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Accounting for Lifecycle Wealth Accumulation: The Role of Housing Institution

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Accounting for Lifecycle Wealth Accumulation: The Role of Housing Institution

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Abstract

This paper constructs a quantitative general equilibrium lifecycle model with uninsurable labor income to account for the differences in the pattern of wealth accumulation across two countries, Korea and the United States. The model incorporates the differences in the housing market institution in the two countries, namely, the mortgage market and the rental market. As a focal point of the model, housing plays multiple roles for households: collateral as well as a source of service flows. The results from the calibrated model can quantitatively explain some empirical findings on the profile of wealth and homeownership in the aggregate as well as over the life cycle. The mortgage market can account for around 60 percent of the differences in the aggregate homeownership ratios in the two countries as well as 23 percent of the differences in the asset portfolio composition. However, the difference in the rental market does not play large role in accounting for the differences in wealth accumulation and homeownership patterns.

JEL classification : D91, E21, H31, R21
Keywords : Lifecycle model, Consumption, Wealth, Housing Institution

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1 Introduction

In this paper, I examine the cross-country differences in household's wealth accumulation and asset portfolio choices over the life cycle. Specifically, I compare the United States and Korea. Empirical studies about household portfolios have been undertaken in some developed countries, but little attention has been paid to developing countries mainly due to the lack of quality data. I use the recent Korea Labor Income Panel Study (KLIPS) to examine how average Korean households accumulate their wealth over the life cycle. I then make a cross-country reference in order to highlight the differences in the profile of various assets in the aggregate as well as over the age-groups. This enables me to pay close attention to the points that are specific to the two countries in focus.

Housing is the most important form of wealth in Korea. According to the KLIPS data, while approximately 60% of households are homeowners, housing assets make up close to 50% of total assets held by all households. The share of financial assets, on the other hand, is around 25%. This is a significant departure from the United States, where the homeownership ratio is around 68% and the shares of housing and financial assets are approximately 30% and 37%, respectively. Thus, despite a lower homeownership ratio in Korea, for those who are homeowners, housing becomes the most predominant source of wealth. This also indicates that the decision to purchase a house has important implications for the portfolio composition of a Korean household over the life cycle, as housing not only provides a flow of service for consumption but also can be used as collateral.

Unique to the Korean housing market is the existence of a 'chonsae' system, a rental market system in which a tenant pays a deposit upfront (usually 40-80% of the property value) with no additional periodic rent payments, and receives the nominal value of the deposit from the landlord upon maturation. Given this structure of the chonsae system, renters in Korea have a proportion of their assets indirectly tied up to housing with zero nominal returns. This contrasts sharply with the situation in the United States, where renters do not own any assets related to housing and therefore are able to diversify their financial portfolio. Another unique aspect is the lack of an affordable mortgage system, which reflects the under-developed nature of the financial sector in Korea. For instance, Lam [31] reports the average mortgage to GDP ratio in Korea between 1996 and 2000 to be around 11%, whereas the corresponding figure in the United States was approximately 55%. Also, the average loan-to-value ratio[1] during the same period was 28% in Korea, as opposed to around 80% in the United States. A full-scale government-endorsed mortgage system was only introduced in 2004, prior to which such a system was almost non-existent.

I set up a general equilibrium lifecycle model allowing for these specific housing features in Korea and I calibrate it to match wealth accumulation and portfolio choice over the life cycle. I

[1]Loan-to-value (LTV) ratio is defined as the ratio of the fair market value of an asset to the value of the loan that will finance the purchase.

also do a similar set up for the United States without these specific housing institutions present in Korea. The results from the calibrated model can quantitatively explain some empirical findings on the profile of wealth and homeownership in the aggregate as well as over the life cycle.

In addition, I assess the roles played by the institutional features of the mortgage market and the rental market arrangement, and ask how much they can individually and jointly account for the observed differences of the wealth accumulation and homeownership between Korea and the United States. For the mortgage market, an expansion of the current mortgage system is represented by a higher loan-to-value ratio, matching the ratio in the United States. Expanding the current mortgage system lowers the overall level of wealth accumulation in the economy, while increasing the homeownership ratio and the fraction of wealth invested into housing assets. Wider availability of mortgage loans weakens the saving motives since households, especially younger ones, save primarily to purchase a house. However, as it becomes easier for households to purchase a house, the fraction of wealth invested into housing and the overall homeownership increase. For reasonable parameter values, I find that increasing the loan-to-value ratio to the level of the United States will cause 1.2% to 1.8 % decrease in the aggregate net worth, a 5.5 to 6.5 percentage points increase in the homeownership ratio, and a 1.9 to 2.3 percentage points increase in the fraction of wealth invested into housing asset. The changes in the homeownership ratio could potentially account for more than 50 percent of the observed differences between Korea and the United States.

Next, the rental arrangement in the benchmark Korean model is altered to mimic the American rental arrangement, that is, households pay periodic rental payment which is assumed to be a fraction of the house value. Contrary to the mortgage expansion case, introducing a US-type rental arrangement led to a fall in the overall level of wealth accumulation ranging from 3.9% to 6.7%. The homeownership ratio showed a sizeable decline, falling more than 20 percentage points. This might indicate that the US-type rental arrangement is a cheaper alternative to homeownership than the Korean 'chonase' system. In addition, the fraction of wealth in housing assets falls by 1.8 to 2.8 percentage points.

When the mortgage system and the rental arrangement are jointly modified, the overall level of wealth accumulation declines by 5.5% to 7.8%, as both institutions lowers the savings motive of the households. On the other hand, the decrease in the homeownership ratio ranged from 18.5 to 19.5 percentage points, where the negative impact of switching to a US-type rental arrangements have been dampened by the expansion of the mortgage loan. On the other hand, the share of wealth held in housing assets decreased by 1.2 to 2.0 percentage points. The decrease in the overall net worth is due to wider availability of mortgage loans or cheaper rental cost. Looking at different age groups, the net worth fell most for households in the age group of 30-45, while the fall in the homeownership only affects households aged 35 or older.

Finally, I use the model to analyze the quantitative effects of introducing a property tax as

well as tax on housing transaction upon the pattern of wealth accumulation and portfolio choice over the life cycle. The tax experiment shows that imposing taxes on housing unambiguously lowers the homeownership ratio and the aggregate wealth in the economy. However, the effect on aggregate welfare could be shown to be positive if the tax revenue is distributed back to the renters, who are mostly households in the early part of their lifecycle. This positive effect could range up to 0.56 percent change.

This paper builds on the emerging literature that document household portfolio allocation[2]. With a few papers allowing for housing in models of portfolio choice, the role of housing wealth has received greater attention due to its unique role: people can borrow against housing; housing is indivisible and relatively illiquid (buying and selling entail significant liquidation costs); and housing not only provides a flow of real benefits to the owner as a consumption good, but also, acts as an investment good that provides potential for capital gains or losses. Grossman and Laroque [18], using an infinite horizon model, are the first to analyze housing in the portfolio allocation in the presence of adjustment costs. Díaz and Luengo-Prado [12] and Gruber and Martin [19] also use a standard infinite horizon model to study the role of durable goods and collateral credit in accounting for wealth inequality and the level of precautionary savings in the United States. Cocco (2004) [10] specifies the housing price risk to study the asset allocation decision in the presence of housing. Some papers explicitly include housing in the context of a general equilibrium lifecycle framework. For example, Chen [8] investigates the implications of privatizing social security system, while Chambers, Garriga and Schlagenhauf [7] use a similar framework to examine the recent changes in the US homeownership ratio. Other important works include, among many others, Fernandez-Villaverde and Krueger [13], Flavin and Yamashita [14], and Campbell and Cocco [5]. Additionally, an alternative to the housing market is that people can rent instead of purchasing a house. In the case of renting, renters receive a similar flow of services, although somewhat less than from their own house, and are not subject to capital gains or losses. Platania and Schlagenhauf [39], Gervais [15], Ortalo-Magné and Rady [38], Hu [24], Yao and Zhang [44], Miles, Černý and Schmidt [37], Li and Yao [34] all explicitly incorporate the rental versus homeownership decision into their models. Other similar papers include: Yang [43], which looks at the housing versus non-housing consumption over the lifecycle, but does not incorporate rental market and thus does not look at the homeownership vs. rental choice in depth as mine does. Also there is no housing taxation as this paper does explicitly. Silos [41] also analyzes homeownership over the lifecycle, but more focuses on the impact of housing on wealth inequality.

In general, models of housing have made predictions closer to what have been observed empirically in areas such as wealth distribution, household portfolio allocations, and tenure decisions; however, these models have been calibrated mostly to the United States. It would be interesting to evaluate the predictions of these models on other economies while incorporating their unique

[2]A comprehensive review of the literature is provided by McCarthy [36].

features. This will indirectly help to examine the role of these features in accounting for the differences in wealth accumulation and portfolio choice across countries. This paper makes a first attempt to fill this void and extends beyond the literature by offering distinct contributions in both empirical and theoretical aspects. First, the paper conducts an empirical study of wealth in Korean households from the KLIPS data and points out some stylized facts in the average wealth portfolio as well as the cross-section profile of various assets and homeownership ratios by age groups. It highlights the similarities and differences in the pattern of wealth accumulation and portfolio choice with those shown in the United States and other countries. Theoretically, the model framework of this paper is closest in spirit to Miles, Černý and Schmidt [37]. They also set up a calibrated model in the context of uninsurable labor income and uncertainties in housing price to simulate the housing and portfolio choice of Japanese households and study the impact of changes in the social security regimes and demography. However, this paper explores several other distinct aspects. First, my model set-up explicitly incorporates the chonsae system in the Korean housing market, which is not modelled in Miles, Černý and Schmidt [37]. Second, the paper looks at the housing institutions in Korea and explores the joint implications of the specific rental choices and mortgage institutions faced by Korean households. The model is then calibrated to the Korean economy, providing the groundwork for various policy analyses. The paper then highlights the role of institutional factors by altering the market institutions individually and jointly, and examine the impact on the profile of wealth, wealth composition, and homeownership. Third, to the extent to our knowledge, the paper is the first attempt to conduct a cross-country comparison of the lifecycle model with housing.

