and Portfolio Choice

3.8. Life Cycle Profile

Figure 6 and 7 plot the average asset portfolio and accumulative retirement rate from simulated data. As described before, when simulating the model, I take the joint distribution of total net worth and labor income for home owners at age 50 directly from Survey of Consumer Finance 1998.

For each housing price sequence withdrawn, I simulate a cohort of 10,000 households with different realization of income process from age 50 to age 90. I repeat this procedure for 1000 different housing price sequences and then average all cohorts to get a life-cycle profile for total net worth and net housing value, both of which have hump-shaped profile.[33] The share of net housing value falls rapidly after age 75 in the data, but it moves downwards slowly in the model. This may be related to shifting taste for housing in the later life in the data.

The cumulative retirement rate for home owners in the model exhibits a spike at age 62. This is due to assumption that households cannot receive any pension payment before age 62 in the model. My model abstracts from health risk. Incorporating it in the model will force part of households to retire earlier and match the cumulative retirement rate before 62 better.

[32] Social Security payroll-tax rate in the US is 15.3 percent. Since my focus is the retirement benefit, I subtract the part of the tax rate due to Medicare and Disability Insurance.

[33] The net housing value is defined as the value of housing stock minus mortgage debt in my model.

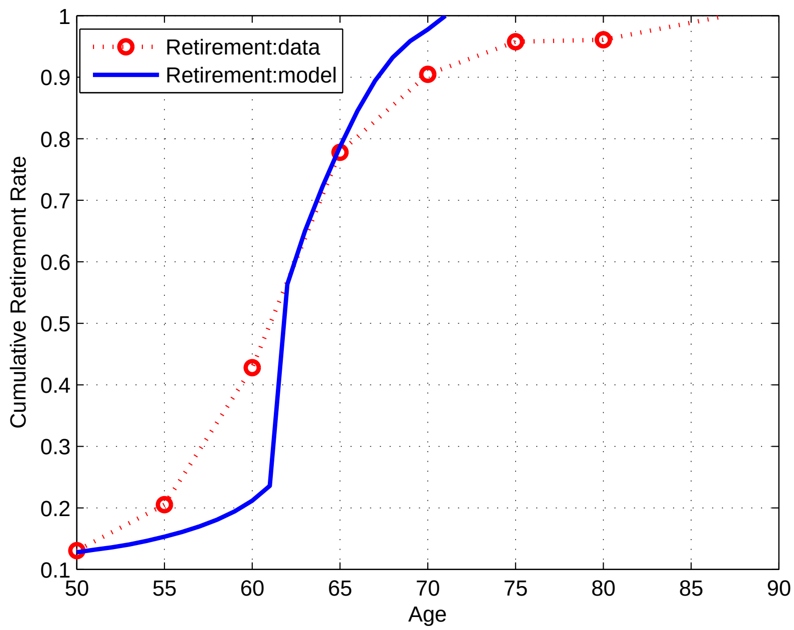

Figure 7: Cumulative Retirement Rate

3.9. Housing Wealth Effect on Retirement

Before I use the structural model to draw any quantitative conclusions, I first run the same regression on model simulated panel data as I did to the HRS and CPS data. When constructing the panel, I again take the joint distribution of total net worth and labor income for home owners at age 50 directly from empirical data. The simulated panel consists of households aged 50-70. There are 200 "MSAs" in the panel, with 200 different housing price sequences. There are 5,000 households in each simulated MSA. To be consistent with the empirical analysis, I also apply the band-pass filter to the model generated housing price series.[34] The results for the simulated panel data is given in column 3, Table 6.

The column 1 and 2 in Table 6 are taken directly from previous empirical results. The column 3 shows that the simulated panel has an estimated housing wealth effect of .20 on home owners. The effect is 40 percent higher than the HRS estimate and 67 percent higher than the CPS estimate. However, keep in mind that some features of the benchmark model tend to enlarge the housing wealth effect. For example, the transaction cost in selling and buying the house will reduce the response of retirement to housing price. Therefore, the benchmark model can serve as an estimate on the upper bound of housing wealth effect on retirement. Later on, I will relax the assumptions in the benchmark model and perform some counterfactual experiments.

[34]Since my simulated data is in annual sequence, I apply the band-pass filter using parameters 2 and 8, with a lead-lag length set to 3 as recommended in Baxter and King [37]

Table 6: Regression Results for the Simulated Panel Data

Dependent Variable: Retirement	HRS	CPS	Benchmark Model
Housing Price^{BP}	.14***	.12**	.20
Lagged Labor Earnings (1000$ in 1998)	-1.4e-3***	-1.4e-3***	-4.1e-3
Age Dummies	Yes	Yes	Yes
Overall R^2	0.33	0.34	0.55

The regression results only estimate the average retirement rate in response to housing prices. I will complement the above analysis by showing the heterogeneous responses to housing price shocks for different age groups using the structural model. Suppose the housing price unexpected decreases by 27.7 percent for certain cohort at age i.[35] I label this cohort by age i and compute the average rate retirement age for that cohort. After repeating this for each cohort i, i=51...71, I plot the average retirement age profile in dotted line in Figure 8. The solid line in Figure 8 is the average retirement age in absence of unexpected one-time housing price drop. Keep in mind that all cohorts start with the same initial joint distribution of total asset and labor income. The only difference between them is the date at which one-time unexpected housing price decline will hit. Therefore, the solid line is flat.

