CONSUMPTION OVER THE LIFE CYCLE: HOW DIFFERENT IS HOUSING?*

FANG YANG†
SUNY-Albany

First draft: February 2004
This version: October 2006

Abstract

Micro data over the life cycle shows different patterns of consumption for housing and non-housing goods: the consumption profile of non-housing goods is hump-shaped while the consumption profile for housing first increases monotonically and then flattens out. These patterns hold true at each consumption quartile. This paper develops a quantitative, dynamic general equilibrium model of life-cycle behavior, which generates consumption profiles consistent with the observed data. Borrowing constraints are essential in explaining the accumulation of housing assets early in life, while transaction costs are crucial in generating the slow downsizing of the housing assets later in life.

JEL Classification: E21, J14, R21
Keywords: Consumption, Housing, Life Cycle, Wealth Distribution

---

*I am grateful to my thesis advisors, Michele Boldrin and Mariacristina De Nardi, for numerous suggestions and continuous encouragement. I would like to thank John Boyd, Marco Cagetti, V. V. Chari, Zvi Eckstein, Larry Jones and seminar participants at 2004 CESifo Venice Summer Institute, Federal Reserve Bank at Atlanta, 2005 Midwest Macroeconomics Meetings, 2005 SED meeting, Federal Reserve Bank at Minneapolis, Federal Reserve Bank at Chicago, University of Colorado-Boulder, Rutgers University, SUNY-Albany, University of Toronto, Indiana University, Purdue University, Bank of Canada, Hong Kong University of Science and Technology, University of Hong Kong, for helpful comments and suggestions. Financial support from the Gross Fellowship is gratefully acknowledged. All remaining errors are my own.

†Mailing Address: Department of Economics, Business Administration Building, Room 123E, University at Albany, State University of New York, Albany, NY 12222. Email: fyang@albany.edu. URL: www.albany.edu/~fy554862.

1 Introduction

Micro data shows different patterns of consumption for housing and non-housing goods over the life cycle. Consumption expenditure on non-housing goods is hump-shaped over the life cycle: it starts low early in life, rises considerably around middle age, and then falls at more advanced ages. On the contrary, household holdings of the housing stock are not hump-shaped: the lifetime profile of housing stock is monotonically increasing and then rather flat. The different patterns of housing and non-housing consumption over the life cycle contradict a key prediction of the standard life-cycle model without market frictions: the ratio of housing and non-housing consumption should not be age-dependent. That is to say, housing consumption should follow the same pattern as non-housing consumption.

These stylized facts of life-cycle consumption motivate asking which modifications of the basic life-cycle framework could produce consumption profiles that more closely resemble the US consumption profiles. To answer this question, I construct a general equilibrium life-cycle model of consumption and saving that explicitly models housing. Housing has a dual role: it directly provides utility, and it can be used as collateral. In my framework, households face several frictions: uninsurable labor income risk, lack of an annuity market to insure against uncertain lifetime, borrowing constraints, and transaction costs for trading houses. Households save to self-insure against labor income and life-span risk, for retirement, to enjoy services from housing, and possibly to leave bequests.

I show that a plausibly parameterized version of my model accounts well for the empirical findings. The interaction between housing (which can be used as collateral) and borrowing constraints leads to the accumulation of housing stock early in life, while transaction costs tend to slow the decline of the housing stock later in life. Households begin their economic lives without any housing stock. During the early part of their lives, because of the existence of borrowing constraints and the role of housing as a collateral, they build housing stock quickly and compromise on non-housing consumption. As households age, they start to decrease their non-housing consumption because their time preference is higher than the interest rate and mortality rates are increasing along the life cycle. The high transaction costs associated with trading houses prevent households from decreasing their housing stock quickly later in life.

The model is not calibrated to fit these two life-cycle consumption profiles. Some parameters, such as the discount factor, are set so that the model-generated data match aggregate targets. Other parameters are based on existing literatures.

In addition to explaining life-cycle consumption profiles, the model is able to generate the observed life-cycle wealth portfolio profiles. In the US, young households virtually own no liquid financial assets, but hold a major fraction of their wealth as housing. Later in life, households shift their portfolios to financial assets. The benchmark model also matches the distribution of wealth, housing and financial wealth quite well. It replicates the empirical finding that inequality in financial assets is much higher than in housing. One reason is that households are allowed to borrow against housing, so financial assets can be negative but the housing stock can not be. Also the return to housing, namely the marginal utility of housing, is decreasing, while the return to financial assets, the interest rate, is constant. As a result, housing as a fraction of net worth is decreasing with net worth.

The most closely related works are the ones by Fernandez-Villaverde and Krueger (2001) and Heathcote (2002). Fernandez-Villaverde and Krueger (2001) build a life-cycle model with endogenous borrowing constraints to explain the expenditure patterns of durable and non-durable goods. However, their model abstract from housing transaction costs and cannot generate the slow decline of the housing stock. Heathcote (2002) incorporates home production in an otherwise standard model to account for the drop of consumption at retirement.

There are several papers that exploit the idea that in the presence of collateralized loans, borrowing constraints distort the allocation of resources between durables and non-durables.[1] In contrast to the literature that tests the empirical significance of borrowing constraint from the data, I impose borrowing constraints in the model in conjunction with the transaction costs and maintenance-remodeling option.

Several mechanisms have been offered in the literature to explain hump-shaped life-cycle consumption profile, without considering the interaction of housing and non-housing consumption.[2] I incorporate precautionary saving, borrowing constraints, and mortality risk in my model with housing and see how each feature affects consumption profiles. Instead of modeling the stochastic process for changing in family size, I directly control for the variations in household size when constructing consumption profiles.

This is paper is related to the literature on life-cycle general equilibrium models that incorporate bequest motives, such as Laitner (2001), Ocampo and Yuki (2005). De Nardi (2004) shows that voluntary bequests can explain the emergence of large estates and the long upper tail of the wealth distribution. I generalize her framework by modeling housing and transaction costs.

The paper is organized as follows. In Section 2, I present some empirical results from the Consumer Expenditure Survey (CEX) and Survey of Consumer Finances (SCF) documenting households' consumption and asset accumulation over the life cycle. In Section 3, I present my model. The calibration of the model is presented in Section 4. Section 5 presents the quantitative results of the benchmark model. Section 6 investigates the quantitative importance of the transaction costs, bequest motives, borrowing constraints and social security. Brief concluding remarks are provided in Section 7.

[1] See, for example, Jappelli (1990), Brugianini and Weber (1992), Chah, Ramey and Starr (1995), Alessie, Devereux, and Weber (1997), and Attanasio, Goldberg and Kyriazidou (2000)).

[2] Examples include, mortality risk (Hansen and Imrohoroglu (2005)), precautionary saving (Carroll and Summers (1991), Carroll (1997), Gourinchas and Parker (2002)), borrowing constraints (Hubbard, Skinner and Zeldes (1994)), variations in household size (Attanasio and Weber (1995), Attanasio, Banks, Meghir and Weber (1999) and Browning and Ejrnæs (2002)) and the substitutability of leisure and consumption (Bullard and Feigenbaum (2004)).

2 Empirical Findings

This section presents empirical evidence on non-housing and housing consumption over the life cycle. I use data from the CEX and SCF. I construct synthetic cohorts from each data set. I use the age of the reference person to define 10 cohorts with a length of 5 years, starting from age 20, and follow them through the whole sample, generating a panel. Then I control for cohort, time, and age effects by employing a semi-nonparametric partially linear model. Appendix 8.1 describes those two datasets and the estimation procedure in greater detail.

I first study the life-cycle profile of consumption of non-housing goods using data from the CEX (1986-2001), controlling for cohort and time effects. Non-housing data is deflated to be in 1986 dollars using the CPI price index for non-durables.

Figure 1 plots total household annual expenditure on non-housing goods against the head of the household's age. Estimated consumption increases from around \$10,500 to nearly \$18,200, and then decreases to about \$9,400. The peak is reached at age forty-five. The size of the hump, measured by the ratio of consumption expenditure between the peak and the beginning of the life cycle, is around 1.74. The consumption expenditure on non-housing goods declines dramatically later in life.

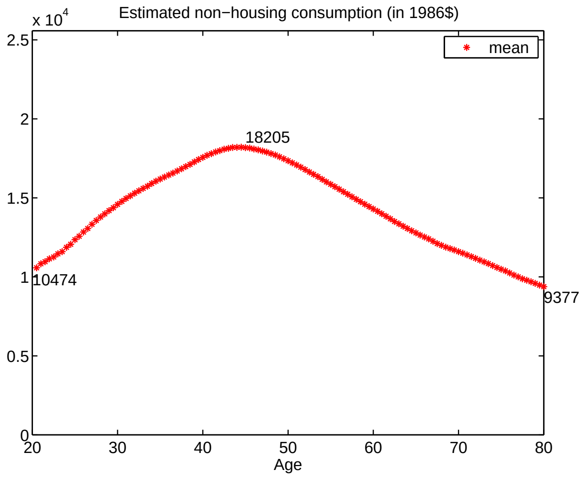

Figure 1: Average non-housing consumption

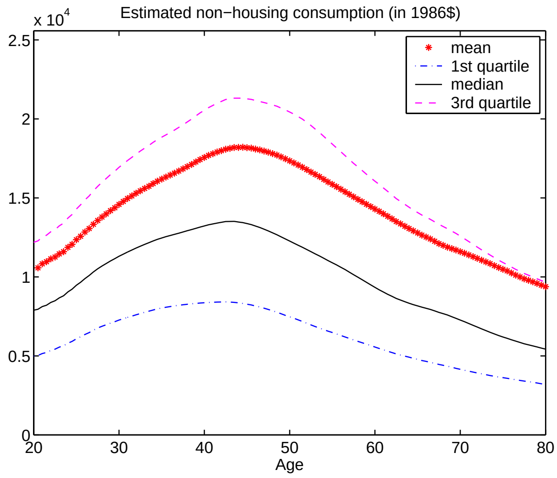

Figure 2: Non-housing consumption (quartiles)

If we go beyond mean consumption and look at the distribution of consumption, the hump-shaped non-housing consumption pattern still holds. For example, Figure 2 plots total household expenditure on non-housing goods at the mean level and at each quartile. We observe that the non-housing consumption is hump-shaped at each quartile. We also see that mean consumption is higher than the median, and lower than the 3rd quartile at each age, indicating that the distribution of consumption in each age is skewed to the right.

Households of different size plausibly face different marginal utilities from the same consumption expenditure. Consequently, changes in household size along the life cycle might explain the hump in consumption. Thus I adjust the data for the change in household size using equivalence scales, which quantify the change in consumption expenditure needed to keep the welfare of families constant, regardless of its size (see for example Zeldes (1989), Blundell, Browning and Meghir (1994)). Appendix 8.1 describes the equivalence scales used. The results are shown in Figure 3. The adjusted consumption increases from around $8,260 to nearly $11,300, and then decreases to about $8,960. The peak in adjusted consumption is postponed to age fifty. The ratio of consumption expenditure between the peak and the beginning of the life cycle, is around 1.37.[3] The consumption expenditure on non-housing goods declines dramatically later in life. We observe that the non-housing consumption is hump-shaped at each quartile and mean consumption is higher than the median, indicating that the distribution of consumption at each age is skewed to the right.