The rest of this paper is organized as follows. Section 2 presents the empirical findings and stylized facts from the analysis of the KLIPS data and documents some features of wealth accumulation and portfolio changes for average Korean households. Section 3 describes the calibrated lifecycle model framework. Section 4 outlines the calibration and the parametrization of the model. In Section 5, I present the results from the benchmark simulation. In Section 6, I quantitatively assess the roles played by the housing market institutions in Korea as well as some implications of introducing taxation on housing. Brief concluding remarks are provided in Section 7. The appendix presents the model set up for the United States as well as the algorithm for the computation.

2 Data and Empirical Evidence

2.1 Average Wealth Portfolio

In this study, I use the Korean Labor Income Panel Study (KLIPS) from 1998 to 2002. It is a socio-demographic panel study which includes data about household income and wealth. In the wealth category, the KLIPS survey asks households about various types of assets and liabilities. I group assets into primary housing ("House"), financial assets, and other non-financial assets

excluding owner-occupied housing such as secondary home, land, and rental real estate ("Other non-financial"). Within the financial assets category, I closely examine different financial assets, such as rent deposit, time deposits (checking and savings account), stocks and bonds, and life insurance. A rent deposit, or 'chonsae' deposit, is a lump-sum deposit in lieu of periodic rental payments that is unique to Korea. Since renters pay an upfront deposit at the beginning of the contract and receive the exact nominal amount back at the end of the contract, a chonsae is considered a financial instrument with a zero nominal interest rate[3]. I also look at outstanding financial liabilities. Net worth is defined as the difference between total assets and total financial liabilities. Table 1 below summarizes the wealth holdings of the average household for each asset type from the 2001-2002 KLIPS data. For reference, the table also shows the average wealth holdings in the United States compiled by Kennickell [28], which uses the 1995 Survey of Consumer Finances.

Table 1. Summary Statistics of Average Wealth - Korea vs. United States

	Korea	United States
Total asset(normalized by average income)	5.247	5.560
- House	2.580	1.670
- Financial asset	1.315	2.041
. Rent deposit	0.613	-
. Deposits	0.450	0.399
. Stock & Bond	0.074	0.852
. Insurance	0.089	0.147
. Others	0.089	0.643
- Other non-financial	1.352	1.849
Total liabilities	0.816	0.813
Net Worth	4.431	4.747

For a comparison of wealth composition, I present the share of different assets as well as the different components of financial assets. Also, an additional summary of statistics for Korea by Lee and Lee [33] is provided, which uses a different panel study (Korean Household Panel Study) for 1998. This comparison is shown in Table 2 below.

Table 2. Wealth Portfolio Comparison - Korea vs. United States

[3]The survey also asks landlords whether or not they have received the chonsae deposit. Since this is considered part of the financial liabilities, there is no double counting of financial assets in the aggregate.

	Korea (1998)	United States (1995)	Korea (2001-02)
Total Asset	100.0	100.0	100.0
Financial	19.8	36.7	25.1
Deposit	8.1	7.2	8.6
Stock	0.7	12.5	1.4 †
Bond	0.3	2.8	-
Insurance	3.0	2.6	1.7
Other ‡	7.8	11.6	13.4
Non-financial	80.2	63.3	74.9
Owned house	51.4	30.0	49.2
Other	28.8	33.3 §	25.7
Total Liabilities	10.0	14.6	16.0

† Stocks and bonds are combined under the KLIPS survey.

‡ Mainly rent deposits in Korea and pension fund in the US, respectively.

§ Out of other non-financial assets, business equity (18%) is the main component.

From the cross-country comparison of wealth portfolio, I summarize some idiosyncracies of the Korean households' wealth portfolio when compared to that of the US households.

1. Housing asset is the most important asset in Korea (around 50% of the total asset); whereas, financial asset is the major asset in the United States (37% of total asset). In fact, as a proportion of their total asset, Korean households have a relatively smaller proportion (around 25%) of assets in financial assets in contrast to their American counterparts.

2. Among different types of financial assets, Americans invest primarily in stocks followed by pension funds. However, in Korea, the most common form of financial asset is a deposit, either in the form of a rent deposits or a time deposit, such as a savings account. In fact, the fraction of financial assets invested in stocks and bonds is only 6% in Korea, whereas in the US, the fraction of financial assets held in stocks alone stands at 35%. As rent deposits take almost 45% of total financial assets in Korea, this implies that renters have a large share of their financial assets indirectly tied up to housing. This contrasts sharply with the situation in the United States, where renters do not own any assets related to housing and therefore are able to diversify their financial portfolio.

The characteristics of the Korean households' wealth portfolio are emphasized further by looking at similar works conducted for other countries. Banks, Blundell and Smith [3] document the wealth portfolio in the United Kingdom using the British Household Panel Survey (BHPS), and reports that an average UK household holds 60%[4] of total household wealth in home equity.

[4]The British Household Panel Survey presents both upper and lower bound estimates. This figure is the average.

As for types of financial assets, the BHPS reports a 35% share for stocks and mutual funds. Iwaisako [26] studies household portfolios in Japan and shows that financial assets comprise 31% of the total asset. The rest is invested into housing or other real estate assets. Looking into the shares of different types of financial assets, time deposits make up 46% of total financial assets followed by life insurance at 41%. The share of stocks and bonds is only around 8% of total financial assets. The cases of the United Kingdom and Japan indicate some similarities in the composition of the wealth portfolio in Korean, Japanese, and British households in contrast to American households. Excluding the United States, not only is housing (or home equity) the most important investment, but also the portfolio composition of the financial assets is more risk-averse, with only a small fraction invested in risky assets such as stocks.

One issue is how well the household survey of wealth matches the aggregate measures. On top of the usual misreporting problem, the KLIPS data does not over-sample the wealthy, and, thus, gross wealth estimated from the survey is likely to under-represent the aggregate wealth of the economy. Regarding the composition of wealth, since the wealthy tend to hold more of their wealth in financial assets other than housing, the relative share of financial assets is expected to be higher in the aggregate economy than in the KLIPS data. Further study is needed to bridge the gap between the two different data sources.

2.2 Wealth Portfolio by Age Cross-Section

In addition to the summary statistics of the wealth portfolio, I examine the age-related pattern of wealth accumulation and portfolio choice in this section. The level of household wealth and the composition of the wealth portfolio strongly vary by age. Typically, young households do not invest in risky assets. Most live in rental housing and are saving to buy a house. This is more prominent in Korea since young households are not eligible to receive mortgage loans and, thus, are forced to live in rental housing. Once they accumulate enough savings to buy a house, they then start investing in risky assets. In Korea, investment in risky assets takes the form of housing and other non-financial assets, not financial assets, such as stocks, as shown in the US. Older age families seem to sell their risky assets and shift their portfolios into safer assets. Some older age households move in with their children, which involves significant inter-vivos transfers.

Figures 2.1 and 2.2 show the average accumulation of different types of wealth, as well as their relative shares for different age groups, taken from cross-sectional series of the KLIPS data. A fifth order polynomial is used to fit the trend lines.

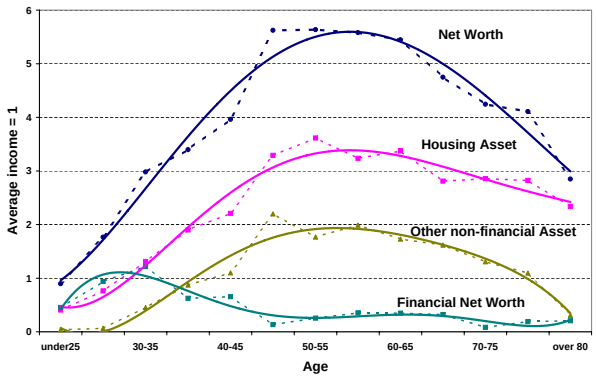

Figure 2.1 Wealth Accumulation Over Cross-Section (Korea)

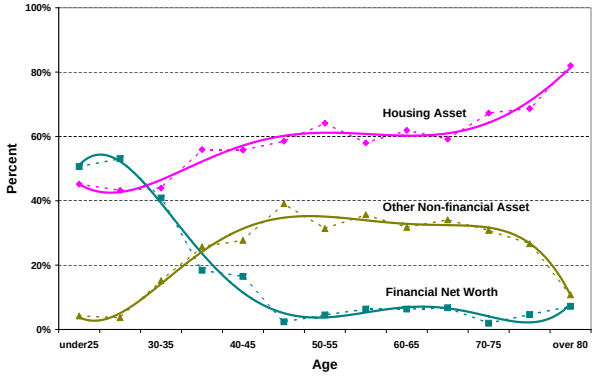

Figure 2.2 Wealth Composition Over Cross-Section (Korea)

The main features of the level of wealth and the wealth portfolio are summarized as follows:

1. Both housing and other non-financial assets show a hump-shaped pattern over the age groups, which is similar to the profile of the net worth. The profile of the net worth, housing, and other non-financial assets all reach their peaks between the 45 to 60 age groups. On the other hand, the financial net worth shows an early peak, but remains low and constant after the late thirties age group.

2. In terms of the wealth composition, financial net worth is the most important type of wealth for younger households in the twenties and early thirties, but afterwards its share declines and stays below 10% for age groups older than 45.

3. Housing becomes the dominant asset type after the late thirties age group. The share of housing in total wealth increases with age and stays almost constant until the early sixties. In the latter part of the life cycle, housing share increases even further, reaching 80% of total net worth in the last period. This poses a question as to how retired households finance their consumption at this stage of the life cycle.

4. The share of real estate assets also increases rapidly in age groups until late forties, stays constant until the early seventies and declines rapidly afterwards.

Finding corresponding figures for a cross-country comparison was not easy. For the United States, the age profile of wealth composition was taken from the cross-section study of Panel of Income Dynamics 2001 survey data, as shown in Figure 2.3 below.

