Too Poor to Retire? House Prices and Retirement[☆]

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Abstract

This paper finds that the retirement probability for old home owners (but not for renters) decreases more in the area where home price declines more. It argues that the wealth effect of home prices on retirement can account for this fact. The paper builds up a calibrated incomplete-market life-cycle partial-equilibrium model with risky housing consumption and endogenous retirement. The joint response of retirement and non-durable consumption implied by the structural model is consistent with the consumption and retirement elasticity of home prices found in the empirical studies using Health and Retirement Survey data, i.e., home owners' retirement probability drops by .9 percentage points and their non-durable consumption drops by 2.5 percent when home price declines by 10 percent. Counterfactual experiments find that after one-time unexpected 28 percent home price decline, the home owners aged 50-65 will reduce their non-durable consumption by 11.6 percent and delay their retirement by 5.8 months. The counterfactual experiment quantifies three channels (resizing effect, bequest motive, and collateral borrowing) through which home prices can affect retirement. The structural model also quantifies the endogenous retirement as self-insurance for the old homeowners against home price risk. It finds that after the one-time unexpected 28 percent home price decline, the drops in non-durable consumption for the home owners aged 50-65 with endogenous retirement is 14 percent smaller than the drops in the consumption of the home owners with exogenous retirement.

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

1. Introduction

The financial crisis 2007-2009 in the U.S. has brought huge wealth loss and caused declined consumption and rising unemployment rate. Its impacts across age groups are also different. Figure 1 plots the average annual growth rate of nondurable consumption for different age groups during pre-crisis period 2002-2007 and the crisis period 2007-2009. The young age group 16-24 and the near-retirement age group 55-64 have the largest drop in consumption across all working-age

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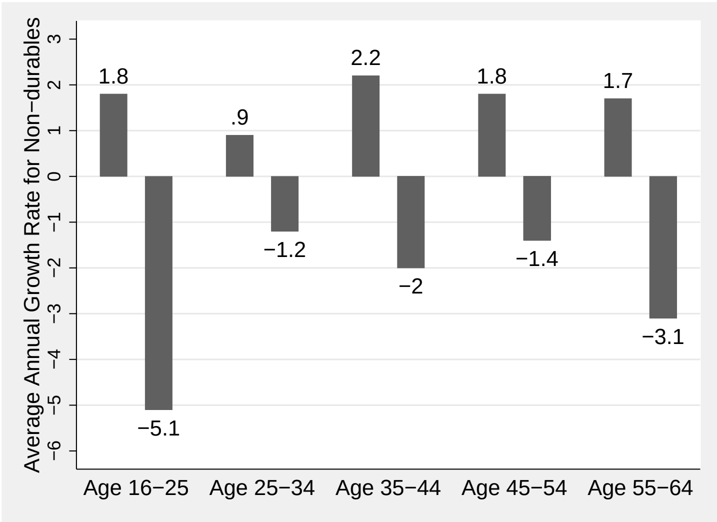

Figure 1: **Average Annual Growth Rate of Nondurable Households Consumption in 2002-2007 (left bar) and 2007-2009 (right bar) For Households Aged 16-64.** Consumption Data are from Consumer Expenditure Survey (CEX). The nondurables consist of food consumption, alcohol beverages, utilities, household operations, public transportation, gas and motor oil, entertainment, personal care, tobacco, miscellaneous expenditures. All data are deflated by CPI and denoted in 2008 dollars.

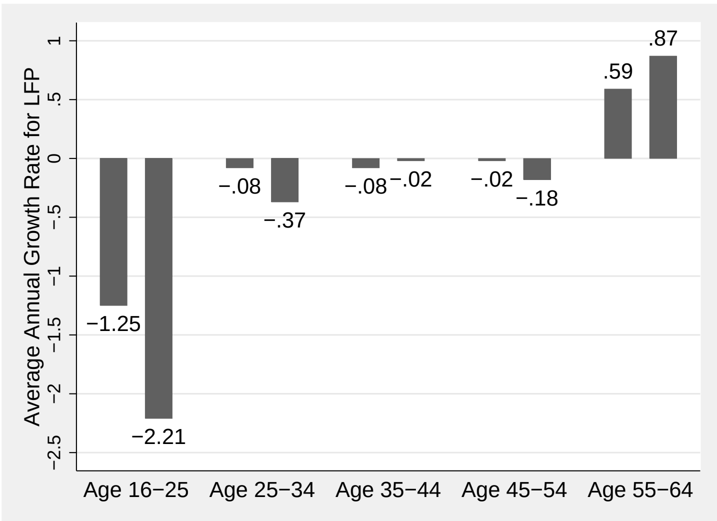

Figure 2: **Average Annual Growth Rate of Labor Force Participation Rate in 2002-2007 (left bar) and 2007-2009 (right bar) For Households Aged 16-64.** Labor Force Participation Rate is defined as the total labor force divided by the total population in each age group. Source: BLS computed time series LNS11324887, LNS11300089, LNS11300091,LNS11300093, and LNU01300095.

groups.[1] Figure 2 plots the average annual growth rate of labor force participation rate for different age groups during 2002-2007 and 2007-2009. First, all the age groups except the near-retirement age group has experienced the decline in the labor force participation rate, with the highest drop for the 16-24 age group. Second, the growth rate labor force participation rate of the near-retirement age group 55-64 has increased during the crisis period.

Conventional Wisdom says that the old households are too poor to retire because of the financial crisis.[2] The S&P/Case-Shiller home price index for the U.S. dropped by 31 percent during 2006-2009, which implies huge wealth losses for home owners. Because of the higher ownership rate during the late life, the old households are particular vulnerable to house price shocks.

This paper takes that argument seriously. It analyzes all waves from the Health and Retirement Study 1992-2010, a nationally representative panel survey of individuals 50 and over, and studies how the home prices affect the joint behavior of actual retirement and non-durable consumption. By exploiting the geographic and time variations in the home prices, I find that decreased home prices contributed to the decline of retirement probability and non-durable consumption for home owners, but not for the renters.

Motivated by those facts, this paper takes the off-the-shelf incomplete-market life-cycle model with risky housing asset and endogenous retirement to estimate the impact of home price shocks on retirement and non-durable consumption of old home owners. The model predicts that the old households will reduce their consumption and self-insure against negative housing wealth shocks through delayed retirement. Benchmark model simulation shows that after an unexpected 28 percent decline in home price, households aged 55-64 reduce their non-durable consumption by 11.6 percent and delay their retirement by 5.8 months on average.

In the model, households have non-separable preference over non-durable consumption, leisure, and housing consumption. More importantly, households can choose the timing of retirement as well as other consumption subject to income risk, home price risk, and mortality risk. The decline in home price immediately reduces the total networth of home owners. This wealth effect tends to reduce households non-durable consumption, housing services, and leisure consumption. When house is cheaper, households also wants to substitute non-durable consumption and leisure consumption for housing consumption. Combing the two effects altogether, the home price decline will make home owners consume less non-durable goods and leisure, which takes the form of delayed retirement. This mechanism relies on the ability to freely adjust the size of houses, which implies that households can upgrade or downgrade their houses after the home price shock[3]. After the adjustment in house sizes, the capital gain or loss due to fluctuating home prices is realized, which in turns affects the reservation wage and the probability of retirement. I call this first channel the resizing effect.

Even if households can not adjust the size of their houses, home price can also influence households consumption and retirement decision through other two channels. The second one is called the collateral borrowing channel. Housing not only provides services flows, but also serves as the most important collateral for households. When households suffers from wealth loss, they want to borrow more against housing asset to smooth consumption. This provides incentive for the indebted households to work longer to pay back their mortgages. The collateral borrowing channel also works when home price increases. Old home owners who are asset rich but income poor may also take reverse mortgage loan to cash out housing value.[4] Therefore, rising home price brings more available resource to home owners and reduces their incentive to work.