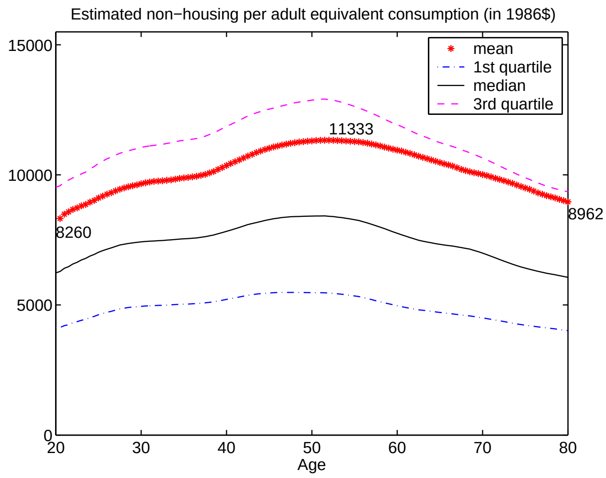

Figure 3: Non-housing consumption (adult equivalent)

I then use the six waves of the SCF (1983-1998) to estimate the life-cycle profile of housing stock, net worth and non-housing assets controlling for cohort and time effects. Housing, net worth and non-housing assets are deflated to be in 1983 dollars using the CPI price index. The housing asset is the value of the primary residential house. To avoid selection bias, I include renters even if they do not have housing assets. I control for cohort, time, and age effects by using the same partially linear model described in Appendix 8.1.

Figure 4 plots the estimated housing stock over the life cycle from the SCF.[4] The estimated housing value increases until age sixty-five, and then flattens out until the end of the life cycle. That is to say, if the service flow from housing is proportional to housing stock, then consumption from housing is not hump-shaped. Figure 5 plots housing stock at the mean level and at each quartile. We observe that the housing consumption is increasing and then flattens out at each quartile. Also mean consumption is higher than the median at each age,

[3] Fernandez-Villaverde and Krueger (forthcoming) estimate the ratio of peak to age 22 non-durable consumption to be 1.3.

[4] The profile for homeowners only has similar pattern as Figure 4 , but the levels are higher, especially when young. This is simply because Figure 4 is estimated from samples containing renters who do not have any housing assets.

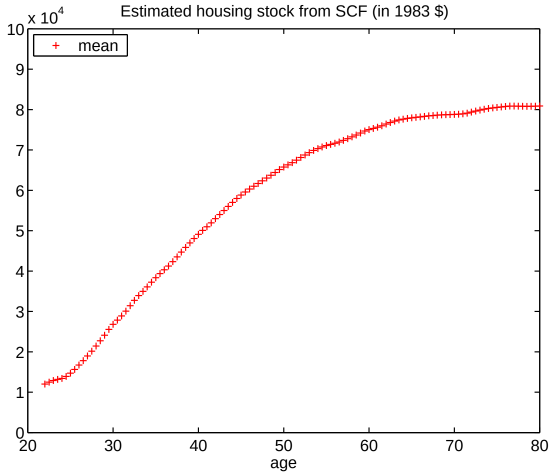

Figure 4: Housing consumption

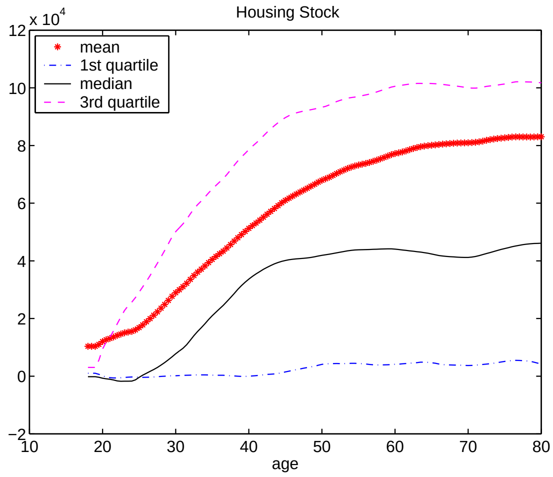

Figure 5: Housing consumption (quartiles)

indicating that the distribution of housing consumption at each age is also skewed to the right.

The finding that elderly households do not decrease their housing consumption is consistent with the empirical findings from other literature. For example, Feinstein and McFadden (1989) suggest that more than one-third of elderly households reside in dwellings with at least three more rooms than the number of inhabitants, and are thus consuming large housing services. Fernandez-Villaverde and Krueger (forthcoming) show that, when controlling for time and cohort effects, the peak of (market valued) housing service does not occur until age fifty-five, then decreases slightly, and then flattens out until the end of the life cycle.

The different patterns of housing and non-housing consumption over the life cycle thus contradicts to a key prediction of the standard life-cycle model without market frictions, age-dependent utility of consumption, or home production: the ratio of housing and non-housing consumption should not be age-dependent. That is to say, consumption of housing should follow the same pattern as non-housing consumption (see Appendix 8.2 for more details).

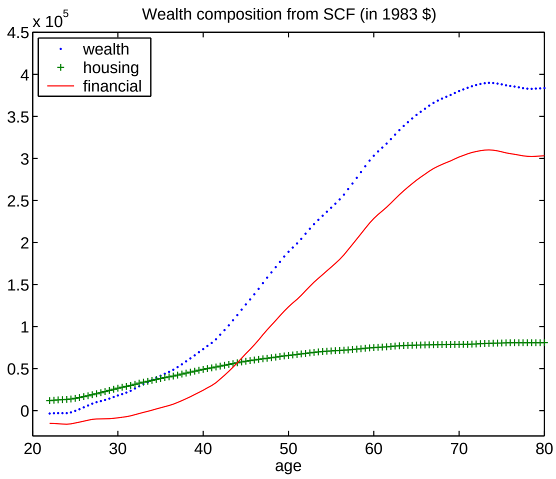

Figure 6: Age profile of wealth composition

I now show the patterns of wealth accumulation and portfolio composition over the life cycle. Figure 6 plots mean net worth, housing stock, and financial assets against age. Young agents tend to hold little wealth. Early in life households borrow to buy houses, and thus save in the form of housing. As time goes by, agents have built stocks of houses and start to increase their holding of financial assets. The profiles of financial assets and housing assets intersect in their early 40's. Wealth holding peaks at age 70. However, we do not observe quick decumulation of wealth later in life. Instead, households continue to hold large amount of wealth.

3 The Model

The economy is a discrete-time overlapping generation world with an infinitely-lived government. The government taxes labor earnings, and provides pensions to the retirees. There are uninsurable idiosyncratic income shocks. The only financial instrument is a one-period bond. Housing has a dual role: it provides utility as consumption goods, and it can be used as collateral. Thus the borrowing limit of each household depends on the value of the house. Purchase or sale of a house incurs transaction costs. For simplicity, I assume there is no housing rental market.

3.1 Technology and Timing

There is one type of good produced according to the aggregate production function $F(K; L)$ where K is the aggregate capital stock and L is the aggregate labor input. I assume a standard Cobb-Douglas functional form. The final goods can be either consumed or invested into physical capital or transformed into housing. Physical capital and housing depreciate at rate δ^k and δ^h, respectively. Let H denote the aggregate housing stock, C the aggregate consumption of non-housing, I^h the aggregate investment on housing, I^k the aggregate investment on physical capital, Tc the total transaction costs for trading housing, respectively. The aggregate resource constraint is:

$$F(K, L) = K^{\alpha} L^{1-\alpha} = C + I^k + I^h + Tc. \tag{1}$$

At the beginning of each period, households observe their idiosyncratic earning shocks and possibly receive some inheritance from their parents. Then labor and capital are supplied to firms and production takes place. Next, the households receive factor payments and make their consumption and asset allocation decisions. Housing stocks are not transferred until the end of the period. Thus the addition or subtraction to the stock will not influence the present period service flow. Finally uncertainty about early death is revealed.

3.2 Demographics

During each model period, which is 5 years long, a continuum of people is born. I denote age $t = 1$ as 20 years old, age $t = 2$ as 25 years old, and so on. At age 20 each person enters into the model and starts working and consuming. Since there are no inter-vivos transfers, all agents start their economic life with no financial assets and no houses. At the beginning of period 3, the agent's children are born, and four periods later the children are 20 and start working. The agents are retired at $t = 10$ and die for sure by the end of age $T = 12$. From $t = 10$, each person faces a positive probability of dying given by $(1 - p_t)$. The probability of dying is exogenous and independent of other household characteristics. The population grows at rate n. Since the demographic patterns are stable, agents at age t make up a constant fraction of the population at any point in time. Figure 7 illustrates the demographics in the model.

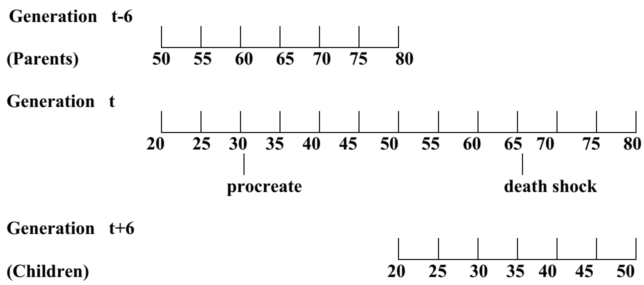

Figure 7: Demographics

3.3 Consumer's maximization problem

3.3.1 Preferences

Individuals derive utility from consumption of non-housing goods, c, from the service flow of the housing, h and from bequests transferred to their children upon death. Preferences are assumed to be time separable, with a constant discount factor β. The momentary utility function from consumption is of the constant relative-risk aversion class given by

$$U(c, h) = \frac{g(c, h)^{1-\eta} - 1}{1 - \eta}. \tag{2}$$

I choose $g(c, h) = (\omega c^\sigma + (1 - \omega)h^\sigma)^{\frac{1}{\sigma}}$, and h is assumed to be equal to the value of housing stock. Following De Nardi (2004), the utility from bequest is denoted by

$$\phi(b) = \phi_1(1 + b/\phi_2)^{1-\eta}. \tag{3}$$

The term ϕ_1 reflects the parent's concern about leaving bequests to his/her children, while ϕ_2 measures the extent to which bequests are luxury goods.[5]

[5]This form of 'impure' bequest motives implies that an individual cares about the bequests left to his/her children, but not about consumption of his/her children. If an individual is assumed to care about utility of

3.3.2 Transaction costs

Due to the heterogeneity of housing and the spatial fixity of housing, both potential buyers and sellers in the housing market are forced to spend considerable amounts of time and resources in acquiring information about the value of a specific housing unit. As a consequence, there are both implicit and explicit search costs associated with moving (Chinloy (1980)). These include the opportunity cost of time associated with market search, brokerage and agent fees, recording fees, legal fees, origination fees. Besides, households have to physically move to a new house, which entails moving costs and psychological costs of breaking neighborhood attachments (Smith, Rosen, Fallis (1988)).

I consider non-convex transaction costs in the housing stock, as in Grossman and Laroque (1990). The specification of the transaction costs is:

$$\tau(h, h') = \begin{cases} 0 & \text{if } h' \in [(1-\mu_1)h,\ (1+\mu_2)h] \\ \rho_1 h + \rho_2 h' & \text{otherwise.} \end{cases} \tag{4}$$

This formulation of transaction costs allow households to change their level of housing consumption by undertaking housing renovation up to a fraction of μ_2 the value of house or by allowing depreciation up to a fraction of μ_1 the value of house as an alternative to moving. If the housing depreciates by more that a fraction μ_1 of the value, or if the value of the stock increases by more that a fraction μ_2 of the value, I assume that the stock has been sold. In those cases, the household has to pay the transaction costs as a fraction ρ_1 of its selling value and ρ_2 of its buying value.