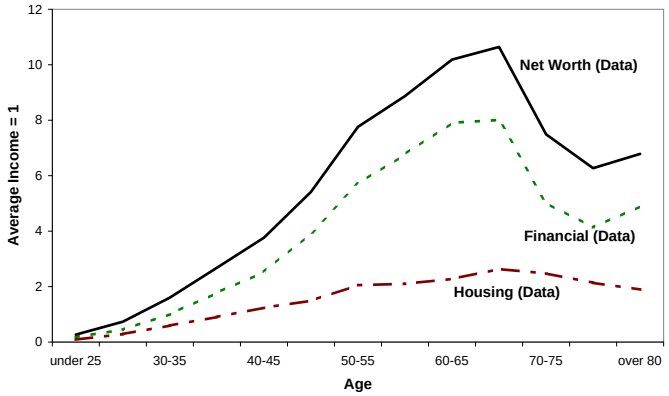

Figure 2.3 Age-profile of Wealth Composition (United States)

From the cross-country comparison, we see a different composition of wealth over different age groups for the United States in contrast to Korea. First of all, for the US households aged less than forty five, housing wealth is the most important form of wealth, but its share declines rapidly afterwards as more wealth is held in the form of financial wealth. Additionally, the distribution of wealth in financial and housing wealth in the United States is more evenly allocated for households below the age of 40 years. For age groups over 60 years, however, average households hold approximately 70% of wealth in financial wealth. This marks a sharp contrast to Korea, where the importance of housing in the portfolio increases over age groups and vice versa for financial net worth[5].

Not only is there a difference in the wealth portfolio, but there is also a difference in the amount of net worth held by different age groups. The average amount of net worth held by US households under the age of 40 years is around 39% of the average net worth held by all households. In Korea, on the other hand, the fraction is almost 70%.

2.3 Homeownership Ratio

Since owner-occupied housing is the most important part of household wealth in Korea, the decision to buy a house or to rent has a significant implication on the wealth portfolio. Thus, it is important to take a closer look at how the distribution of owner-occupied housing varies by age. Figure 2.4 below shows the average fraction of households in the KLIPS data who are homeowners, or homeownership ratio, determined by the age of the head of the household averaged over the years 2001 and 2002. The trend line is fitted to a fifth order polynomial.

[5]Studies from other countries show different patterns. In the United Kingdom, for households aged less than forty, housing is the most important form of wealth, but its share declines steadily over the life cycle. However, housing still remains the predominant form of wealth. In Japan, the share of housing assets in total gross wealth increases with age and stays relatively constant after the mid-fifties. Conditional on homeownership, real estate (including owner-occupied housing) accounts for about 70 to 90 percent of households' total assets.

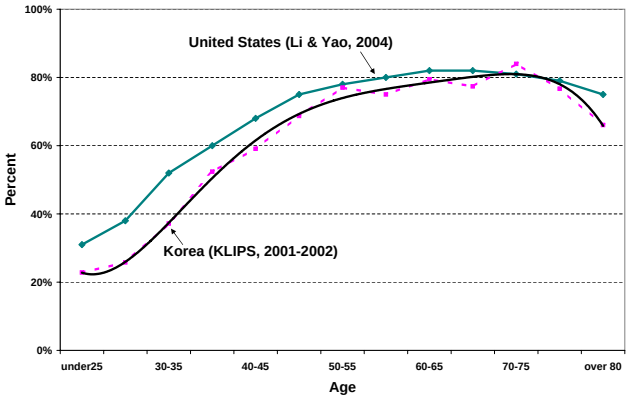

Figure 2.4 Homeownership Over Cross-Section (Korea vs. United States)

The average homeownership ratio was around 58%, which is higher than other studies have shown for Korea[6]. However, compared to other countries, the homeownership ratio in Korea is low. For example, in the United States and the United Kingdom, the average ratios are 68% (SCF, 2001)[7] and 67% (BHPS 1999), respectively. Looking at the age-related pattern, greater than half of the households aged less than 40 years do not own their housing. The low homeownership ratio in the early stages of life cycle can be somewhat explained by the lack of long-term mortgage loans and the unusually high down payment ratio, which ranges between 70 to 80 percent in Korea. The lack of long-term mortgage loans makes the time needed for young households to purchase a house longer. A comparison of homeownership ratio for different age groups in Korea and the United States shows a wider gap for younger households than for older households. For example, in the age groups 30-35 years, the gap was 15 percentage points, while the corresponding number was 3 percentage points on average for age groups 50 years or higher. In the meantime, young households have no option but to live in rental housing under the 'chonsae' system, where they pay huge rental deposits, or to stay with their parents. The homeownership ratio increases with age until the early seventies, after which households either sell their house or move in with their children. This explains the decline in the homeownership ratio in the age groups of 70 years or higher.

2.3.1 Chonsae System

As mentioned earlier, the chonsae (or 'chonsei') is a rental market system in Korea in which a tenant pays an upfront deposit (usually 40-80% of the property value) upon contract, with no additional periodic rent payments. The tenant also receives the nominal value of the deposit from the landlord upon expiration of the contract, which typically lasts two years. Landlords can earn interest income from the deposit or use the deposit for other investment purposes. The

[6]In another study by Lee and Lee [33], the homeownership ratio was around 55%.

[7]The homeownership ratio in the United States was stable around 65% until mid 1990s, and has steadily increased to around 68%.

current legal system offers tenant protection in case the landlord does not return the deposit. According to Ambrose and Kim [1], the wide prevalence of the chonsae system is partly attributed to the underdeveloped financial sector and heavy government intervention during the period of high growth in Korea. Due to low government-led interest rates for business firms, banks demanded high interest rates for consumer credit and housing finance. Under this circumstance, the chonsae system provided means for credit demand for landlords while providing affordable housing options for renters who didn't have enough cash to purchase a house. The chonsae contract system is more widespread in large cities where housing is more expensive. An estimate by Cho [9] indicates that, as of 2003, the aggregate chonsae deposit is around 40% of GDP, or 80% of total equity value in Korea.

3 Benchmark Model

A simple and parsimonious finite-horizon general equilibrium lifecycle model will be set up to calibrate the wealth accumulation and portfolio choice of the households in both Korea and the United States, so that the model predictions match some key features of the data shown in the previous section. Once the model is set up, it will provide useful grounds for various policy experiments such as the introduction of mortgage loans or different tax policies. This will be introduced in the next section.

3.1 Technology

There is a representative firm producing an aggregate output good Y under the aggregate production function using aggregate capital stock K and aggregate labor input L:

$$Y = F(K, L) \tag{1}$$

The production function is a standard Cobb-Douglas form. The production function is increasing in both arguments, strictly concave, homogeneous of degree one, and satisfies the Inada conditions. The aggregate output can be either consumed or invested into business capital or housing capital. Let I^k and I^h denote the aggregate investment in business capital and housing capital, respectively. The aggregate resource constraint is:

$$Y = C + I^k + I^h + \Pi \tag{2}$$

where C denotes aggregate consumption of non-housing goods and Π denotes the transaction costs incurred from sales of housing. In addition, the business capital and the housing capital depreciate at a rate δ^k and δ^h, respectively.

3.2 Demographics

Each model period is calibrated to correspond to five years. Agents or households, which will be considered as an equivalent concept, actively enter into working life at 20 (denoted as $j = 1$ in the model)[8] and live until 80 (denoted as $J = 13$), when he/she dies for certain. All agents enter their working life as renters with zero financial and housing asset. They work and receive earnings until the age of mandatory retirement denoted as j^*.[9] Following each period, agents face a positive probability of dying. This is denoted by s_j which is the exogenously given survival probability at age $j+1$ conditional on being alive at age j. The unconditional survival probability for an agent aged j is thus given by $\prod_{t=1}^{j} s_t$. Since death is certain after age J, $s_J = 0$. Upon death, household's net worth is seized away by the government and re-distributed to all working households as transfers[10]. For simplicity there is no population growth and the measure of the households is normalized to one. Therefore the fraction of new agents entering into lifecycle is constant and replaces the number of agents dying each period.

3.3 Preferences

Agents derive utility from consumption of nondurable goods, c, and from the flow of service from housing stock, h, as well as from bequests, q, left upon death. Agents deriving utility from leaving bequest (or 'warm glow' bequest motive) is a simple way to incorporate bequest into the model without introducing the complexities of strategies between parents and children. The service flow from housing is proportional to the housing stock. Following the set up by Ortalo-Magné and Rady [38], the utility derived from housing is made higher for a homeowner than for a renter[11]. That is, renters will only derive a fraction $\lambda < 1$ of utility than does a homeowner who has the same housing stock. The instantaneous utility function for a household aged j is of CRRA type as follows:

$$\begin{aligned} U(c_j, h_j, n_j) &= n_j \frac{\left[\left(\frac{c_j}{n_j}\right)^{(1-\omega)} \left(\frac{f(h_j)}{n_j}\right)^{\omega} \right]^{1-\gamma}}{1-\gamma} \\ &= n_j^{\gamma} \frac{\left[c_j^{(1-\omega)} f(h_j)^{\omega} \right]^{1-\gamma}}{1-\gamma} \end{aligned} \tag{3}$$

[8] Age is indexed with subscript j and time is indexed with subscript t.

[9] The retirement age is 60 and 65 for Korea and the United States, respectively.

[10] One way to interpret this redistribution is to consider it as the sum of inter-vivos transfers and bequests.

[11] Glaeser and Shapiro [16] explain in detail about the externalities of homeownership over renting in addition to various tax benefits such as home mortgage interest deductions and tax deductions on the capital gains from selling the house. In Korea, however, there is no deduction on mortgage interests.

where

$$\begin{aligned} f(h_j) &= I_j h_j + (1 - I_j)(\lambda h_j) \\ I_j &= \begin{cases} 1 & \text{if homeowner} \\ 0 & \text{otherwise} \end{cases} \end{aligned}$$

Here, n_j is the exogenously given average effective family size adjusted by the adult equivalence scale, as measured by Fernandez-Villaverde and Krueger [13]. The family size enters into the equation 3 to capture the scale economies as was introduced by Lazear and Micheal [32]. The parameter ω measures the relative importance of housing service in relation to the non-durable goods consumption, and γ is the relative risk aversion parameter. I_j is an indicator function denoting whether the household of age j is a homeowner or a renter in the given period. As for the utility derived from leaving bequests, q, we follow the specification made by De Nardi [11] denoted as:

$$\varphi(q) = \varphi_1 \left[1 + \frac{q}{\varphi_2}\right]^{1-\gamma}$$

The term φ_1 reflects the parent's concern about leaving bequests to children, while φ_2 measures the extent to which bequests are luxury goods. The remaining bequests are seized by the government and equally redistributed to all people between the ages of twenty and sixty. Finally, the lifetime utility function can then be written as:

$$E\left\{\sum_{j=1}^{J} \beta^{j-1} (\prod_{t=1}^{j} s_{t-1})[U(c_j, h_j, n_j) + (1 - s_j)\varphi(b_j)]\right\}$$

where $s_0 = 1$.