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[1]See Hurd and Rohwedder [26] for similar findings using the panel data from Health and Retirement Study.

[2]Hurd and Rohwedder [26] also finds that the old revise their retirement expectation to delay retirement over 2007-2009. Goda et al. [20] documents similar evidence on delayed retirement plan of old households during 2006-2008.

[3] Because housing transaction is costly, there have been debates on whether housing, like other liquid assets, is being used by old households to finance consumption. The home ownership rate in the US remains stable until age 70s and declines significantly afterwards (Yang [40]). The adjustment to housing can take place along intensive margin as well. Banks et al. [2] 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. [25] finds that housing asset helps to cushion the consumption drops of home owners in the presence of negative labor market shocks.

[4]Old home owners aged above 62 can use reverse mortgage to cash out their home value and don't have to pay back the loan until they die or move out of the house. Shan [39] documents that the Home Equity Conversion Mortgage (HECM is the majority of reverse mortgage loan in the US) has an annual growth rate of 38 percent during 2003-2007. She also estimates that one percentage increase in the annual real home price appreciation is correlated with 3.4 percentage point increase in the HECM loan origination growth rate.

The third channel is the bequest motive.[5] Households with warm-glow bequest motive care about the adequacy of total net worth when they die. Other things being equal, home owners experiencing adverse home price shock tends to work longer in order to buffer the negative effect of home price on the value of accidental bequest. Even if one lives in the same house, the liquidation value of that house after his death still affect the retirement decision when he is alive.

In order to verify the model prediction is consistent with the data, I compare the consumption and retirement elasticity of home price implied by the structural model with empirical findings from Health and Retirement Study 1992-2010. The empirical studies finds that a 10 percent decline in local home price will reduce the mean retirement probability for home owners aged 50-65 by .9 percent which is consistent with the prediction by the theoretical model. It also finds that a 10 percent decline in home price will reduce the non-durable consumption of home owners aged 50-65 by 2.3 percent, which is smaller than the prediction by the theoretical model.

Then I use the structural model to quantify the impact of home prices on retirement and consumption. It finds that after a one-time unexpected 28-percent home price decline, households aged 50-65 will reduce the non-durable consumption by 11.8 percent and retire nearly 6 months earlier than they would have done if home price had not declined. The structural model also quantifies the effectiveness of the endogenous retirement as self-insurance for home owners against home price risk. It finds that after the one-time unexpected 28 percent home price decline, the drops in non-durable consumption for the home owners aged 50-65 with endogenous retirement is 14 percent smaller than the drops in the consumption of the home owners with exogenous retirement.

Early literature about wealth effect focus on its impact on households non-durable consumption.[6] Recent studies by Case et al. [6] and Campbell and Cocco [4] look at one important component of household wealth, the housing asset.[7] They find that consumption of old homeowners is most responsive to home prices. However, these studies ignore the endogenous retirement, which turns out be an important way of self-insurance against home price risk 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 the bear market force old households to stay in the labor force.[8] However, the findings about housing wealth effect on retirement are mixed. Farnham and Sevak [15] 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 [11] finds no evidence that old workers respond to fluctuating housing market. More recently, French and Benson [18] 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

[5] Nardi [34] 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.

[6] Holtz-Eakin et al. [24] and Imbens et al. [27] 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 [35] and Juster et al. [29], 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.

[7] Case et al. [6] 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 [4] investigate the response of household consumption to home price by constructing a pseudo panel. They find the largest effect of home 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.

[8] Cheng and French [9] 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 [38] 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 [12] 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. [21] finds that recent stock market decline lead the early boomers to postpone retirement by 1.5 months on average. Chai et al. [7] build up a structural model with stocks and endogenously labor supply to study the effect of stock price crisis on households consumption and retirement.

retirement and non-durable consumption *jointly* using panel data from Health and Retirement Study.

In terms of structural model, most previous papers emphasize the role of social security, private pension, health insurance, earning shocks, and taxation in determining retirement (French [17], Ljungqvist and Sargent [32], Prescott et al. [36]). From a different perspective, this paper analyzes the impact of wealth changes on retirement. My model is close to studies by Bottazzi et al. [3], Farhi and Panageas [14], Yogo [41], Imrohoroglu and Kitao [28], and Hryshko et al. [25]. However, none of these authors look at the effect of home prices on retirement.

The rest of the paper is organized as follows. Section 2 describes the data sets, estimation strategy, 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 home prices with the empirical estimates. I also use the model to perform some counterfactual experiments. Section 4 concludes.

2. Empirical Evidence

2.1. Data

The empirical findings are based on the Health and Retirement Study (HRS). 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 pension plans etc. I use the RAND [37] version of HRS data 1992-2010 to study the retirement behavior.

However, the core HRS data does not contain information on consumption. In order to study the consumption behavior, I use a HRS supplement, the Consumption and Activities Mail Survey (CAMS) 2001-2009. 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 on consumption record individual consumption in the last month or last 12 months. The Rand CAMS contains the cleaned annualized consumption 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. I merge the income data from Rand HRS data 2002-2010 to the CAMS 2001-2009 sample.

To exploit the time variations in home prices across different regions, I use the home price indices for 9 census divisions from Federal Housing Finance Agency. The 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 census divisions are East North Central, East South Central, Middle Atlantic, Mountain, New England, Pacific, South Atlantic, West North Central, and West South Central.

I restrict the sample based on the following standards. First, I look at the HRS respondents aged between 50 and 65 during 1992-2010. Second, I only include married respondents to keep the family composition stable. Third, I keep only respondents with positive total household net worth.

2.2. Home Prices and Retirement

The regression model is formulated as follows:

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

R_t^i is a binary variable. It equals 1 if the respondent i reports she/he has 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 fixed effects and regional unemployment rates. P_t denotes logarithm of census-division home prices deflated by CPI index.[9] H_t^i is an indicator of renter for respondent i at time t. This interaction term

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

exploits the regional variations in home prices and variations in home ownership in order to identify the housing wealth effect on retirement. $\mathbf{X}_t^i$ includes labor earnings in the last calender year, type of health insurance plan, and other social demographic variables, such as age, health status, etc. In the random effect models, I also control for the education, race, etc.

Table 1: Regression Results for Retirement Decision

Dependent Var.: Retirement Dummy	FE Linear Prob.	FE Linear Prob.	RE Linear Prob.	RE Linear Prob.	FE Logit	FE Logit
	All	Home Owners	All	Home Owners	All	Home Owners
Earnings Last Year (1000$ in 1998)	-1.90e-3***	-1.93e-3***	-2.24e-3***	-2.29e-3***	.978***	.978***
	(−8.64)	(−8.41)	(−10.6)	(−10.5)	(−14.7)	(−14.3)
Census-Division House Price	.0877**	.0895**	.0839**	.0897**	4.08***	4.26***
	(2.41)	(2.40)	(2.44)	(2.52)	(2.72)	(2.72)
Renter	.901***	—	.507**	—	5.4e+3**	—
	(3.3)		(2.3)		(2.0)	
Renter×Census-Division House Price	-.199***	—	-.125***	—	.145**	—
	(−3.22)		(−2.60)		(−2.20)	
Health Status (Very Good)	-8.28e-3	-9.49e-3	6.5e-3	5.5e-3	.934	.946
	(−1.82)	(−1.44)	(1.15)	(.94)	(−.73)	(−.57)
Health Status (Good)	-.0113	-.0147*	.0116*	.010	.944	.95
	(−1.45)	(−1.84)	(1.80)	(1.50)	(.52)	(−.44)
Health Status (Fair)	.0224**	.0222**	.0649***	.0674***	1.28*	1.31*
	(2.15)	(2.05)	(7.66)	(7.63)	(1.86)	(1.89)
Health Status (Poor)	.130***	.124***	.220***	.216***	2.97***	2.94***
	(7.98)	(7.13)	(17.5)	(16.2)	(5.15)	(4.84)
Gov. Provided Health Insurance	.0684***	.0613***	.145***	.136***	1.38***	1.31**
	(7.21)	(6.30)	(18.3)	(16.6)	(2.72)	(2.22)
Employer Provided Health Insurance	-.137***	-.140***	-.110***	-.111***	.433***	.430***
	(−19.2)	(−18.9)	(−18.9)	(−18.4)	(−9.93)	(−9.69)
Census-Division Unemployment Rate	8.9e-3 *	.0102**	0.127 ***	.0144***	1.20***	1.23***
	(1.82)	(1.98)	(2.72)	(2.96)	(2.57)	(2.80)
Age, Age^2, Age^3, Education, Race	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Census-Division Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	38,763	36,366	38,763	36,366	19,049	17,960