3.3.3 Borrowing constraints

I assume that only collateralized credit is available and that the borrowing interest rate, mortgage interest rate and deposit interest rate are all equal. This implies that mortgages and deposits are perfect substitutes. I use a_t to denote the net asset position. To buy a house, a household must satisfy a minimum down payment requirement as a fraction θ of the value of house. Housing also serves as collateral for loans (through home equity loans or refinancing) up to a fraction $(1-\theta)$. At any given period household's financial assets must hence satisfy:

$$a' \geq -(1-\theta)h', \tag{5}$$

and a household's net worth is bounded below by a fraction θ of the value of house: $a' + h' \geq \theta h'$.[6]

his/her children, and both parents and kids are maximizing utility as different units, the strategic interaction across generations complicates the analysis.

[6] For a household without a house, the borrowing constraint reduces to the standard form $a' \geq 0$.

3.3.4 Labor productivity

In this economy all agents of the same age face the same exogenous age-efficiency profile ϵ_t. Workers also face stochastic productivity shocks y_t. These shocks are represented by a Markov process. This Markov process is the same for all households so that there is no uncertainty over the aggregate labor endowment. The total productivity of a worker at age t is given by the product of the worker's age-t productivity shock and age-t deterministic efficiency index: $y_t \epsilon_t$.

To capture the positive correlation in human capital across generations, I assume that the parent's productivity shock at age 50 is transmitted to children at age 20 according to the transition function Q_{yh}. What the children inherit is only their first draw; from age 20 on, their productivity y_t evolves stochastically according to Q_y.

For computational reasons, I assume that children cannot observe directly their parent's assets, but only their parent's productivity when their parent is 50 and the children are 20, that is, the period when they leave the house and start working. Based on this information, children infer the size of the bequests they are likely to receive.[7]

3.3.5 The household's recursive problem

In the stationary equilibrium, the household's state variables are given by (t, a, h, y, yp), the first 4 variables of which denote the agent's age, financial assets and housing stock carried from the previous period and the agent's productivity, respectively. The last term yp denotes the value of the agent's parent's productivity at age 50 until the agent inherits and zero thereafter. The law of motion of yp is dictated by the death probability of the parent. When yp is positive, it is used to compute the probability distribution on bequests that the household expects from the parent. After the agents have received their inheritance, yp is set to be 0. Households solve the dynamic programming problem described below.

(i) From $t = 1$ to $t = 3$ (from age 20 to 35), the agent survives with certainty until next period and does not expect to receive a bequest soon because his or her parent is younger than 65. For these sub periods $yp' = yp$.

$$V(t, a, h, y, yp) = \max_{c,a',h'} \Big\{ U(c, h) + \beta E(V(t + 1, a', h', y', yp)) \Big\} \tag{6}$$

subject to (5) and

$$c + a' + h' + \tau(h', h) = (1 - \tau_l) w \epsilon y + (1 + r)a + (1 - \delta^h)h, \tag{7}$$

$$c \geq 0, \; h' \geq 0. \tag{8}$$

At any subperiod, the agent's resources are derived from asset holdings, a, labor endow-

[7] Allowing children to observe parents productivity at two periods adds one more state variable and also increases substantially the time needed to iterate over the bequest distributions. Since income in the calibration is very persistent, an observation of one income is likely to be not much less informative than two.

ment, $\epsilon_t y$, and housing stock, h. Asset holdings pay a risk-free rate r and labor receives a real wage w. Government taxes labor income at the rate τ_l.

(ii) From $t = 4$ to $t = 6$ (from age 35 to 50), the worker survives for sure until the next period. However, the agent's parent is at least 65 years old and may die in the next period; hence, a bequest might be received at the beginning of the next period. Since the evolution of the state variable yp is dictated by the death process of the parent, yp' jumps to zero with probability $1 - p_{t+6}$. Let $I_{yp>0}$ be the indicator function for $yp > 0$; it is one if $yp > 0$ and zero otherwise.

$$V(t, a, h, y, yp) = \max_{c,\widetilde{a},h'} \Big\{ U(c, h) + \beta E(V(t + 1, a', h', y', yp')) \Big\} \tag{9}$$

subject to (5), (8), and

$$\begin{aligned} c + \widetilde{a} + h' + \tau(h', h) &= (1 - \tau_l)w\epsilon y + (1 + r)a + (1 - \delta^h)h, \\ a' &= \widetilde{a} + b' I_{yp>0} I_{yp'=0}, \end{aligned} \tag{10}$$

where $\widetilde{a}$ denotes the financial assets at the end of the period before receiving bequest.

(iii) The subperiods $t = 7$ to $t = 9$ (from age 50 to 65) are the periods before retirement, during which no more inheritances are expected because the agent's parent is already dead by that time. Thus yp is not in the state space any more. The agent does not face any survival uncertainty.

$$V(t, a, h, y) = \max_{c,a',h'} \Big\{ U(c, h) + \beta E(V(t + 1, a', h', y')) \Big\} \tag{11}$$

subject to (5), (7) and (8).

(iv) From $t = 10$ to $t = 12$ (from age 65 to 80), the agent does not work and does not inherit any more. Households receive pension income P which is independent of household's income history.[8] The agent faces a positive probability of dying. When the agent dies, the house is sold automatically and transaction costs are incurred.[9] The agent derives utility from bequeathing his or her wealth.

$$V(t, a, h) = \max_{c,a',h'} \Big\{ U(c, h) + \beta p_t(V(t + 1, a', h')) + (1 - p_t)\phi(b) \Big\} \tag{12}$$

subject to (5), (8) and

$$c + a' + h' + \tau(h', h) = (1 + r)a + (1 - \delta^h)h + P, \tag{13}$$

$$b = a' + h' - \tau(h', 0). \tag{14}$$

[8]A more realistic assumption is that social security benefit is a concave function of the accumulated contributions. Under this assumption, the total contributions become state variables, which increases the computation time dramatically.

[9]I made this simplification since the children already have houses of their own when they inherit.

3.3.6 Definition of stationary equilibrium

A formal definition of stationary equilibrium is provided in Appendix 8.3. The model is solved numerically. Appendix 8.6 describes the computation algorithm in greater detail.

4 Calibration

I choose some parameters used in the benchmark model from estimates in other studies. The remaining parameters are chosen so that the data generated by the model's equilibrium match a given set of aggregate targets. Nones of the parameters are calibrated against the life-cycle consumption profiles. Since one period in my model corresponds to 5 years in real life, I adjust parameters accordingly.

The rate of population growth, n, is set to the average population growth from 1950 to 1997 from Economic Report of the President (1998). The p_t's are the vectors of conditional survival probabilities for people older than 65. I use the mortality probabilities of people born in 1965 provided by Bell, Wade, and Goss (1992).

Parameters		Calibrations
Demographics		
n	population growth	1.2%
p_t	survival probability	see text
Technology		
α	capital share in National Income	0.226
δ^k	depreciation rate of capital	0.0700
δ^h	depreciation rate of housing	0.0294
Endowment		
ϵ_t	age-efficiency profile	see text
ρ_y	AR(1) coefficient of income process	0.85
σ_y^2	innovation of income process	0.30
ρ_{yh}	AR(1) coefficient of income inheritance process	0.677
σ_{yh}^2	innovation of income inheritance process	0.37
Government policy		
τ_l	social security tax	0.07
P	social security replacement rate	0.40
Housing market		
θ	down payment ratio	0.20
ρ_1	transaction costs of selling housing	6%
ρ_2	transaction costs of buying housing	2%
μ_1	Maximum depreciation	0
μ_2	Maximum renovation	0
Preference		
η	risk aversion coefficient	1.5
σ	substitutability of housing and non-housing	0
ω	weights of non-housing in utility function	0.8615
β	discount factor	0.946
ϕ_1	weight of bequest in utility function	-17
ϕ_2	shifter of bequest in utility function	8

Table 1: Parameters used in the benchmark model

I construct measures of output Y, capital K and housing H and their investment counterparts using data from the National Income and Product Accounts and the Fixed Assets Tables for the year 1959-2001. The aggregate ratios for US economy are calibrated to explicitly consider the existence of housing that comprises residential assets. Output is defined as measured GDP minus housing services. Capital is defined as the sum of nonresidential private and government fixed assets plus the stock of inventories. The housing stock is defined as the stock of private residential assets. Investment in capital and in housing are defined accordingly. The term α is the share of income that goes to nonresidential stock of capital, which turns out to be 0.226. This capital share is much lower than that in other calibrations, which abstract from housing. I calibrate δ^k to be 0.0700 and δ^h to be 0.0294. The rate r is the interest rate on capital net of depreciation and turns out to be 4.37%. Appendix 8.7 explains the rationale behind these choices in greater detail.

The deterministic age-profile of the unconditional mean of labor productivity, ϵ_t, is taken from Hansen (1993). Since I impose mandatory retirement at the age of 65, I take $\epsilon_t = 0$ for $t > 9$. The stochastic productivity process is assumed to be an AR(1) process: $\ln y_t = \rho_y \ln y_{t-1} + \mu_t$, $\mu_t \backsim N(0, \sigma_y^2)$. The persistence ρ_y and variance σ_y^2 are estimated from Panel Study on Income Dynamics data, aggregated over five years in order to be consistent with the model period (Altonji and Villanueva (2002)). The parent's productivity shock at age 50 is transmitted to children at age 20 according to the following transition function: $\ln y_1 = \rho_{yh} \ln y_{h,7} + \nu_1$, $\nu_1 \sim N(0, \sigma_{yh}^2)$. I take ρ_{yh} from Zimmerman (1992), and choose σ_{yh}^2 to match the Gini coefficient of 0.44 for earnings.

The down payment ratio θ is set to be 0.2, which is commonly used in the housing literature. Recently some households are allowed to purchase houses without much initial wealth. However, Caplin, Chan, Freeman and Tracy (1997) argue that "it is almost impossible for a household to purchase a home without available liquid assets of at least 10% of the home's value". In addition, what is crucial for my model is the assumption that young and poor households can not borrow beyond the liquidation value of their collateral. I show the effect of the down payment ratio in Section 6.

Since one of my main goals is to look at how transaction costs affect consumption and saving decisions, one key calibration is the type of transaction costs that I choose. Martin (2002) finds that the monetary costs of buying a new home, which include agent fee, transfer fee, appraisal and inspection fee, range on average from 7 to 11 percent of purchase price of a home. Gruber and Martin (2003) estimate the reallocation cost of tax and agency costs from CEX and find the median household pays costs of the order of 7 percent to sell a house and 2.5 percent to purchase. In my simulation, I choose transaction costs from sales to be $\rho_1 = 6\%$, and transaction costs from purchase to be $\rho_2 = 2\%$. These values are lower than the transaction costs reported above, and therefore serve as a lower bound of the effect of transaction costs. I set $\mu_1 = \mu_2 = 0$. That is to say, if the value of the housing stock increases or decreases, I assume that the house has been sold. I show the effect of μ_1 and μ_2 in Section 6.

The social security income P is chosen to be 40% of the average household after tax earnings, a number commonly used in the social security literature. The labor income tax τ_l is chosen to balance government budget.

I take the risk aversion parameter, η, to be 1.5, from Attanasio, Banks, Meghir and Weber (1999) and Gourinchas and Parker (2002), who estimate it from consumption data. This value is in the commonly used range (1-5) in the literature. σ governs the elasticity of substitution between housing and non-housing. Ogaki and Reinhart (1998) use aggregate data and a similar specification, and obtain an estimated $\sigma = 0.145$, not significantly different from zero. I thus choose σ to be 0 so that the momentary utility function $g(c, h)$ takes the Cobb-Douglas form.[10] I show the effect of elasticity of substitution between housing and non-housing in Section 6.

