Too Poor to Retire? Housing Prices and Retirement*

Bo Zhao†

October 25, 2017

Abstract

The near-retirement households among all working-age groups in the United States experienced larger drops in consumption and greater increases in labor force participation during the financial crisis of 2007-2009. Also, the retirement probability for near-retirement homeowners (but not for renters) decreases more in those areas where housing prices also decline more. This paper argues that the wealth effect of housing prices on retirement can account for those issues. It creates an incomplete-market life-cycle partial-equilibrium model with risky housing assets and endogenous retirement and verifies that the joint response of retirement and non-durable consumption implied by the structural model is consistent with the empirical findings using data from the Health and Retirement Study 1992-2012. It then shows that, after an unexpected 28 percent housing price decline, near-retirement homeowners ages 55-64 will reduce their non-durable consumption by 4.6 percent and increase their labor force participation by 1 percentage point immediately and delay their retirement by 2.8 months in the long run. The model also quantifies endogenous retirement as self-insurance for elderly homeowners against housing price risk.

Keywords: housing wealth effect, endogenous retirement, self-insurance

JEL: E21, E24, J26

1 Introduction

The impact of the 2007-2009 financial crisis on household consumption and labor supply differs across age groups. Table 1 shows the average annual growth rate of nondurable consumption during the pre-crisis period from 2002 to 2007, the crisis period from 2007 to 2009, and the post-crisis period from 2009 and 2014. Both the young age group (age 16-24) and the near-retirement age group (age 55-64) had the largest drop in consumption during the crisis period. Table 2 shows the average annual changes of labor force participation rates during the same period. All age groups except for the

*I would like to thank seminar participants at the 2011 European Economic Association and Econometric Society Meeting, 2011 European Winter Meeting of the Econometric Society, University of Oslo, Federal Reserve Bank of Minneapolis, University of Cologne, and 2014 National Bureau of Economic Research-China Center for Economic Research conference. This project was supported by the National Science Fund for Young Scholars of China (Grant No. 71603011). All errors are my own.

†China Center for Economic Research, National School of Development, Peking University, Beijing 100871, China. Email: bo.robert.zhao@gmail.com. Tel: 0086-010-62758375

Table 1: **Average annual growth rate of non-durable consumption for households aged 16-64**. Source: Consumer Expenditure Survey database from the US Bureau of Labor Statistics. Consumption growth rates are denoted in percentage point. Consumption data is deflated by consumer price index. Nondurables consist of food consumption, alcohol beverages, utilities, household operations, apparel, public transportation, gas and motor oil, entertainment, personal care products, tobacco products and smoking supplies, and miscellaneous expenditures. The age of a household head is defined as the age of the reference person in a household. The standard errors are in parentheses and are computed based on Consumer Expenditure Survey standard error table.

Time period	Age of households head				
	16-24	25-34	35-44	45-54	55-64
2002-2007	1.5	0.7	2.0	1.6	1.5
	(0.9)	(0.4)	(0.4)	(0.5)	(0.6)
2007-2009	-4.6	-1.6	-1.7	-1.9	-3.4
	(2.9)	(1.2)	(1.1)	(1.4)	(1.5)
2009-2014	-1.1	-1.0	-0.8	-0.1	-0.4
	(1.2)	(1.2)	(0.5)	(0.6)	(0.5)

near-retirement age group experienced a decline in the labor force participation rate during the crisis period. Surprisingly, the labor force participation rate of the near-retirement age group increased at a higher rate during the crisis period than in the pre-crisis period.

Conventional wisdom says that the households of the elderly are too poor to retire because of falling asset prices during the financial crisis, for example, the S&P Case-Shiller Home Price Indices for the United States dropped by 30 percent between 2006 and 2009.[1] Because of the high fraction of housing wealth in total household wealth as well as the high home-ownership rate during later life, the households of the elderly are particular vulnerable to housing price shocks.

This paper analyzes all waves from 1992 to 2012 from the Health and Retirement Study (HRS), a nationally representative panel survey of individuals 50 years older. The study shows how housing prices affect the joint behaviors of retirement and consumption. By using the geographic and time variations in housing prices, the study finds that the decline in regional housing prices is positively correlated with a drop in retirement probability and consumption of homeowners 50-65 years old. Such a positive correlation is absent for renters in this same age group.

Motivated by the empirical results, this paper takes the off-the-shelf, incomplete-market life-cycle model with risky housing asset and endogenous retirement to estimate the impact of housing price shocks on retirement and non-durable consumption of older homeowners. In the model, households derive utilities from non-durable consumption, leisure, and housing services. More important, households can choose the timing of retirement subject to uninsurable labor income risk, housing price risk, health risk, and mortality risk. Calibrated to the US data, the structural model delivers predictions that are consistent with the empirical study. The regression using the HRS finds that a 10 percent

[1]Hurd and Rohwedder (2010) also find that the elderly revised their retirement expectations to delay retirement from 2007 to 2009. Goda, Shoven and Slavov (2011) document similar evidence on delayed retirement plans of elderly households from 2006 to 2008.

Table 2: **Average annual changes of labor force participation for individuals aged 16-64**. Source: US Bureau of Labor Statistics, time series LNS11324887, LNS11300089, LNS11300091, LNS11300093, and LNU01300095. Labor force participation rate is defined as total labor force divided by total population in each age group.

Time period	Age of individuals				
	16-24	25-34	35-44	45-54	55-64
2002-2007	0.8	-0.1	-0.1	0.0	0.4
2007-2009	-1.3	-0.3	0.0	-0.2	0.6
2009-2014	-0.4	-0.3	-0.3	-0.4	-0.2

decline in local housing prices will reduce the mean retirement probability for homeowners ages 50-65 by a 0.7 percentage point and will reduce the non-durable consumption for homeowners ages 50-65 by 2.5 percent, which align with the structural model. Numerical simulation also shows that after the housing prices drop by 28 percent, an amount close to that experienced during the financial crisis of 2007-2009, households with members 50-65 years old reduced their non-durable consumption by 4.6 percent and increased their labor force participation rate by 1 percentage point immediately and delayed their retirement by 2.8 months in the long run.

The decline in housing prices immediately reduces the total wealth of homeowners. This wealth effect tends to reduce households consumption of non-durables, housing services, and leisure. When a house is not worth as much, households also want to substitute consumption of non-durables and leisure for housing. Combining the two effects, the decline in housing prices will cause homeowners to consume fewer non-durable goods and to engage in fewer leisure activities, which take the form of delayed retirement. This mechanism relies mostly on the ability to freely adjust the size of the house, which implies that households can upgrade or downgrade their houses after the housing price shock.[2] After the adjustment in house size, the capital gain or loss because of fluctuating housing prices is realized, which, in turn, affects the reservation wage and the probability of retirement.

The structural model also quantifies the effectiveness of endogenous retirement as self-insurance for homeowners against housing price risk. It finds that after the one-time unexpected 28 percent housing price decline, the drops in non-durable consumption for homeowners ages 55-64 with endogenous retirement is 34 percent smaller than the drops in the consumption of homeowners with exogenous retirement.

Early literature regarding wealth effects focuses on the impact of wealth on households non-durable consumption.[3] Recent studies by Case, Quigley and Shiller (2001) and Campbell and Cocco (2007)

[2]Because housing transactions are costly, there have been debates on whether housing, like other liquid assets, is being used by older households to finance consumption. The home-ownership rate in the United States remains stable until age 70 and then declines significantly afterwards(Yang, 2009). Banks et al. (2007) find that US 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, Jos Luengo-Prado and Sørensen (2010) find that housing assets help to cushion the consumption drops of homeowners in the presence of negative labor market shocks.

[3]Holtz-Eakin, Joulfaian and Rosen (1993) and Imbens, Rubin and Sacerdote (2001) use exogenous wealth variations, such as inheritances or lottery winnings, to identify the wealth effect on consumption. The virtue of this method is that it avoids the endogeneity problem of wealth accumulation. Other studies, including Parker (2000) and Juster et al. (2004), 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.

examine only one important component of household wealth, the housing asset.[4] They find that consumption of older homeowners is most responsive to housing prices. Mian, Rao and Sufi (2013) investigate the consumption consequences of the 2006-2009 housing collapse and estimate a large elasticity of consumption with respect to housing net worth of 0.6 to 0.8. They find that the average marginal propensity to consume (MPC) out-of-housing wealth is 5-7 cents per dollar, with substantial heterogeneity across ZIP codes. The housing wealth effect can have large welfare implications. Glover et al. (2011) construct a stochastic overlapping generations general equilibrium model in which households are subject to aggregate shocks that affect both wages and asset prices, and they find that a model recession translates into a large welfare loss of around 10 percent of lifetime consumption for households ages 70 and over. This paper complements the existing literature by investigating the role of endogenous retirement as a self-insurance against housing price risk for the near-retirement age households.

A growing literature, most of which consists of empirical studies, is trying to estimate the wealth effect on labor supply and retirement. Early research use household-level data to estimate the effect of the stock market boom on the retirement decision. Those studies confirm the anecdotal story that the bear market forces older households to remain in the labor force.[5] However, the findings regarding housing wealth effects on retirement are mixed. Farnham and Sevak (2007) find that a 10 percent increase in housing wealth will reduce the expected retirement age by 3.5 to 5 months. Coile and Levine (2009) find no evidence that older workers respond to a fluctuating housing market. More recently, French and Benson (2011) argue that the overall labor force participation rate would be 0.7 percentage point lower were it not for the decline in the values of stocks and houses from 2006 to 2010. This paper examines the evidence of the housing wealth effect on both retirement and non-durable consumption using panel data from the HRS.

In terms of a structural model, most previous literature emphasizes the role of Social Security, private pensions, health insurance, earning shocks, and taxation in determining retirement (French, 2005; Ljungqvist and Sargent, 2010; Prescott, Rogerson and Wallenius, 2009). From a different perspective, this paper analyzes the impact of wealth changes on retirement. The model is similar to Yogo (2009); Glover et al. (2011); Telyukova and Nakajima (2010); Hryshko, Jos Luengo-Prado and Sørensen (2010); Bottazzi, Low and Wakefield (2007); Farhi and Panageas (2007); Imrohoroglu and Kitao (2010). However, none of these papers studies the effect of housing prices on retirement.

The rest of the paper is organized as follows. Section 2 describes the data sets, estimation strat-

[4]Case, Quigley and Shiller (2001) use aggregate data to find a 10 percent increase in housing wealth, which increases aggregate consumption by 0.4 percent in the United States and by roughly 1.1 percent for other countries. Meanwhile, they find only insignificant effects of rising financial wealth on aggregate consumption. Using the UK household data, Campbell and Cocco (2007) investigate the response of household consumption to housing prices by constructing a pseudo panel. They find the largest effect of housing prices on consumption for older homeowners and the smallest effect for younger renters. In their benchmark regression, a 1 percent increase in housing value increases the non-durable consumption of the elderly homeowner by approximately 1.2 percent, which accounts for 8 percent of the increase in housing value.

[5]Cheng and French (2000) show that the run-up in the stock market in the 1990s, which brought greater than $50,000 gains to more than 15 percent of the individuals ages 55 and above, decreases the participation rate for people older than 50 by 3.2 percent. Sevak (2002) use the HRS data to find that an increase of $50,000 in wealth shocks will lead to a 1.9 percent increase in retirement probability among individuals ages 55-60. Coronado and Perozek (2003) use the same data set and finds that households that held corporate equity immediately before the bull market of the 1990s, on average, retired 7 months earlier than other respondents. Gustman, Steinmeier and Tabatabai (2009) find that the recent stock market decline led the early boomers to postpone retirement, on average, by 1.5 months. Chai et al. (2011) create a structural model with stocks and an endogenously labor supply to study the effects of the stock price crisis on household consumption and retirement.

egy, and empirical evidence. Section 3 presents an incomplete-market life-cycle model with housing and endogenous retirement and compares the model-implied consumption and retirement elasticity of housing prices with the empirical estimates. The model is also used to perform counterfactual experiments. Section 4 concludes the paper.

2 Empirical Evidence

2.1 Data

The empirical findings are based on the HRS. The HRS is a national, biennial panel survey of individuals over the age 50 and their spouses. It includes detailed information about demographics, income, wealth, health status, job status, pension plans, and others. This paper uses the RAND (2015) version of the HRS data from 1992 to 2012.