This average retirement age profile for different cohorts is hump-shaped. Note that the full retirement age in my simulation is age 70. Therefore, the unexpected housing price shock at age 71 will not affect the retirement decision. Households have the largest increase in average retirement age when shocks hit them at age 55-64. They on average retire 5.4 months later than they would have done if housing price had not unexpectedly decreased by 28 percent. The result is smaller than the estimates by Farnham and Sevak [25], which finds that a 10 percent increase in housing wealth will reduce the expected retirement age by 3.5 months to 5 months. As shocks hit earlier than age 62, the response in retirement age is smaller. This is because households still have plenty of time to make up the wealth loss at young age.

3.10. Model Mechanisms and Counterfactual Experiments

In this section, I first explain how housing price can affect the non-durable consumption and retirement using an infinite horizon model. Then I will compare my benchmark model to the infinite horizon model and explain what are the implications coming from different model assumptions. Suppose the infinite horizon model model has the following features

A1 infinite horizon

A2 fully predicted housing price

A3 no borrowing constraint

[35] Consider this as a one-time shock and the housing price still follows the same stochastic process after the unexpected shock. The number 27.7 percent comes from the Markov approximation to housing price process. The minimum distance between two grid points is 27.7 percent. Clearly, I can get finer grids by increasing the number of grid points. Since the housing price drops by nearly 30 percent in the 2008 recession, I use this exercise as a simulation about the crisis.

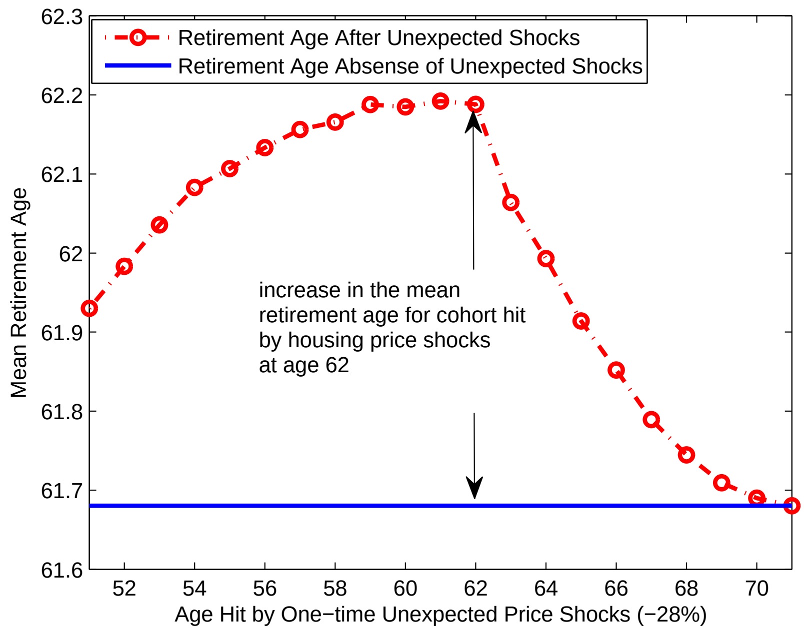

Figure 8: Mean Retirement Age after Negative Housing Price Shocks

A4 no adjustment cost

A5 CRRA preference with Cobb-Douglas utility on consumption and housing services

Here, the assumption *A1* should not be interpreted literally. It can also be understood as a dynasty model where parents care about the utility of their children. In the latter, each individual lives for one period and chooses whether to retire or not.

Under the assumptions *A2-A5*, the housing prices will not affect the consumption or housing expenditure given the same total net worth. This is because the substitution effect and wealth effect of housing price on non-durable consumption cancel out under Cobb-Douglas utility. In other words, after the total net worth is controlled, the current movement in housing price will not affect consumption. However, we usually ask how housing price affect consumption without control for total wealth. Now write the budget constraint as follows

$$c + a' + p'h' = p'h + (1 + r)\, a \tag{26}$$

Under assumption *A1-A5*, housing price will not affect housing consumption if $h = h'$.[36] Generally speaking, $h \neq h'$. It can be shown that if housing prices are fully predicted, the Cobb-Douglas utility implies a constant ratio between non-durable consumption and

[36]However, if assumptions *A1-A5* are not satisfied, then housing price can still affect consumption and retirement even if $h = h'$. In the counterfactual experiment with infinite adjustment to housing, I shows that the housing wealth effect is still present.

Table 7: Regression Results for the Simulated Panel Data

Dependent Variable: Retirement	Benchmark	No Bequest	Zero Borrowing	Infinite Cost
Lagged Labor Earnings (1000$ in 1998)	-4.1e-3	-4.1e-3	-4.1e-3	-4.1e-3
Housing Price^{BP}	.20	.17	.16	.04
Age Dummies	Yes	Yes	Yes	Yes
Overall R^2	.55	.41	.56	.56

housing value.[37] This is because households want to "rebalance" the consumption portfolio each period to make sure the ratio of consumption to housing value is constant over time. Suppose one starts period with housing stock h and today's housing price p' is higher than yesterday's p. If he chooses same consumption and housing size as before, then the consumption/housing expenditure ratio is declining. To rebalance his portfolio, he has to sell the houses and increase consumption.