The first four columns in Table 1 report the regression coefficients of fixed effect linear probability model and random effect linear probability model. The last two column report the odds ratio of fixed effect Logit model. Column 1,3 and 5 look at the whole sample while column 2, 4, and 6 focus on home owners only. The linear and non-linear models give the same qualitative predictions. T-statistics are given in parenthesis and standard errors are clustered at individual level.

Higher labor income in the last year leads to less retirement. According to the definition of RAND [37], 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. The labor earning is deflated by the annual CPI index and measured in 1998 thousand dollars. Holding other variables constant, A 10,000 increase in the labor income reduces the odds of retirement by 1.9 percentage points.

Renters are more likely to retire.[10] On one hand, renters tend to have less wealth, which reduces the likelihood of retirement due to wealth effect. On the other hand, renters tend to be less healthy and less educated, which increases the likelihood of retirement. The regression tells us the net effect is positive.

I use the monthly home price index from Federal Housing Finance Agency for 9 census divisions. I match home prices to the HRS respondents according to the dates they finished the survey and the census divisions they are living in. Because

[10] Renter 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.

the assignment of the interview date is considered to be exogenous (Goda et al. [20]), this procedure tries to address the concerns that home prices may not be fully exogenous. Home prices are log value deflated by CPI index.

The main effect of home price is .087 in column 1. Remember that the reference group here is the home owners. Therefore, it means 10 percent increase in home price is associated with .87 percentage increase in the retirement probability. The net effect of home price on the renters' retirement probability is the sum of main effect and the interaction effect, which is -.11. One possible explanation is that rising home price positively correlate with rental price, which has a negative wealth effect on the renters. Logit model presents the similar picture, but the effect is larger. A 10 percent rise in home price increases the odds of retirement for home owners by 30.8 percent.

There are possibility that home prices only capture the growth rate of the whole economy. In order to control for the economic prospective, I include the year fixed effect and census-division specific unemployment rate in all the specifications. It is interesting to find that higher unemployment rate increases the odds of retirement. This is consistent with the story of discouraged workers that the old tends to quit the labor force after long period of unemployment (Coile and Levine [11]).

There is concern about the endogeneity of home 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 2 looks at subsample of home owners, which gives the similar estimate about housing wealth effect. This suggests that these results are to some degree robust to the selection of home owners.

Poor health encourages retirement. The health index ranges from 1 to 5, with the most healthy status indexed by 1. Clearly, the effect of health index on retirement probability is nonlinear. The odds of retirement for a person with most excellent health is 13 percentage smaller than the person with poorest health.

Retirement planning is closely related to the type of health insurance. The retirement probability of the worker covered by employer provided health insurance plans is 14 percent smaller than their non-insured counterparts. On the other hand, government provided health insurance, like Medicare and Medicaid, positively correlates with the respondent's retirement probability.

2.3. Home Prices and Consumption

This section examines the effect of home prices on households consumption. This topic has been discussed in Case et al. [6], Campbell and Cocco [4], Hryshko et al. [25], and many other works. None of them have used the HRS data. Here I only look at HRS household respondents aged 50-65 who satisfy sample selection criteria in the previous section and who are also covered in the CAMS survey in the following year. Due to the sample attrition problem, there are less than 600 respondents in 2009.

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 the C_t^i is the log non-durable households consumption deflated by CPI index. 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. However, it also includes car payment and mortgage payment. I take those two out because they can be considered as savings. 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 fixed effects and regional unemployment rates. P_t denotes logarithm of census-division home prices deflated by CPI index. H_t^i is an indicator of renter for respondent i at time t. This interaction term exploits the regional variations in home prices and variations in home ownership in order to identify the housing wealth effect on retirement. $\mathbf{X}_t^i$ includes labor earnings in the last calender year, type of health insurance plan, and other social demographic variables, such as age, health status, etc. In the random effect models, I also control for the education, race, etc.

The first two columns in Table 2 show the fixed effect panel regression. The elasticity of consumption to home prices is .33, which means 10 percent growth in home prices increases the growth rate of non-durable consumption of homeowners aged

50-65 by 3.3 percentage points. When I restrict the sample to homeowners only, the housing wealth effect on consumption become smaller. The coefficient before the changes in log households non-capital income is .035, which says the non-durable consumption increases by 3.5 percent if non-capital income increases by 10,000 dollars.

As a robustness check, I also show the results from random effect estimation in the last two columns in Table 2. In the random effect models, I also control for the education, race, etc. Most coefficients do not differ much. It is worth noting that the coefficients before health status now become significant. Poor health leads to fewer non-durable consumption because it is usually associated with negative wealth shocks such as medical expenditures.

Table 2: Regression Results for Non-durable Consumption

Dependent Var.: Non-durable Consumption	Fixed Effect	Fixed Effect	Random Effect	Random Effect
	All	Home Owners	All	Home Owners
Non-capital Income (1000$ in 1998)	.0350***	.0295***	.121***	.107***
	(3.2)	(2.55)	(11.1)	(9.60)
Census-Division House Price	.329***	.246**	.342***	.297**
	(2.9)	(2.1)	(3.6)	(3.0)
Renter	2.65***	—	2.49***	—
	(3.2)		(3.3)	
Renter×Census-Division House Price	-.596***	—	-.595***	—
	(−3.3)		(−3.6)	
Health Status (Very Good)	-.026	-.007	-.051**	-.039
	(−.93)	(−.26)	(−2.2)	(−1.57)
Health Status (Good)	-.026	-.006	-.078***	-.066**
	(−.82)	(−.84)	(−3.02)	(−2.44)
Health Status (Fair)	-.027	-.010	-.101***	-.088***
	(−.66)	(−.24)	(−3.11)	(−2.62)
Health Status (Poor)	-.079	-.070	-.182***	-.160***
	(−1.05)	(−.86)	(−3.39)	(−3.35)
Census-Division Unemployment Rate	.0148	.0210	.0189	.0274
	(.51)	(.89)	(.87)	(1.22)
Age, Age^2, Age^3, Education, Race	Yes	Yes	Yes	Yes
Year Dummy	Yes	Yes	Yes	Yes
Census-Division Dummy	Yes	Yes	Yes	Yes
Number of Observations	4,752	4,183	4,747	4,180

3. The Structural Model

I have shown the micro evidence for the housing wealth effect on the consumption and labor supply decision of the elderly. The standard life-cycle will also predict that old households will adjust their labor supply to self-insure against income and wealth shocks. In this section, I will build up a structural model that is suitable for answering the following questions quantitatively. What is the impact of home prices on households non-durable consumption and retirement? What are the possible channels through which home prices can affect consumption and retirement? How effectively can endogenous retirement cushion home price risks as a self-insurance tool?