However, the core HRS data does not contain information on consumption. To study the consumption behavior, I look at the Consumption and Activities Mail Survey (CAMS) 2001-2011, which is a supplementary dataset to the HRS. 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 selected at random from households that participated in the HRS 2000 core survey. The questions about consumption record individual consumption in the last month or last 12 months. The RAND CAMS contains the cleaned annualized consumption data. Because the survey usually starts in September in odd numbered years, I simply treat the consumption data as values for 2001, 2003, 2005, 2007, 2009, and 2011. I merge the income data from the RAND HRS data 2002-2012 to the CAMS 2001-2011 sample.

To use the time variations in housing prices across different regions, I use the housing price indices for 9 census divisions from the Federal Housing Finance Agency (FHFA). The indices are based on repeat transactions on the same physical property units to control for differences in the quality of the houses comprising the sample used for statistical estimation. The 9 census divisions are the following: East North Central, East South Central, Middle Atlantic, Mountain, New England, Pacific, South Atlantic, West North Central, and West South Central.[6]

I restrict the sample based on the following standards. First, I look at the HRS respondents aged between 50 and 65 between 1992 and 2012. Second, I only include married respondents to keep the family composition stable. Third, I keep only respondents with positive total household net worth. In the end, there are 43,881 observations in the retirement regression and 4,579 observations in the consumption regression.

2.2 House Prices and Retirement

The regression model is formulated as follows:

$$R_t^i = \alpha^i + \mathbf{Z}_t + P_t \times H_t^i + \mathbf{X}_t^i + \epsilon_t^i \quad (1)$$

[6] In the public data, detailed geographic information such as metropolitan statistic areas are not available.

Table 3: **Regression results on retirement decision**. The variable renter is a binary dummy. The reference group is the homeowners. Significance levels: *** 1 percent, ** 5 percent, * 10 percent.

Dependent var.: Retirement dummy	FE	FE	RE	RE
Sample coverage	All HH	Homeowner	All HH	Homeowner
	(1)	(2)	(3)	(4)
Log(House price)	0.073**	0.072**	0.070**	0.075**
	(2.1)	(2.0)	(2.2)	(2.2)
Renter	1.0***	—	0.64***	—
	(3.8)		(3.0)	
Log(House price)×Renter	-0.22***	—	-0.16***	—
	(-3.3)		(-2.6)	
Earnings last year(Thousands $)	-1.3e-3***	-1.3e-3***	-1.6e-3***	-1.6e-3***
	(-9.5)	(-9.4)	(-12.0)	(-12.0)
Year/C-D dummy	Yes	Yes	Yes	Yes
No. of Obs.	43,881	40,789	43,881	40,789

R_t^i is a binary variable. It equals 1 if the respondent i reports she or he has fully/partly retired at time t and 0 otherwise. α^i is the individual unobserved characteristics, which may be correlated with other explanatory variables. $\mathbf{Z}_t$ is a vector of observable aggregate economic factors, including year dummy, census division unemployment rates, census division dummy, and others. To control the trend of labor force participation, I also add the linear time trend interacted with the census division dummy. P_t denotes the logarithm of census division housing prices deflated by the Consumer Price Index (CPI). I use the monthly housing price index from the FHFA for 9 census divisions. I match the monthly census division housing prices to the HRS respondents based on the month they finished the survey and the census divisions they lived in.[7] Housing prices are the log value deflated by the CPI. H_t^i is an indicator of a renter for respondent i at time t. It equals 0 if the respondent reports a positive gross value of her or his primary residence. It equals 1 if the value of the primary residence is zero. This interaction term exploits the regional variations in housing prices and variations in home-ownership to identify the housing wealth effect on retirement. $\mathbf{X}_t^i$ includes earnings in the last calendar year, type of health insurance plan, and other social demographic variables, such as age, age^2, age^3, health status dummy, education, race, self-employment status, and others.

The first two columns in Table 3 report the regression coefficients of a fixed effect linear probability model. The last two columns report the regression results of a random effect linear probability model.[8] Columns (1) and (3) examine the whole sample while columns (2) and (4) focus on homeowners only. T-statistics are given in parentheses and standard errors are clustered at the individual level.

Housing prices may be correlated with economic growth and, therefore, endogenously determined in the economy. I am unable to find ideal instrument variables that are correlated with housing prices but not correlated with economic growth at all, so I have tried to partially alleviated the endogeneity problem of housing prices. First, all regressions include the year fixed effect and census division unemployment rate. Second, the retirement response of homeowners is compared with renters. If

[7]Results remain robust if yearly housing prices are used instead. See the Appendix for more robustness check.

[8]The model can also be estimated using fixed effect logit model. The linear and non-linear models give the same qualitative predictions. The results can be found in the earlier version of this paper but are omitted here for simplicity.

owning a house is the only difference between the groups, then the retirement probability should increase for homeowners and change little for renters after housing prices increase.

In the regression, the homeowners are the reference group. The coefficient for housing price is 0.073 in column (1), which means that a 10 percent increase in housing price is associated with a nearly 0.7 percentage point increase in the retirement probability of homeowners. Adding the coefficient before housing prices and the coefficient before the interaction term between the housing price and the indicator for a renter gives -0.15, which measures the impact of housing prices on renters. It suggests that a 10 percent decline in housing price is associated with a 1.5 percentage point decline in the retirement probability of renters. One possible explanation for the negative impact is that rising housing prices are positively correlated with rental prices, which has a negative wealth effect on renters.

There are concerns about the endogeneity of home ownerships (for example, some unobserved individual characteristics that are correlated with both the ownerships and retirement decisions). First, household earnings are included. Higher labor income in the last year leads to less retirement.[9] Holding other variables constant, a $10,000 increase in labor income reduces the odds of retirement by 1.3 percentage point. Second, as long as the unobserved individual characteristics are not time varying, the fixed effect model control for those characteristics. Column (2) shows the regression results using homeowners only, which gives a similar estimate about housing wealth effect. This similarity suggests that the results are, to some degree, robust to the selection of homeowners.[10]

The coefficient before the renter dummy is positive and significant, which implies that renters are much more likely to retire than homeowners.[11] On one hand, renters tend to have less wealth, which reduces the likelihood of retirement because of the wealth effect. On the other hand, renters tend to be less healthy and less educated, which increases the likelihood of retirement. The regression results show that the second effect is larger.

The United States experienced an unprecedented housing price decline during the 2007-2009 subprime crisis. I estimate the housing wealth effect during the crisis period and compare it with the rest of the sample period. To do so, I specify the regression model that allows the retirement response of households to differ from other episodes. The results are reported in Table 4. Both the fixed effect model and the random effect model suggest that homeowners' retirement response to housing price shocks was stronger in the subprime crisis than in the other episodes. Column (1) of Table 4 shows that a 10 percent increase in housing prices is associated with a 1.8 percentage point increase in the retirement probability of homeowners during the crisis, which is 1.1 percentage point higher than the rest of the sample period.

Several robustness checks were performed and can be found in the Appendix. First, the checks

[9]According to the definition of RAND (2015), the respondent's labor earnings is the sum of his or her wage income, bonuses, overtime pay, commissions, tips, 2nd job or military reserve earnings, professional practice, and trade income. The labor earning is deflated by the annual CPI and measured in 2006 dollars (in thousands).

[10]Other variables, such as, health status and health insurance coverage, also affect retirement decisions. Poor health encourages retirement. The health index ranges from 1 to 5, with the "most healthy" status indexed by 1. The effect of the health index on retirement probability is nonlinear. The odds of retirement for a person with the best possible health are 12 percentage point smaller than a person with the poorest health. Retirement planning is closely related to the type of health insurance. The retirement probability of workers covered by employer provided health insurance is 14 percent smaller than their non-insured counterparts. However, government-provided health insurance, such as Medicare and Medicaid, positively correlate with respondents' retirement probability.

[11]Renter dummy 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.

Table 4: **Regression results on retirement decision**. The variable renter and subprime are both binary dummies. The reference group is the homeowners that experienced the subprime crisis. Significance levels: *** 1 percent, ** 5 percent, * 10 percent

Dependent var.: Retirement dummy Sample coverage	FE All HH (1)	FE Homeowner (2)	RE All HH (3)	RE Homeowner (4)
Log(House price)	0.18***	0.17**	0.24***	0.23***
	(2.6)	(2.4)	(3.5)	(3.4)
Log(House price)×Owner×(Subprime=0)	-0.11*	-0.10*	-0.18***	-0.17***
	(-1.8)	(-1.7)	(-2.8)	(-2.6)
Log(House price)×Renter×(Subprime=1)	-0.47***	—	-0.57***	—
	(-2.8)		(-2.0)	
Log(House price)×Renter×(Subprime=0)	-0.34***	—	-0.33***	—
	(-4.3)		(-3.0)	
Earnings last year(Thousands $)	-1.4e-3***	-1.3e-3***	-1.6e-3***	-1.6e-3***
	(-9.5)	(-9.4)	(-12.0)	(-12.0)
Year/C-D dummy	Yes	Yes	Yes	Yes
No. of Obs.	43,881	40,789	43,881	40,789

allow the housing wealth effect to differ across census divisions during the subprime crisis. Different census divisions experienced different housing price declines during the crisis, and the housing wealth effect may be nonlinear in housing prices. Second, the checks use yearly housing price data instead of monthly data. In the end, the checks also look at the impact of housing prices on the amount of working hours, the expectation of retirement, and the value of housing assets, as well as other things.

2.3 House Prices and Consumption

This section examines the effect of housing prices on household consumption. This topic has been discussed in Case, Quigley and Shiller (2001); Campbell and Cocco (2007); Hryshko, Jos Luengo-Prado and Sørensen (2010); Mian, Rao and Sufi (2013). None of them has used the HRS data. In this paper, I only examine HRS household respondents ages 50-65 who satisfy the sample selection criteria in the previous section and who are also covered in the CAMS survey the following year. Because of the sample attrition problem, there are less than 400 respondents in the sample in 2011.

The regression model can be formulated as follows:

$$C_t^i = \alpha^i + \mathbf{Z}_t + P_t \times H_t^i + \mathbf{X}_t^i + \epsilon_t^i \tag{2}$$

where C_t^i is the log non-durable household consumption deflated by the CPI. According to the Rand version of the CAMS data, non-durable consumption includes gifts, clothing, charitable contributions, dining out, medications and medical supplies, utilities, food and beverages, health insurance and services, telecommunications, tickets, trips and vacations, personal care items, furnishings, hobbies, sports, housekeeping services and supplies, and yard services and supplies.

α^i is the individual unobserved characteristics, which may be correlated with other explanatory variables. $\mathbf{Z}_t$ is a vector of observable aggregate economic factors, including year dummy and regional

Table 5: **Regression results on non-durable consumption**. The variable renter is a binary dummy. The reference group is the homeowners. Significance levels: *** 1 percent, ** 5 percent, * 10 percent

Dependent var.: Log(Non-durable consumption)	FE	FE	RE	RE
Sample coverage	All HH	Homeowner	All HH	Homeowner
	(1)	(2)	(3)	(4)
Log(House price)	0.28**	0.25**	0.35***	0.35***
	(2.4)	(2.0)	(3.0)	(2.9)
Log(House price)×Renter	-0.66***	—	-0.59***	—
	(-2.6)		(-2.6)	
Renter	2.6***	—	2.4***	—
	(3.1)		(3.0)	
Log(Non-capital income)	0.036***	0.027**	0.13***	0.11***
	(3.0)	(2.1)	(10.0)	(10.4)
Year/C-D dummy	Yes	Yes	Yes	Yes
No. of Obs.	4,579	4,056	4,579	4,056

unemployment rates. P_t denotes logarithm of census division housing prices deflated by CPI. H_t^i is an indicator of renter for respondent i at time t. This interaction term exploits the regional variations in housing prices and variations in home ownership to identify the housing wealth effect on consumption. $\mathbf{X}_t^i$ includes log non-capital income , type of health insurance plan, and other social demographic variables, such as age, age^2, age^3, health status dummy, education, race, and others.