To address the issue of endogenous retirement, I include the fixed cost of working. Now the utility function is no longer homogenous. An increase in the total wealth will reduce the marginal return to work. Therefore, households are less likely to work when housing price increases.[38]

In this paper, I keep the assumption *A5* and modify the assumption *A1-A4*. First of all, housing price is risky in my benchmark model, which changes the assumption *A2*. Therefore, the expectation about the future housing price will matter. In counterfactual experiment A, I break the assumption *A1* by introducing warm-glow bequest motive. The rationale for this assumption is discussed in the calibration part. In counterfactual experiment B, I break the assumption *A3* by assuming households can not use housing as collateral. In counterfactual experiment C, I will introduce infinite adjustment cost to housing asset, which violates the assumption *A4*.

In the reminder of the section, I will describe the three counterfactual experiments. By doing this, I quantify the housing wealth effect on retirement through three different channels: the bequest motive, collateral constraint, and the resizing effect. Table 7 summarizes the results.

3.10.1. Experiment A: No Bequest Motive

The first experiment is to quantify the effect of warm-glow bequest motive. First, I remove the bequest motive by setting the bequest strength ϕ to zero and keep other parameters in the benchmark model constant. After fitting a linear probability model on retirement with fixed effect, I find that a 10 percent decrease in housing price will reduce the probability of retirement by 1.8 percent.

[37] The ratio may remain constant even if the housing price follows a stochastic process. One sufficient condition for that is to assume the returns on housing price can be fully replicated by stock returns. The intuition is that housing serves as both consumption good and investment good. If its returns can be replicated by stocks, then housing asset can be treated as normal consumption goods. The constant ratio between consumption and housing value then comes from the properties of constant elasticity of substitution between housing and consumption.

[38] If I study the effect of housing price on retirement controlling for the total net worth, then the households are actually more (rather than less) likely to work when housing price increases. This is because with higher housing price and same initial wealth, households are worse off since their wealth in real value is smaller.

The drops in housing wealth effect may be smaller than one would expect. The removal of bequest motive induces households to accumulate less wealth over the life cycle. Households will retire earlier on average than in the benchmark case. This in turns reduces the responsiveness of retirement to housing price shocks. However, the housing asset now accounts for a larger fraction of total net worth than in the benchmark case. This is because housing can be used as collateral, which makes it more valuable to the poor households than to the rich households.

To isolate the effect from changing wealth profile, I redo the calibration. Since I assume away bequest motive, I calibrate the model only to match three moments: the average share of net housing value in total net worth for householders age 50-70, the normalized net worth of households aged 50-70 , the average cumulative retirement rate of households for age group 65. This gives me $\omega = .81$, $\beta = .99$, $\theta = 4.5$. Column "No Bequest" in Table 7 gives the regression results after the new calibration. The housing wealth effect equals .17, which is 15 percent less than the benchmark model.

There is a subtle difference between the warm-glow bequest motive and altruism.[39] If the altruism is assumed, then the housing price fluctuations will not affect the amount of unintentional bequest given that households have the same total net worth and housing price is fully predicted (or if it follows a random walk). However, this will not happen given the warm-glow bequest motive. The idea is that with altruism, we are essentially going back to the infinite horizon model. Hence, given the same total net worth and Cobb-Douglas preference, the wealth effect and substitution effect of housing prices on consumption will cancel out. In this sense, introducing warm-glow bequest instead of altruism inflates the housing wealth effect in the benchmark model.

3.10.2. Experiment B: Zero Borrowing Constraint

In the benchmark model, the average mortgage debt stays high at age 50 and then declines. Over the life cycle, households downsize houses and pay back mortgage gradually. After the retirement, the speed of decumulating debt is slower than in the working period. Households still hold some mortgage debt in late life. In fact, the mortgage leverage ratio is decreasing before retirement and increasing after retirement. This is because households in the model optimally use housing to finance their old-age consumption by taking reverse mortgage.

To study the effect of collateral constraint, I assume that households cannot borrow at all. This is done by simply setting the down-payment ratio λ to 100 percent. If I leave the rest of parameters unchanged, it turns out a 10 percent decrease in housing price reduces the retirement probability by 1.8 percent. Surprisingly, the housing wealth effect on retirement drops only by 10 percent compared to the benchmark model.

This is because two counter-acting forces are at work. On one hand, the high down-payment ratio reduces the incentive to hold housing asset as collateral. Under the zero borrowing constraint, households hold less housing (in gross value) than they do in the benchmark model. This in turn reduces the housing wealth effect on retirement and consumption, because of smaller proportion of gross housing value in the total wealth. On the other hand, the zero borrowing constraint limits the ability to self-insure against

[39] One can think of the bequest utility of altruism as $u_B = \phi \frac{\left(c_j^{\omega} h_{j+1}^{(1-\omega)}\right)^{1-\sigma}}{1-\sigma}$

income risk and housing price risk. In the case of negative housing prices shocks, households want to increase the mortgage debt to housing value ratio in order to smooth consumption. The zero borrowing constraint prevents them from doing this. Although households can accumulate more financial assets than in the benchmark model, their retirement likelihood may still become smaller.

To isolate the two counter-acting forces, I recalibrate the model to the average share of net housing value in total net worth for householders age 50-70, the normalized net worth of households aged 50-70 , the average cumulative retirement rate of households for age group 65, the normalized net worth for households aged above 83. The new parameters are $\omega = .836$, $\beta = .981$, $\theta = 6.13$, $\phi = 19.9$. The results are shown in column "Zero Borrowing" of Table 7. The housing wealth effect on consumption is .16, which is 20 percent less than the benchmark model.