The remaining parameters are chosen so that the model-generated data match a given set of aggregate targets. I choose the discount factor, β, to match the capital-output ratio. The parameter ω is set to match the ratio of non-housing expenditure to housing stock. I use ϕ_1 to match bequest output ratio in the US simulation (Gale and Scholz (1994)). ϕ_2 is chosen to match the ratio of average bequest left by single decedents at the lowest 80th percentile over average household earnings (Hurd and Smith (2001)).

5 Numerical Results

This section studies the implications of the model economy on the life-cycle consumption and wealth profiles, wealth distribution.

5.1 Life-cycle profiles

Now I show the average life-cycle profiles of financial assets, total net worth, non-housing consumption and housing consumption. These averages are obtained by integrating the policy function over the equilibrium distribution of agents, holding age fixed. All figures are normalized by average household earnings.

Figure 8 compares the life-cycle profiles of non-housing and housing consumption in the model with those in the data reported in Figures 3 and 4. In the model, the family size is constant, thus I use the per adult-equivalent non-housing consumption data. I do not adjust family size for housing consumption. Nelson (1988) finds that the economics of scale in shelter is so high that "two can live as cheap as one". I adjust the data so that aggregate

[10] In this case I add a positive number ε so that utility function is well defined at $h = 0$. The term ε is small enough that it does not affect the results. The utility function takes form $g(c, h) = c^{\omega}(h + \varepsilon)^{1-\omega}$.

non-housing consumption is the same in the data as in the model,[11] and the aggregate housing stock is the same in the data as in the model. From Figure 8, we see that average non-housing consumption is hump-shaped and peaks at age 50. Non-housing consumption at age 50 is 80% more than that at age 20. After the peak, non-housing consumption decreases steadily with age. Non-housing consumption at age 50 is 25% more than that at age 75. Facing an increasing future income profile, young agents would like to borrow to finance their current consumption but they are borrowing-constrained. This explains why early in life consumption increases as income does. As households age, they start to decrease their non-housing consumption due to the fact that time preference is higher than the interest rate and mortality rates are increasing along the life cycle. Since there is no perfect annuity market to insure against mortality risk, old agents discount their future consumption at a higher rate. This implies that the consumption profile is declining later in life. Compared with the data, the model under-predicts non-housing consumption between ages 20-30. This may be due to the lack of inter-vivos transfers or housing rental market in the model. Inter-vivos transfers relax borrowing constraints, while a housing rental market allows young households to have high non-housing consumption while renting. For detailed discussions of the implications of those two limitations, see Section 7.

The housing consumption profile in the model reproduces the empirically observed profiles, increasing early in life and downsizing slowly later in life. Households begin their economic lives without any housing stock. During the early part of their lives, because of the existence of borrowing constraints and the role of housing as a collateral, they build housing stock quickly and compromise on non-housing consumption. Agents build up their highest housing stock at age 60, 10 years later than the peak of non-housing consumption. The elderly do not decrease their housing stock later in life.

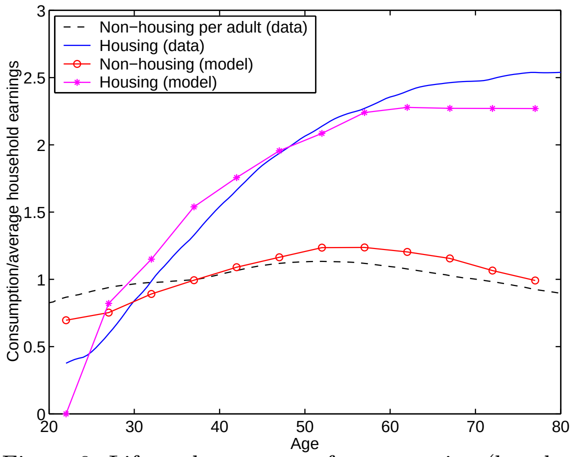

Figure 8: Life-cycle patterns of consumption (benchmark)

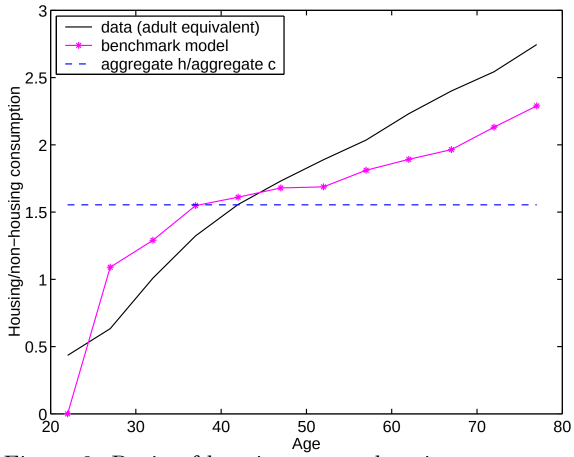

Figure 9: Ratio of housing to non-housing consumption (benchmark)

[11] In the model I match the aggregate consumption with this in the NIPA. Compared with NIPA, CEX underreports consumption% (Attanasio, Battistin and Ichimura (2004)). Thus I adjust for the difference accordingly.

The model also generates the pattern that the ratio of housing to non-housing consumption increases over the life-cycle. Figure 9 compares this ratio in the model and in the data. Early in life, housing consumption increases faster than non-housing consumption. Thus housing to non-housing consumption ratio is upward sloping. This ratio is higher than that in the data, because the model under-predicts non-housing consumption. Later in life housing consumption stays constant while non-housing consumption declines. Thus this ratio continues to increase. This ratio is lower than that in the data, because the model over-predicts non-housing consumption. A parsimonious model without borrowing constraints and transaction costs in trading houses implies a constant ratio of housing to non-housing consumption, which is equal to $\frac{H}{C} = 1.55$. The model accounts for 65.5% of the difference between the constant ratio and the ratios observed in the data.

Moving beyond mean consumption, Figures 10 and 11 plot non-housing consumption and housing consumption at the mean level and at each quartile, respectively. The benchmark economy generates a hump-shaped non-housing consumption at each quartile. We also see that mean consumption is higher than the median at each age, indicating that the distribution at each age group is skewed to the right. We also see increasing housing stock early in life and a flat portion later in life at each quartile. The distribution of housing consumption in each age group is skewed to the right. All of these features are consistent with the data shown in Figures 3 and 5.

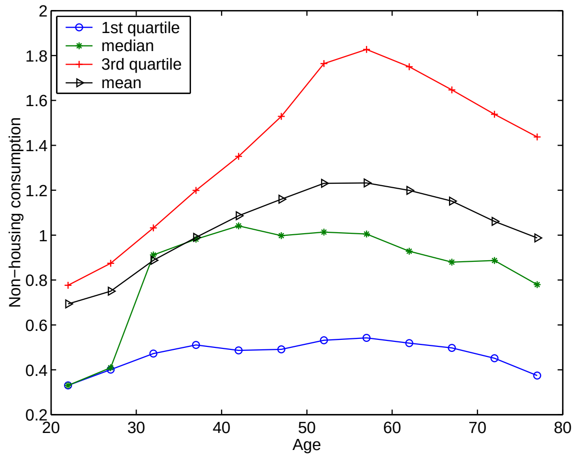

Figure 10: Non-housing consumption (quartiles)

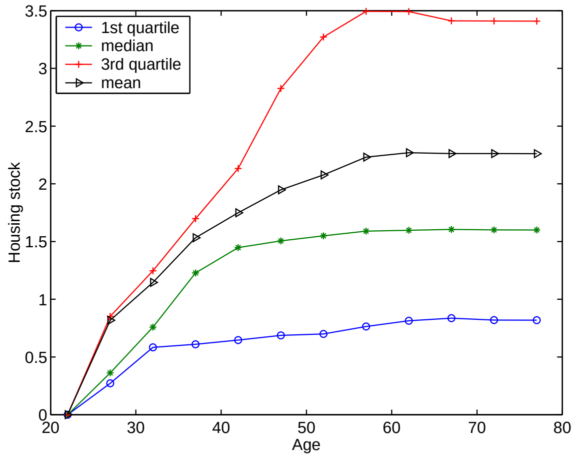

Figure 11: Housing consumption (quartiles)

The introduction of transaction costs forces agents to reduce the frequency of transactions in the housing market. Agents make no change to the stock of the housing unless their non-housing assets and housing stocks are too unbalanced. Figure 12 shows the policy function for housing next period as a function of current non-housing and housing assets for a 70-year-old agent. Given the current housing stock, there is a wide range of non-housing assets within which households do not adjust their housing stock. The inactive region can be defined by two boundaries, $(a_L(h), a_H(h))$. If a household with a housing stock of h holds non-housing assets greater than the upper boundary $a_H(h)$, the household will move to a bigger house next period and hold a smaller fraction of non-housing assets in the wealth portfolio. If instead he/she holds non-housing assets less than the lower boundary $a_L(h)$, the household will move to a smaller house next period and hold a larger fraction of non-housing assets in the wealth portfolio. The size of the inactive region is different according to agents age and income and also is affected by parameters such as the size of the transaction costs. Figure 13 shows the boundaries of the inactive region for a 70-year-old agent and a 65-year-old agent, respectively.[12] Even for relatively small transaction costs, those inactive regions are quite large. One reason that the inactive region for a 65-year-old agent is smaller than a 70-year-old agent is because a 65-year-old agent has a longer life expectancy, which increases the benefit of changing the housing stock.

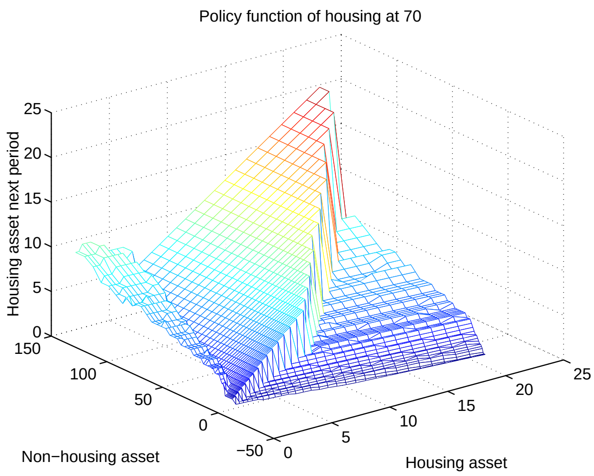

Figure 12: Policy function of housing stock next period for a 70-year-old

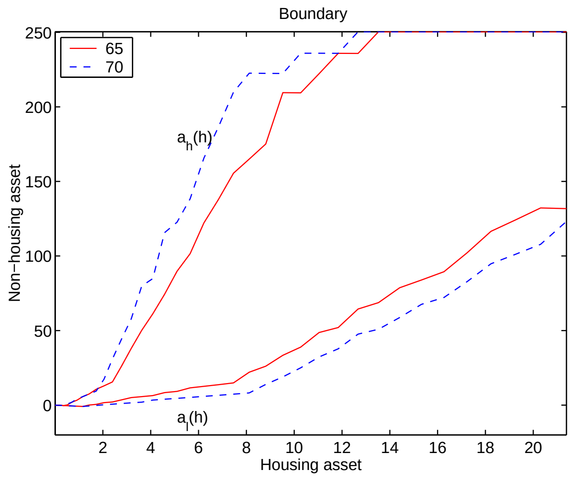

Figure 13: Boundaries of inactive zones

The existence of transaction costs affects young agents and old agents differently. Young households face increasing income profiles and would like to purchase large houses, but they lack of non-housing assets to pay the down payment. As a result, they have to increase their housing stock fairly often. As the households age and their income profile stabilizes, households would keep their level of housing stock unchanged, giving that trading of housing stock would incur transaction costs. Old households are less likely to move than young households, since they can only consume the new house for a relatively short period of time. Table 2 shows the fraction of households moving at the end of each period for each age group. Moving rates by age in the data is taken from Schachter (2001) and are aggregated to five years. We see moving rates decline with age in the model, as in the data. Moving rates in the data are higher than in the model. One reason is that renters are also included in calculating the moving rates, and renters tend to move much more frequently than homeowners. The

[12]Since bequest is modeled as luxury goods, the utility function is not homothetic. Thus the policy functions are not necessarily homogeneous and the boundaries are not strict lines.

other reason is that households move for reasons other than income shocks and aging.