The first two columns in Table 5 show the results of the fixed effect regression. The elasticity of consumption to housing prices is 0.28, which means that 10 percent growth in housing prices increases the growth rate of non-durable consumption of homeowners ages 50-65 by 2.8 percentage point. When the sample is restricted to homeowners only, the housing wealth effect on consumption becomes smaller. The coefficient before the changes in log households' non-capital income is 0.036, which shows that non-durable consumption increases by 3.6 percent if non-capital income increases by 100 percent. As a robustness check, the last two columns in Table 5 shows that the results from random effect estimation. Most coefficients do not differ much except that the consumption elasticity of non-capital income becomes larger.

I also look at the housing wealth effect on consumption by splitting the sample period into two: the subprime crisis period and the rest. The results are shown in Table 6. The consumption elasticity of homeowners in the subprime crisis period does not differ statistically from that in the rest of the sample period.

Instead of estimating consumption elasticity with respect to housing prices, I also estimate the marginal propensity of consumption (MPC) out of housing wealth, as in Mian, Rao and Sufi (2013). The results are given in the Appendix, where the results compared to Mian, Rao and Sufi (2013) in a similar setup. The estimates for the MPC is between 3.9 cents per dollar and 4.5 cents per dollar, which is close to the lower bound of Mian, Rao and Sufi (2013).

Table 6: **Regression results on non-durable consumption**. The variable renter and subprime are both binary dummies. The reference group is the homeowners that experienced the subprime crisis. Significance levels: *** 1 percent, ** 5 percent, * 10 percent

Dependent var.: Log(Non-durable consumption)	FE	FE	RE	RE
Sample coverage	All HH	Homeowner	All HH	Homeowner
	(1)	(2)	(3)	(4)
Log(House price)	0.28*	0.22	0.35**	0.28**
	(1.9)	(1.5)	(2.5)	(2.0)
Log(House price)×Owner×(Subprime=0)	6.0e-3	7.4e-2	8.0e-3	7.0e-2
	(0.04)	(0.43)	(0.05)	(0.41)
Log(House price)×Renter×(Subprime=1)	-0.86**	—	-0.89***	—
	(-2.0)		(-2.6)	
Log(House price)×Renter×(Subprime=0)	-0.41	—	-0.37	—
	(-1.2)		(-1.2)	
Log(Non-capital income)	0.036***	0.027**	0.12***	0.11***
	(3.0)	(2.2)	(10.0)	(8.8)
Year/C-D dummy	Yes	Yes	Yes	Yes
No. of Obs.	4,579	4,056	4,579	4,056

3 Structural Model

In this section, I build up an incomplete market life-cycle model with housing assets and endogenous retirement. First, I verify that the housing wealth effect on retirement and consumption predicted by the model are consistent with the empirical findings. Second, I use counterfactual experiments to quantify three channels through which housing prices affect retirement. Third, I measure the importance of self-insurance through the endogenous retirement.

3.1 Demographics

Households have a minimum age 50 and a maximum life span J. They face uninsurable health risk and mortality risk. The health status at age j is denoted by m_j, which takes two values, $m_j = 0$ if health is good and $m_j = 1$ if health is bad. Next year's health status depends on current health status and age, with conditional probability $Pr\left(m_{j+1}|m_j, j\right)$. Mortality rates depends on age and health status. The conditional survival probability from age j to $j+1$ is $s_j\left(m_j\right)$, $50 \leq j \leq J$.

3.2 Endowment

Labor income risk is uninsurable. Let j^r denote the endogenous retirement age. The wage rate of the working households consists of three parts: deterministic age-specific labor efficiency unit e_j, persistent shock $z_{i,j}$, and transitory shock $\epsilon_{i,j}$.

$$\ln w_{i,j} = e_j + z_{i,j} + \epsilon_{i,j} \tag{3}$$

$$z_{i,j} = \rho_z z_{i,j-1} + \eta_{i,j} \tag{4}$$

where $\eta_{i,j}$ and $\epsilon_{i,j}$ are iid normally distributed. with mean 0 and variances σ_η^2 and σ_ϵ^2 respectively. Let τ denote the payroll tax rate. The after-tax labor income $y_{i,j}$ is $(1-\tau)\, w_{i,j} n_{i,j}$, $50 \leq j \leq j^r - 1$.

After retirement, households can collect Social Security benefits under certain circumstances. The Social Security benefits b depend on average indexed monthly earnings (AIME), which is the average earnings in the 35 highest earning years. The AIME also depend on the endogenous retirement age. The earliest age to receive Social Security benefits is 62. For every year before the normal retirement age that the individual applies for benefits, the benefits are adjusted downward. For every year after the normal retirement age (up to 70) that the benefit application is delayed, the benefits are adjusted upward. Therefore, the labor income of retirees $y_{i,j}$ is equal to $b\,(AIME_{i,j}, j^r)$, $j = j^r \leq j \leq J$.

The AIME is computed using following formula:

$$AIME_{i,j} = \begin{cases} AIME_{i,j-1} + \frac{1}{35}\max\left(0, w_{i,j}n_{i,j} - AIME_{i,j-1}\right), & j \geq 60 \\ AIME_{i,j-1} + \frac{1}{35} w_{i,j} n_{i,j}, & j < 60 \end{cases} \tag{5}$$

3.3 Asset 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 is the housing asset. Its price follows an AR(1) process:

$$\ln p_t = \rho_p \ln p_{t-1} + \zeta_t \tag{6}$$

where ζ_t is iid normally distributed. with mean 0 and variance σ_ζ^2. Housing depreciates at a rate of δ_h.

In this model, I assume that households start as homeowner at the initial age (which is age 50 in the calibration) and can not switch to renters. This is because the homeownership rate for the elderly is quite stable. The average homeownership rate for US households between 1990 and 2015 for different age groups are the following: 39.3 percent (less than 35 years), 65.7 percent (35-44 years), 74.8 percent (45-54 years), 79.7 percent (55-64 years), and 79.5 percent (65 years and over).[12]. Therefore, changing homeownership is not a key margin of adjustment to shocks for the elderly.

Households (homeowners) cannot borrow against labor income. They can only borrow up to $1-\lambda$ fraction of current housing value, where λ denotes the down-payment ratio. For simplicity, I assume that the mortgage loan has the same interest rate as the risk-free bond. Following Cocco (2005), I assume that credit balance can be adjusted without any cost.

Housing assets are fully divisible. The transaction of the housing asset will incur the adjustment cost $tr(h_{i,j}, h_{i,j+1})$, which is proportional to the housing value.

$$tr(h_{i,j}, h_{i,j+1}) = \begin{cases} \tau_s p_{j+1} h_{i,j}, & h_{i,j} \neq h_{i,j+1} \\ 0, & h_{i,j} = h_{i,j+1} \end{cases} \tag{7}$$

[12]Author's calculation using annual homeownerships by age groups from the US Census Bureau, "Homeownership Rates by Age of Householder and Family Status for the United States", Table 17, https://www.census.gov/housing/hvs/data/ann15ind.html

3.4 Households' Problem

Let V^W denote the value function of the working households (homeowners) who have the option to quit the labor force during the current period. Let V^R denote the value function of the households who have retired at current period. Following Farhi and Panageas (2007), I assume that retirement is an irreversible choice. Therefore, households solve an optimal stopping problem. I make this assumption for two reasons: first, the proportion of old retirees that re-enter the labor market is small; second, there is a measurement error with retirement status.[13]

Let $\Theta^W_{i,j} \equiv \{h_j, x_{i,j}, p_j, z_{i,j}, \epsilon_{i,j}, m_j, AIME_{i,j}, j\}$ denote the state variables of the working households. It contains the housing stocks h_j, total wealth $x_{i,j}$ at the beginning of period j, housing price p_j , persistent income shock $z_{i,j}$, transitory income shock $\epsilon_{i,j}$, health status m_j, $AIME_{i,j}$, and age j. The state variables of the retired households are given by $\Theta^R_{i,j} \equiv \{h_j, x_{i,j}, p_j, m_j, AIME_{i,j}, j\}$.

At the beginning of the period, households start with total household net worth $x_{i,j}$ and housing value $p_j h_j$, where h_j is a state. The working households decide whether to retire after their income shocks are randomly drawn. If households continue to work, they receive labor income and pay taxes. If households choose to retire, they receive Social Security benefits. After the labor supply decision is made, households choose the non-durable consumption, hours worked, housing assets, and risk-free bond. At the beginning of age j+1, health risk, mortality risk, and housing price for next period are revealed. Households receive interest payments from the risk-free bond. If one dies, the total assets are left as a bequest. If one survives, the next period starts with total net worth $x_{i,j+1}$.

The optimization problem for households can be formulated recursively as follows. Before retirement, working households solve the problem:

$$V^W\left(\Theta^W_{i,j}\right) = \tag{8}$$

$$\max\left\{ \begin{array}{c} V^R\left(\Theta^R_{i,j}\right), \\ \max\limits_{c_{i,j}, h_{i,j+1}, n_{i,j}} \left\{u\left(c_{i,j}, h_{i,j+1}, n_{i,j}\right) + \beta E_j\left[s_j V^W\left(\Theta^W_{i,j+1}\right) + \left(1-s_j\right) u^B\left(\Theta^W_{i,j+1}\right)\right]\right\} \end{array} \right\}$$

subject to

$$x_{i,j+1} = R\left(x_{i,j} + (1-\tau) w_{i,j} n_{i,j} - tr\left(h_{i,j}, h_{i,j+1}\right) - c_{i,j} - p_j h_{i,j+1}\right) + p_{j+1} h_{i,j+1}\left(1-\delta_h\right) \tag{9}$$

$$c_{i,j} \leq x_{i,j} + (1-\tau) w_{i,j} n_{i,j} - tr\left(h_{i,j}, h_{i,j+1}\right) - \lambda p_j h_{i,j+1} \tag{10}$$

$$c_{i,j} \geq 0 \tag{11}$$

$$h_{i,j+1} \geq 0 \tag{12}$$

$$x_{i,j+1} \geq 0 \tag{13}$$

$$n_{i,j} \in (0,1) \tag{14}$$

Equation 9 is the budget constraint for the working households who enter the age j with total net worth $x_{i,j}$. Equation 10 is the borrowing constraint. Equation 13 is the bequest constraint, which rules out that households leave a negative bequest. The endogenous retirement age j^r is defined as

[13] Alternatively, I can assume that retirees re-enter the labor market with entry cost and their labor market participation rate has a measurement error.

Table 7: **Distribution of the initial sample.**

Quartiles of Networth	Earnings (Thousands $)	Net housing value (Thousands $)	Networth (Thousands $)	Poor Health (Percent)	Retirement (Percent)
1st Quartile	62.1	89.1	63.8	18.4	15.5
2nd Quartile	74.0	232.4	222.8	8.01	0.9
3rd Quartile	87.0	371.6	458.5	8.1	8.2
4th Quartile	75.4	709.0	1821.7	10.8	17.3

$j^r \equiv \min\{j \mid n_{i,j} = 0, 50 \leq j \leq J\}$

Households cannot choose to go back to work after retirement. Therefore, the retiree's value function is given by the following:

$$V^R\left(\Theta_{i,j}^R\right) = \max_{c_{i,j},h_{i,j+1}} \left\{u\left(c_{i,j}, h_{i,j+1}, 0\right) + \beta E_j\left[s_j V^R\left(\Theta_{i,j+1}^R\right) + \left(1 - s_j\right) u^B\left(\Theta_{i,j+1}^R\right)\right]\right\} \tag{15}$$

subject to 11, 12, 13, 16, and 17.

$$x_{i,j+1} = R\left(x_{i,j} + b\left(AIME_{i,j}, j^r\right) - tr\left(h_{i,j}, h_{i,j+1}\right) - c_{i,j} - p_j h_{i,j+1}\right) + p_{j+1} h_{i,j+1}\left(1 - \delta_h\right) \tag{16}$$

$$c_{i,j} \leq x_{i,j} + b\left(AIME_{i,j}, j^r\right) - tr\left(h_{i,j}, h_{i,j+1}\right) - \lambda p_j h_{i,j+1} \tag{17}$$

3.5 Calibration

The maximum age J is set to 90. Households can choose to work until age 70. In all simulations in this paper, the initial joint distribution of total household net worth, health status, working status, and wage rate for homeowners ages 48-52 are taken from the 2006 HRS data. The same sample selection criteria as the one used in the empirical studies is then applied. This gives 220 individuals in 2006. The sampling weight is used to draw the random sample. The initial sample statistics are summarized in Table 7. I normalize the age-specific efficiency units taken from Hansen (1993) such that the average labor income at age 50 is 1.