3.10.3. Experiment C: Infinite Adjustment Cost

The third experiment investigates how housing price can affect retirement through house resizing. To get a lower bound on the resizing effect, I assume infinite adjustment cost, i.e., households cannot buy or sell their houses. One can think of the true world lies somewhere between the economy with infinite adjustment cost and the frictionless benchmark economy.

In the simulation, I use the empirical joint distribution of net housing value, wage income, and total net worth from home owners aged 48-52 in the Survey of Consumer Finance 1998 data. The resizing channel turns out to be the most important one for the housing wealth effect on retirement. After removal of resizing channel, a 10 percent decrease in housing price will only reduce the average retirement rate in the sample by only 0.4 percent. This magnitude is only 20 percent of the frictionless benchmark model. The reason that housing wealth effect does not disappear in the infinite adjustment cost case is the following: first, households have bequest motive. When the adjustment cost is infinite, households choose to leave housing asset as a bequest instead of saving financial asset; second, the collateral borrowing channel allows households to consume out of their housing asset by taking more debt when they still live in them.

3.11. Housing Wealth Effect on Consumption

Although the main aim of this paper is to quantify the housing wealth effect on old-age labor supply, the structural model can also be used to quantify the housing wealth effect on households consumption. There are many researches trying to estimate the housing wealth effect on non-durable consumption. However, because of the lack of panel data on households consumption, Campbell and Cocco [20] constructs a pseudo-panel data to address the issue. Other researches use PSID and study the effect of housing price on food consumption, e.g., Hryshko et al. [13]. In this paper, I use consumption data from HRS to provide evidence of housing wealth effect on old-age consumption, which can be think of as a cross-validation of their studies.

The HRS data is not designed for study of households consumption. However, it has a supplement called the Consumption and Activities Mail Survey (CAMS) from 2001. It is a paper-and-pencil survey that is collected biennially in odd-numbered years. One of its primary objectives is to measure total household spending over the previous 12 months. In September 2001, the first CAMS survey was mailed to 5,000 households

Table 8: Comparison between HRS data and Simulated Data

Dependent Variable: Δc	HRS	HRS Homeowners	Benchmark Model
ΔHousing Price	.29**	.28**	.39
	(2.13)	(1.98)	
Renter	-.13	—	—
	(-1.52)		
Renter$\times\Delta$Housing Price	-.11	—	—
	$(-.46)$		
ΔStock Price	.18**	.21**	—
	(2.1)	(2.23)	
Non-Stock Owner	-.02	-.008	—
	$(-.36)$	$(-.20)$	
Non-Stock Owner$\times\Delta$Stock Price	-.008	.028	—
	(.31)	(.34)	
ΔNon-capital Income (1000$ in 1998)	-3.6e-4	-.017e-3	.075
	$(-.27)$	(-1.22)	
Age Dummies	Yes	Yes	Yes

selected at random from households that participated in the HRS 2000 core survey. I use the entire five waves of the CAMS data 2001-2009. The questions on consumption record individual consumption last month or last 12 months. The Rand CAMS data clean the data by annualizing the consumption into yearly data. Since the survey usually starts in September in odd-number years, I will simply treat the consumption data as values for the year 2001, 2003, 2005, 2007, and 2009.

To be consistent with my model setting, I only look at households aged 50-70 in the data. The first two columns in Table 8 shows the fixed effect panel regression allowing for AR(1) error terms. The dependent variable is changes in log households non-durable consumptions.[40] The explanatory variables include the changes in log housing prices and its interaction term with home ownerships. I also include the changes in log stock price and its interactions with stock ownerships.

The housing wealth effect on consumption is .29, which means 10 percent growth in housing prices increases the growth rate of non-durable consumption of homeowners aged 50-70 by 2.9 percentage points. The stock wealth effect is .18, which says that 10 percent growth in stock prices increases the average growth rate of non-durable consumption by 1.8 percentage points. When I restrict the sample to homeowners only, the wealth effect do not change much. Note that the coefficient before the changes in log households non-capital income is negative and not significantly different from zero. This is possibly related to the measurement errors.[41]

Column 3 in Table 8 shows the regression results using the model simulated panel data. This is the same data set I use to estimate housing wealth effect on retirement.

[40] According the Rand Version of CAMS data, the non-durable consumptions include the home/renter insurance, vehicle insurance, health insurance, trips and vacations, gift, rent, electricity, water, home repairs, clothing and apparel, personal care products, drugs, tickets, sport equipment etc.

[41] In the HRS, the questions on income are retrospective. Households are asked about their last year's income. Although the survey is conducted in even-number years, the survey does not always finish within one year. The income data are only available up to year 2008 because the Rand HRS data for 2010 is not currently available. In order to include the 2009 CAMS sample, I use the changes in log income from year t-3 (t-4) to t-1 (t-2) as a measure of changes to log income from t-2 to t.