3.4 Labor Income Dynamics

Agents enter into economy with zero financial or housing assets but possibly some transfers received from the government distributed as a part of intergenerational transfers. During each period prior to mandatory retirement age of sixty denoted as j^*, agents are endowed with one unit of time which they supply inelastically. Agents also face the same exogenous age-efficiency profile, ϵ_j, during their working years. This profile is estimated from the data and recovers the fact that productive ability changes over the life cycle. Each unit of effective labor is paid the wage rate w. Workers are also subject to stochastic shocks to their productivity level. These shocks are represented by a finite-state Markov process defined on $(Y, \mathcal{B}(Y))$ and characterized by a transition function Q_y, where $Y \subset R_{++}$ and $\mathcal{B}(Y)$ Borel algebra on Y. This Markov process is the same for all households. The total productivity of a worker of age j at period t is given by the product of the workers stochastic productivity in that period and the workers deterministic efficiency index at the same age: $y_t \epsilon_j$. Working agents also pay social security payroll taxes

on their labor income. Under an unfunded pay-as-you-go (PAYG) social security system, the government distributes the tax revenue across the retired agents. For simplicity, the level of social security benefits (b) is fixed at a constant amount regardless of the contribution made during the working stage.

3.5 Housing and Tenure Choice - Korea

This subsection describes the housing and the tenure choice decisions made by households in Korea, taking into account the unique chonsae arrangements in the rental market. Every period, households decide to become a renter or a homeowner. A renter has the option to continue renting or to buy a house and become a homeowner. If the renter of age j at period t decides to rent in the next period, a rental deposit priced at $p_t h_{j+1}$ is paid to the rental agency. In the beginning of the next period, the renter receives the exact nominal amount net of any interests. [12] The renter may also decide to stay at the same rental property and renew the existing contract or decide to move into a rental house of different size. Moving to a different rental property incurs transaction cost, which is divided into a selling cost, ϕ^s, and a purchasing cost, ϕ^b. Selling and purchasing costs are proportional to the existing and the new rental property, respectively.

On the other hand, if the renter wants to become a homeowner, the renter can purchase a house at h_{j+1} and incur transaction costs $\phi^s h_j$ and $\phi^b h_{j+1}$ for selling and purchasing, respectively.

We assume that the housing capital is not perfectly divisible, as we introduce a minimum size, $\underline{H}$, for owner-occupied housing as introduced by Cocco [10]. The constraint on minimum housing size is as follows:

$$h_j \quad \geq \quad \underline{H} \quad \forall j.$$

For renters, there is no such lower bound on the size of the rental property.

A homeowner, on the other hand, can decide whether to keep the house or to sell and move. Homeowners also pay a maintenance cost equal to the level of depreciation (δ^h) in the period during which the house was owner-occupied. If the household sells the house, he can decide to buy a different-sized house or become a renter. Due to the illiquid nature of the housing investment, selling the house incurs a transaction (or liquidation) cost (ϕ^s) proportional to the value of the house to be sold. In addition, buying a house incurs a transaction cost (ϕ^b) proportional to the value of the house to be purchased. In addition, the house can be used as collateral for homeowners to borrow up to a fraction, κ, of the next period housing value. As such, κ is the loan-to-value (LTV) ratio, and $1 - \kappa$ is commonly known as the down payment ratio. The collateral constraint for household of age j is as follows:

$$a_{j+1} \quad \geq \quad -\kappa h_{j+1} \quad \forall j \tag{4}$$

[12] For the landlord's point of view, the rental income is the forgone interest on the rental deposit.

3.6 Rental Agency - Korea

The rental market in the economy is operated by a rental agency. Following Gervais (2001) [15], this rental agency is a two-period lived institution which in the first period takes deposits from the homeowners (D_t)[13] and buys rental properties (S_t). Renting out the rental properties, the agency receives rental deposits $(p_t S_t)$, which is loaned out and earns interest r next period. In the next period, a cohort of new institutions enter into the market, while the existing institution earns interest on the rental deposit and returns the principal to the renters. Using the proceeds, the institution pays interests on the deposit as well as bearing the maintenance costs on the rental properties. At the end of the second period, the existing institution sells the undepreciated part of the residential stock to a new institution. The problem of this rental agency is formulated as follows:

$$\max_{S_{t+1}, D_{t+1}} \quad = \quad rpS_{t+1} - \delta^h S_{t+1} - rD_{t+1} \tag{5}$$

subject to

$$S_{t+1} \quad \leq \quad D_{t+1} \tag{6}$$

For this maximization problem to be well defined, the following no-arbitrage condition needs to be satisfied:

$$rp - \delta^h \quad = \quad r \tag{7}$$

or

$$p \quad = \quad \frac{\delta^h}{r} + 1 \tag{8}$$

In other words, renting out a property, receive interest on the rental deposit and pay the maintenance costs yields the same profit as opening a deposit in the bank and obtaining interests. This condition implies that the rental agency will also satisfy zero-profit conditions in equilibrium. In addition, given the interest rate and the depreciation rate, the rental deposit price of a unit of rental property is uniquely determined.

3.7 Government

Here the government collects various tax revenues. One source is social security payroll tax collected on the working households at a rate τ_{SS} proportional to their labor earnings. The

[13] Note that the homeowners are indifferent between making deposits and buying business capital as the rate of return on both assets are equalized at r.

payroll taxes are used to fund the retirees' income. For simplicity, I assume that the level of social security benefits is constant regardless of the actual contributions made in the past. The replacement rate is linked to the average earnings of a person in the economy. On the other hand, when the household dies and leaves bequests, the government collects the bequests and re-distributes to working households as transfers. Later on, we will introduce additional taxes on housing and examine the implications.

3.8 Household Recursive Problems

This subsection describes the recursive problems faced by Korean households. For American households, the set up is shown in the Appendix. The state space is a set $x = \{j, h, a, I, y\}$, where j is the age of the household, h is the stock of housing, a is the financial net worth carried from the previous period, I is the tenure status of the household in the current period, and y is the productivity.

In the beginning of period t, working households receive labor earnings net of social security payroll taxes, $(1 - \tau_{SS})w\epsilon y$ and some transfers, T, from the government. If the households are retired ($j^* \leq j \leq J$), on the other hand, they receive pension benefits b, which is a constant fraction χ of the average household earnings. I use the capital letter E to denote the earnings and transfer of the households over the lifecycle.

$$\begin{aligned} E &= I_j\{(1-\tau_{SS})w\epsilon y + T\} + (1 - I_j)b \\ \text{where} & \\ I_j &= \begin{cases} 1 & \text{if} \quad j \leq j^* \\ 0 & \text{if} \quad j^* \leq j \leq J \end{cases} \end{aligned}$$

Given the tenure status, households decide whether to maintain the current tenure status or not. If former, they also decide whether to stay in the current property or move to a different sized property which will incur transaction costs. Incorporating this tenure decision, the value function for a household is the maximum of six different values, which depend on the tenure choice made for the next period:

$$V(x) = \max\left\{V^i(x)\right\}_{i=1}^{6} \tag{9}$$

The functions V^i, $i = 1, \ldots, 6$, are respectively, the value functions of a household with different housing tenure status of the current and the next period as summarized in Table 1.

3.8.1 Homeowners selling and buying a new house: V^1, $(I, I') = (1, 1)$

In the beginning of period t, households have a position on the housing capital and pay maintenance costs as well as transaction costs for selling. In net, household receives $(1 - \delta^h - \phi^s)h$.

Table 1: Value Functions

Current Tenure Status	V_i	**Decision for the Next Period**
Homeowner	V_1	Sell and buy a new house
	V_2	Maintain existing house
	V_3	Sell existing house and rent
Renter	V_4	Buy new house
	V_5	Stay at existing rental property
	V_6	Move to a different rental property

Households also receive financial net worth with realized riskfree returns, $(1+r)a$. Given the available resources, the households then chooses consumption of non-durable goods, c, next period financial net worth, a', and buys a new house with transaction costs, $(1+\phi^b)h'$. In case the retired households do not survive until the next period, all assets are left as bequest. As the household stays as a homeowner, the minimum housing size constraint holds and the household can borrow up to a certain fraction of the value of the house. The problem for homeowners selling and buying a new house can be formed recursively as follows:

$$V^1(j,h,a,I,y) = \max_{c,h',a'} \left[U(c,h,n) + s\beta E(V(j+1,h',a',I',y')) + (1-s)\varphi(q)\right] \quad (10)$$

subject to

$$c + a' + (1+\phi^b)h' \leq E + (1+r)a + (1-\delta^h-\phi^s)h \quad (11)$$

$$c \geq 0 \quad (12)$$

$$a' \geq -\kappa h' \quad (13)$$

$$q = a' + h' \quad (14)$$

$$h' \geq \underline{H} \quad (15)$$

3.8.2 Homeowners maintaining existing house: V^2, $(I, I') = (1, 1)$

In the beginning of period t, households have a position on the housing capital and pay maintenance costs. In net, household receives $(1-\delta^h)h$. Households also receive financial net worth with realized riskfree returns, $(1+r)a$. Given the available resources, the households then chooses consumption of non-durable goods, c, next period financial net worth, a', and maintains the same housing size ($h' = h$). In case the retired households do not survive until the next period, the sum of the housing and financial assets are left as bequest. As the household stays as a homeowner and does not change the housing size, the minimum housing size constraint holds automatically, and the household can borrow up to a certain fraction of the value of the house as collateral. The problem for homeowners maintaining their existing houses can be formed recursively as follows:

$$
\begin{aligned}
V^2(j,h,a,I,y) &= \max_{c,h',a'} \left[U(c,h,n) + s\beta E(V(j+1,h',a',I',y')) + (1-s)\varphi(q)\right] && (16)\\
&\text{subject to} \\
c + a' + h' &\leq E + (1+r)a + (1-\delta^h)h && (17)\\
c &\geq 0 && (18)\\
a' &\geq -\kappa h' && (19)\\
q &= a' + h' && (20)\\
h' &\geq \underline{H} && (21)\\
h' &= h && (22)
\end{aligned}
$$