The natural candidate model is the incomplete-market life-cycle model, with extensions to allow for housing consumption and retirement decision. I will first use the calibrated model to quantify the effect of home prices on retirement through different channels. Then I compare the housing wealth effect on non-durable consumption with endogenous retirement with a second economy where households cannot schedule their retirement. By doing this, I am able to quantify the role of endogenous retirement as self-insurance against home 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 and live up to the maximum age J. The conditional survival probability from age j to $j+1$ is s_j, $j \in [50, J)$;s_J=0.

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

Households derive utility from non-durable consumption goods c_j , housing services h_{j+1}, leisure $1 - n_j$. Households also have warm-glow bequest utility $u^B(x_{j+1})$. Each household is endowed with one unit of labor endowment. Labor supply n_j is indivisible.[11] The household provides one unit of labor when at work and zero when retired. The household's utility function can be written as

$$E_0 \sum_{j=1}^{J} \beta^j \left[\pi_j u(c_j, h_{j+1}, n_j) + (\pi_j - \pi_{j+1}) u^B(x_{j+1})\right] \tag{5}$$

where x_{j+1} is the amount of accidental bequest, which is also the total networth at the beginning of period j+1 if one survives.

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

$$\ln w_j = e_j + z_j + \epsilon_j \tag{6}$$
$$z_j = \rho_z z_{j-1} + \eta_j \tag{7}$$

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

$$y_j = (1 - \tau) w_j \tag{8}$$

The model also abstracts from home-production. After retirement, households with age qualified for social security are able to collect social security benefit $b(z_{j^r-1}, j^r)$ each year, which is a function of persistent income shock before retirement and the retirement age.

$$y_j = b(z_{j^r-1}, j^r) \tag{9}$$

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

[11] 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 (Prescott et al. [36]). 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.

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 home 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.[12]

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 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

Let V^W denote the value function of the households who was working last period and has the option either to work or to retire at current period. Let V^R denote the value function of the households who has retired at current period. Following Farhi and Panageas [14], I assume retirement is an irreversible choice. Therefore, households solves a discrete version of the optimal stopping problem.

The working households are heterogeneous in $\Theta_j^W = \{x_j, p_j, z_j, z_{j-1}, \epsilon_j, j\}$, which denotes total wealth at the beginning of period j, home price, current persistent income shock, last period persistent income shock, transitory income shock, and age respectively.[13] The retired households are heterogeneous in the following dimensions $\Theta_j^R = \{x_j, p_j, z_{j^r-1}, j^r, j\}$, where j^r is the endogenous retirement age.

The timing of the economy is the following. At the beginning of period, households are endowed with total net worth x_j at given home price level p_j. For the working households, their income shocks z_j and ϵ_j are randomly drawn. Households then decide whether to work or not. If they continue to work, they receive labor income and pay taxes. If they choose to retire, they receive retirement benefit $b\left(z_{j^r-1}, j^r\right)$ which depends on the current age and last period persistent shock. Then households choose the housing consumption, non-durable consumption, and savings. By the end of age j, households receive interest from savings account. At the beginning of age j+1, the mortality risk and home price next period are revealed. If one dies, the total amount of financial asset and housing asset are left as accidental bequest. If one survives, he starts the next period with total net worth at new home price level.

The optimization problem for households can be formulated recursively as follows:

Before the retirement, the working households solve the problem

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

subject to

[12]Without transaction cost, rental price will be a fraction of home 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.

[13]Because there is no transaction cost in the benchmark model, I am able to combine "savings" and "housing stocks" into one state variable, the total net worth.

$$
\begin{align}
x_{j+1} &= R\left(x_j + (1-\tau) w_j - c_j - p_j h_{j+1}\right) + p_{j+1} h_{j+1} (1-\delta_h) \tag{12}\\
x_j + (1-\tau) w_j - c_j &\geq \lambda p_j h_{j+1} \tag{13}\\
c_j &\geq 0 \tag{14}\\
h_{j+1} &\geq 0 \tag{15}\\
x_{j+1} &\geq \tag{16}
\end{align}
$$

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. (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 home 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

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

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

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

subject to (14), (15), (16), (19), and (20).

$$
\begin{align}
x_{j+1} &= R\left(x_j + b\left(z_{j^r-1}, j^r\right) - c_j - p_j h_{j+1}\right) + p_{j+1} h_{j+1} (1-\delta_h) \tag{19}\\
x_j + b\left(z_{j^r-1}, j^r\right) - c_j &\geq \lambda p_j h_{j+1} \tag{20}
\end{align}
$$

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. I use the same notation for the policy function of both retired households and working households. 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.

$$
\begin{align}
u_c(j) &= \beta s_j R E_j\left[u_c(j+1)\right] + \beta (1-s_j) R E_j\left[u_x^B(j+1)\right] \tag{21}\\
u_h(j) &= \beta s_j E_j\left[u_c(j+1)\left(R p_j - (1-\delta_h) p_{j+1}\right)\right] + \beta (1-s_j) E_j\left[u_x^B(j+1)\left(R p_j - (1-\delta_h) p_{j+1}\right)\right] \tag{22}
\end{align}
$$

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

From (21), 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 (21) becomes the standard consumption Euler equation.

Equation (22) 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

$$
\begin{align}
u_h(j) = {} & \beta (1-s_j) E_j\left[u_x^B(j+1)\left((1-\lambda) R p_j - (1-\delta_h) p_{j+1}\right)\right] + u_c(j) \lambda p_j \\
& + \beta s_j E_j\left[u_c(j+1)\left((1-\lambda) R p_j - (1-\delta_h) p_{j+1}\right)\right] \tag{23}
\end{align}
$$

and the optimal consumption is determined by

$$c_j = x_j + y_j - \lambda p_j h_{j+1} \tag{24}$$

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 (22).

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 home price and persistent income shocks with a 7-state Markov Chain using Rouwen-Hurst's method summarized in Kopecky and Suen [30]. The transitory income shock is simply approximated by 2-state Markov Chain.

3.7. Calibration

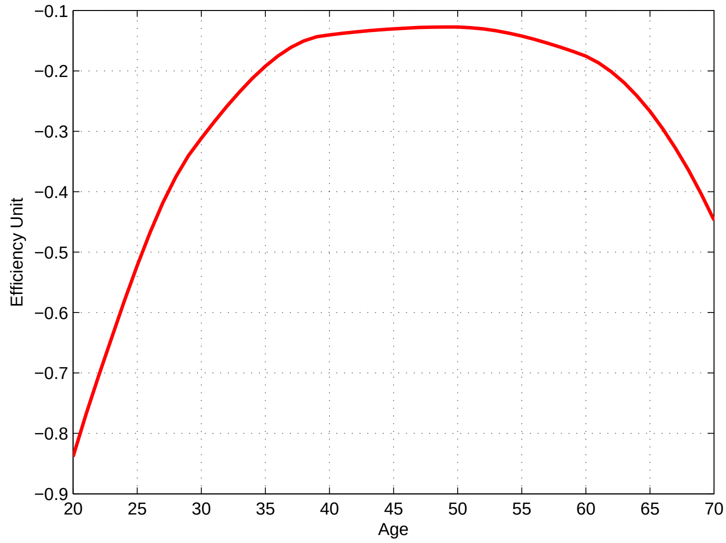

Figure 3: Logarithm of Efficiency Unit

The model economy starts at age 50 and ends at age 90. Households are allowed to work up to age 70. 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.[14] 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. I normalize the age specific efficiency units taken from Hansen [22] such that the average labor income at age 50 is 1. The logarithm value of efficiency unit e_j are plotted in Figure 3. The age-specific survival probabilities are taken from the 2005 life table for white males in the United States.

[14] 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.

Table 3: 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

The household's utility function takes the form

$$u\left(c_j, h_{j+1}, n_j\right) = \frac{\left(\left[c_j\left(1-\theta n_j\right)\right]^{\omega} h_{j+1}^{(1-\omega)}\right)^{1-\sigma}}{1-\sigma} \tag{25}$$

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 [16], I set the elasticity of substitution between consumption and housing services ξ to be 1. The parameter ω controls the share of housing services in the total consumption expenditure.