Health status in the model takes two values. In the HRS data, the self-report of health has five categories, which are then classified into two groups: the healthy group (including health status from good health to excellent health) and the unhealthy group (including fair and poor health). The age-specific survival probabilities are computed using Bayes' Rule:

$$1 - s_j\left(m_j = k\right) = \frac{Pr\left(m_j = k \mid dealth_{j+1}\right)}{Pr\left(m_j = k\right)} Pr\left(dealth_{j+1}\right), k = 0, 1 \tag{18}$$

where $Pr\left(m_j = k \mid dealth_{j+1}\right)$ and $Pr\left(m_j = k\right)$ are computed using HRS and the death rate $Pr\left(dealth_{j+1}\right)$ is taken from the 2005 life table for total population in the United States provided by Centers for Disease Control and Prevention. The health process is also directly computed using HRS data. These exogenous variables are plotted in Figure 1.

The household's utility function $u\left(c_{i,j}, h_{i,j+1}, n_{i,j}\right)$ takes the following form:

$$\alpha\omega\log\left(c_{i,j}\right) + (1-\alpha)\omega\log\Big(1 - n_{i,j} - \theta_p I_{(n_{i,j}>0)} - \theta_m I_{(m_j=1)}\Big) + (1-\omega)\log\left(h_{i,j+1}\right) \tag{19}$$

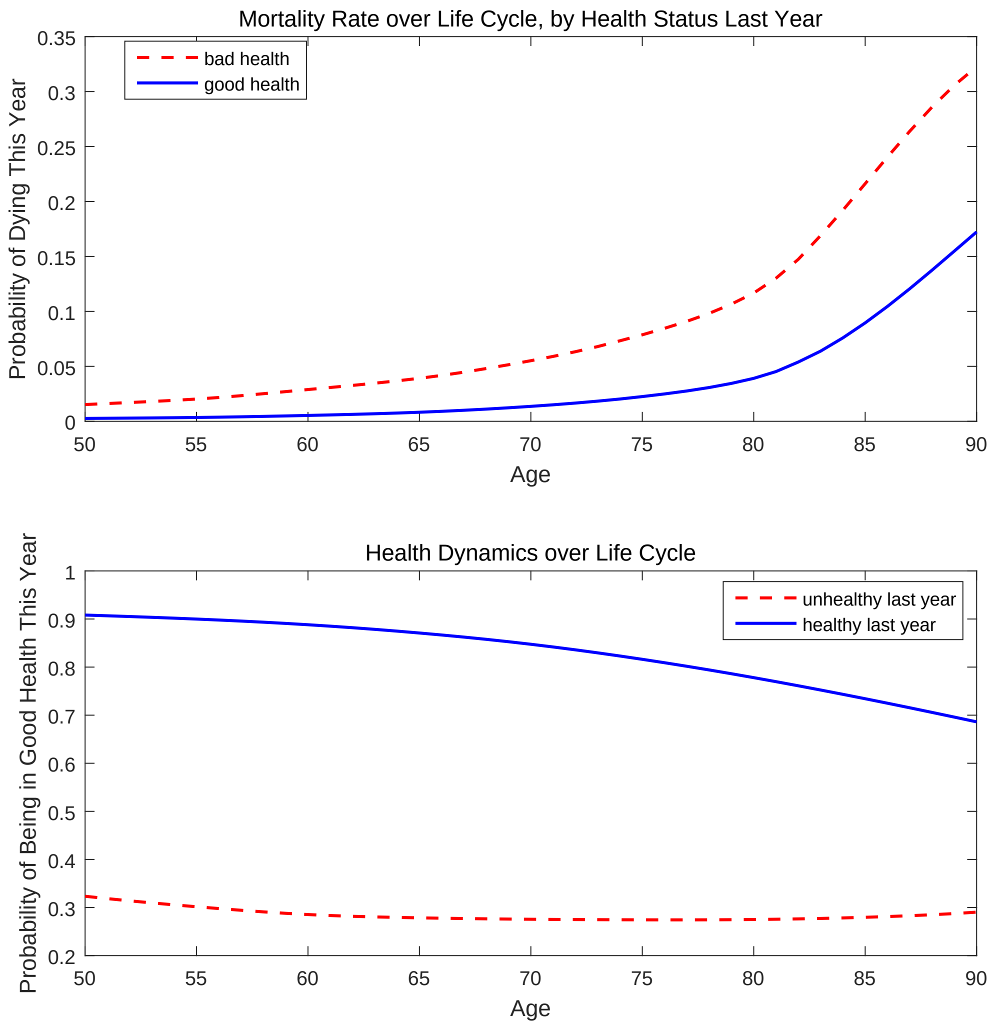

Figure 1: **Life cycle profile for mortality rate and health process.**

where I follow Davis and Ortalo-Magne (2011) to assume a unitary elasticity between consumption and housing services.

The housing adjustment cost is given by $tr\left(h_{i,j}, h_{i,j+1}\right) = \tau_s p_{j+1} h_{i,j}$. Following Hryshko, Jos Luengo-Prado and Sørensen (2010), I set τ_s to be 6 percent. The annual real interest rate is 2 percent. Nagaraja, Brown and Zhao (2011) estimates the housing price process for 20 metropolitan areas using the FHFA quarterly housing price index for 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 8.8e-4 to 2.5e-3 . Translated into a yearly frequency gives $\rho_p \in [0.93, 0.99]$,$\sigma_p \in [0.06, 0.10]$. In the benchmark model, I set $\rho_p = 0.98$,$\sigma_p = 0.075$, which corresponds to the median value of estimates in 19 metropolitan statistical areas.

Following Cocco (2005), the housing depreciation rate δ_h is set at 1.5 percent.

According to the report by RealtyTrac about home purchase down payment used for buying a home, the average down payment for single family homes, condos, and townhomes purchased in the fourth quarter of 2006 was about 12 percent.[14] The true downpayment constraint will certainly be lower than that number. Cocco (2005) writes that (for the United States) reasonable values for a down payment are between 10 and 20 percent of the value of the home. Hence, the downpayment ratio λ is set to 10 percent in the benchmark calibration.

The bequest function is written as the following:

$$u_B = \phi \log\left(x_{i,j} + \xi\right) \tag{20}$$

I follow De Nardi (2004) and assign the same power to the bequest as to the composite of durable and non-durable consumption. $\xi > 0$ is a parameter that determines the distribution of the bequest. The parameter ξ, is calibrated to match the median households net worth to the lowest 30-th percentile of households net worth for those older than 83 in 2006, which is 1.77. This gives a lower coefficient for $\xi = 3.7$.

In this formulation, the utility from leaving bequest only depends on the total value of a household's net worth. In other words, housing and financial assets are perfect substitutes in the bequest utility function, which is consistent with the facts that relatively poor households leave bequests in terms of housing and relatively rich households leave bequests in terms of financial assets. The other interpretation for the warm-glow bequest motive is the utility from living in a nursing home. Households can use either financial wealth or housing wealth to pay the nursing home cost in their late life, which is an important expense in later life.[15] All parameters in the utility are calibrated within the model.

The stochastic wage process is taken from Heathcote, Storesletten and Violante (2010). I set the persistency of income shock $\rho_z = 0.97$, the standard variance of persistent shock $\sigma_\eta = 0.15$, and the standard variance of transitory shock $\sigma_\epsilon = 0.28$. The payroll tax for Social Security is set to 12.4 percent.[16]

---

[14] www.realtytrac.com/news/home-prices-and-sales/q1-2015-u-s-home-purchase-down-payment-report/

[15] Kopecky and Suen (2010) find 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 nursing home expenses play an important role in the savings of the wealthy and on aggregate.

[16] The Social Security part of the payroll tax is assessed at a rate of 6.2 percent each for the employer and employee, for a combined rate of 12.4 percent.

In the HRS data, the information on AIME for each respondent is not available. I assume everyone enters the labor market at age 25 and work the same amount of hours until age 50. Using the calibrated wage process, I can simulate the joint distribution of AIME and labor income at age 50. I impute the AIME for each individual in the initial sample using the joint distribution of AIME and labor income at age 50. Each individual receives a random draw for the AIME conditional on his or her labor income at age 50 in the sample. AIME is converted into a primary insurance amount (PIA) using the following formula, which uses 2006 dollars.

$$PIA = \begin{cases} 0.9 \times AIME & \text{if} \quad AIME < 7,872 \\ 7,084.8 + 0.32 \times (AIME - 7,872) & \text{if} \quad 7,872 \leq AIME < 47,460 \\ 19,753 + 0.15 \times (AIME - 47,460) & \text{if} \quad AIME \geq 47,460 \end{cases} \tag{21}$$

For the individuals born between 1939 and 1940, the normal retirement age (NRA) is between 65 years 4 months and 65 years 6 months. Therefore, I choose NRA to be 65. Social Security benefits are equal to PIA if an individual retires at NRA. For every year before NRA that an individual first draws benefits, the benefits are reduced by 6.67 percent and for every year (up to age 70) that the benefit receipt is delayed, the benefits increase by 7 percent.[17]

The consumption weight α, housing weight $1-\omega$, discount rate β, two parameters of the bequest function ϕ and ξ , fixed cost of working θ_p, and fixed cost of bad health θ_m are jointly calibrated to match the following 7 moments: average net housing wealth of homeowners ages 65 and 80, average net-worth of homeowners ages 65 and 80, average cumulative retirement rate for homeowners ages 50-70 with good and bad health, and median household net worth to the lowest 30-th percentile of household net worth for households ages 83 and over in 2006. In the end, this gives $\alpha = 0.45$, $\omega = 0.86$, $\beta = 0.97$, $\theta_p = 0.36$, $\theta_m = 0.29$, $\phi = 15.1$, and $\xi = 3.7$. Table 8 summarizes all calibrated parameters.

The life-cycle model is solved backwards from the end of the life cycle using value function iteration. The conditional expectation is computed by Gaussian quadrature. I approximate the stochastic process for housing price and persistent income shocks with a 5-state Markov chain using the Rouwenhorst method (Kopecky and Suen, 2010). The transitory income shock is simply approximated by 2-state Markov chain. I chose 50 states for total net worth, 10 states for housing asset, 10 states for working hours, 10 states for AIME, and 2 states for health status.[18] The parameters are calibrated using simulated annealing method. I use multi-linear interpolation for value function on intermediate points.

Figure 2 plots the simulated and true profiles.[19] The model simulates 5,000 households for each housing price sequence drawn. It repeats this simulation for 200 different housing price sequences and computes the average retirement rate and wealth profile. The simulated net worth profile fits the data very closely. The simulated net housing wealth profile is flatter than the empirical data. The model overall does well in matching the retirement rate of healthy and unhealthy households, except for the

[17] The credit for delayed retirement is 7 percent for a cohort born between 1939 and 1940.

[18] I chose the number of the grid points by experiment. There is a trade-off between speed and accuracy. I find that adding more grid points will not significantly change the quantitative results.

[19] The raw cumulative retirement-population rate for homeowners by health status is computed from the HRS 2002-2006 data. The average net-worth and housing wealth for homeowners is estimated from the HRS 2006 using the sample weight. Housing wealth is defined as the sum of the net value of the primary residence, net value of the secondary residence, net value of nonresidential real estate, and net value of all vehicles held by the household. Lowess smoothing is used to obtain the asset profiles.