3.8.3 Homeowners selling house and renting: V^3, $(I, I') = (1, 0)$

As the homeowner is selling the house in the current period, the right hand side of the budget constraint is identical to the one shown in (3.8.1). Given the available resources, the household then chooses consumption of non-durable goods, c, next period financial net worth, a', and pays the rental deposit, which is priced at p per unit of rental housing. As the household becomes a renter, the household does not have any collateral and thus cannot borrow. In case the retired household does not survive until the next period, all assets are left as bequest. The problem for homeowners selling their houses and renting can be formed recursively as follows:

$$
\begin{aligned}
V^3(j,h,a,I,y) &= \max_{c,h',a'} \left[U(c,h,n) + s\beta E(V(j+1,h',a',I',y')) + (1-s)\varphi(q)\right] && (23)\\
&\text{subject to} \\
c + a' + (p+\phi^b)h' &\leq E + (1+r)a + (1-\delta^h-\phi^s)h && (24)\\
c &\geq 0 && (25)\\
a' &\geq 0 && (26)\\
q &= a' + ph' && (27)
\end{aligned}
$$

3.8.4 Renters buying a house: V^4,$(I, I') = (0, 1)$

In the beginning of period t, households receive the rent deposit paid in the last period net of interest they would have earned if they had it deposited at a financial institution. Since the renter is moving out of the rental property to buy a new house, there is a cost of moving out proportional to the rent deposit received. This is equivalent to the selling transaction cost mentioned earlier. In net, the household receives $(\frac{p}{1+r} - \phi^s)h$. Households also receive financial net worth with realized riskfree returns, $(1+r)a$. Given the available resources, the household then chooses consumption of non-durable goods, c, next period financial net worth, a', and buys

a new house with transaction costs involving the purchase $(1+\phi^b)h'$. In case a retired household does not survive until the next period, all assets are left as bequest. As the household becomes a homeowner, the minimum housing size constraint holds and the household can borrow up to a certain fraction of the value of the new house. The problem for renters buying a new house can be formed recursively as follows:

$$\begin{aligned} V^4(j,h,a,I,y) &= \max_{c,h',a'} \left[U(c,h,n) + s\beta E(V(j+1,h',a',I',y')) + (1-s)\varphi(q)\right] && (28) \\ &\text{subject to} \\ c + a' + (1+\phi^b)h' &\leq E + (1+r)a + (\frac{p}{1+r} - \phi^s)h && (29) \\ c &\geq 0 && (30) \\ a' &\geq -\kappa h' && (31) \\ q &= a' + h' && (32) \\ h' &\geq \underline{H} && (33) \end{aligned}$$

3.8.5 Renters staying at the same rental property: V^5, $(I, I') = (0, 0)$

In the beginning of period t, households receive $(1-r)ph$, the rent deposit paid in the last period net of interest they would have earned if they had it deposited at a financial institution. Households also receive financial net worth with realized riskfree returns, $(1+r)a$. Given the available resources, the household then chooses consumption of non-durable goods, c, next period financial net worth, a', and stays at the existing rental property ($h' = h$). In case a retired household does not survive until the next period, all assets are left as bequest. As the household remains as a renter, the household does not have any collateral to borrow. The problem for renters staying at the same rental property can be formed recursively as follows:

$$\begin{aligned} V^5(j,h,a,I,y) &= \max_{c,h',a'} \left[U(c,h,n) + s\beta E(V(j+1,h',a',I',y')) + (1-s)\varphi(q)\right] && (34) \\ &\text{subject to} \\ c + a' + ph' &\leq E + (1+r)a + \frac{p}{1+r}h && (35) \\ c &\geq 0 && (36) \\ a' &\geq 0 && (37) \\ q &= a' + ph' && (38) \\ h' &= h && (39) \end{aligned}$$

3.8.6 Renters moving to a different rental property: V^6, $(I, I') = (0, 0)$

As the renter is moving out of current rental property in the current period, the right hand side of the budget constraint is identical to the one shown in (8.0.10). Given the available resources, the

household then chooses consumption of non-durable goods, c, next period financial net worth, a', and pays rental deposit for the new rental property with transaction cost $(p+\phi^b)h'$. In case a retired household does not survive until the next period, all assets are left as bequest. As the household remains as a renter, the household does not have any collateral to borrow. The problem for renters moving to a different sized rental property can be formed recursively as follows:

$$V^6(j,h,a,I,y) = \max_{c,h',a'} \left[U(c,h,n) + s\beta E(V(j+1,h',a',I',y')) + (1-s)\varphi(q)\right] \quad (40)$$

subject to

$$c + a' + (p+\phi^b)h' \leq E + (1+r)a + (\frac{p}{1+r} - \phi^s)h \quad (41)$$

$$c \geq 0 \quad (42)$$

$$a' \geq 0 \quad (43)$$

$$q = a' + ph' \quad (44)$$

3.9 Definition of a stationary equilibrium

A stationary equilibrium is given by a set of government policy arrangements $\{\tau_{SS}, b, T\}$; a set of prices $\{p, r, w\}$; value functions $V(x)$; and allocations $c(x), a'(x), h'(x)$; a time-invariant distribution of agents over the state variables $x = \{j, h, a, I, y\}$, $m^*(x)$; and aggregate quantities $\{Y, C, H, K, L, S, D\}$ such that given prices and the government policies:

(i) the functions $V(x), c(x), a'(x), h'(x)$ solve the dynamic maximization problem of the households given in Section (3.8).

(ii) factor prices are equal to their marginal products:

$$r = F_K(K,L) - \delta^k \quad (45)$$

$$w = F_L(K,L) \quad (46)$$

(iii) $\{S, D\}$ solves the rental agency's problem given in (5) and (6).

(iv) the government policies satisfy:

$$\tau_{SS} wL = b \int_{j=j^*,\ldots,J} m^*(dx) \quad (47)$$

$$b = \frac{\chi wL}{\int_{j=1,\ldots,j^*-1} m^*(dx)} \quad (48)$$

$$T = \frac{\int_{j=j^*,\ldots,J} q \; m^*(dx)}{\int_{j=1,\ldots,j^*-1} m^*(dx)} \quad (49)$$

(v) m^* is the invariant distribution of households over the state variables for this economy.

(vi) all markets clear.

$$K = \int a \; m^*(dx) - D \tag{50}$$

$$H = \int h \; m^*(dx) - S \tag{51}$$

$$L = \int \epsilon y \; m^*(dx) \tag{52}$$

$$C = \int c \; m^*(dx) \tag{53}$$

$$S = \int_{I=0} h \; m^*(dx) \tag{54}$$

$$S = D \tag{55}$$

$$Y = C + \delta^k K + \delta^h H + \delta^h S + \Pi \tag{56}$$

$where$

$$\Pi = (\phi^s + \phi^b)H \tag{57}$$

As for the government policies, the condition (47) states that the sum of the social security payroll tax revenue is equal to the pension benefit paid to the retired households. The equation (48) states that the pension benefit for a retiree in a given period is a fraction χ of the average earnings of the working households. Finally, the equation (49) states that the bequest left by the deceased is equally distributed to the working households as transfers.

The first market clearing condition (50) states that the total aggregate of the financial net worth held by the household which is not deposited into the rental agency must be equal to the aggregate stock of business capital in the economy. The second condition (51) states that the aggregate stock of housing is the sum of stocks of owner-occupied and rental housing, where the latter is equivalent to the sum of deposits accepted by the rental agency, as shown in (**??**).

3.10 Benchmark Model - US

For the case of the US, one difference comes from the demographics, where the retirement age is 65. I thus change $j^* = 10$ for the US accordingly. In terms of housing market institutions, the model set-up differs from that in Korea in two aspects: the mortgage market and the rental arrangement. The differences in the mortgage market is essentially determined by the loan-to-value parameter κ, and this will be shown in the calibration section. On the other hand, the rental arrangements in the US will include periodic rental payments. In addition, the no-arbitrage condition (8) shown in the rental agency's problem in subsection 3.6, is modified as follows:

Table 2: Parameter Definition and Values

Parameters	**Definition**	**US**	**Korea**
γ	Risk-aversion coefficient	1.5	1.5
λ	Dispremium of rental vs. homeownership	0.70	0.70
ϕ^s	Selling transaction cost	0.06	0.06
ϕ^b	Buying transaction cost	0.02	0.02
α	Capital income share	0.237	0.237
δ^h	Housing depreciation rate	0.042	0.042
δ^k	Business capital depreciation rate	0.076	0.076
ρ	Persistence of income process	0.85	0.85
τ_{SS}	Payroll tax rate	0.09	0.09
ϵ_j	Age-efficiency profile	Hansen	Hansen
κ	Loan-to-value ratio	0.75	0.25
r	Risk-free interest rate	endogenous	endogenous
σ_y^2	Innovation of income process	0.30	0.07
j^*	Retirement age	65	60
ϕ_1	Bequest parameter	-17	Table 3
ϕ_2	Bequest parameter	8	Table 3

$$\tilde{p} - \delta^h = r \tag{58}$$

or

$$\tilde{p} = \delta^h + r \tag{59}$$

Here, $\tilde{p}$ denotes the price paid per unit of rental service flow. Equation (59) states that renting a residential capital and earning a revenue equal to $\tilde{p}$ and pay for the maintenance cost δ^h provides the same yield as earning riskfree interest from a bank deposit. Detailed specification of the US case is shown in the Appendix.

4 Calibration

The set of parameters will be divided into those that can be estimated independently of the model or are based on estimates provided by other literature and the data, and those that are chosen such that the predictions generated by the model can match a given set of targets. All parameters were adjusted to the five year span that each period in the model represents. The first set of calibrated parameters for the US and Korea are shown in Table 2.

Regarding the preference parameters, the relative risk aversion coefficient, γ, is taken from Attanasio et. al. [2], and this value falls in the range commonly used in the macroeconomics literature. The rental utility parameter, λ, is set as 0.7 to incorporate the fact that agents derive less utility from a rental housing than an owner-occupied housing. This value was also used in Platania and Schlagenhauf [39]. The deterministic age-efficiency profile ϵ_j, was calculated form the estimate of the mean age-income profile from Hansen [21] for both US and Korea. However, since the retirement age is 65 in the US, the age-efficiency profile is adjusted accordingly. For retired households, $\epsilon_j = 0$. The logarithm of the stochastic productivity process is assumed to be an AR(1) following Huggett [25].

$$\begin{aligned} z_t &= \rho z_{t-1} - \mu_t \\ where & \\ z_t &= \ln y^t \end{aligned} \tag{60}$$

The disturbance term μ_t is normally distributed with mean zero and variance σ_y^2. The variance σ_y^2 as well as the persistence parameter ρ for the US are taken from estimates by De Nardi [11]. For Korea, it is assumed that the persistence parameter is identical to the case of the US, while the variance term is adjusted for the differences in the Gini coefficients for earnings in Korea versus the US.