Age	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74
Data	89	86	71	55	55	39	39	30	30	20	20
Model	100	50.3	38.0	20.5	20.9	17.8	20.0	13.6	11.2	3.3	0.0

Table 2: Moving rates by age (in percentage)

Figure 14 displays the evolution of the wealth portfolio over the life cycle. Young agents, who start with zero wealth and expect to have much higher earnings in the future, do not hold much wealth. Early in life households borrow as much as possible to buy houses, and thus save in the form of housing. As time goes by, agents build stocks of houses and start to increase their holding of financial assets. The profile of financial assets and housing assets intersect in their early 40's, as is observed in the data. Wealth holding peaks at age 65, the year before retirement. After retirement, households start to dissave assets to finance consumption. Compared with the data reported in Figure 6, the wealth profile and assets profile have humps that are more pronounced. Since I abstract from health expenditure uncertainty or other shocks, old agents in my model do not have precautionary saving motives and run down their assets more quickly than in the data.

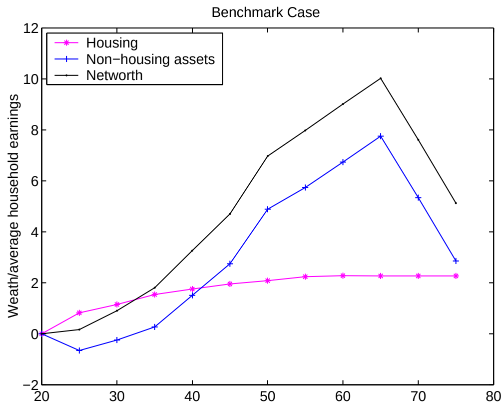

Figure 14: Life-cycle patterns of wealth composition

5.2 Wealth distribution

Table 3 reports the distribution of total, housing and financial wealth for my benchmark economy. The US wealth distribution is calculated from 1998 SCF. In the data wealth is highly unevenly distributed with a Gini coefficient of 0.80. The top 1% of the households hold 34% of the total wealth and the 95-99% of the households hold 24% of the total wealth. Housing is more evenly distributed than net worth with a Gini coefficient of 0.63. The top 1% of the households hold 11% of the total housing wealth and the 95-99% of the households hold 17% of the total housing wealth. Financial assets are more unevenly distributed than net worth with a Gini coefficient of 0.99. The top 1% of the households hold 46% of the total financial wealth and the 95-99% of the households hold 28% of the total financial wealth.[13]

	Gini	1st	2nd	3rd	4th	5th	90-95	95-99	99-100
Total wealth									
U.S. data	0.80	-0.28	1.35	5.14	13.00	81.59	11.48	23.72	33.65
Model	0.74	0.13	0.67	4.04	17.35	77.81	19.91	25.12	10.00
Housing									
US data	0.63	0	1.09	13.66	24.10	61.15	13.87	17.12	11.32
Model	0.48	1.73	8.39	14.71	24.59	50.58	13.02	11.79	3.74
Financial wealth									
US data	0.99	-6.00	-0.12	1.26	7.23	97.64	11.98	28.20	46.35
Model	0.86	-6.07	-2.68	-0.29	12.32	96.71	24.51	33.70	14.07

Table 3: Wealth distribution

The benchmark model matches the distribution of wealth, housing and financial wealth quite well, with the exception of top 1%. It also replicates the empirical finding that inequality in financial assets is much higher than housing. This is because households are allowed to borrow against housing, so financial assets can be negative but the housing stock can not be. Also for households that are not borrowing-constrained, the return to housing, namely the marginal utility of housing, is decreasing, while the return to financial assets, the interest rate, is constant. Thus housing as the fraction of net worth is decreasing.

The model also does a good job at matching the bequest distribution. Details are available from the author.

6 Decomposition

Given that the benchmark model does a good job in generating the different patterns of housing and non-housing consumption and the evolution of asset composition, it is useful to investigate how each ingredient of the model affects the results. I change one parameter at a time, keeping other parameters as in the benchmark economy. To measure the evolution of consumption and assets over the life cycle, I report the level at the peak relative to that at age 25 and age 75. The peak of non-housing consumption, housing consumption, and financial assets is reached at age 50, 60 and 65, respectively. I also show the ratio of housing to financial assets at age 65.

6.1 Transaction cost

Now I investigate the effects of transaction costs on household consumption and asset holding by setting the costs to 0. Figure 15 compares the ratio of housing to non-housing consumption in the model with and without transaction costs. The ratio is increasing early in life because of the existence of borrowing constraints. Without transaction costs, the ratio increases

[13] All Gini coefficients are calculated without replacing the negative numbers with zeros. If I replace the negative numbers with zeros, then the Gini coefficients become slightly smaller.

faster. Later in life when borrowing constraints are less likely to be binding, a model without transaction costs implies a flat pattern of the ratio of housing to non-housing consumption.

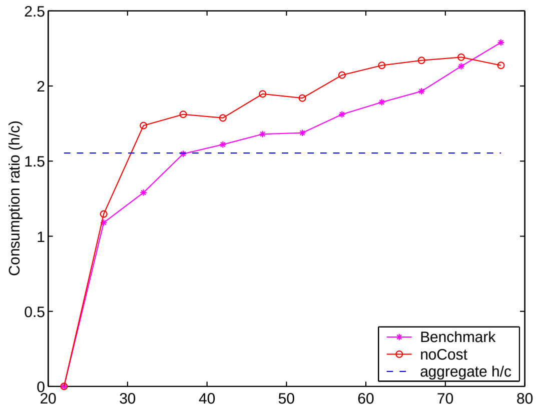

Figure 15: Ratio of housing to non-housing consumption (no transaction costs: $\rho_1 = \rho_2 = 0\%$)

Line three in Table 4 shows that in a model without transaction costs, housing consumption at age 60 relative to age 75 is higher than the benchmark model. This shows that the transaction costs play an important role in explaining the slow decline of housing consumption later in life. We also see that a household's portfolio shifts from financial assets to housing assets. The reason is that, removing transaction costs makes housing assets more attractive. The evolution of the financial assets over the life cycle is similar to that in the benchmark case.

1		c_{50}/c_{25}	c_{50}/c_{75}	h_{60}/h_{25}	h_{60}/h_{75}	h_{65}/a_{65}	a_{65}/a_{25}	a_{65}/a_{75}
2	Benchmark	1.64	1.25	2.78	1.0	0.29	-11.8	2.72
3	$\rho_1 = \rho_2 = 0\%$	1.61	1.24	2.93	1.21	0.34	-10.5	2.75
4	$\mu_1 = \mu_2 = 15\%$	1.65	1.24	2.64	1.09	0.31	-10.9	2.62
5	$\phi_1 = 0$	1.6	1.33	2.79	1.02	0.36	-9.54	9.69
6	$\phi_1 = -22$	1.72	1.25	2.96	1.0	0.24	-15.6	1.74
7	$\theta = 0$	1.67	1.25	2.25	0.99	0.31	-7.43	2.89
8	$\theta = 0.4$	1.61	1.24	3.68	1.01	0.29	-20.9	2.69
9	$\sigma = -0.2$	1.68	1.24	3.35	1.01	0.34	-12.2	2.81
10	$\sigma = 0.2$	1.61	1.25	2.39	1.0	0.23	-15	2.58
11	P=0	1.61	1.28	2.65	1.01	0.19	-17.7	2.42

Table 4: Decomposition

6.2 Remodeling-maintenance option

Now I give agents the remodeling-maintenance option. I set $\mu_1 = \mu_2 = 15\%$ (which is equal to the depreciation rate in 5 years). That is to say, households can change their level of housing consumption by allowing depreciation up to 15% the value of the house or by undertaking housing renovation up to a fraction of 15% the value of the house as an alternative to moving.

The results are summarized in line four in Table 4. As an alternative to moving, young households increase housing consumption by remodeling their houses, so that housing consumption at age 60 relative to age 25 is lower than the benchmark model. At the last period, elderly households allow the house to depreciate, so that housing consumption at age 60 relative to age 75 is higher than the benchmark model.

6.3 Bequest motive

Line five in Table 4 shows the results from a model without voluntary bequest motives ($\phi_1 = 0$). Consumption at age 50 relative to age 75 is higher. This is because without bequest motive the marginal return from postponing consumption is smaller. The profile of housing consumption, however, have a similar shape as in the benchmark economy. Thus bequest motives are not the key factor explaining the slow downsizing of housing stock later in life for the average household. The intuition is that the household faces transaction costs to downsize his/her housing stock, but can run down his/her financial assets without any costs. Without bequest motives, he/she chooses to run down his/her net worth completely by the time he/she expects to be dead for sure. The best way to do this is by running down his/her financial assets, rather than by trading the large house he/she lives in to a smaller one and paying large transaction costs in the process.[14]

Line five in Table 4 shows that the bequest motives play an important role in determining the evolution of financial assets. Without bequest motive, accidental bequest received is much smaller thus the ratio of financial assets relative to housing assets at age 65 is much lower than that in the benchmark economy. Without bequest motive, households in the late age run down their assets more dramatically.

Since the bequest-output ratio reported in Gale and Scholz (1994) is a low estimate of the magnitude of the bequest motives, I present in line six in Table 4 the results from a model with stronger voluntary bequest motives ($\phi_1 = -22$). This raises bequests thus the ratio of financial assets relative to housing assets at age 65 is much higher. With stronger bequest motive, households in the late age run down their assets more slowly.

6.4 Down payment

Now I check the effect of the borrowing constraints on consumption paths and wealth paths by changing down payment ratio. If the down payment ratio is low, then young households are more likely to move into big houses by holding more financial debt. Housing consumption is higher and financial debt is bigger early in life. As a result, housing consumption at age 60 relative to age 25 and financial assets at age 65 relative to age 25 are smaller compared with the benchmark (line seven in Table 4).

[14]In the model, mortgages and deposits are perfect substitutes therefore the net mortgage position is indeterminant. The fact that households run down their financial assets does not necessary mean that households are borrowing against their houses using reverse mortgage products. The fraction of households aged 65 and above who hold wealth more than the value of the house are still pretty high, around 70% in the benchmark economy, and 67% in the case without bequest motive.

On the contrary, when the down payment ratio is high, young households have to wait longer to accumulate financial assets to pay higher down payments. Housing consumption is lower and financial debt is smaller early in life. As a result, housing consumption at age 60 relative to age 25 and financial assets at age 65 relative to age 25 are bigger compared with the benchmark (line eight in Table 4). These results show that borrowing constraints are essential in explaining the accumulation of housing assets early in life.

6.5 Elasticity of substitution between housing and non-housing consumption

When the elasticity of substitution between the housing and non-housing consumption is lower, households accumulate housing assets faster.[15] Line nine in Table 4 shows that when the elasticity of substitution is 0.83 ($\sigma = -0.2$), housing consumption at age 60 relative to age 25 is higher than the benchmark. Later in life, non-housing consumption declines, but transaction costs for trading houses prevent households from downsizing houses despite the low elasticity.