Following Cocco [10] and Campbell and Cocco [4], I assume the warm-glow bequest motive, which takes the following form

$$u_B = \phi \frac{x_j^{1-\sigma}}{1-\sigma} \tag{26}$$

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, which is consist with the facts that relatively poor households leave bequest in terms of housing and the relatively rich households leave bequest in terms of financial asset. 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 to pay the nursing home cost in their late life, which is an important expense in later life.[15] 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. [33] estimates the home price process for 20 metropolitan areas using FHFA quarterly home price index 1985-2004. Their model consists of a fixed time effect, a random

[15] Kopecky and Koreshkova [31] 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 4: Parameters Calibrated in the Benchmark Model

Calibration inside the model				
Parameters		Value	Target Moments	Value
Discount Factor	β	0.962	Net worth of age 50-70	8.05
Consumption Weight	ω	0.77	Share of Net Real Asset of age 50-70	0.555
Bequest Strength	ϕ	10.3	Net worth of HHs older than 83	4.10
Fixed cost of working	θ	0.84	Cumulative Retirement Rate of age group 63	0.662
Relative Risk Aversion	σ	1.12	Average Consumption Drop Upon Retirement	-17%
Calibration outside the model				
Parameters		Value		
Interest Rate	R	1.02		
EIS Between c and h	ξ	1.00	Fernandez-Villaverde and Krueger [16]	
Maximum Age	J	90		
Minimum Age		50		
Efficiency Unit	e_j	Figure 3	Hansen [22]	
Persistency of House Price	ρ_p	0.976	Nagaraja et al. [33]	
Std. of House Price	σ_p	0.0748	Nagaraja et al. [33]	
Persistency of Income	ρ_z	0.973	Heathcote et al. [23]	
Std. of Persistent Shocks	σ_η	0.148	Heathcote et al. [23]	
Std. of Transitory Shocks	σ_ϵ	0.278	Heathcote et al. [23]	
Depreciation Rate	δ_h	0.005		
Down Payment Ratio	λ	0.200		
Social Security	b		See Text	
Payroll Tax	τ	0.100	See Text	

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 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. [23]. I set the persistency of income shock $\rho_z = 0.973$, the standard variance of persistent shock $\sigma_\eta = 0.148$, and the standard variance of transitory shock $\sigma_\epsilon = 0.278$.[16] The payroll tax for social security is set to 0.10.[17]

The social security payment function $b\left(z_{j^r-1}, j^r\right)$ is based on the Average Indexed Monthly Earnings (AIME), which is the average labor income over one's 35 highest earnings years. In the model, I calibrate AIME to be

$$AIME\left(z_{j^r-1}, j^r\right) = \frac{(1-\tau)\exp\left(z_{j^r-1}\right)}{35} \sum_{k=j^r-35}^{j^r-1} \exp\left(e_k\right) \tag{27}$$

AIME is converted into a Primary Insurance Amount (PIA) using the following formula where all dollars amount is in 1998 value (French and Jones [19]).

[16] The persistent shock and transitory shock is set to the their value in year 1998

[17] 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.

$$PIA = \begin{cases} 0.9 \times AIME & \text{if} \quad AIME < \$5,724 \\ \$5,151.6 + 0.32 \times (AIME - 5,724) & \text{if} \quad \$5,724 \leq AIME < \$34,500 \\ \$14,359.9 + 0.15 \times (AIME - 34,500) & \text{if} \quad AIME \geq \$34,500 \end{cases}$$

Social Security benefits $b(z_{j^r-1}, j^r)$ also depends on the age at which individual retires. It will equal to the PIA if individual retires at age 65. For every year before age 65 that individual first draws benefits, benefits are reduced by 6.67 % and for every year (up to age 70) that benefit receipt is delayed, benefits increase by 8 %.[18] The total amount of PIA is capped above at \$ 102,000.

The share of consumption in the utility function ω, the discount rate β, fixed benefit from retirement θ, the bequest strength ϕ, and the Relative Risk Aversion parameter σ are calibrated jointly to match the following five 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-population rate of households for age group 63, the normalized net worth for households aged above 83, and the average drop in non-durable consumption upon retirement -.17 (Aguiar and Hurst [1]). The average wealth profile is from the SCF 1998 data. The cumulative retirement-population rate is taken from the HRS 1998 data. These give $\omega = .77$, $\beta = .962$, $\theta = 0.84$, $\phi = 10.3$, and $\sigma = 1.12$. Table 4 summarizes all calibrated parameters.

The relative risk aversion parameter σ is larger than the elasticity of substitution between consumption and housing services. Note that this implies that housing consumption and non-durable consumption are substitutes.

3.8. Life Cycle Profile

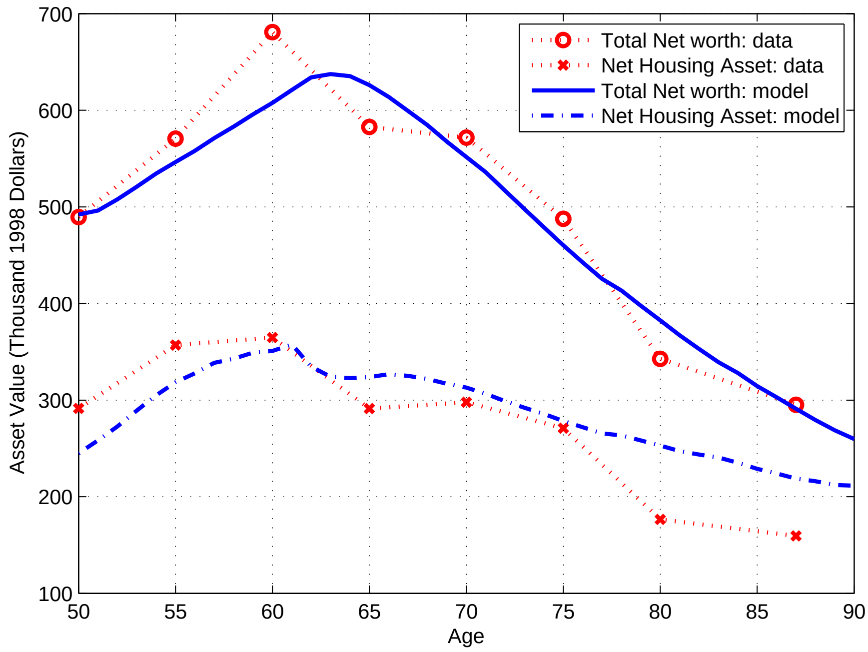

Figure 4: Life Cycle Profile of Wealth Accumulation and Portfolio Choice

Figure 4 plots the average total networth and net housing value over 50-90. For each home price sequence withdrawn, I simulate a cohort of 10,000 households with different realizations of income shocks from age 50 to age 70 (the full retirement

[18]The credit for delayed retirement is 8% for the cohort born in 1948, which is the cohort I simulate.

age is 71 in the model). I repeat this procedure for 1000 different home 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.[19] 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.