The conditional survival probabilities for working households were assumed to be 1. For retired households, the probabilities in Korea were taken from the Korea Life Table (2001) supplied by the National Statistics Office of Korea. For the US, the probabilities are taken from Bell, Wade and Goss [4].

The KLIPS data was used to calibrate the average effective family size n_t for Korea, while the census data was used for the case of the US. For the adult equivalent scale, I adopted the measure used by Fernandez-Villaverde and Krueger [13]. In the aggregate production function, I calibrate the parameters for the US first. First, α is the share of income that goes to physical capital, which is calibrated at 23.7% in the US. The annual depreciation rate of the capital stock and the housing stock are 7.6% and 4.2%, respectively. For the transaction cost parameters, ϕ^s and ϕ^b, Gruber and Martin [19] estimate the relocation cost of tax and agency cost from the US Consumer Expenditure Survey (CEX), and find that the median household pays costs on the order of 7%. I assume the selling and buying transaction costs to be 6% and 2% of the property value, respectively. The loan-to-value ratio, κ, was taken from the average of the loan-to-value ratio between the years 1996 and 2000 compiled by the Housing and Commercial Bank in Korea. For the US, the loan-to-value ratio was taken to be 0.75. This figure is lower than the figures suggested by Jappelli and Pagano [27] , but their paper gives the maximum loan-to-value ratio whereas this paper looks at the average ratio. For the bequest parameters in the United States, ϕ_1 and ϕ_2 were taken from Yang [43].

Table 3: Parameter to match given set of targets

Parameters	**Definition**	**US**	**Korea**
β	Discount factor	0.944	0.920
$\underline{H}$	Minimum housing size	1.425	1.136
ω	Share of housing consumption	0.14	0.05
χ	Replacement rate	0.34	0.26
ϕ_1	Bequest parameter	-	-29
ϕ_2	Bequest parameter	-	1.5

Table 3 shows the parameters used to match some given set of targets in the data.

The discount factor, β, is calibrated to match the capital-output ratio in both countries. For the United States, the capital-output ratio was 3.175, whereas for Korea the ratio was 2.448. The minimum housing size is calibrated to match the the average homeownership ratio in the two countries. The unit is in terms of average income which is set to be equal to one. For the United States, the Survey of Consumer Finances in 2001 reports that 68 percent of households lived in owner-occupied housing. In Korea, the corresponding figure according to the KLIPS survey was 58 percent. As for the parameter ω, it was chosen to match the ratio of housing capital to the total capital stock in the two countries. The ratios were 0.385 and 0.201 for the United States and Korea, respectively. Finally, with the social security payroll tax rate of 9% for working households, the replacement rates for the social security were chosen so that the government balances budget each period. For Korea, the bequest parameters were calibrated separately. For the bequest parameter ϕ_1, the value was chosen to match the level of wealth in the last period of the life cycle shown in the KLIPS data, whereas the bequest parameter ϕ_2 was chosen to match the level of wealth in the initial period of the life cycle in the data.

5 Results

In this section, the results from the benchmark simulation are presented and the fit of the model is evaluated. Next, the roles of the institutional factors, namely, the mortgage market and the rental arrangements, are examined. Finally, using the benchmark simulation as a reference, a policy experiment of different tax system is presented and the implications on wealth accumulation and portfolio composition are analyzed.

Table 4: Aggregate Statistics for Benchmark Simulation - US

	Benchmark Simulation	US data
Capital Output Ratio ($\frac{H+K}{Y}$)	3.175	3.173
Homeownership Ratio	0.671	0.680
Housing Capital Ratio ($\frac{H}{H+K}$)	0.377	0.385
Payroll tax rate	0.09	0.09

5.1 Benchmark Case

5.1.1 US

To begin with, the table below compares the aggregate statistics of the benchmark simulation and the data.

Now, we turn to the profile of net worth and homeownership over the cross section. In the model, net worth is defined as the sum of the housing asset, financial net worth and any transfers received in the beginning of the period. In addition, housing asset for homeowners and financial net worth are plotted against the profile in the data. Finally, the fraction of homeowners for different age groups from the model simulation is plotted against the data taken from SCF 2001 wave. The results from the benchmark simulation are shown in Figure 5.1 to 5.3.

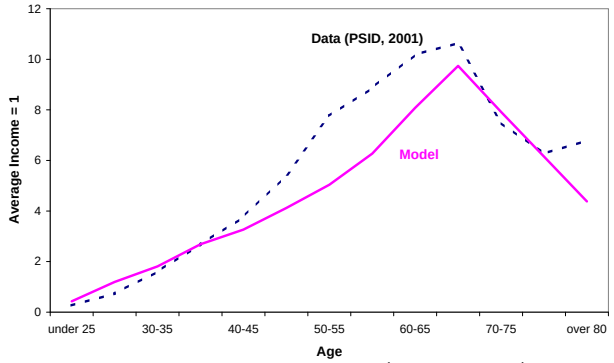

Figure 5.1 Net Worth - US (Benchmark)

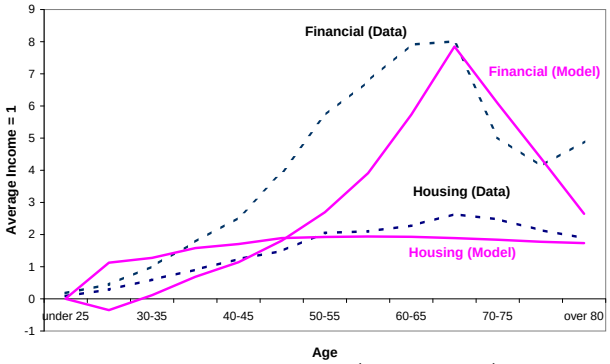

Figure 5.2 Assets - US (Benchmark)

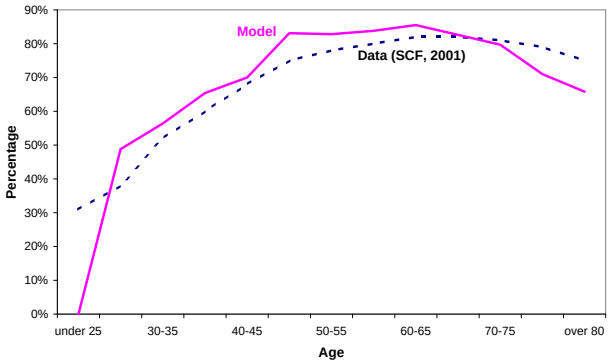

Figure 5.3 Homeownership Ratio - US (Benchmark)

5.1.2 Korea

To begin with, the table below compares the aggregate statistics of the benchmark simulation and the data.

Now, we turn to the profile of net worth and homeownership over the cross section shown in Figure 5.4 to 5.6. While the aggregate ratios from the benchmark simulation match the data well, the cross-section profiles do not, especially the profile of housing versus financial net worth.

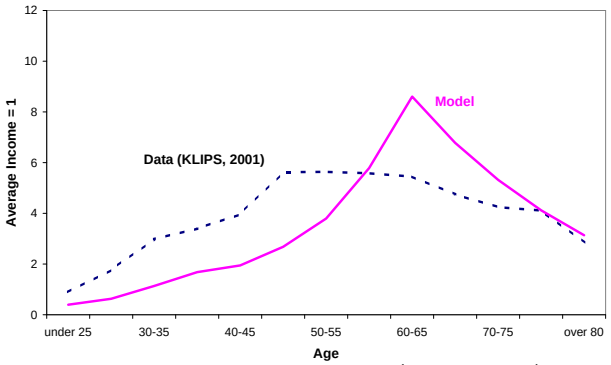

Figure 5.4 Net Worth - Korea (Benchmark)

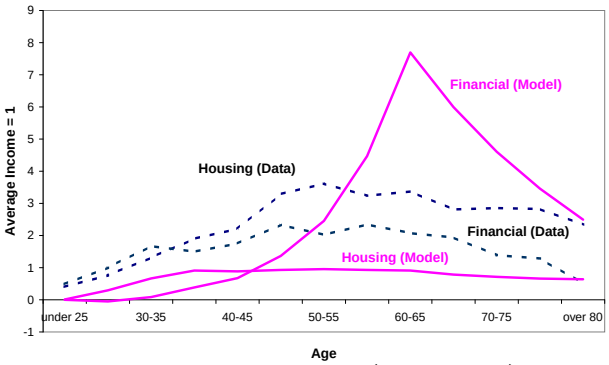

Figure 5.5 Assets - Korea (Benchmark)

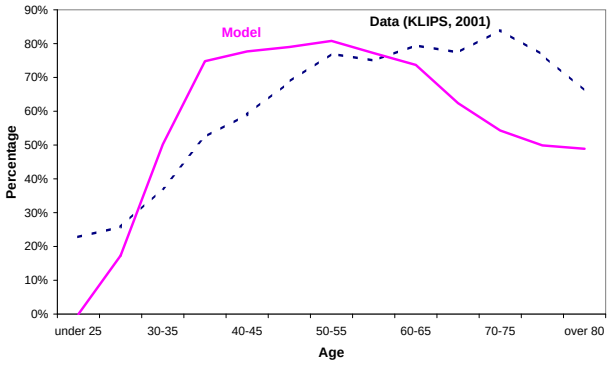

Figure 5.6 Homeownership Ratio - Korea (Benchmark)

Table 5: Aggregate Statistics for Benchmark Simulation - Korea

	Benchmark Simulation	Korean data
Capital Output Ratio ($\frac{H+K}{Y}$)	2.450	2.448
Homeownership Ratio	0.578	0.58
Housing Capital Ratio ($\frac{H}{H+K}$)	0.224	0.201
Payroll tax rate	0.09	0.09
Wealth at 25	0.395	0.89
Wealth at 80	3.135	2.85

5.2 Changes in the Housing Institutions

In this section, the quantitative roles played by the institutional features of the mortgage and the rental market are analyzed. First, to highlight the role of mortgage system, the current system was modified to resemble the mortgage system in the United States. In fact, the Korean government recently introduced a full-fledged mortgage loan program similar to that in the United States. Even though it is too early to assess the impact of this recent policy introduction, modifying the model by incorporating mortgage loans may shed light on how households' tenure decision will be affected, as well as the overall portfolio composition of wealth over the life cycle. One way to incorporate mortgage into the model is to introduce an asset from which people can borrow against. However, given the existing number of state variables, adding another state variable would only complicate further the computation without providing many beneficial implications. Thus, instead of adding another state variable, the loan-to-value (LTV) ratio is changed to 50% and then to 75% from the benchmark ratio of 25%. The first case is denoted as a 'partial mortgage expansion' while the latter is denoted as 'full mortgage expansion'. This implies that households can now finance their home purchase with an upfront down-payment of only 50% and 25% of the value of the house, respectively. It is also assumed that households with a mortgage can refinance and adjust their mortgage balance without any adjustment cost. Relaxing the collateral constraint will enable households to purchase a house earlier and accumulate more housing assets. Next, to document the importance of the rental system, the rental arrangements in the benchmark Korean model was modified to mimic the rental system in the United States. Under the US-type rental market arrangement, renters pay periodic rental payment. Finally, when the mortgage system and the rental arrangement are jointly modified, the effects on housing wealth and homeownership ratio are further amplified, whereas the effect on the overall net worth becomes negative for all possible arrangements.