Table 8: **Parameters calibrated in the benchmark model**

	Calibration Inside the Model	
Parameters	Value	Source
β	0.97	See Text
α	0.45	See Text
ϕ	15.1	See Text
θ_p	0.36	See Text
θ_m	0.29	See Text
ω	0.86	See Text
ξ	3.7	See Text
	Calibration outside the model	
Parameters	Value	Source
R	1.02	
J	90	
$\{e_j\}_{j=25}^{70}$		Hansen (1993)
ρ_p	0.98	Nagaraja, Brown and Zhao (2011)
σ_p	0.075	Nagaraja, Brown and Zhao (2011)
ρ_z	0.97	Heathcote, Storesletten and Violante (2010)
σ_η	0.15	Heathcote, Storesletten and Violante (2010)
σ_ϵ	0.28	Heathcote, Storesletten and Violante (2010)
δ_h	1.5%	Cocco (2005)
λ	10%	See Text
τ_s	6%	Hryshko, Jos Luengo-Prado and Sørensen (2010)
b		See Text
τ	12.4%	See Text

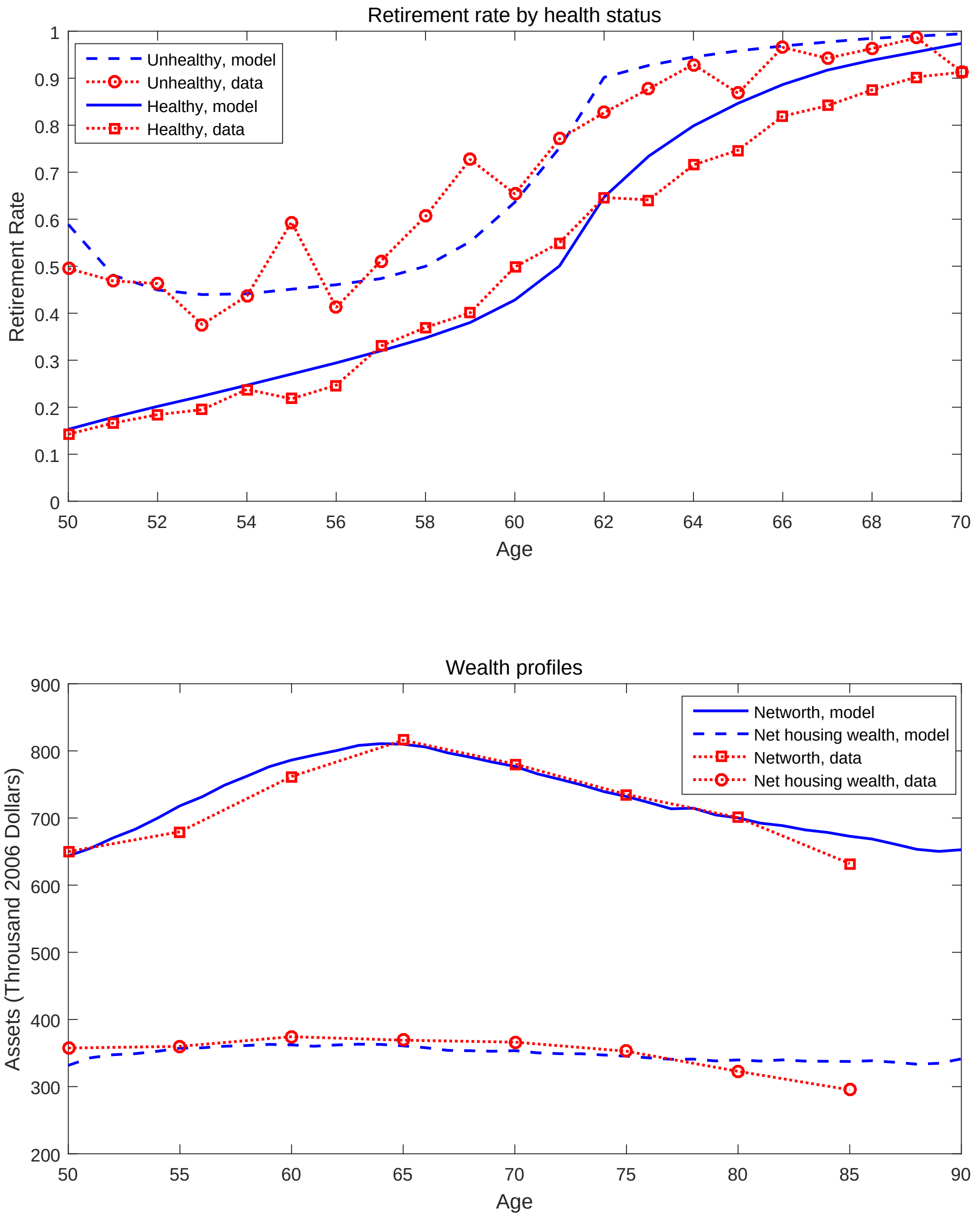

Figure 2: **Simulated retirement and asset profiles.**

Table 9: **Elasticity of retirement to housing prices.** Significance levels: *** 1 percent, ** 5 percent, * 10 percent

Dependent var.	Data	Model		
Retirement dummy	FE	Benchmark	Experiment A	Experiment B
	(1)	(2)	(3)	(4)
Log(House price)	0.072^{**}	0.067^{***}	0.082^{***}	0.106^{***}
Non-capital income(Thousands $)	$-1.30e\text{-}3^{***}$	$-2.06e\text{-}3^{***}$	$-3.58e\text{-}3^{***}$	$-2.16e\text{-}3^{***}$

healthy groups after age 63.[20]

3.6 Counterfactual Experiments

In this section, I first verify that the structural model predicts reasonable retirement and consumption responses to housing price fluctuations. Then I conduct counterfactual experiments to study the impacts of the bequest motive and housing adjustment cost on the retirement and consumption response.

I estimate the following reduced form, fixed effect linear probability model using the panel data generated by the structural model.

$$R_t^i = \alpha^i + P_t + X_t^i + \epsilon_t^i \tag{22}$$

R_t^i is an indicator function for retiree. X_t^i includes the labor income and a cubic polynomial of age. When constructing the panel, the joint distribution of total net worth, wage income, and health status for homeowners ages 48-52 are taken directly from the HRS 2006 data as the initial condition. The simulated panel consists of households ages 50-65 living in 50 different regions with 50 independent housing price sequences drawn from the stationary distribution. There are 5,000 households in each simulated region. The equation 22 is estimated using the simulated households data and the results are shown in Table 9. The coefficient before housing prices is 0.067, which means that a 10 percent decline in housing prices will reduce the retirement probability for households ages 50-65 by 0.67 percentage point. The elasticity of retirement in the benchmark model is very close to the coefficient found in the empirical data, which is 0.072.

I also estimate the following reduced-form fixed-effect regression model on non-durable consumption.

$$C_t^i = \alpha^i + P_t + X_t^i + \epsilon_t^i \tag{23}$$

where X_t^i includes the log non-capital income, which equals to wage income if households is working and equal to social security income if households is retired. It also includes a cubic polynomial of age. C_t^i is the log non-durable consumption.

The regression results are shown in Table 10. The coefficient before log housing price is 0.17. A 10 percent decline in housing prices will reduce the non-durable consumption of homeowners ages 50-65 by 1.7 percent. The elasticity of consumption to housing prices in the benchmark model is smaller

[20]The retirement rate of unhealthy individuals drops in the early age (from 50 to 52). This is because some healthy individuals move into the unhealthy group but have a higher probability of working than the initial unhealthy individuals.

Table 10: **Elasticity of non-durable consumption to housing prices.**
Significance levels: *** 1 percent, ** 5 percent, * 10 percent

Dependent var.	Data	Model		
Log(Non-durable consumption)	FE	Benchmark	Experiment A	Experiment B
	(1)	(2)	(3)	(4)
Log(House price)	0.25**	0.17***	0.34***	0.26***
Log(Non-capital income)	0.027**	0.099***	0.107***	0.097***

than the empirical estimate, which is 2.5 percent.

I consider two counterfactual experiments that will affect the housing wealth effect on retirement and consumption.[21] The first experiment (Experiment A) is to quantify the effect of the warm-glow bequest motive. I investigate the role of the bequest motive by setting the bequest strength ϕ to 0. Column (3) in Table 9 and Table 10 summarize the regression results. The housing wealth effect on both retirement and non-durable consumption becomes larger.

The removal of the bequest motive encourages one to accumulate less wealth in later life. Because housing can be used as collateral, it is more valuable to poor households than to rich households. Therefore, the housing assets now account for a larger fraction of total net worth over a life-cycle than in the benchmark case, which tends to increase the responsiveness of retirement and consumption to housing prices.

However, there is a counteracting force. Households with a warm-glow bequest motive care about the adequacy of total net worth when they die. Other things being equal, homeowners experiencing adverse housing price shock tend to work longer or cut non-durable consumption to buffer the negative effect of housing prices on the value of accidental bequest. Therefore, the decline in the bequest motive tends to reduce the retirement response to housing price shocks. The numerical simulation shows that the counteracting force is not strong enough and the removal of the bequest motive alone will amplify the housing wealth effect on retirement and consumption.

I conduct a second policy experiment that sets the housing transaction cost to zero (Experiment B) to study the role of housing adjustment cost. The consumption elasticity and retirement elasticity increase by 42 and 47 percent respectively. When there is no housing adjustment cost, the life-cycle profile of housing share in total net worth is more hump-shaped. It turns out that households on average accumulate higher housing wealth between the ages of 50-65 and decumulate housing assets at a faster speed after the removal of the housing adjustment cost. By doing so, households can increase their late-life consumption. Therefore, when estimating the impact of housing price effect on retirement and consumption, the impact will be higher mainly because of the changing composition of asset portfolios.

So far, I have estimated the average consumption response and retirement response with respect to housing prices. Households in the model have great heterogeneity and may respond differently to housing price shocks. I want to show the heterogeneous response that is conditional on homeowners' initial wealth, net housing wealth, and earnings at age 50. After generating the artificial households panel, households are grouped into different quartiles based on initial net worth, initial net housing

[21] I also perform the counterfactual experiment that changes the down payment ratio to 100 percent. It has a very small impact on retirement or consumption elasticity with respect to housing prices. The retirement and consumption elasticity will become 0.061 and 0.17 respectively.

Table 11: **Heterogenous housing wealth effect on retirement.**

Dependent var.	Homeowners grouped by quartiles of		
Retirement dummy	Initial net worth	Initial housing value	Initial earnings
1st Quartile	0.076	0.077	0.050
2nd Quartile	0.089	0.082	0.076
3rd Quartile	0.066	0.053	0.081
4th Quartile	0.041	0.072	0.066

Table 12: **Heterogenous housing wealth effect on consumption**

Dependent var.	Homeowners grouped by quartiles of		
Non-durable Consumption	Initial net worth	Initial housing value	Initial earnings
1st Quartile	0.12	0.13	0.18
2nd Quartile	0.19	0.18	0.17
3rd Quartile	0.18	0.17	0.16
4th Quartile	0.18	0.18	0.15

value, and initial earnings at age 50. The same regression (equation 22 and 23) is then performed on each subgroup. Table 11 and Table 12 report the coefficient before log housing prices. Clearly, the housing wealth effect is not monotonic as the regression moves from the lowest to highest quartile.

3.7 The Short and the Long-term Effects of the Housing Crisis

The reduced form regressions that use simulated panel data show the predictive power of the structural model. Therefore, I can use the model as a laboratory to study both the short and long-term impact of the housing crisis. Suppose the model economy starts from a stationary equilibrium in 2006 and is shocked by a one-time, unexpected -28 percent housing price shock, which is a magnitude close to that experienced during the financial crisis of 2007-2009.[22] To evaluate the short-term impact of the housing crisis, I compute the instant changes in retirement rate and non-durable consumption for different age groups. To evaluate the long-term impact of the housing crisis, I simulate the economy onwards and compute the changes in the average retirement age, the impulse response of retirement rate and non-durable consumption relative to the baseline scenario where no housing crisis happens.

The short-term impact of the housing crisis on different age groups is shown in Figure 3. Keep in mind that all age groups start with the same initial joint distribution at age 50. The only difference among them is the date when the housing price shock hits them, which is denoted by the x-axis. The model economy that experienced the one-time housing price decline is compared with the stationary distribution of the model economy that experienced no such one-time shock. I compute the consumption and labor force participation rate difference (that is, 100-retirement rate) between the two economies and show the results in Figure 3.

The upper panel shows that older households experienced a larger instant non-durable consumption drop than younger households. This drop occurred because younger households have a longer working

[22]Consider this as a one-time shock and the housing prices still follow the same stochastic process after the unexpected shock. 28 percent comes from the Markov approximation to the housing price process. The minimum distance between two grid points is 28 percent. Clearly, I can obtain finer grids by increasing the number of grid points. Because the housing price dropped by nearly 30 percent in the 2008 recession, this exercise is used as a simulation about the current crisis.