When the elasticity of substitution is high, households could substitute more easily between non-housing and housing goods, thus they shift consumption from housing to non-housing and portfolio from housing to financial assets.[16] Line ten in Table 4 shows the results when the elasticity of substitution is 1.25 ($\sigma = 0.2$). The accumulation of housing is slower when the elasticity is high.

6.6 Pay-as-you-go social security system

Line eleven in Table 4 shows results for an economy without a social security system. Non-housing consumption at age 50 relative to age 75 is higher, indicating that consumption declines slightly faster without social security, an annuity against mortality risk. Abandoning a social security system encourages private saving for retirement, thus financial assets at retirement age is much higher than in the benchmark case, and household's portfolio shifts to financial assets at age 65.

7 Conclusions

I develop a quantitative and realistically calibrated dynamic general equilibrium model to solve numerically for the optimal housing and non-housing consumption decisions for a finitely-lived individual who faces several market frictions. The model is able to match two basic

[15] In the extreme case where housing and non-housing are perfect complements ($\sigma = -\infty$), agents would like to consume non-housing goods and housing goods in the same proportion.

[16] In the extreme case where housing and non-housing are perfect substitutes ($\sigma = 1$), agents will consume non-housing goods but no housing goods. One reason is that the net worth is bounded below by fraction θ of the value of houses, thus a bigger house implies a tighter borrowing constraint.

patterns observed in the data: the hump-shaped non-housing consumption profile and non-hump-shaped housing consumption profile. Households begin their economic lives without any housing stock. During the early part of their lives, they are forced to build housing stock and compromise on non-housing consumption. As households age, they start to decrease their non-housing consumption due to the fact that the time preference is higher than the interest rate and mortality rates are increasing along the life cycle. The high transaction costs for trading houses prevent households from decreasing their housing stock quickly later in life.

The model is also able to capture the life-cycle wealth portfolio profiles. In the US, young households virtually own no liquid financial assets, but hold a major fraction of their wealth as housing. Later in life, households shift their portfolios to financial assets.

In this paper I have abstracted from some important issues in order to make the model manageable and solvable. Now I discuss these simplifications and their likely quantitative implications.

One important assumption is that there are no inter-vivos transfers. In the data, parents tend to give children money when they need money the most, although data from Health and Retirement Study suggests that these transfers are fairly small (Cardia and Ng (2000)). Allowing for inter-vivos transfers would make young households have higher housing and non-housing consumption.

Another important assumption that I make is that there is no housing rental market. Venti and Wise (2004) show that housing ownership stays flat after age 30, and discontinuing home ownership is the exception rather than the rule. Thus the rental market is probably relevant for young households but less relevant for middle and old age households.

I assume that there is no cost of borrowing using housing as collateral. Hurst and Stafford (2003) explore the use of equity as a mechanism by which households smooth their consumption over time. Their analysis assumes households have fixed housing stocks and focuses on the impact of temporary income shocks on refinancing decisions. It would be interesting to extend my model to look at the effect of income shocks on households moving decisions and refinancing decisions jointly.

I assume that the elderly do no face any health shocks. Even in the presence of social insurance (Medicare and Medicaid), households can face substantial out-of-pocket medical expenses (French and Jones (2004), Palumbo (1999) and Feenberg and Skinner (1994)) and uninsurable nursing home expenses (Cohen, Tell and Wallack(1986)). The risk of incurring such medical expenses might generate precautionary savings and affect the wealth profile (De Nardi, French and Jones(2005)). The effect of medical costs on the life-cycle consumption and saving in an environment with housing is left for future research.

8 Appendix

8.1 Estimation procedure

This appendix describes data sources and explains the non-parametric regression used to construct life-cycle profiles reported in section 2.

The CEX is the only micro-level data set reporting comprehensive measures of consumption expenditure for a large cross-section of households in the US. I use the Interview Survey which is designed to collect data on major items of expense, household characteristics, and income. I construct synthetic cohorts by using 16 longitudinal annual surveys of the CEX (1986-2001). I use the age of the reference person to define 10 cohorts with a length of 5 years, starting from age 20, and follow them through the whole sample, generating a panel. For example, the households born between 1961-1966 were 20-25 years old in 1986. The pseudo panel approach treats the 21-26 year-old households in the 1987 wave as if they were the same people as the 20-25 year-old in the 1986 data. The data on "expenditure on non-housing consumption" include food, alcoholic beverages, tobacco, personal care, utilities, household operations, household furnishings and equipment, transportation, books and electronic equipment, apparel, out-of-pocket health expenditure, entertainment and miscellaneous expenditures. Only households with positive consumption expenditure and all the necessary demographic information for household size adjustment are selected. Non-housing data is deflated to be in 1986 dollars using the CPI price index for non-durables.

I take non-housing consumption expenditure from the CEX and the demographic information of the household, and adjust consumption using the equivalence scales. I use the same equivalence scales as Fernandez-Villaverde and Krueger (forthcoming), which are close to the equivalence scales used in the literature. Table 5 shows the equivalence scales I use.

Family Size	1	2	3	4	5
Equivalence scales	1	1.34	1.65	1.97	2.27

Table 5: Equivalence scales

The SCF, sponsored by the Federal Reserve Board and conducted by the University of Michigan and the National Opinion Research Center, has become the main source of microeconomics data on wealth for the US. It is conducted triennially and collects detailed information about wealth for a cross section of households, and unfortunately, it only includes a limited, small, panel between 1983 and 1989. To provide a more accurate measure of wealth inequality, the SCF over-samples rich households by including samples drawn from tax records. Standard weights are used. The survey defines wealth as owner-occupied housing, other real estate, cash, financial securities, unincorporated business equity, insurance and pension cash value, miscellaneous assets less mortgages, and other debt. Consumer durables and housing inventories are not measured in the survey data.

As in Fernández-Villaverde and Krueger (forthcoming), I control for cohort, time, and age effects by employing a semi-nonparametric partially linear model. Since there are no obvious patterns for the time and cohort effects, dummy variables seem to be appropriate. On the other hand, consumption and wealth changes along the life cycle are the main focus of my paper; I thus choose to model age effect non-parametrically. This procedure provides efficiency advantages in estimating age profiles compared to the use of dummy variables, yet is tractable and relatively straightforward to implement.

In particular, I specify the following partially linear model to control for age, cohort and time effects,

$$w_{it} = \beta + \pi_i cohort_i + \pi_t \gamma_t + m(age_{it}) + \varepsilon_{it},$$

where w_{it} is the variable that I am interested in, $cohort_i$ is a dummy for each cohort, γ_t is a dummy for each year and age_{it} is the age of cohort i at time t. $m(age_{it})$ is a smooth function of age_{it}, and I assume that this function represents a smooth unparametrized functional relationship. The error terms ε_{it} capture measurement error in assets as well as unobserved cross-sectional heterogeneity and are assumed to be uncorrelated with zero mean and variance σ.

I estimate the partially linear model using the two-step estimator proposed by Speckman (1988). The nonparametric component is estimated using a Nadaraya-Watson estimator. The kernel chosen in Nadaraya-Watson estimator is an Epanechnikov kernel. Details of the estimation are available in Yang (2006).

8.2 Consumption ratio in a standard life-cycle model

Given budget constraints, a household chooses c_t, a_{t+1}, h_{t+1} to maximize its expected lifetime utility,

$$\max_{c_t,a_{t+1},h_{t+1}} \{\sum_{t=1}^{T} \beta^t E(s_{t-1}U(c_t,h_t) + (1-s_t)V(h_{t+1}+a_{t+1}))\}$$

subject to

$$c_t + a_{t+1} + h_{t+1} = y_t + (1+r)a_t + (1-\delta^h)h_t \tag{15}$$

$$c_t \geq 0, h_{t+1} \geq 0, \tag{16}$$

where c_t is consumption of non-housing assets at age t, a_{t+1} is non-housing assets at age $t+1$, h_{t+1} is housing stock at age $t+1$, y_t is stochastic labor income at age t, s_t is the probability of surviving up to age t, where s_0 is 1, r is the interest rate, δ^h is depreciation rate of housing stock, V is the utility from leaving bequest to the kids, while $V = 0$ implies no bequest motives.

Theorem 1: The ratio of consumption of housing to non-housing goods should be age-independent.

Proof of Theorem 1: Utility maximization implies that the following first order conditions hold:

$$[c_t]: \quad \beta^t s_{t-1}U_1(c_t,h_t) = \lambda_t \tag{17}$$

$$[a_{t+1}]: \quad \beta^t(1-s_t)V'(a_{t+1}+h_{t+1}) + (1+r)E_t\lambda_{t+1} = \lambda_t \tag{18}$$

$$[h_{t+1}]: \quad \beta^t(1-s_t)V'(a_{t+1}+h_{t+1}) + \beta^{t+1}s_tE_tU_2(c_{t+1},h_{t+1}) + (1-\delta^h)E_t\lambda_{t+1} = \lambda_t. \tag{19}$$

Therefore from equation (18) and (19), we get

$$\beta^{t+1}s_tE_tU_2(c_{t+1},h_{t+1}) = (r+\delta^h)\beta^{t+1}s_tE_tU_1(c_{t+1},h_{t+1}). \tag{20}$$

Which implies that

$$\frac{E_tU_2(c_{t+1},h_{t+1})}{E_tU_1(c_{t+1},h_{t+1})} = (r+\delta^h). \tag{21}$$

After retirement, households do not face income risk so equation (21) takes the deterministic form.

If we assume

$$U(c,h) = \frac{g(c,h)^{1-\eta}-1}{1-\eta} \tag{22}$$

$$g(c,h) = (\omega(c)^\sigma + (1-\omega)h^\sigma)^{\frac{1}{\sigma}}, \tag{23}$$

then the ratio of housing to non-housing consumption is independent of age t

$$\frac{h}{c} = (\frac{(r+\delta^h)\omega}{(1-\omega)})^{\frac{1}{\sigma-1}}. \tag{24}$$

The above model implies that the ratio of consumption of housing to non-housing goods should not be age-dependent. The implication of the above model is not consistent with the facts that later in life consumption of housing is flat while consumption of non-housing goods is declining.

8.3 Definition of the stationary equilibrium

I focus on an equilibrium concept where factor prices are constant over time, capital and labor are constant in per capita terms, and the age-wealth distribution is stationary over time. Each agent's state is denoted by x. An equilibrium is described as follows.

Definition 1 *A stationary equilibrium is given by government policies τ_l, P; an interest rate r and a wage rate w; value functions $V(x)$, allocations $c(x)$, $a'(x)$, $h'(x)$; a family of probability distributions for bequests $\mu_b(x;:)$ for a person with state x; and a constant distribution of people over the state variables x: $m^*(x)$, such that the following conditions hold:*

(i) Given the government policies, the interest rate, the wage, and the expected bequest distribution, the functions $V(x)$, $c(x)$, $a'(x)$, and $h'(x)$ solve the above described maximization problem for a household with state variables x.

(ii) m^* is the invariant distribution of households over the state variables for this economy..[17]

(iii) All markets clear.

$$\begin{aligned} K &= \int am^*(dx),\ H = \int hm^*(dx),\ C = \int cm^*(dx), \\ L &= \int \epsilon ym^*(dx),\ Tc = \int \tau\left(h', h\right) m^*(dx), \\ F(K;L) &= C + (1+n)K - \left(1-\delta^k\right)K + (1+n)H - ((1-\delta^h)H - Tc). \end{aligned}$$

(iv) The price of each factor is equal to its marginal product.

$$r = F_1(K,L) - \delta^k,\ w = F_2(K,L).$$

(v) The family of expected bequest distributions is consistent with the bequests that are actually left by the parents.[18]

(vi) Government budget is balanced at each period.