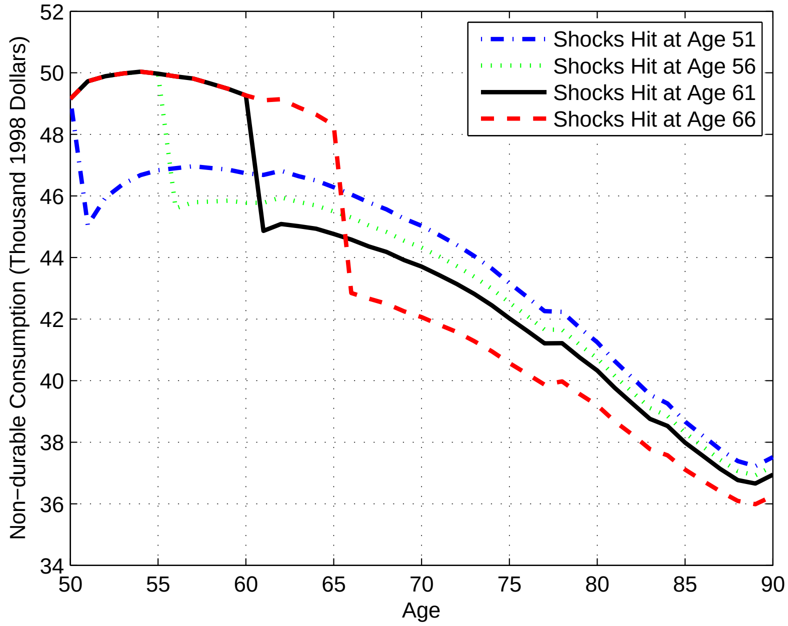

Figure 9: Consumption Profile After Negative Housing Price Shocks (Endogenous Retirement)

The structural model implies a housing wealth effect on consumption that is 34 percent higher than the empirical findings. According to the previous counterfactual experiment, this is largely due the frictionless housing market in the benchmark model.

So far, we are looking at the average consumption response for households aged 50-70 to the housing price shocks. It is also interesting to look at the heterogenous response for different age groups. Figure 9 plots the non-durable consumption response of four different age groups, for which housing price unexpectedly drops by 27.7 percent at age 51, 56, 61, and 66 respectively. It can be seen from the graph that non-durable consumption drops immediately after the decline in housing price. Those who experience a negative housing price shocks later in life will have a lower non-durable consumption profile than households who experiences it at younger age.

It worth noticing that Hryshko et al. [13] ask the role of housing asset as a risk-sharing tool for consumption. They find that home owner tends to have less drops in food consumption than a renter when both of them experience a bad shock in the labor market. However, both Campbell and Cocco [20] and Hryshko et al. [13] ignore the role of retirement as a self-insuring instrument against housing price risks for old homeowners.

In order to demonstrate the role of endogenous retirement in cushioning the housing price risk, I calibrate a second structural model with exogenous retirement, where all households retire at the age 66. I also include the initial retiree at age 50 in the data and assume they stay in retirement until the end of life. Households (including the initial

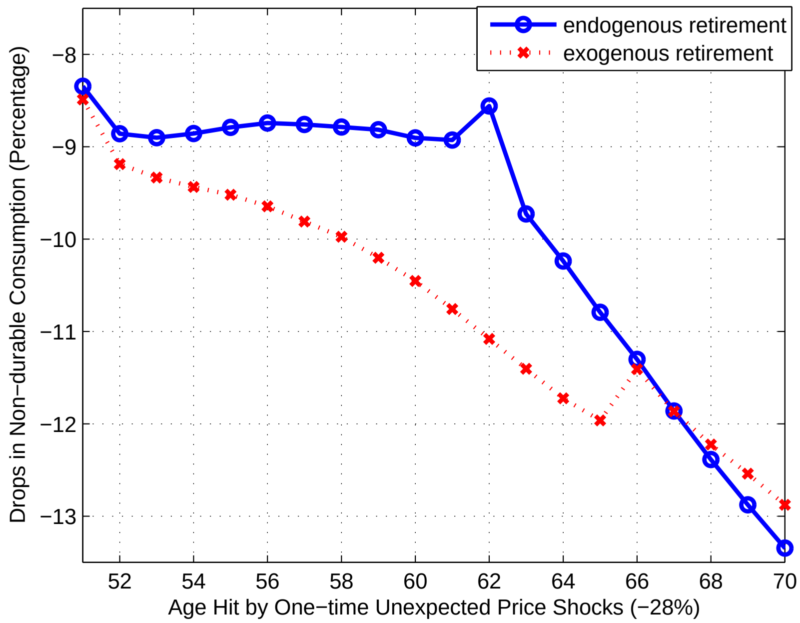

Figure 10: Instant Drops in Consumption After Negative Housing Price Shocks

retirees) can get the same retirement benefit as in my benchmark model after age 66.[42] Figure A.13 shows the similar non-durable consumption response for households in the economy without endogenous retirement. Like the economy with endogenous retirement, the non-durable consumption drops right after the housing price shocks. However, the drops in consumption level is smaller in the endogenous retirement case.

To make the comparison easier, I compute the instant percentage drops in the non-durable consumption level for cohorts which experienced one-time unexpected housing price at different ages and plot them in Figure 10.[43] Two findings are worth mentioning. First, old age households suffer larger loss in the non-durable consumption than younger households, this is because younger households have longer working period left to recover from wealth loss. Second, households in the economy with endogenous retirement on average have smaller drops in non-durable consumption than the households who cannot choose the retirement.[44] It turns out that the drops in non-durable consumption for the

[42] I calibrate the consumption weight in the utility ω, the bequest strength ϕ, the discount factor β to match three moments in the data: the average share of net housing value in total net worth for householders age 50-70, normalized net worth of households aged 50-70, the normalized net worth for households aged above 83. These give $\omega = .814$, $\beta = .976$, $\phi = 21.0$.