For all the experiments, we look at the case where the interest rate is fixed at the benchmark level versus the case where the interest rate is allowed to adjust. In addition, as the model prediction fits the cross section data well in the net worth and the homeownership in comparison to the profile of different assets, we will only focus on the profile of the former two variables in this section.

5.2.1 Partial Mortgage Expansion

Table 6 compares the aggregate statistics for the case when the mortgage system is partially expanded with the loan-to-value ratio equal to 50%.

An increase in the loan-to-value ratio from 25% to 50% results in a lower capital output ratio when the interest rates are fixed, but not when the interest rates are allowed to adjust to the mortgage expansion. The homeownership ratio increases from 3.1 to 3.6 percentage points, which accounts for around 30 percent of the observed differences in the homeownership ratios

Table 6: Aggregate Statistics for Partial Mortgage Expansion

	Benchmark	r fixed	r variable
Capital Output Ratio ($\frac{H+K}{Y}$)	2.45	2.405	2.46
Homeownership Ratio	0.578	0.614	0.609
Housing Capital Ratio ($\frac{H}{H+K}$)	0.224	0.239	0.23
Interest rate (r)	5.14%	5.14%	5.22%

between Korea and the United States.

Now, we turn to the profile of net worth and homeownership over the cross section. In the model, net worth is defined as the sum of the housing asset, financial net worth and any transfers received in the beginning of the period. In addition, housing asset for homeowners and financial net worth are plotted against the profile in the benchmark for Korea and the United States. Finally, the fraction of homeowners for different age groups from the model simulation is plotted against the profile in the benchmark for Korea and the United States. For net worth, the largest decline in wealth occurs in the age groups of 35 to 45, as they will be more indebted from buying a house. In terms of homeownership, the biggest increase takes place among younger households in the age group of 25 to 30. The results from the partial mortgage expansion are shown in Figure 5.7 and 5.8.

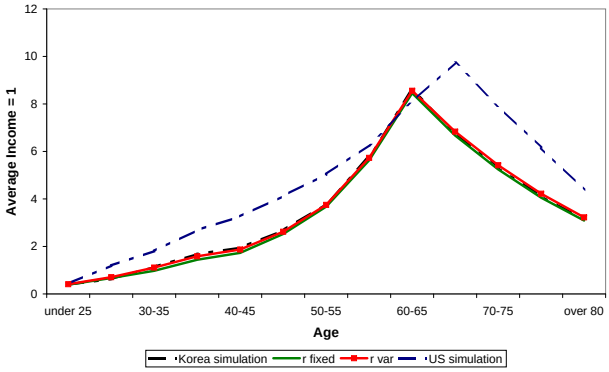

Figure 5.7 Net Worth (Partial Mortgage Expansion)

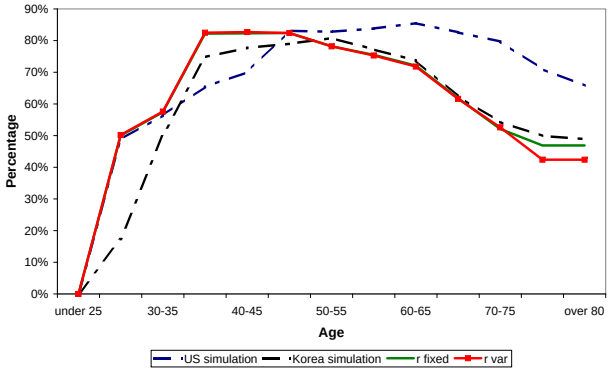

Figure 5.8 Homeownership Ratio (Partial Mortgage Expansion)

5.2.2 Full Mortgage Expansion

Table 7 compares the aggregate statistics for the case when the mortgage system is expanded with the loan-to-value ratio equal to 75%, which matches the ratio in the United States.

An increase in the loan-to-value ratio from 25% to 75% results in a decline in the capital output ratio ranging from 1.2 to 1.8 percent. The homeownership ratio increases from 5.5 to 6.5 percentage points, which accounts for around 60 percent of the observed differences in the homeownership ratios between Korea and the United States. In addition, the housing capital ratio increases by 1.9 to 2.3 percentage points.

Table 7: Aggregate Statistics for Full Mortgage Expansion

	Benchmark	r fixed	r variable
Capital Output Ratio ($\frac{H+K}{Y}$)	2.45	2.405	2.42
Homeownership Ratio	0.578	0.643	0.633
Housing Capital Ratio ($\frac{H}{H+K}$)	0.224	0.247	0.243
Interest rate (r)	5.14%	5.14%	5.31%

Table 8: Aggregate Statistics for US-Type Rental Arrangement

	Benchmark	r fixed	r variable
Capital Output Ratio ($\frac{H+K}{Y}$)	2.45	2.285	2.355
Homeownership Ratio	0.578	0.344	0.376
Housing Capital Ratio ($\frac{H}{H+K}$)	0.224	0.206	0.196
Interest rate (r)	5.14%	5.14%	5.22%

Now, we turn to the profile of net worth and homeownership over the cross section. For net worth, the largest decline in wealth occurs in the age groups of 35 to 45, where the average wealth falls in the range of 15 to 20 percent. In terms of homeownership, the biggest increase takes place among younger households in the age group of 25 to 35 with homeownership increasing by more than 30 percentage points. The results from the full mortgage expansion are shown in Figure 5.9 and 5.10.

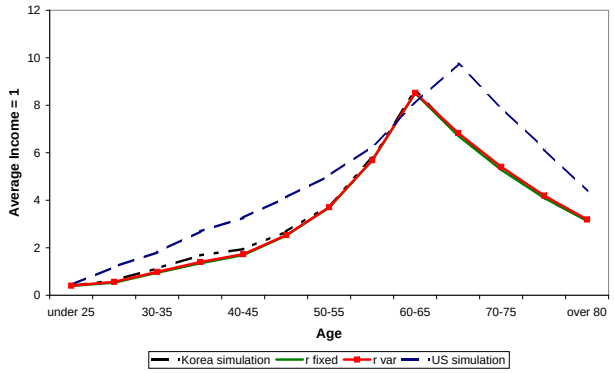

Figure 5.9 Net Worth (Full Mortgage Expansion)

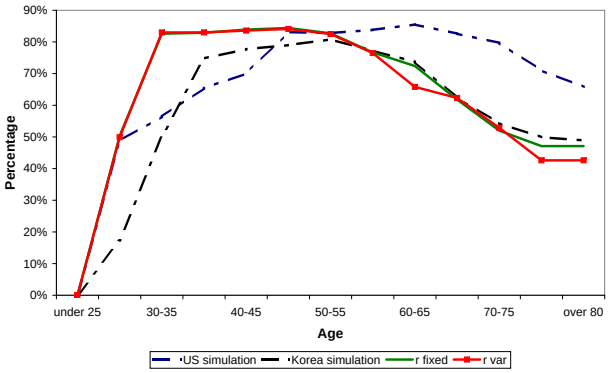

Figure 5.10 Homeownership Ratio (Full Mortgage Expansion)

5.2.3 Change in Rental Arrangement

Table 8 compares the aggregate statistics for the case when the rental arrangement is altered to a US-type rental arrangement.

A switch from the chonsae to a US-type rental arrangement results in a decline in the capital output ratio ranging from 3.9 to 6.7 percent. The homeownership ratio falls significantly by more

than 20 percentage points. This large fall in the homeownership might indicate that the US-type rental housing is a cheaper alternative to the chonsae rental arrangement. In addition, the housing capital ratio decreases by 1.8 to 2.8 percentage points.

Now, we turn to the profile of net worth and homeownership over the cross section. For net worth, the largest decline in wealth occurs in the age groups of 35 to 50, where the average wealth falls in the range of 10 to 15 percent. In terms of homeownership, the decline takes place among all household age groups. The results from the US-type rental arrangement are shown in Figure 5.11 and 5.12.

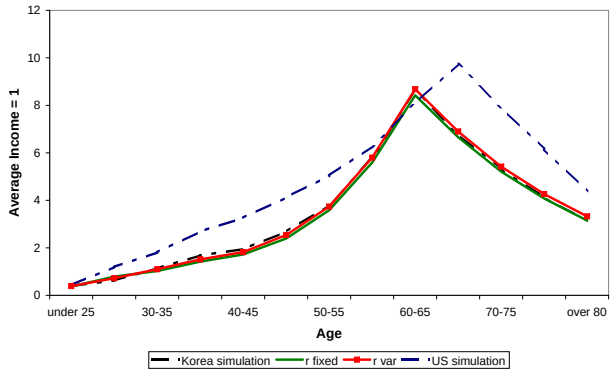

Figure 5.11 Net Worth (US Rental Arrangement)

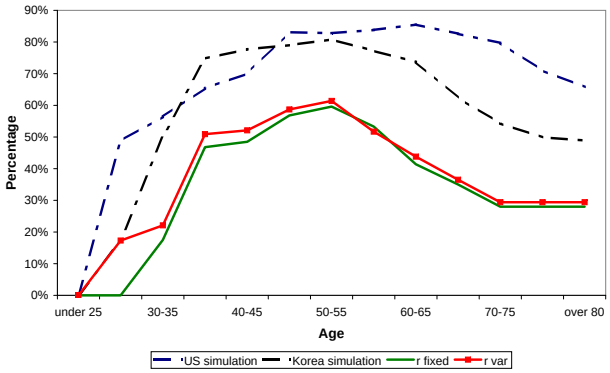

Figure 5.12 Homeownership Ratio (US Rental Arrangement)

5.2.4 Rental Change and Mortgage Expansion

Table 9 compares the aggregate statistics for the case when the mortgage is fully expanded to the level in the US as well as rental arrangement being altered to a US-type rental arrangement.