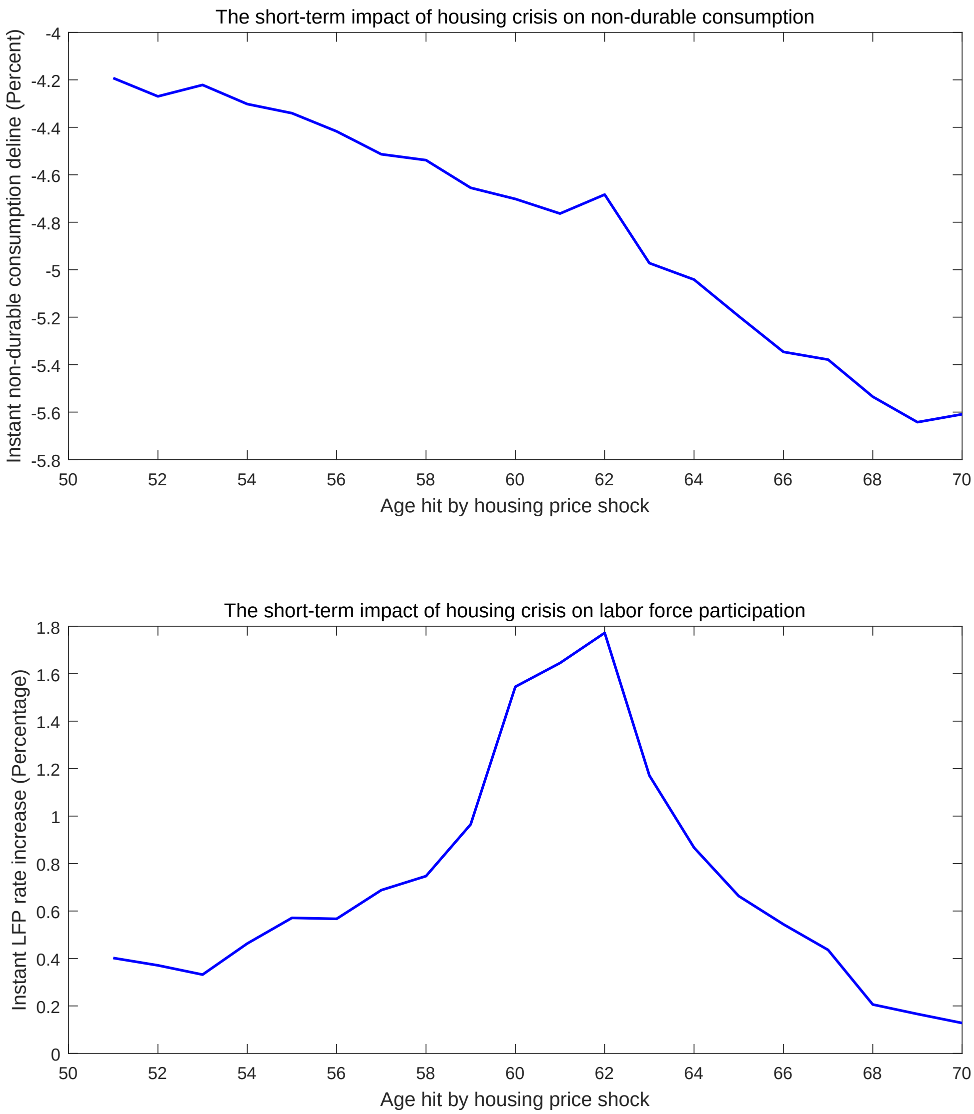

Figure 3: **The short-term impact of the housing crisis on consumption and retirement**

career and have more flexibility to delay retirement. The lower panel shows that the instant increase in the labor force participation rate is not a monotonic function of age. The age group closet to age 62 has the largest instant increase in the labor force participation rate because the younger households are still far away from the optimal retirement age and the older households have limited flexibility to adjust their retirement plan.

How do the model predictions fit the data? I compare the model predictions on average consumption drop and labor force participation rate increase for households ages 55-64 with the data(Table 1 and Table 2). Our model predicts that homeowners ages 55-64 will reduce consumption by 4.6 percent and will increase their labor participation rate by 1 percentage point. Therefore, our model accounts for 70 percent of the actual consumption drop and 90 percent of the actual labor force participation rate increase in the data.[23]

To understand the long-term impact of the housing crisis, I simulate the model economy onwards and compute the impulse response of the non-durable consumption and the labor force participation rate for different age groups. As before, I calculate the consumption and labor force participation rate difference (that is, 100-retirement rate) between the two economies and show the results in Figure 4. Each circle represents the starting age when housing price shock hits those homeowners. The "hair" graph shows the long-term response of consumption and retirement for homeowners hit by shocks at different ages.

The upper panel shows that the impact of the housing crisis on the non-durable consumption is very persistent. Even for the homeowners hit by shocks at age 50, their consumption at age 70 is still 2.8 percent lower than the homeowners experiencing no housing crisis. The lower panel shows that homeowners hit by the housing price shocks at the youngest age will have the largest increase in the labor participation rate over the life-cycle. Therefore, although the youngest cohorts do not exhibit the largest instant increase in the labor force participation rate, their retirement behavior will be greatly affected several years later.

To summarize the long-term impact of the housing crisis on retirement behavior, I plot the long-term impact of the housing crisis on the average retirement age (Figure 5). Again, the baseline economy is the stationary distribution where no housing crisis happens. I calculate the difference in the retirement age for different age groups between the crisis and baseline economy. Consistent with the previous figure on the impulse response of labor force participation, the youngest age group does have the largest increase in retirement age. For those ages 55-64, the average retirement age increases by 2.8 months. The quantitative effect may look small; however, many counterfactual experiments in the literature predict a similar retirement response. For example, French (2005) finds that a 20 percent reduction in Social Security income will cause workers to delay exit from the labor force by only three months. French and Jones (2011) find that raising the Medicare eligibility age from 65 to 67 leads individuals to work an additional 0.88 months for ages 60-69. In comparison, eliminating 2 years' worth of Social Security benefits increases years of work by 0.91 months.

[23]This may overestimate the fit of the model because the statistics in Table 1 and 2 are computed using the full households sample, including renters. Given that the home ownership rate for households ages 55-64 is about 80 percent and the assumption that rental prices do not change, then the model can explain about 56 percent of the actual consumption drop and 72 percent of the actual increase in the labor force participation rate.

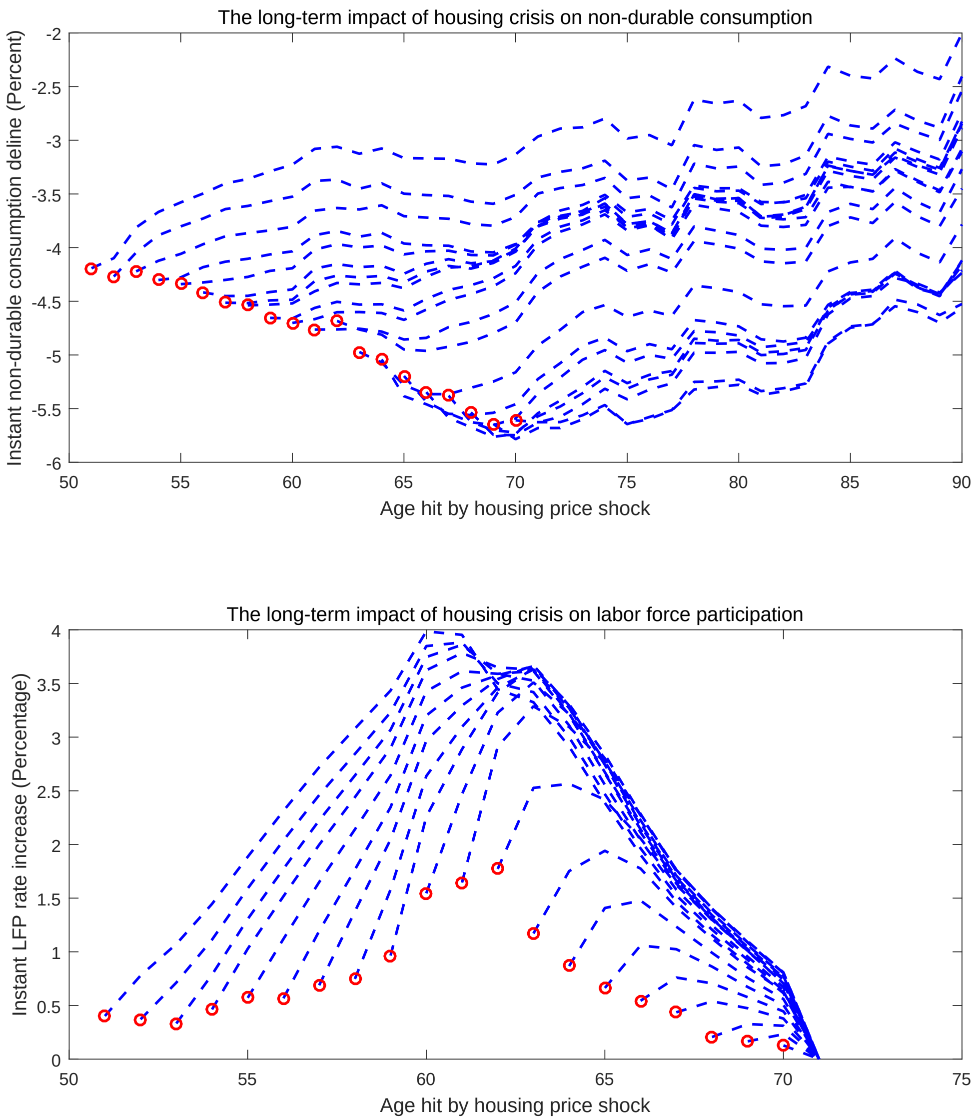

Figure 4: **The long-term impact of the housing crisis on consumption and retirement**

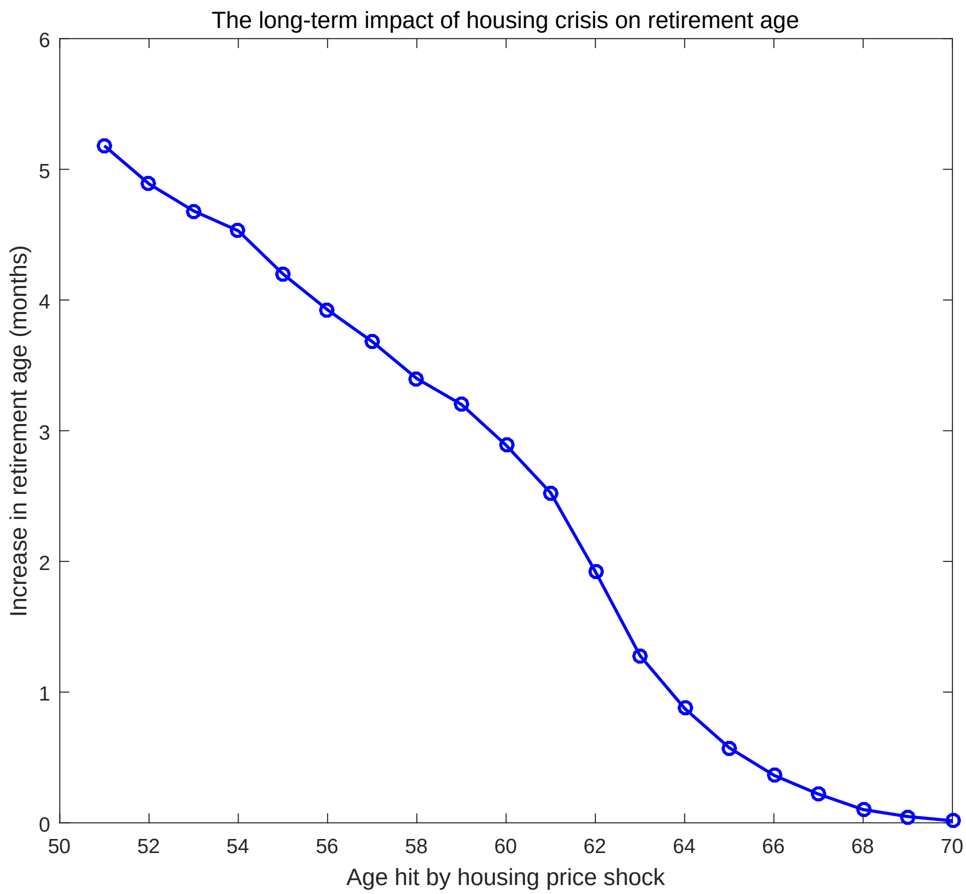

Figure 5: **The long-term impact of the housing crisis on retirement age**

3.8 Retirement as Self-Insurance Against Housing Price Risks

In the incomplete market model literature, we know that the labor adjustment is an important channel for households to self-insure against income shocks.[24]

To demonstrate the role of endogenous retirement in cushioning the housing price risk, I build up a comparison model with exogenous retirement, where each household in the initial distribution retires at the same age as in the endogenous retirement model. Therefore, both model economies exhibit the same retirement age distribution. Figure 6 shows the consumption growth rate for working households after an unexpected -28 percent housing price shock in the endogenous retirement model (solid line) and in the exogenous retirement model (dashed line).