8.4 Transition function

From the policy rules and the exogenous Markov process for productivity, we can derive a transition function $\widetilde{M}(x;\cdot)$, which is the probability distribution of x' (the state in the next period), conditional on x, for a person who behaves according to the policy rules $c(x)$, $a'(x)$ and $h'(x)$. Let $\mathcal{P}$ be the cardinal set of $\{1,...,T\}$ and D indicates that a person is dead, and $\mathbb{W} = \{(a,h) \in \mathbb{R} \times \mathbb{R}_+ : a \geq -(1-\theta)h\}$. The measurable space over which $\widetilde{M}$ is defined is $(\widetilde{X}, \mathfrak{B}(\widetilde{X}))$, with

$$\begin{aligned} X &= \{1,...,T\} \times \mathbb{W} \times Y \times (Y \cup \{0\}) \\ \mathfrak{B}(X) &= \mathcal{P}(\{1,...,T\}) \times \mathfrak{B}(\mathbb{W}) \times \mathfrak{B}(Y) \times \mathfrak{B}(Y \cup \{0\}) \\ \widetilde{X} &= X \cup D \\ \mathfrak{B}(\widetilde{X}) &= \{x : x = X \cup d, X \in \mathfrak{B}(X), d \in (\phi, D)\}), \end{aligned}$$

To characterize $\widetilde{M}$, it is enough to display it for the sets $L(\overline{t},\ \overline{a},\ \overline{h},\ \overline{y},\ \overline{yp}) = \{(t', a', h', y', yp') \in$

[17] I normalize m^* so that $m^*(X) = 1$, which implies that $m^*(\chi)$ is the fraction of people alive that are in a state χ. Appendix 8.4 describes the calculation of invariant distribution in greater detail.

[18] Appendix 8.5 describes the consistency of bequest distribution in greater detail.

$X : t' \leq \bar{t}, a' \leq \bar{a}, h' \leq \bar{h}, y' \leq \bar{y}, yp' \leq \overline{yp}\}$. On such sets $\widetilde{M}$ is defined by

$$\begin{aligned}
&\widetilde{M}(x, L(\bar{t}, \bar{a}, \bar{h}, \bar{y}, \overline{yp})) \\
= &\begin{cases} p_t I_{t+1 \leq \bar{t}} Q_y(y, [0, \bar{y}] \cap Y) I_{h'(x) \leq \bar{h}} \{ I_{a'(x) \leq \bar{a}} (I_{yp=0} + I_{yp \leq \overline{yp}} p_{t+6}) \\ \quad + \mu_b(x : [0, \bar{a} - a'(x)](1 - p_{t+6}) I_{yp>0} \}, & \text{if } x \neq D \\ 0, & \text{if } x = D, \end{cases}
\end{aligned}$$

where I is an indicator function, which equals one if the subscript property is true and zero otherwise.

In the above equation, p_t is the probability of surviving into the next period. The presence of $I_{t+1 \leq \bar{t}}$ shows that conditional on survival, a person currently at age t will be at age $t + 1$ next period. The person's evolution of productivity is described by Qy. Note that the evolution of productivity, a person's survival, and the survival of the person's parent are independent of each other. If the person's parent is already dead, that is, $yp = 0$, the person cannot receive bequests anymore, and his or her assets next period are $a'(x)$ for sure. (As discussed above, this is always the relevant case for people younger than 30 or older than 50.) If, instead, the parent is still alive, that is, $yp > 0$, the parent can survive into the next period with probability p_{t+6}. In that case, tomorrow's assets for the person will be $a'(x)$ and $yp' = yp$. Alternatively, the parent may die, with probability $1 - p_{t+6}$. In this case, the person inherits next period, $yp' = 0$, and the probability that next period's assets are no more than $\bar{a}$ is the probability of receiving a bequest between 0 and $\bar{a} - a'(x)$. The last line shows that death is an absorbing state.

In the economy as a whole, I am not interested in keeping track of dead people, so I will define an operator on measures on $(X, \mathfrak{B}(X))$. Furthermore, I must take into account that new people enter the economy in each period. The transition function is defined as

$$M(x, L(\bar{t}, \bar{a}, \bar{h}, \bar{y}, \overline{yp})) = \frac{\widetilde{M}(x, L(\bar{t}, \bar{a}, \bar{h}, \bar{y}, \overline{yp})) + n^6 I_{t=6} Q_{yh}(y, [0, y] \cap Y) I_{y=yp'}}{n}. \tag{25}$$

The transition function M differs from $\widetilde{M}$ in two ways. First, it accounts for population growth: when population grows at rate n, a group that is 1% of the population becomes $1/(1+n)$% in the subsequent period. Second, it accounts for births, which explains the second term in the numerator. If a person is 50 years old ($t = 7$), that person's children (there are $(1 + n)^6$ of them) will enter the economy next period. All of those children have age $t = 1$ and zero assets and zero housing. Their stochastic productivity is inherited from their 50-year-old parents, according to the transition function Q_{yh}. y is their parent's productivity at 50.

Let i^* be the invariant distribution of earnings at age 20 and parent's earnings at age 50. The invariant distribution is defined recursively as following:

$$\begin{aligned}
m^*(\{0\} \times \chi \times \{0\} \times \{0\}) &= i^*(\chi) && \forall \chi \in \mathfrak{B}(Y) \times \mathfrak{B}(Y \cup \{0\}) \\
m^*(\{0\} \times \chi \times \mathbb{W} \setminus \{\{0\} \times \{0\}\}) &= 0 && \forall \chi \in \mathfrak{B}(Y) \times \mathfrak{B}(Y \cup \{0\}) \\
m^*(\{t+1\} \times \chi) &= \int M(x, \chi) m^*(\{t\} \times dx) && \forall t > 1, \forall \chi \in \mathfrak{B}(\mathbb{W}) \times \mathfrak{B}(Y) \times \mathfrak{B}(Y \cup \{0\}).
\end{aligned}$$

8.5 Consistency of bequest distributions

I want to calculate the distribution $l(\cdot|t, y)$ of parents at age 50-80, conditional on the parent's productivity at age 50 and conditional on being alive. First I define $m^*_{t,y}$ as the marginal distribution of x given age t and productivity y as

$$m^*_{t,y}(\chi_{t,y}) = m^*(x \in X : (t, y) \in \chi_{t,y}) \quad \forall \chi_{t,y} \in \mathcal{P}(\{1, ..., T\}) \times \mathfrak{B}(Y). \tag{26}$$

Next I define $m^*(\cdot|t,y)$ as a probability distribution on $(X,\ \mathfrak{B}(X))$ for any given (t,y). For any $\chi \in \mathfrak{B}(X)$, $m^*(\cdot|t,y)$ is measurable with respect to $\mathcal{P}(\{1,...,T\}) \times \mathfrak{B}(Y)$ and is such that

$$\int_{\chi_{t,y}} m^*(\cdot|t,y) m^*_{t,y}(dt,dy) = m^*(\chi) \quad \forall \chi \in \mathfrak{B}(X)\ \forall \chi_{t,y} \in \mathcal{P}(\{1,...,T\}) \times \mathfrak{B}(Y).$$

The children observe the parent's productivity at age 50. Therefore the conditional distribution of the parent at age 50 at productivity level y_p is $m^*(\cdot|t=7, y=y_p)$. Therefore $l(\chi|t=7, y=y_p) = m^*(\chi|t=7, y=y_p)$ and recursively using the transition function $\widetilde{M}$ defined in the section above, we define

$$l(\chi|t+1, y_p) = \frac{\int_X \widetilde{M}(x,\chi) l(dx|t, y_p)}{p_t}. \tag{27}$$

Since the bequest is evenly distributed among children, the probability distributions for bequests $\mu_b(x;:)$ for a person with state $x = (t,a,h,y,yp)$ is given by

$$\begin{aligned} \mu_b(x &: \chi) = l(a \in \mathbb{R}_+, h \in \mathbb{R}_+ : ((1+n)^6 a + (1+n)^6 (h(1-\rho_1)) \in \chi | t+6, y_p) \\ \forall \chi &\in \mathfrak{B}(\mathbb{R}_+),\ \forall a,h \in \mathbb{W}\ \forall y, yp \in \mathfrak{B}(Y). \end{aligned}$$

8.6 Computation of the model

Since I introduce the non-convex transaction costs on housing, I could not use Euler equation approximation or policy function iteration. Hence I solve the model using approximation of value functions.

I first discretize income process and income inheritance process following Tauchen and Hussey (1991). The state space for housing and asset holdings are discretized. The upper bounds on the grids are chosen large enough so that they do not constitute a constraint on the optimization problem. Using these grids I can store the value functions and the distribution of households as finite-dimensional arrays.

I solve the approximated optimal consumption and saving plans recursively. Households surviving to the last period T has an easy problem to solve. Based on the period T policy functions, I solve the consumption and saving decisions that maximize the period $T-1$ value function. The same procedure is carried back until decision rules in the first period are computed for a large number of states.

I solve for the steady state equilibrium as follows:

1. Given an initial guess of interest rate r, use the equilibrium conditions in the factor markets to obtain the wage rate w.
2. Set the interval for housing and assets.
3. Guess an initial bequest distribution.
4. Set value function after the last period to be 0 and solve the value function for the last period of life for each of the points of the grid. This yields policy functions and value function at the last period.
5. By backward induction, repeat step 4 until the first period in life.
6. Compute the associated stationary distribution of households by forward induction using the policy functions starting from the known distribution over types of age.
7. Given the stationary distribution and policy functions, compute the bequest distribution. If the bequest distributions converges, go to step 8; otherwise go to step 3.
8. Check if the distributions of housing and assets do not have a large mass at the maximum levels. If so, increase the maximum level and go back to step 2. If not, continue to step 9.
9. Given the stationary distribution and prices, compute factor input demands and supplies and check market clearing conditions hold. If all markets clear, an equilibrium is found. If not, go to step 1 and update interest rate r.

8.7 Calibration

I calibrate my model following Cooley and Prescott (1995) and Diaz and Luengo-Prado (2003). I use data from the National Income and Product Accounts and the Fixed Assets Tables for the year 1959-2001. In order to properly calibrate a model with two assets and without government taxes and expenditures, I make some imputations.

I define measured GDP as the sum of each final expenditures:

$$GDP = (c + sh + i_{cd} + c_g) + (i_{prk} + i_{pnrk} + i_g) + nx + \triangle inv, \tag{28}$$

where c, sh, i_{cd} and c_g are expenditures on non-housing and service excluding housing, housing services, expenditures on consumer durables, government consumption expenditures, respectively. Thus $c+sh+i_{cd}+c_g$ are total consumption expenditure. i_{prk}, i_{pnrk} and i_g are total private residential investment, nonresidential investment and government investment, respectively. Thus $i_{prk}+i_{pnrk}+i_g$ are total investment. I also write GDP as the sum of wages plus rents of residential and nonresidential stocks of capital:

$$GDP = we + prk \cdot r_{prk} + pnrk \cdot r_{pnrk}.$$

To explicitly consider the existence of residential housing I rearrange output as

$$GDP = (c + i_{cd} + c_g) + sh + i_{prk} + (i_{pnrk} + i_g + nx + \triangle inv). \tag{29}$$

Since there is no rental market in this model, I subtract rental income from residential housing from GDP.

$$\begin{aligned} Y &= we + pnrk \cdot r_{pnrk} = GDP - sh \\ K &= pnrk + inv + g \\ H &= prk \\ i_h &= i_{prk}, \end{aligned}$$

where K includes private fixed non-residential assets and government fixed non-residential assets, H includes private fixed residential assets and government fixed residential assets.