[43] For the drops in levels of consumption, please look at Figure A.14.

[44] The spike at age 66 and 62 is due the availability of retirement benefit to those borrowing-constrained initial retirees. In the SCF, the initial retirees at age 50 are on average poorer than the initial working population. When the retirement benefit is available, the borrowing-constrained households increase their consumption and have smaller drops in consumption in the presence of negative price shocks.

home owners aged 55-64 with the ability to adjust retirement is 14 percent smaller than the drops in the case with exogenous retirement. This confirms the idea that endogenous retirement can cushion the negative housing prices shocks on home owners' consumption. This exercise implies that the endogenous retirement is important aspect when estimating the wealth effect on consumption for the near-retirement households. Neglecting this will overestimate the housing wealth effect on the consumption of old working households.

4. Conclusion

It is particular important to understand the key factors that influence the timing of retirement when the Post-World War II baby boomers are preparing to retire. This paper finds that housing price and stock price changes can explain the puzzling countercyclical old-age labor force participation during the recent recessions in the US. The retirement probability of home/stock owners drops when housing/stock price unexpectedly declines.

The paper then sets up an incomplete-market life-cycle partial-equilibrium model, in which households choose housing consumption and timing of retirement subject to exogenous labor income risk, housing price risk, and mortality risk. Calibrated to match the U.S. data, the model's predictions about retirement are consistent with empirical evidence. Counterfactual experiments indicate that households respond to housing price shocks through three channels: resizing effect, bequest motive, and collateral borrowing. Using the structural model, the paper also emphasizes the role of endogenous retirement as a risk-sharing tool for households suffering from housing price and income shocks.

Since most the variation in aggregate hours for the near-retirement age group comes from extensive margin rather than intensive margin, this paper suggests that the government should take wealth effect into consideration when making policy such as taxation, the early retirement age, and pension reform.

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Appendix A. Tables and Figures

Table A.9 shows the mapping from 20 MSAs used by Case-Shiller Index to the Geographic Identifiers in the CPS. The specific metropolitan identifiers in this table are based on the Office of Management and Budget's definition in several years.

Table A.10 and A.11 are the robustness check for shows the same regression as in Table 2 and 3. It uses different measure of housing price shocks. Table A.10 also use an alternative definition of retirement in HRS

Figure A.11 it the normalized efficiency units taken from Hansen [40]. Figure A.12 plots the joint distribution of total net worth and wage income for homeowners aged 48-52 from Survey of Consumer Finance 1998.

I compute the instant percentage drops in the non-durable consumption level for cohorts which experienced one-time unexpected housing price at different ages, and plot them in Figure A.14.

Table A.9: Geographic Identifiers of 20 MSAs in the CPS data

MSA	HG_MSAC 1989M12-1993M12	GEMSA 1994M1-2004M4	GTCBSA 2004M5-2011M4
Phoenix-Mesa-Scottsdale, AZ	6200	6200	38060
Los Angeles-Long Beach-Santa Ana, CA	4480,5945	4480,5945	31100
San Diego-Carlsbad-San Marco, CA	7320	7320	41740
San Francisco-Oakland-Fremont, CA	7360,5775	7360,5775	41860
Denver-Aurora, CO	2080	2080	19740
Washington-Arlington-Alexandria, DC-VA-MD-WV	8840	8840	47900
Miami-Fort Lauderdale-Pompano Beach, FL	5000,2680,8960	5000,2680,8960	2.8
Tampa-St. Petersburg-Clearwater, FL	8280	8280	45300
Atlanta-Sandy Springs-Marietta, GA	520	520	12060
Chicago-Naperville-Joliet, IL	1600	1600	16980
Boston-Cambridge-Quincy, MA-NH	1120,1200,4160	1120,1200,2600,4160	71650
	4560,5350,7090	4560,5400,4760,6450	
Detroit-Warren-Livonia, MI	2160	2160	19820
Minneapolis-St. Paul-Bloomington, MN-WI	5120	5120	33460
Charlotte-Gastonia-Concord, NC-SC	1520	1520	16740
Las Vegas-Paradise, NV	4120	4120	29820
New York City Area	0875,1160,1930,3640	1160,1930,2281,3640,5015	35620,45940
	5190,5380,5600,5640	5190,5380,5600,5480,5640	71950,75700
	5760,5950,8040	5660,8040,8480,8880	
Cleveland-Elyria-Mentor, OH	1680,4440	1680	17460
Portland-Vancouver-Beaverton, OR-WA	6440,8725	6440	38900
Dallas-Fort Worth-Arlington, TX	1920,2800	1920,2800	19100
Seattle-Tacoma-Bellevue, WA	7600,8200	7600,8200	42660