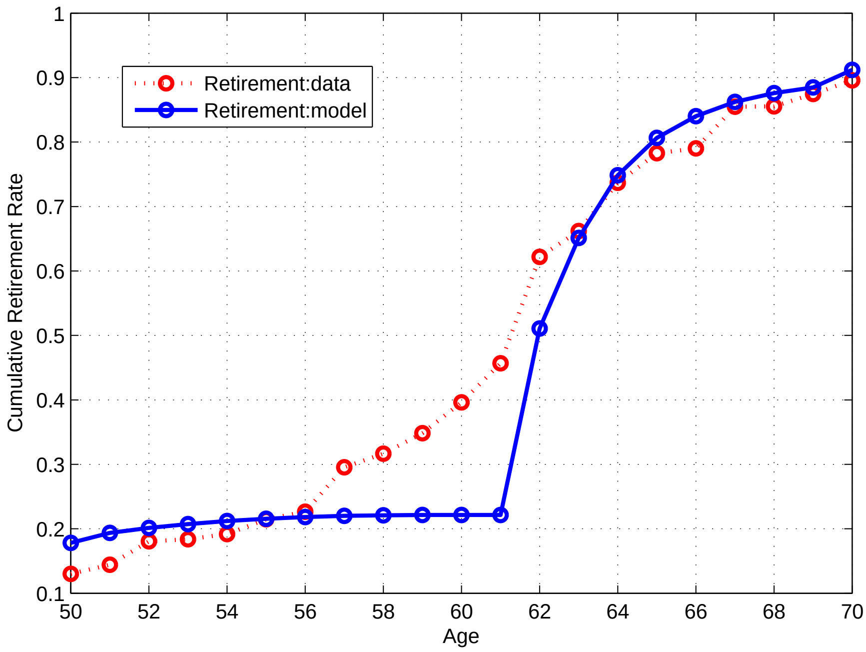

Figure 5: Cumulative Retirement-population Rate

Figure 5 plots the accumulative retirement-population rate from simulated data. The cumulative retirement-population rate for home owners in the model exhibits a spike at age 62. This is due to fact that households cannot receive any social security 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 more closely to the cumulative retirement-population rate before 62 in the data.

3.9. Elasticity of Retirement to House Prices

After the model calibration, I want to first verify that the structure model can deliver reasonable elasticity of retirement to house prices. I estimate the following linear probability model with fixed effect

$$R_t^i = \alpha^i + P_t + X_t^i + \epsilon_t^i \tag{28}$$

where 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, I 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 50-65. There are 200 regions in the panel, with 200 different home price sequences drawn from the stationary distribution. There are 5,000 households in each simulated region. The results

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

for the simulated panel data is shown in Table 5. The coefficient before home prices is .18, which means a 10 percent decline in home prices will reduce the retirement probability for households aged 50-65 by 1.8 percentage point. The elasticity of retirement in the benchmark model is higher than the elasticity of retirement in the data. This is largely due the frictionless housing market assumption in the benchmark model.

The linear probability regression model assumes that the response of retirement probability to home price is the same for all age groups. In order to show the heterogenous retirement response, I perform the following experiment. Suppose the model economy is at stationary equilibrium. Then it is shocked by a one-time unexpected -27.7 percent home price shock. [20] I simulate the economy onwards and compute the average retirement age for different cohorts after the shock, which is the dotted line in Figure 6. The solid horizontal line in Figure 6 is the average retirement age in absence of the unexpected one-time home 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 when the one-time unexpected home price shock hits.

Table 5: Elasticity of Retirement to House Prices

Dependent Var.: Retirement Dummy	HRS	Benchmark	No Bequest	Zero Borrowing	Infinite Cost
Lagged Non-Capital Income (1000$ in 1998)	-1.93e-3	-1.73e-3	-1.6e-3	-1.6e-3	-1.7e-3
House Price	.090	.18	.15	.14	.05
Age, Age^2, Age^3	Yes	Yes	Yes	Yes	Yes

The average retirement age for different cohorts is hump-shaped. Among all the cohorts that suffer from one-time unexpected negative home price shock, the cohort that is hit at age 62 has the largest increase in the average retirement age. The cohorts that are hit at age 50-65 on average retire 5.8 months later than they would have done if home price had not unexpectedly declined. The result is smaller than the estimates by Farnham and Sevak [15], which finds that a 10 percent increase in housing wealth will reduce the expected retirement age by 3.5 months to 5 months.

When shock hits at age younger than 62, the response in retirement age becomes smaller. This is because the relatively young households have a longer working career and their age-specific efficiency unit is still rising. Hence, they have plenty of time to make up the wealth loss and delay retirement slightly. If the shock hit at the age close to the full retirement age, the increase in the retirement age is also smaller. This is because the majority of the households have already retired at the date when shock hit. For those who are still in the labor force when shock hit, their remaining working career is shorter. Therefore, households do not have much flexibility to adjust their retirement. Note that the full retirement age in my simulation is age 70. Therefore, the unexpected home price shock at age 71 will not affect the retirement age at all.

3.10. Elasticity of Non-durable Consumption to House Prices

There are many empirical literature aiming to estimate the housing wealth effect on consumption. It is useful to compare the model implied elasticity of non-durable consumption to home prices with the those studies. I first construct a households panel, which consist of 1,000,000 households living in 200 regions. Each regions has its own home prices withdrawn from the same stochastic process. House Prices across different regions are independently distributed. Then I estimate the following fixed effect panel regression

$$C_t^i = \alpha^i + P_t + X_t^i + \epsilon_t^i \tag{29}$$

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

[20] Consider this as a one-time shock and the home price still follows the same stochastic process after the unexpected shock. The number 27.7 percent comes from the Markov approximation to home 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 home price drops by nearly 30 percent in the 2008 recession, I use this exercise as a simulation about the current crisis.

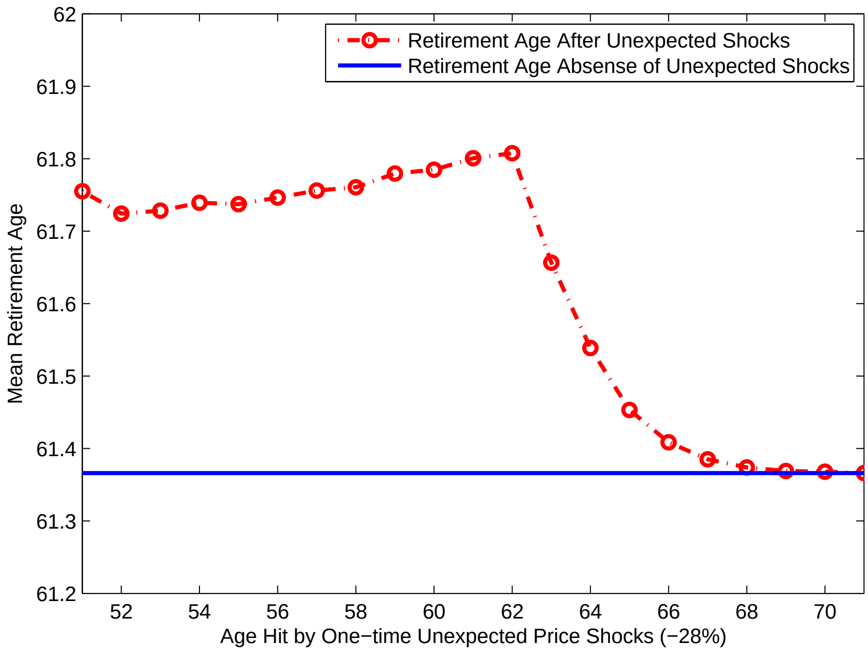

Figure 6: Mean Retirement Age after Negative House Price Shocks

Table 6: Elasticity of Non-durable Consumption to House Prices

Dependent Variable: Non-durable Consumption	HRS	Benchmark Model
Non-Capital Income	.030	.10
House Price	.25	.40
Age, Age^2,Age^3	Yes	Yes

The regression results are shown in Table 6. The coefficient before home price growth rate is .40, it is interpreted as a 10 percent decline in home prices will reduce the non-durable consumption of home owners aged 50-65 by 40 percent. The elasticity of consumption to house prices in the benchmark model is larger than .25 from HRS estimate. This elasticity is also larger than the 2.9 percent point estimate in Hryshko et al. [25], but smaller than the estimate by Campbell and Cocco [4]. This is largely due the frictionless housing market assumption in the benchmark model.