I define unambiguous capital income (UCI) as rental income, corporate profits and net interest, and define ambiguous capital income (ACI) as other income excluding wage and depreciation. Thus capital income Y_k is defined as UCI+α·ACI+depreciation-sh=$\alpha \cdot Y$. Subtracting housing from output, the share of capital is calibrated as

$$\alpha = (UCI + dep - sh)/(Y - ACI). \tag{30}$$

I compute an average share of capital $\alpha = 0.2261$, an average capital-output ratio $\frac{K}{Y} = 1.9887$, an investment-capital ratio $\frac{i_k}{k} = 0.082$, a housing stock to output ratio $\frac{H}{Y} = 1.2141$, an investment-housing stock ratio $\frac{i_h}{H} = 0.041$ and a non-housing to housing investment ratio $\frac{C}{i_h} = 15.9443$. The implied depreciation rates is $\delta^k = \frac{i_k}{k} - n = 0.07, \delta^h = \frac{i_h}{H} - n = 0.0294$, interest rate net of depreciation in a steady state is $r = \alpha\frac{Y}{K} - \delta^k = 4.37\%$.

References

[1] Alessie, Rob, Michael P. Devereux, and Guglielmo Weber, "Intertemporal Consumption, Durables and Liquidity Constraints: A Cohort Analysis," *European Economic Review*, 41 (1997), 37-59.

[2] Altonji, Joseph G., and Ernesto Villanueva, "The Effect of Parental Income on Wealth and Bequests," NBER working paper No. 9811, 2002.

[3] Attanasio, Orazio, James Banks, Costas Meghir and Guglielmo Weber, "Humps and Bumps in Lifetime Consumption," *Journal of Business and Economics,* 17 (1999), 22-35.

[4] ———, Erich Battistin and Hidehiko Ichimura, "What Really Happened to Consumption Inequality in the US?" NBER Working Paper No. 10338, 2004.

[5] ———, Pinelopi K. Goldberg and Ekaterini Kyriazidou, "Credit Constraints in the Market for Consumer Durables: Evidence from Micro Data on Car Loans," NBER Working Paper No. 7694, 2000.

[6] ——— and Guglielmo Weber, "Is Consumption Growth Consistent with Intertemporal Optimization? Evidence for the Consumer Expenditure Survey," *Journal of Political Economy* 103 (1995), 1121-1157.

[7] Beaulieu, Joseph J., "Optimal Durable and Nondurable Consumption with Transactions Costs," Federal Reserve Board Finance and Economics Discussion Series, April 1993.

[8] Bell, Felicitie C., Alice H. Wade and Stephen C. Goss, "Life Tables for the United States Social Security Area 1900-2080," Actuarial Study No. 107, US Department of Health and Human Services, Social Security Administration, Office of the Actuary, August 1992.

[9] Bennett, Paul, Richard Peach and Stavros Peristiani, "Structural Changing in the Mortgage Market and the Propensity to Refinance," *Journal of Money, Credit and Banking*, 33 (2001), 955-75.

[10] Blundell, Richard, Martin Browning and Costas Meghir, "Consumer Demand and the Life-Cycle Allocation of Household Expenditures," *Review of Economic Studies,* 61 (1994), 57-80.

[11] Browning, Martin, and Mette Ejrnæs, "Consumption and Children," Centre for Applied Microeconometrics Working Paper, 2002.

[12] Brugiavini, Agar, and Guglielmo Weber, "Durable and Nondurable Consumption: Evidence from Italian Household Data," IFS Working Paper 92/13, 1992.

[13] Bullard, James and James Feigenbaum, "A Leisurely Reading of the Life-cycle Consumption Data," Working Paper, 2004.

[14] Caplin, Andrew, Sewin Chan, Charles Freeman and Joseph Tracy, *Housing Partnerships: A New Approach to a Market at a Crossroads* (Cambridge: MIT Press, 1997).

[15] Cardia, Emanuela, and Serena Ng, "How Important are Intergenerational Transfers of Time? A Macroeconomic Analysis," Working paper, 2000.

[16] Carroll, Christopher D., "Buffer-Stock Saving and the Life-Cycle/Permanent Income Hypothesis," *Quarterly Journal of Economics*, 112 (1997), 1-55.

[17] ——— and Lawrence H. Summers, "Consumption Growth Parallels Income Growth: Some New Evidence," in B. Douglas Bernheim and Jonh Shoven eds. *National Saving and Economic Performance* (Chicago: University of Chicago Press, 1991).

[18] Chah, Eun, Valerie Ramey and Ross Starr, "Liquidity Constraints and Intertemporal Consumer Optimization: Theory and Evidence from Housing," *Journal of Money, Credit and Banking* 27 (1995), 272-287.

[19] Chinloy, Peter, "An Empirical Model of the Market for Resale Homes," *Journal of Urban Economics*, 7 (1980), 279-292.

[20] Cohen, Marc, Eileen J. Tell and Stanley J. Wallack, "The Lifetime Risks and Costs of Nursing Home Use among the Elderly," *Medical Care*, 24 (1986), 1161–1172.

[21] Cooley, Thomas F., and Edward Prescott, "Economic Growth and Business Cycles," In Thomas F. Cooley eds., *Frontiers of Business Cycle Research* (Princeton: Princeton University Press, 1995), 1-38.

[22] De Nardi, Mariacristina, "Wealth Inequality and Intergeneration Links," *Review of Economic Studies,* 71 (2004), 734-768.

[23] ———, Eric French and John B. Jones, "Differential Mortality, Uncertain Medical Expenses, and the Saving of Elderly Singles," Federal Reserve Bank of Chicago working paper no.13, 2005.

[24] Diaz, Antonia, and Maria J. Luengo-Prado, "Precautionary Saving and Wealth Distribution with Housing," Working paper, 2003.

[25] Eberly, Janice, "Adjustment of Consumers Durables Stocks: Evidence from Automobile Purchases," *Journal of Political Economy,* 106 (1994), 403-436.

[26] Engelhardt, Gary, "House Prices and Home Owner Saving Behavior," *Regional Science and Urban Economics*, 26 (1996), 313-336.

[27] Feenberg, Daniel, and Jonathan Skinner, "The Risk and Duration of Catastrophic Health Care Expenditures," *Review of Economics and Statistics*, 76 (1994), 633-647.

[28] Feinstein, Jonathan and Daniel McFadden, "The Dynamics of Housing Demand by the Elderly: Wealth, Cash Flow and Demographic Effects," in David Wise, ed., *The Economics of Aging* (Chicago: University of Chicago Press, 1989).

[29] Fernandez-Villaverde, Jesus, and Dirk Krueger, "Consumption and Saving over the Life Cycle: How Important are Consumer durables?" *Proceedings of the 2002 North American Summer Meetings of the Econometric Society, 2001.*

[30] ——— and ———, "Consumption over the Life Cycle: Some Facts from Consumer Expenditure Survey Data," *Review of Economics and Statistics,* forthcoming.

[31] French, Eric, and John B. Jones, "On the Distribution and Dynamics of Health Care Costs," *Journal of Applied Econometrics*, 19 (2004), 705-721.

[32] Gale, William, and John K. Scholz, "Intergenerational Transfers and the Accumulation of Wealth," *Journal of Economic Perspectives*, 8 (1994), 145-160.

[33] Gourinchas, Pierre-Olivier, and Jonathan A. Parker, "Consumption over the Life Cycle," *Econometrica*, 70 (2002), 47-89.

[34] Grossman, Sanford, and Guy Laroque, "Asset Pricing and Optimal Portfolio Choice in the Presence of Illiquid Housing Consumption Goods," *Econometrica*, 58 (1990), 25-51.

[35] Gruber, Joseph, and Robert F. Martin, "The Role of Durable Goods in the Distribution of Wealth: Does Housing Make Us Less Equal?" Working Paper, 2003.

[36] Hansen, Gary D., "The Cyclical and Secular Behavior of the Labor Input: Comparing Efficiency Units and Hours Worked," *Journal of Applied Econometrics*, 8 (1993), 71-80.

[37] ———, and Selahattin Imrohoroglu, "Consumption over the Life Cycle: The Role of Annuities, " Working Paper, 2005.

[38] Heathcote, Jonathan, "Home Production and Retirement," Working Paper, 2002.

[39] Hubbard, R. Glenn, Jonathan Skinner and Stephen P. Zeldes, "The Importance of Precautionary Motives in Explaining Individual and Aggregate Saving," *Carnegie-Rochester Conference Series on Public Policy 40* (1994), 59-126.

[40] Hurd, Michael, and James P. Smith, "Anticipated and Actual Bequests", *Themes in the Economics of Aging*, David Wise, editor, 2001, Chicago: University of Chicago Press, 357-389.

[41] Hurst, Erik, and Frank Stafford, "Home is Where the Equity is: Mortgage Refinancing and Household Consumption," Working Paper, 2003.

[42] Jappelli, Tullio, "Who is Credit Constrained in the US Economy?" *Quarterly Journal of Economics*, 105 (1990), 219-234.

[43] Laitner, John, "Wealth Accumulation in the US: Do Inheritances and Bequests Play a significant Role?" Working paper, 2001.

[44] Martin, Robert F., "Consumption, Housing and Transaction Costs," Board of Governors Federal Reserve System International Finance Discussion Paper No 756, 2003.

[45] Nelson, Julie, "Household Economics of Scale in Consumption: Theory and Evidence," *Econometrica* 56 (1988) 1301-1304.

[46] Ocampo, Ignacio, and Kazuhiro Yuki, "Saving, Intergenerational Transfers, and the Distribution of Wealth," *Macroeconomic Dynamics*, 2005.

[47] Ogaki, Masao, and Carmen M. Reinhart, "Measuring Intertemporal Substitution: The Role of Durable Goods," *Journal of Political Economy,* 106 (1998), 1078-1098.

[48] Palumbo, Michael, "Uncertain Medical Expenses and Precautionary Saving Near the End of the Life Cycle," *Review of Economic Studies*, 66 (1999), 395–421.

[49] Schachter, Jason, "Geographical Mobility: March 1999 to March 2000," US Census Bureau, 2001.

[50] Speckman, Paul, "Kernel Smoothing in Partial Linear Models," *Journal of the Royal Statistical Society* B50 (1988), 413-436.

[51] Smith, Lawrence B., Kenneth T. Rosen, and George Fallis, "Recent Developments in Economic Models of Housing Markets," *Journal of Economic Literature*, 26 (1988), 29-64.

[52] Tauchen, George, and Robert Hussey, "Quadrature-Based Methods for Obtaining Approximate Solutions to Nonlinear Asset Pricing Models," *Econometrica,* 59 (1991), 371-396.

[53] Venti, Steven F., and David A. Wise, "Aging and Housing Equity: Another Look", in David A. Wise eds. *Perspectives in the Economics of Aging* (University of Chicago Press, 2004).

[54] Yang, Fang, "How Do Households Portfolio Vary with Age?" Working Paper, 2006.

[55] Zeldes, Stephen, "Consumption and Liquidity Constraints: An Empirical Investigation," *Journal of Political Economy* 97 (1989), 305-346.

[56] Zimmerman, David J., "Regression Toward Mediocrity in Economic Stature," *American Economic Review*, 82 (1992), 409-429.