Table A.10: Regression Results for the HRS data: robustness check

Dependent Variable: Retirement	(1)	(2)	(3)	(4)	(5)
	Retirement Recoded		Self-reported Retirement		
Housing Price^{HP}	.139***	—	—	—	.074*
	(3.26)				(1.68)
Housing price^{Diff}	—	.0573 **	—	.0822 ***	—
		(2.20)		(2.95)	
Housing Price^{BP}	—	—	.104**	—	—
			(1.98)		
Renter	-1.4e-3	1.42e-3	7.7e-3	7.2e-3	5.4e-3
	(−.20)	(.20)	(.95)	(.96)	(.73)
Renter×Housing price^{HP}	-.015	—	—	—	-.103
	(−.14)				(−.99)
Renter×Housing price^{Diff}	—	-.191 ***	—	-.128 **	—
		(−3.31)		(−2.30)	
Renter×Housing Price^{BP}	—	—	-.157	—	—
			(−1.24)		
Stock Price^{HP}	.0249	—	—	—	.0282
	(1.49)				(1.58)
Stock Price^{Diff}	—	-.011	—	.019	—
		(−.88)		(1.13)	
Stock Price^{BP}	—	—	.117***	—	—
			(4.98)		
Non-stock Owner	2.93e-3	2.0e-3	.0147***	.0130***	.0130***
	(.73)	(.52)	(3.12)	(3.02)	(3.07)
Non-Stock Owner×Stock Price^{HP}	-.093***	—	—	—	-.0344
	(−4.21)				(−1.45)
Non-Stock Owner×Stock Price^{Diff}	—	.0417***	—	.0187	—
		(2.65)		(1.13)	
Non-Stock Owner×Stock Price^{BP}	—	—	-.0414*	—	—
			(−1.74)		
Labor Earnings (1000$ in 1998)	-1.49e-3***	-1.49e-3***	-1.19e-3***	-1.29e-3***	-1.29e-3***
	(−3.48)	(−3.48)	(−2.87)	(−3.19)	(−3.19)
Self-employed	-.213***	-.213***	-.089***	-.087***	-.087***
	(−22.8)	(−22.7)	(−8.76)	(−9.48)	(−9.53)
Health Status	8.0e-3***	7.8e-3***	.0146***	.0156***	.0156***
	(4.1)	(4.0)	(6.6)	(7.7)	(7.7)
Government Provided Health Insurance	.0917***	.0917***	.158***	.165***	.165***
	(13.9)	(13.9)	(22.3)	(24.5)	(24.5)
Employer Provided Health Insurance	-.193***	-.193***	-.171***	-.170***	-.170***
	(−33.9)	(−33.9)	(−28.1)	(−30.1)	(−30.3)
Unemployment Rate^{HP}	4.19e-4	—	—	—	3.2e-3
	(.17)				(1.23)
Unemployment Rate^{Diff}	—	-4.4e-4	—	3.4e-4	—
		(−.22)		(.17)	
Unemployment Rate^{BP}	—	—	.0235***	—	—
			(6.29)		
CD and Age Dummies, Fixed Effects	Yes	Yes	Yes	Yes	Yes
Overall R^2	.33	.32	.37	.38	.38
Number of Observations	96,549	96,549	71,024	80,265	80,265
Number of Households	20,312	20,312	18,347	19,053	19,053

Table A.11: Regression Results for the CPS data: robustness check

Dependent Variable: Retirement	(1)	(2)	(3)	(4)
	All	Home Owners	All	Home Owners
MSA Housing Price$^{\text{Diff}}$	.0285***	.088***	—	—
	(3.01)	(11.2)		
MSA Housing Price$^{\text{HP}}$	—	—	.039	.027
			(1.22)	(.83)
Renter	-.0049	—	-.058***	—
	(−.09)		(−24.9)	
Renter×MSA Housing Price$^{\text{Diff}}$	-.0141	—	—	
	(−1.04)			
Renter×MSA Housing Price$^{\text{HP}}$	—	—	-.003	—
			(−.06)	(−1.50)
Stock Price$^{\text{Diff}}$	.0579***	.070***	—	—
	(2.73)	(3.13)		
Stock Price$^{\text{HP}}$	—	—	.053*	.070**
			(1.70)	(2.10)
No College Degree	.028***	.031***	.025***	.028***
	(9.73)	(10.0)	(9.88)	(10.3)
No College Degree×Stock Price$^{\text{Diff}}$	-.071***	-.081***	—	—
	(−3.04)	(−3.23)		
No College Degree×Stock Price$^{\text{HP}}$	—	—	-.039	-.0683*
			(−1.10)	(−1.81)
Lagged Family Income (1000$ in 1998)	-1.45e-3***	-1.47e-3***	-1.44e-3***	-1.47e-3***
	(−39.0)	(−35.5)	(−42.4)	(−38.8)
Self-employed	-.171***	-.180***	-.173***	-.181***
	(−82.5)	(−80.0)	(−90.1)	(−86.7)
Number of persons	-.011e-3***	-.010e-3***	-1.1e-2***	-9.8e-3***
	(−15.8)	(−12.3)	(−16.7)	(−12.7)
MSA Unemployment Rate$^{\text{Diff}}$	5.4e-4	1.0e-4	—	—
	(−.92)	(.15)		
MSA Unemployment Rate$^{\text{HP}}$	—	—	2.2e-4	8.7e-5
				(.10)
Race, Marital Status, Gender, Age dummies	Yes	Yes	Yes	Yes
Year≥1994, Month-in-sample, MSA Dummies	Yes	Yes	Yes	Yes
R^2	0.34	0.34	0.33	0.34
Number of Observations	626,074	515,033	650,357	534,775