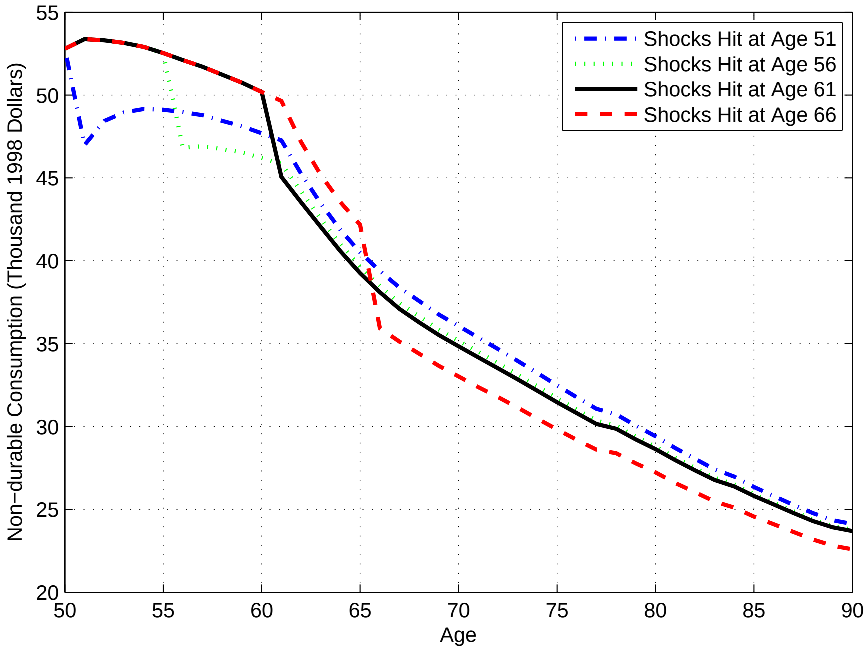

Figure 7: Consumption Profile After Negative House Price Shocks (Endogenous Retirement)

The above linear regression assume that consumption elasticity is the same for all age groups. In order to identify the heterogenous responses for different age groups, I do the following experiment. Suppose the economy is in the stationary equilibrium. House price unexpected decreases by 27.7 percent. I simulate the economy onwards after the price shock. I compute the consumption profile for each cohort and plot them in the Figure 7. I plot the consumption response for households that are hit at age 51, 56, 61, and 66 respectively. It can be seen from the graph that households non-durable consumption drops right after the negative home price shocks. After than the households non-durable consumption slowly recovers, but is still permanently lower than they would have consumed if home price hadn't dropped. Those who experience a negative home price shocks later in life on average have a lower non-durable consumption level than households who experience it at younger age.

How large is that effect for average households in the US? The average net house value is 326,000 dollars, the average consumption drop from the model is 5,911 dollars. Therefore, for each dollar loss in housing wealth, households non-durable consumption immediately drops by 2 cents. This estimate is the same as the results in Carroll et al. [5].

3.11. Retirement as Self-insurance Against House Price Risks

From the incomplete-market life-cycle studies, we know that the labor adjustment is an important channel for households to self-insure against income shocks. In this section, I will study the retirement as self-insurance against home price shocks.[21]

In order to demonstrate the role of endogenous retirement in cushioning the home price risk, I build up a second structural model with exogenous retirement, where all households retire at the age 66.[22] The second model economy has the same social security system as in the benchmark model. I calibrate the consumption weight in the utility ω, the bequest strength ϕ, the discount factor β, and relative risk aversion σ to match four 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, and the average consumption drop at retirement. These give $\omega = .810$, $\beta = .967$, $\phi = 6.0$, and $\sigma = 1.13$.

Figure 8 shows the instant consumption drop for different age groups after an unexpected -28% home price shocks in the endogenous retirement model (the solid line) and in the exogenous retirement model (the dotted line).

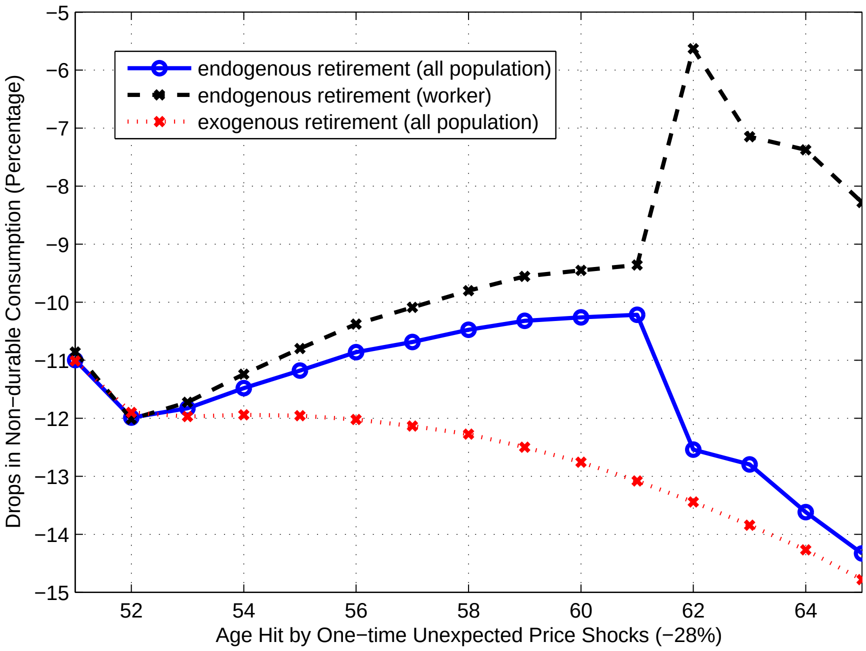

Figure 8: Instant Drops in Consumption After Negative House Price Shocks

Two findings are worth mentioning. First, the average consumption response in the exogenous retirement model shows that old households on average 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. This is intuitive. For the old households close to full retirement age, this one-time unexpected home price shock is more like a permeant shock to them as they have little flexibility to adjust their retirement schedule.

Second, households in the endogenous retirement model on average have smaller drops in non-durable consumption than the households in the exogenous retirement model. The intuition is simple: the fall in home prices makes owners delay

[21] It is worth mentioning that Hryshko et al. [25] identifies house 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.

[22] I also include the initial retiree at age 50 in the data and assume they stay in retirement until the end of life.

retirement in order to buffer negative wealth effect. It turns out that the average drop in non-durable consumption for the home owners aged 50-65 with the endogenous retirement is 14 percent smaller than the average drop for the same age group with exogenous retirement. For households aged 50-65, The average non-durable consumption drop in the endogenous retirement model is 11.5 percent and the average drop in the exogenous retirement model is 13.2 percent. This confirms the idea that endogenous retirement can cushion the negative home prices shocks on home owners' non-durable consumption.

The sudden drops at 62 in the endogenous retirement model is mainly driven by the consumption drop at retirement. The slow decline after age 63 for the economy with endogenous retirement is due the composition effect, i.e., more and more households become retired in the model. The dashed line is the consumption response of households conditional on being working in the endogenous retirement model. Conditional being working, the average consumption drop for households aged 55-64 in the endogenous retirement model is only 8.7 percent. The drops in the consumption is smaller for the old and larger for the young. This is mainly due to the self-selection into workers. Those with high income shocks decide to stay in the labor force and suffer less from the wealth shocks.

This exercise suggests that the endogenous retirement is important aspect when estimating the wealth effect on consumption for the near-retirement households. Neglecting this tends to overestimate the housing wealth effect on the consumption of old working households.

3.12. Model Mechanisms and Counterfactual Experiments

In this section, I first explain how home 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 infinitely lived households

A2 fully predicted home price

A3 no borrowing constraint

A4 perfect housing market with no adjustment cost

A5 CRRA preference with Cobb-Douglas aggregation 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 and choose whether to work or not. The assumption *A4* implies that the rental housing is perfect substitute to owner-occupied housing.