First of all, the consumption growth rate is declining over time in both economies. This decline is mainly because of the life-cycle features of rising mortality rate. Second, the consumption growth decline in the endogenous retirement model is always smaller than in the exogenous retirement model. It implies that homeowners ages 55-64 who can choose their retirement age will, on average, experience a 40 percent less drop in non-durable consumption than homeowners that are forced to retire at a fixed age. However, retirement as a way of self-insurance becomes less effective for very young households and old households close to age 70. For young households, it is still too early to use retirement as self-insurance. For old households, the room for delayed retirement is limited.

4 Conclusion

This paper complements previous studies on retirement by pointing out the importance of housing wealth effect on retirement and consumption decision for the elderly population. It builds 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, health risk, and mortality risk. Calibrated to match the US data, the model's predictions about retirement are consistent with empirical evidence. Counterfactual experiments indicate that households respond to housing price shocks mainly through two channels: the resizing effect and the bequest motive. Using the structural model, this paper argues that the endogenous retirement is a quantitatively important channel for self-insurance against housing price shocks.

[24] It is worth mentioning that Hryshko, Jos Luengo-Prado and Sørensen (2010) identify housing as a risk-sharing tool for consumption. They find that homeowners tend to have less drops in food consumption than renters when both of them experience a bad shock in the labor market.

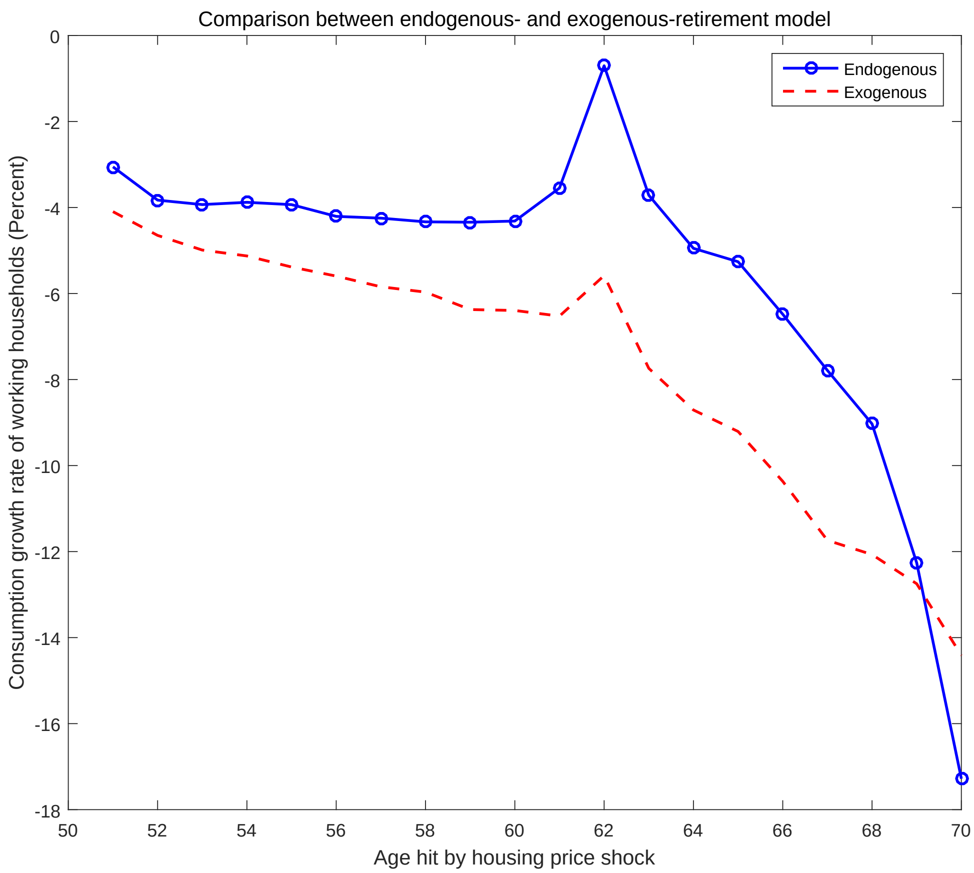

Figure 6: **Consumption insurance by endogenous retirement**. The annual consumption growth rate is computed using working households only.

References

Banks, James, Richard Blundell, Zoë Oldfield, and James P. Smith. 2007. "Housing Price Volatility and Downsizing in Later Life." National Bureau of Economic Research, Inc NBER Working Papers 13496.

Bottazzi, Renata, Hamish Low, and Matthew Wakefield. 2007. "Why do home owners work longer hours?" Institute for Fiscal Studies IFS Working Papers W07/10.

Campbell, John Y., and Joao F. Cocco. 2007. "How do house prices affect consumption? Evidence from micro data." *Journal of Monetary Economics*, 54(3): 591–621.

Case, Karl E., John M. Quigley, and Robert J. Shiller. 2001. "Comparing Wealth Effects: The Stock Market versus The Housing Market." University of California at Berkeley Economics Working Papers E01-308.

Chai, Jingjing, Raimond Maurer, Olivia S. Mitchell, and Ralph Rogalla. 2011. "Lifecycle Impacts of the Financial and Economic Crisis on Household Optimal Consumption, Portfolio Choice, and Labor Supply." National Bureau of Economic Research Working Paper 17134.

Cheng, Ing-Haw, and Eric French. 2000. "The effect of the run-up in the stock market on labor supply." *Economic Perspectives*, , (Q IV): 48–65.

Cocco, Joao F. 2005. "Portfolio Choice in the Presence of Housing." *Review of Financial Studies*, 18(2): 535–567.

Coile, Courtney, and Phillip B. Levine. 2009. "The Market Crash and Mass Layoffs: How the Current Economic Crisis May Affect Retirement." National Bureau of Economic Research, Inc NBER Working Papers 15395.

Coronado, Julia Lynn, and Maria Perozek. 2003. "Wealth effects and the consumption of leisure: retirement decisions during the stock market boom of the 1900s." Board of Governors of the Federal Reserve System (U.S.) Finance and Economics Discussion Series 2003-20.

Davis, Morris A., and Francois Ortalo-Magne. 2011. "Household Expenditures, Wages, Rents." *Review of Economic Dynamics*, 14(2): 248–261.

De Nardi, Mariacristina. 2004. "Wealth Inequality and Intergenerational Links." *Review of Economic Studies*, 71: 743–768.

Farhi, Emmanuel, and Stavros Panageas. 2007. "Saving and investing for early retirement: A theoretical analysis." *Journal of Financial Economics*, 83(1): 87–121.

Farnham, Martin, and Purvi Sevak. 2007. "Housing Wealth and Retirement Timing." University of Michigan, Michigan Retirement Research Center Working Papers wp172.

French, Eric. 2005. "The Effects of Health, Wealth, and Wages on Labour Supply and Retirement Behaviour." *Review of Economic Studies*, 72(2): 395–427.

French, Eric, and David Benson. 2011. "How do sudden large losses in wealth affect labor force participation?" *Chicago Fed Letter.*

French, Eric, and John Bailey Jones. 2011. "The Effects of Health Insurance and SelfInsurance on Retirement Behavior." *Econometrica*, 79(3): 693–732.

Glover, Andrew, Jonathan Heathcote, Dirk Krueger, and Jos-Vctor Ros-Rull. 2011. "Intergenerational Redistribution in the Great Recession." National Bureau of Economic Research Working Paper 16924.

Goda, Gopi Shah, John B. Shoven, and Sita Nataraj Slavov. 2011. "What Explains Changes in Retirement Plans during the Great Recession?" *American Economic Review*, 101(3): 29–34.

Gustman, Alan L., Thomas L. Steinmeier, and Nahid Tabatabai. 2009. "How Do Pension Changes Affect Retirement Preparedness? The Trend to Defined Contribution Plans and the Vulnerability of the Retirement Age Population to the Stock Market Decline of 2008-2009." University of Michigan, Michigan Retirement Research Center Working Papers wp206.

Hansen, G D. 1993. "The Cyclical and Secular Behaviour of the Labour Input: Comparing Efficiency Units and Hours Worked." *Journal of Applied Econometrics*, 8(1): 71–80.

Heathcote, Jonathan, Kjetil Storesletten, and Giovanni L. Violante. 2010. "The Macroeconomic Implications of Rising Wage Inequality in the United States." *Journal of Political Economy*, 118(4): 681–722.

Holtz-Eakin, Douglas, David Joulfaian, and Harvey S Rosen. 1993. "The Carnegie Conjecture: Some Empirical Evidence." *The Quarterly Journal of Economics*, 108(2): 413–35.

Hryshko, Dmytro, Mara Jos Luengo-Prado, and Bent E. Sørensen. 2010. "House prices and risk sharing." *Journal of Monetary Economics*, 57(8): 975–987.

Hurd, Michael D., and Susann Rohwedder. 2010. "The Effects of the Economic Crisis on the Older Population." University of Michigan, Michigan Retirement Research Center Working Papers wp231.

Imbens, Guido W., Donald B. Rubin, and Bruce I. Sacerdote. 2001. "Estimating the Effect of Unearned Income on Labor Earnings, Savings, and Consumption: Evidence from a Survey of Lottery Players." *American Economic Review*, 91(4): 778–794.

Imrohoroglu, Selahattin, and Sagiri Kitao. 2010. "Social Security, benefit claiming, and labor force participation: a quantitative general equilibrium approach." Federal Reserve Bank of New York Staff Reports 436.

Juster, F. Thomas, Joseph Lupton, James P. Smith, and Frank Stafford. 2004. "Savings and Wealth; Then and Now." EconWPA Labor and Demography 0403027.

Kopecky, Karen, and Richard Suen. 2010. "Finite State Markov-chain Approximations to Highly Persistent Processes." *Review of Economic Dynamics*, 13(3): 701–714.

Ljungqvist, Lars, and Thomas J Sargent. 2010. "Career Length: Effects of Curvature of Earnings Profiles, Earnings Shocks, and Social Security." C.E.P.R. Discussion Papers CEPR Discussion Papers 7822.

Mian, Atif, Kamalesh Rao, and Amir Sufi. 2013. "Household Balance Sheets, Consumption, and the Economic Slump." *The Quarterly Journal of Economics*, 128(4): 1687–1726.

Nagaraja, Chaitra H., Lawrence D. Brown, and Linda H. Zhao. 2011. "An autoregressive approach to house price modeling." *The Annals of Applied Statistics*, 5(1): 124–149.

Parker, Jonathan A. 2000. "Spendthrift in America? On Two Decades of Decline in the U.S. Saving Rate." In *NBER Macroeconomics Annual 1999, Volume 14. NBER Chapters*, 317–387. National Bureau of Economic Research, Inc.

Prescott, Edward C., Richard Rogerson, and Johanna Wallenius. 2009. "Lifetime Aggregate Labor Supply with Endogenous Workweek Length." *Review of Economic Dynamics*, 12(1): 23–36.

RAND. 2015. "RAND HRS Data, Version O." Produced by the RAND Center for the Study of Aging, with funding from the National Institute on Aging and the Social Security Administration. Santa Monica, CA (September 2014).

Sevak, Purvi. 2002. "Wealth Shocks and Retirement Timing: Evidence from the Nineties." University of Michigan, Michigan Retirement Research Center Working Papers wp027.

Telyukova, Irina, and Makoto Nakajima. 2010. "Home Equity Withdrawal in Retirement." Society for Economic Dynamics 2010 Meeting Papers 636.

Yang, Fang. 2009. "Consumption over the Life Cycle: How Different is Housing?" *Review of Economic Dynamics*, 12(3): 423–443.