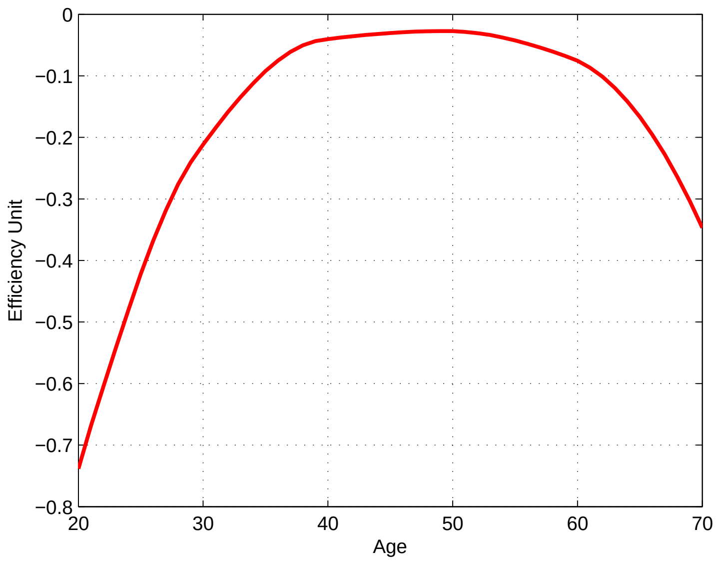

Figure A.11: Logarithm of Efficiency Unit

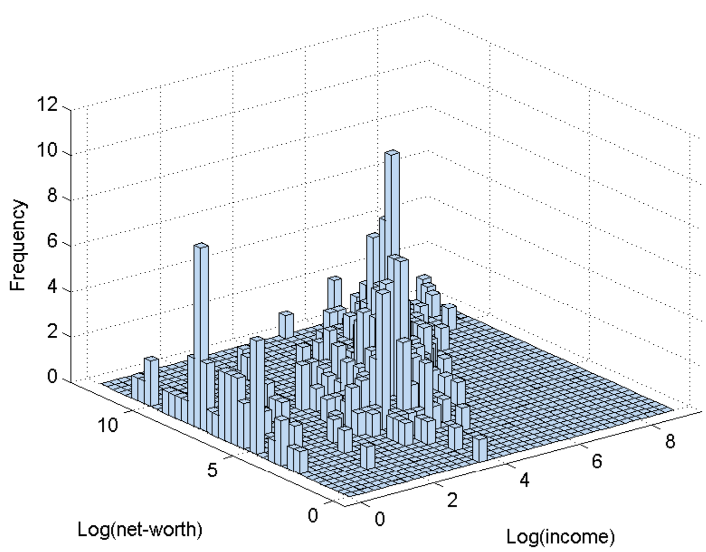

Figure A.12: Joint Distribution of Net worth and Earnings at Age 50

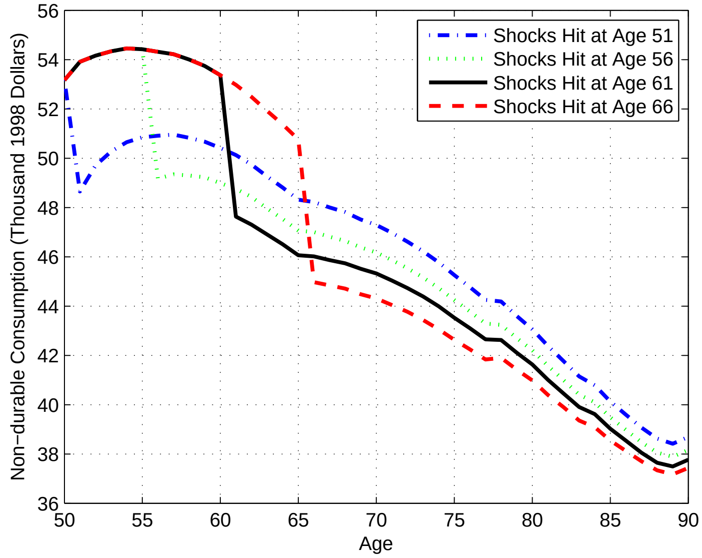

Figure A.13: Consumption Profile After Negative Housing Price Shocks (Exogenous Retirement)

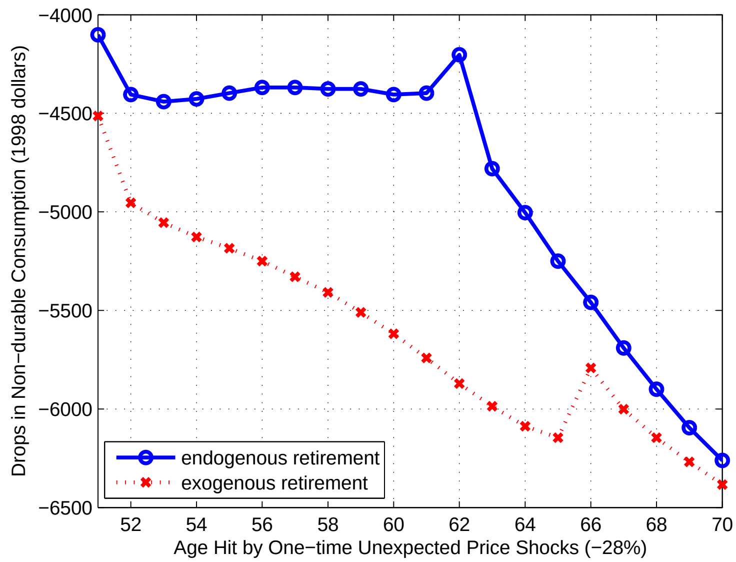

Figure A.14: Instant Drops in Consumption After Negative Housing Price Shocks