Under the assumptions *A2-A5*, the Cobb-Douglas utility implies a constant ratio between non-durable consumption and housing expenditure.[23] This is because the substitution effect and wealth effect of home price on non-durable consumption cancel out under Cobb-Douglas preference. The home prices will not affect the current consumption or housing expenditure given the same total net worth at the beginning of this period (See proof in the appendix). In other words, after the total net worth is controlled, the current movement in home price will not affect non-durable consumption.

However, we usually ask how does home price affect consumption without control for total wealth. To clarify ideas, suppose the budget constraint can be written as follows

$$c + a' + ph' = ph + (1 + r)\, a \tag{30}$$

[23] The ratio may remain constant even if the home price follows a stochastic process. One sufficient condition for that is to assume the returns on home 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.

where c and h' is the non-durable consumption and housing stock in the current period respectively. r is the risk-free interest rate and p is the current home price. h is the housing stock last period (for simplicity, assume zero depreciation rate). Without loss of generality, suppose the housing stock produces the same amount of housing services.

Under assumption *A1-A5*, home price will not affect non-durable consumption if $h = h'$.[24] Generally speaking, $h \neq h'$. This is because households want to "rebalance" the consumption portfolio each period to make sure the ratio of non-durable consumption to housing expenditure is constant over time. Suppose one starts period with housing stock h and today's home price p is higher than yesterday's p^{-1} (the price for the housing service is also higher than yesterday's). If he chooses the same consumption and house size as yesterday's, then the consumption-housing-expenditure ratio is declining. To rebalance his portfolio, he wants to sell the houses and increase non-durable 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 home price increases.[25]

In this paper, I keep the assumption *A5* and modify the assumption *A1-A4*. More precisely, I break the assumption *A1* by introducing warm-glow bequest motive. The rationale for this assumption is discussed in the calibration part. House price is risky in the model, which changes the assumption *A2*. Therefore, the expectation about the future home price growth will matter. I break the assumption *A3* by assuming households can only borrow against the value of their houses. I will later introduce adjustment cost to housing asset, which violates the assumption *A4*.

The reminder of the section describes 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.

3.12.1. Experiment A: No Bequest Motive

The first experiment is to quantify the effect of warm-glow bequest motive. I remove the bequest motive by setting the bequest strength ϕ to zero. I recalibrate the model 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-population rate of households for age group 63. Column "No Bequest" in Table 5 summarizes the regression results. The housing wealth effect equals .15, which is 3 percentage points smaller than the wealth effect in the benchmark model.

Households with warm-glow bequest motive care about the adequacy of total net worth when they die. Other things being equal, home owners experiencing adverse home price shock tends to work longer in order to buffer the negative effect of home price on the value of accidental bequest. The removal of bequest motive shut down this mechanism and tends to reduce the retirement response to home price shocks.

However, the drops in housing wealth effect after the removal of bequest motivate may be smaller than one would expect. One reason is that a counteracting force is functioning. The removal of bequest motive induces one to accumulate less wealth in the his late life. Because housing can be used as collateral, it is more valuable to the poor households than to the rich households. Therefore, the housing asset now accounts for a larger fraction of total net worth over life-cycle than in the benchmark case, which tends to increase the responsiveness of retirement to home prices.

There is a subtle difference between the warm-glow bequest motive and altruism.[26] If the altruism is assumed instead, then we go back to the infinite horizon model. I have proved that the home price fluctuations will not affect households' non-durable consumption and housing expenditure given all households have the same total net worth and fully predicted

[24]However, if assumptions *A1-A5* are not satisfied, then home 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 positive.

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

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

home price. This also implies the same amount of unintentional bequest. However, this argument will no longer be true in the case of warm-glow bequest motive. Households with warm-glow bequest motive care about the value of bequest but not the composition of bequest. In this case, households have different choices over non-durable consumption and saving under different home prices even if their total net worth at the beginning of period are the same. In this sense, introducing warm-glow bequest instead of altruism tends to increase the housing wealth effect.

3.12.2. 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. I recalibrate the model to match 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-population rate of households for age group 63, the normalized net worth for households aged above 83. The results are shown in column "Zero Borrowing" of Table 5. The housing wealth effect on retirement is .14, which is 4 percentage points less than the benchmark model.

Again, the drops in housing wealth effect may be smaller than one would expect. This is because two counter-acting forces are at work. On one hand, the 100 percent down-payment ratio reduces the incentive to hold housing asset as collateral. Under the zero borrowing constraint, households hold less housing in the total wealth than they do in the benchmark model. This in turn reduces the housing wealth effect on retirement and non-durable consumption.

On the other hand, the zero borrowing constraint limits the ability to self-insure against income risk and home price risk. In the case of negative home 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 and forces them to delay retirement. This counteracting force mitigate the drop in the responsiveness of retirement under zero borrowing constraint.

3.12.3. Experiment C: Infinite Adjustment Cost

The third experiment investigates how home 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 model.

Since housing adjustment is costly, the housing stock becomes one state variable. 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 home price will only reduce the average retirement-population rate in the sample by only 0.5 percent. This magnitude is only 30 percent of the housing wealth effect in the frictionless benchmark model.

The reason why housing wealth effect does not disappear completely 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. Even if one lives in the same house, the liquidation house value after his death will still affect the retirement decision when he is alive. Second, the collateral borrowing channel allows households to consume out of their housing asset by taking reverse mortgage debt when they still live in them.

4. Conclusion

This paper complements previous studies on retirement by pointing out the importance of housing wealth effect and stock wealth effect on retirement and consumption decision for the old 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, home 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 home price shocks through three channels: resizing effect, bequest motive, and collateral borrowing. Using the structural model, the paper argues the endogenous retirement is quantitatively important channel for self-insurance against house- and stock-price shocks.

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.[27] Therefore, the near-retirement households are faced with great volatility in total wealth if the portfolios are heavily concentrated in housing assets and stocks.[28] 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. 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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[28] 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. [21]). 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.

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Appendix A. Proof in Section 3.10

Rewrite the infinite horizon problem recursively

$$V(x,p,\eta,\varepsilon) = \max_{c,n,h'} \{u(c,h') - \theta n + \beta V'(x',p',\eta',\varepsilon')\} \tag{A.1}$$

subject to the constraint

$$x' = R(x + wn - c - ph') + p'h'(1-\delta_h) \tag{A.2}$$

$$c > 0, h' > 0, x' > 0 \tag{A.3}$$

Insert A.2 into Bellman Equation and differentiate with respect to c and h'

$$V_c = \beta RE\left[V_x'\left(x', p', \eta', \varepsilon'\right)\right] \tag{A.4}$$
$$V_{h'} = \beta RE\left[V_x'\left(x', p', \eta', \varepsilon'\right)\left(p - (1-\delta)p'/R\right)\right] \tag{A.5}$$

Combine the two first order conditions

$$\frac{V_c}{V_{h'}} = \frac{1}{p - (1-\delta)p'/R} \tag{A.6}$$

Denote that $p^r = p - (1-\delta)p'/R$, which is in fact the rental price. This is because of zero adjustment cost and no borrowing constraint. Using that

$$u\left(c, h', n\right) = \frac{\left(c^{\omega} h'^{(1-\omega)}\right)^{1-\sigma}}{1-\sigma} - \theta n \tag{A.7}$$

Then the consumption-housing-expenditure ratio is given by

$$\frac{c}{p^r h'} = \frac{\omega}{1-\omega} \tag{A.8}$$

which is independent of home price shocks. The budget constraint A.2 is now equivalent to

$$x' = R\left(x + wn - c/\omega\right) \tag{A.9}$$

Therefore, households have the same consume and housing expenditure if their total net worth at beginning of period is the same.