Yogo, Motohiro. 2009. "Portfolio Choice in Retirement: Health Risk and the Demand for Annuities, Housing, and Risky Assets." National Bureau of Economic Research, Inc NBER Working Papers 15307.

5 Appendix

5.1 Robustness Check

In this section, I perform several robustness checks. First, I allow the housing wealth effect to differ across census divisions during the subprime crisis. It focuses on three census divisions (Pacific, Mountain, and South Atlantic) that have the largest housing price decline during the subprime crisis of 2007-2009. Table 13 shows that the retirement response to housing prices in the three census divisions is higher than in the other census divisions. In particular, the South Atlantic region has the largest retirement response to housing price decline. This area also experienced the largest drop in housing prices in the recent subprime crisis (about -38 percent drop over two years).

Table 13: **The retirement response across census divisions.** For simplicity, this table focus on homeowners only. The average housing price decline for the Pacific, the Mountain, and South Atlantic census division is -37.9 percent, -26.3 percent, and -23.2 percent, respectively, during the 2007-2009 subprime crisis. Significance levels: *** 1 percent, ** 5 percent, * 10 percent

Dependent var.: Retirement dummy Sample coverage	FE Homeowner (1)	RE Homeowner (2)
Log(House price)	0.065*	0.065*
	(1.8)	(1.9)
Log(House price)×(Subprime=1)×Other region	0.06	0.06
	(0.5)	(0.5)
Log(House price)×(Subprime=1)×Pacific	0.11	0.64
	(0.2)	(1.1)
Log(House price)×(Subprime=1)×Mountain	0.14	0.34
	(0.4)	(1.0)
Log(House price)×(Subprime=1)×South Atlantic	0.58*	1.1***
	(1.7)	(3.3)
Earnings last year(Thousands $)	-1.3e-3***	-1.3e-3***
	(-9.4)	(-9.4)
Year/C-D dummy	Yes	Yes
No. of Obs.	40,789	40,789

Second, I allow the housing wealth effect on retirement to differ by health status. The results are reported in Table 14 where I separate the sample into two groups based the health status of homeowners. I find a larger point estimate for homeowners with poor health, although the coefficient is not significantly different from zero at the 10 percent significance level. The retirement of homeowners with poor health also responds more to changes in households non-capital income. The structural model predicts a similar retirement elasticity with respect to housing prices.

Third, I estimate the housing wealth effect on retirement using the yearly average housing prices data. The results are shown in Table 15. The quantitative results are similar to Table 3 in the main text where I use monthly housing prices.

Fourth, I study the impact of housing prices on retirement expectations. RAND (2015) contains information on the self-reported probability of working full-time after age 62, ranging from 0 to 100. About 80 percent of the respondents answered this question, and the mean probability reported by respondents ages 50-61 was about 40 percent. Table 16 reports the impact of housing prices on the self-reported probability of working. It finds that a 10 percent increase in housing price is associated with a 0.6 percentage point decline in the working probability of homeowners. For renters, the impact is the opposite. A 10 percent increase in housing is associated with a 0.53 percentage point increase in working probability of renters.

Fifth, I estimate the impact of housing prices on annual working hours. So far, I have investigated the impact of housing prices on the retirement decision, which is the extensive margin of labor adjustment. Now I examine the impact of housing prices on the amount of working hours, which is the intensive margin of labor adjustment. The dependent variable is the annual working hours at

Table 14: **The retirement response by health status.** For simplicity, this table reports results for homeowners only. Significance levels: *** 1 percent, ** 5 percent, * 10 percent

Dependent var.:	Data				Model	
Retirement dummy	FE	FE	RE	RE	FE	FE
Sample coverage	Good	Poor	Good	Poor	Good	Poor
	(1)	(2)	(3)	(4)	(5)	(6)
Log(House price)	0.080**	0.10	0.073**	0.11	0.064***	0.075***
	(2.0)	(1.0)	(2.0)	(1.4)	(34.1)	(21.9)
Earnings last year	-1.2e-3***	-2.8e-3***	-1.5e-3***	-3.6e-3***	-1.9e-3***	-2.0e-3***
(Thousands $)	(-8.7)	(-3.5)	(-11.3)	(-5.9)	(-580.9)	(-142.3)
Year/C-D dummy	Yes	Yes	Yes	Yes	Yes	Yes
No. of Obs.	34,113	6,636	34,113	6,636	3,051,289	948,711

Table 15: **The retirement response to yearly housing prices.** This table estimates the impact of yearly housing prices on retirement decision. Yearly housing prices are the simple average of monthly real housing prices. It also includes the yearly census division average unemployment rates, instead of monthly unemployment rates as the regressor. Significance levels: *** 1 percent, ** 5 percent, * 10 percent

Dependent var.: Retirement dummy	FE	FE	RE	RE
Sample coverage	All HH	Homeowner	All HH	Homeowner
	(1)	(2)	(3)	(4)
Log(Yearly House price)	0.088**	0.086**	0.069**	0.075**
	(2.4)	(2.2)	(2.0)	(2.1)
Renter	0.95***	—	0.62***	—
	(3.6)		(2.9)	
Log(Yearly House price)×Renter	-0.21***	—	-0.15***	—
	(-3.6)		(-3.2)	
Earnings last year(Thousands $)	-0.0013***	-0.0013***	-0.0016***	-0.0016***
	(-9.5)	(-9.4)	(-12.0)	(-12.0)
Year/C-D dummy	Yes	Yes	Yes	Yes
No. of Obs.	43,881	40,789	43,881	40,789

Table 16: **The impact of housing prices on the retirement expectation.** The independent variable is the probability of working full-time after age 62, ranging from 0 to 100. The sample now only includes respondents ages 50-61. The previous sample selection standards still apply. Significance levels: *** 1 percent, ** 5 percent, * 10 percent

Dependent var.: Prob. of working after age 62	FE	FE	RE	RE
Sample coverage	All HH	Homeowner	All HH	Homeowner
	(1)	(2)	(3)	(4)
Log(House price)	-6.0*	-5.2	-5.8**	-5.5*
	(-1.8)	(-1.5)	(-2.0)	(-1.9)
Renter	-48.9*	—	-11.5	—
	(-1.9)		(-0.56)	
Log(House price)×Renter	11.3*	—	3.9	—
	(1.9)		(0.84)	
Earnings last year(Thousands $)	0.02***	0.02***	0.05***	0.05***
	(4.1)	(3.7)	(8.9)	(8.3)
Year/C-D dummy	Yes	Yes	Yes	Yes
No. of Obs.	32,079	29,637	32,079	29,637

the main job of the respondents. I restrict the sample to full-time and part-time workers only, and the regression results are shown in Table 17. I find that a 10 percent increase in housing prices is associated with nearly a 30-hour increase in the annual working hours of homeowners. The structural model predicts a smaller impact of housing prices on working hours. Simple calculations suggest that the extensive margin is more important in explaining the fluctuations in aggregate hours.

Sixth, I investigate homeowners' ability to adjust the housing asset in the data and to compare it with the model. The housing wealth effect depends on the ability of households to buy or sell their houses, which is strongly affected by the housing adjustment cost. If the households cannot buy or sell their houses because of a high adjustment cost when prices fluctuate, I should observe that the value of the housing asset (not the net housing asset) should move at the same pace as regional housing prices. If households can sell their houses when prices go up and buy new houses when prices go down, then the value of housing asset would fluctuate less than the housing prices. Therefore, I estimate the impact of housing prices on the value of primary residence for homeowners. Table 18 shows the results. I find that the coefficient before the housing value is significantly below 1, which is an evidence that households do change the size of their house in response to housing price fluctuations. The structural model with housing adjustment cost can replicate the empirical results, with a smaller impact on housing prices.

In the end, instead of estimating consumption elasticity with respect to housing prices, I can also estimate the impact of housing wealth changes on total households spending, as in Mian, Rao and Sufi (2013). Mian, Rao and Sufi (2013) estimate the impact of housing wealth changes on total households spending. Various specifications in Table IV in Mian, Rao and Sufi (2013) show that the MPC out-of-housing wealth is between 5.1 cents per dollar to 11.9 cents per dollar.

I restrict the HRS sample period data to two years, 2007 and 2009. I look at the impact of the value of total housing wealth (the sum of the value of primary and secondary residence) on the total spending of homeowners. Following definitions in Mian, Rao and Sufi (2013), total household

Table 17: **The impact of housing prices on working hours.** The dependent variables is the annual working hours at the main job. The previous sample selection standards still apply. Significance levels: *** 1 percent, ** 5 percent, * 10 percent

Dependent var.: Hours	Data				Model	
	FE	FE	RE	RE	FE	RE
Sample Coverage	All HH	Homeowner	All HH	Homeowner	Homeowner	Homeowner
	(1)	(2)	(3)	(4)	(5)	(6)
Log(House price)	-291*	-359**	-338**	-408***	-204***	-149***
	(-1.7)	(-2.1)	(-2.2)	(-2.6)	(-55)	(-52)
Renter	-6381***	—	-4600***	—	—	—
	(-5.0)		(-4.3)			
Log(House price)×Renter	1457**	—	1085**	—	—	—
	(2.2)		(4.5)			
Earnings last year	6.4***	6.6***	8.3***	8.6***	14.8***	15.0***
(Thousands $)	(10.7)	(11.3)	(12.9)	(13.4)	(1308)	(1399)
Year/C-D dummy	Yes	Yes	Yes	Yes	Yes	Yes
No. of Obs.	34,943	32,833	34,943	32,833	4,000,000	4,000,000

Table 18: **The impact of housing prices on the housing value.** The independent variable is the log real value of housing asset (primary residence). The sample now only includes homeowners. The previous sample selection standards still apply. Significance levels: *** 1 percent, ** 5 percent, * 10 percent

Dependent var.: Log(Housing Value)	Data		Model	
	FE	RE	FE	RE
	(1)	(2)	(3)	(4)
Log(House price)	0.33***	0.28***	0.16***	0.10***
	(3.2)	(2.7)	(68)	(44)
Earnings last year(Thousands $)	4.0e-5	3.2e-4***	5.6e-4***	7.2e-4***
	(0.73)	(5.8)	(80)	(102)
Year/C-D dummy	Yes	Yes	Yes	Yes
No. of Obs.	47,933	47,933	4,000,000	4,000,000

Table 19: **Marginal propensity of spending out of housing wealth.** The sample only includes homeowners. Significance levels: *** 1 percent, ** 5 percent, * 10 percent

Dependent var.: Total Households Spending	Data		Model	
	FE	RE	FE	RE
	(1)	(2)	(3)	(4)
Housing Wealth	0.039***	0.045***	0.025***	0.038***
	(4.6)	(8.7)	(742)	(1187)
Non-capital Income	0.04	0.11***	0.048***	0.050***
	(1.4)	(5.2)	(762)	(746)
Year/C-D dummy	Yes	Yes	Yes	Yes
No. of Obs.	1,046	1,046	4,000,000	4,000,000

spending includes not only non-durable consumption but also durable spending, which is comprised of the purchase price of five big ticket items: dishwashers, refrigerators, washers and dryers, computers, and televisions. I further add automobile purchases, which is a component of transportation spending (not included in the durable spending) in RAND (2015). Results are shown in Table 19. The estimates of the MPC from HRS is between 3.9 cents per dollar and 4.5 cents per dollar, which are close to the lower bound of Mian, Rao and Sufi (2013).

The structural model does not have durable spending. Using the non-durable consumption instead, the structural model predicts a MPC lies between 2.5 and 3.8, which is also lower than the empirical estimates in Mian, Rao and Sufi (2013).

Following their definitions, the total households spending include not only non-durable consumption but also the durable spending, which is comprised of the purchase price of five big ticket items: dishwashers, refrigerators, washer/dryers, computers and televisions. It does not include automobile purchases, which is a component of transportation spending. I restrict the HRS data to two years, 2007 and 2009. I look at impact of the value of total housing wealth (the sum of value of primary and secondary residence) on the total spending of homeowners. Results are shown in Table 19. Our estimates of the MPC from HRS is between 3.9 cents per dollar and 4.5 cents per dollar, which is close to the lower bound of Mian, Rao and Sufi (2013).

The structural model does not have durable spending. Using the non-durable consumption instead, that lies between 2.5 cents per dollar and 3.8 cents per dollar, which is also lower than the empirical estimates in Mian, Rao and Sufi (2013).