Changing both housing market institutions results in a decline in the capital output ratio ranging from 5.5 to 7.8 percent, as each housing institution has a negative impact on the wealth accumulation of the households. The fall in the homeownership ratio caused by change in the rental arrangement is slightly reversed as the mortgage becomes widely available. The homeownership ratio falls by less than 20 percentage points, nevertheless significantly around 18.2 to 19.5 percentage points.

Table 9: Aggregate Statistics for Full Mortgage Expansion and US-type Rental Arrangement

	Benchmark	r fixed	r variable
Capital Output Ratio $(\frac{H+K}{Y})$	2.45	2.26	2.315
Homeownership Ratio	0.578	0.383	0.396
Housing Capital Ratio $(\frac{H}{H+K})$	0.224	0.211	0.204
Interest rate (r)	5.14%	5.14%	5.22%

Now, turning to the profile of net worth and homeownership over the cross section, the largest decline in wealth occurs in the age groups of 30 to 40, where the average wealth falls by around 20 percent. In terms of homeownership, young households to the age of 35 are unaffected by the change in the institutions, while for households aged over 35 the homeownership fall by around 20 percentage points. The results are shown in Figure 5.13 and 5.14.

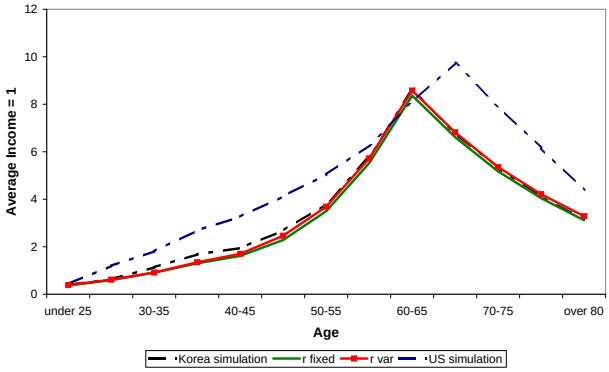

Figure 5.13 Net Worth
(Mortgage Expansion & US Rental)

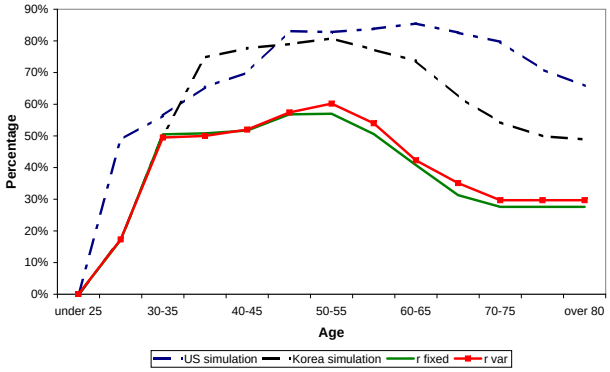

Figure 5.14 Homeownership Ratio
(Mortgage Expansion & US Rental)

6 Policy Experiments and Welfare Analysis

In this section, using the benchmark simulation in the previous section as a reference point, a policy experiment of introducing two different types of taxes related to housing are presented and the implications on aggregate wealth, homeownership ratio and the welfare are analyzed. All other parameters were kept unchanged at the same value as made under the benchmark simulation. One type of taxation related to housing is tax on housing transaction. This transaction tax is levied on the purchase of new housing unit, thus adversely affecting first time home buyers as well as homeowners changing to a different sized housing unit. The other type of taxation is property tax, levied on the current homeowners. On the other hand, the proceeds from tax revenue is equally distributed to the current period renters. Thus, in terms of the value functions, the transaction tax would enter into V^1 and V^4, while the property tax would enter into V^1, V^2, and V^3. On the other hand, the subsidy would enter into the value functions V^4, V^5, and V^6. We look at several different scenarios, where the tax rates are given as 1% and 2%, individually and jointly. In addition, we compare the case where the interest rate is fixed at the benchmark case versus the case where the interest rate changed accordingly. Finally, we compare the case where there is no subsidy given back to the renters versus the case where subsidy is re-distributed to the renters.

6.0.5 Taxes with No Subsidy

Introducing taxes on housing property and housing transaction with no subsidy re-distributed to the renters are analyzed in this subsection. We look at the impact on the aggregate homeown-

ership ratio in percentage change, aggregate capital output ratio as well as welfare in percent change. Table 10 and 11 compare the changes in the aggregate homeownership under the tax experiment when the interest rate is fixed and adjustable, respectively. One percent tax on transaction lowered the aggregate homeownership by 3.2 percentage points when the interest rate is fixed, while the impact is greater at 4.1 percentage points fall when the interest rate is allowed to adjust. On the other hand, a one percent tax on holding housing property lowered the aggregate homeownership ratio by 4.8 percentage points and 4.9 percentage points for fixed and adjustable interest rate, respectively.

r fixed		Transaction Tax		
		0%	1%	2%
Property Tax	0%	-	-3.2%	-3.1%
	1%	-4.8%	-4.7%	-5.5%
	2%	-6.6%	-6.9%	-9.0%

Table 10. Percentage Point Changes in Homeownership - Fixed Interest, No Subsidy

r variable		Transaction Tax		
		0%	1%	2%
Property Tax	0%	-	-4.1%	-4.6%
	1%	-4.9%	-5.0%	-7.0%
	2%	-6.9%	-6.8%	-8.5%

Table 11. Percentage Point Changes in Homeownership - Variable Interest, No Subsidy

Table 12 and 13 show the change in the aggregate capital output ratio in the economy. When the interest rate is fixed, one percent tax on transaction lowered the aggregate wealth by 0.81 percent, while a one percent tax on housing property lowered the aggregate wealth by 1.22 percent. On the other hand, when the interest rate is allowed to adjust, one percent tax on transaction had no impact on the aggregate wealth, while a two percent tax lowered the wealth by 0.81 percent. A one percent tax on holding housing property raised the aggregate wealth by 0.20 percent, while a 2 percent tax lowered the wealth by 3.85 percent.

r fixed		Transaction Tax		
		0%	1%	2%
Property Tax	0%	-	-0.81%	-0.81%
	1%	-1.22%	-0.81%	-1.63%
	2%	-1.43%	-2.24%	-2.24%

Table 12. Percent Changes in Capital Output Ratio - Fixed Interest and No Subsidy

r variable		Transaction Tax		
		0%	1%	2%
Property Tax	0%	-	0%	-0.81%
	1%	+0.20%	-1.62%	-4.66%
	2%	-3.85%	-7.49%	-6.07%

Table 13. Percent Changes in Capital Output Ratio - Variable Interest and No Subsidy

As for the aggregate welfare, the results were unambiguously non-positive for introducing taxes as households consume less and have lower homeownership in general. The impact on aggregate welfare ranged from -0.06 percent to -0.31 percent when the interest rate was fixed. When the interest rate was adjustable, the impact on aggregate welfare ranged from having no impact as in the case of introducing 1 percent tax individually, to -1.32 percent.

r fixed		Transaction Tax		
		0%	1%	2%
Property Tax	0%	-	-0.25%	-0.25%
	1%	-0.13%	-0.06%	-0.31%
	2%	-0.25%	-0.19%	-0.31%

Table 14. Percent Changes in Welfare - Fixed Interest and No Subsidy

r variable		Transaction Tax		
		0%	1%	2%
Property Tax	0%	-	0%	-0.13%
	1%	0%	-0.56%	-0.25%
	2%	-0.56%	-1.32%	-0.44%

Table 15. Percent Changes in Welfare - Variable Interest and No Subsidy

6.0.6 Taxes with Subsidy

Introducing taxes on housing property and housing transaction with the tax revenue re-distributed to the renters as subsidy while keeping the interest rates fixed to the benchmark case are analyzed in this subsection. Table 16 and 17 compare the aggregate statistics of the benchmark simulation versus tax experiment. Compared to the case of no subsidy, providing subsidy to the renters mitigates the negative impact of tax on homeownership ratio in general. When the interest rate was fixed, one percent tax on transaction lowered the aggregate homeownership by 0.9 percentage points, while a one percent tax on holding housing property lowered the aggregate homeownership ratio by 1.3 percentage points. A joint 1 percent tax on housing property and transaction lowered the ratio by 4.5 percentage points. On the other hand, allowing interest rate to vary amplifies the effect on homeownership compared to the fixed interest case, partly due to the fact that changes in the interest rate will induce households to change their asset portfolio. One percent tax on transaction lowered the aggregate homeownership by 3.4 percentage points, while a one percent tax on holding housing property lowered the aggregate homeownership ratio by 6.5 percentage points. A joint 1 percent tax on housing property and transaction lowered the ratio by 7.7 percentage points.

r fixed		Transaction Tax		
		0%	1%	2%
Property Tax	0%	-	-0.9%	-0.9%
	1%	-1.3%	-4.5%	-4.2%
	2%	-4.5%	-5.7%	-7.5%

Table 16. Percentage Point Changes in Homeownership - Fixed Interest and Subsidy

r variable		Transaction Tax		
		0%	1%	2%
Property Tax	0%	-	-3.4%	-5.1%
	1%	-6.5%	-7.7%	-8.5%
	2%	-9.5%	-10.5%	-10.6%

Table 17. Percentage Point Changes in Homeownership - Variable Interest and Subsidy

Table 18 and 19 show the change in the aggregate capital output ratio in the economy. For fixed interest rate, one percent tax on transaction lowered the wealth by 0.41 percent, while a one percent tax on holding housing property had no impact on the aggregate wealth. On the other hand, 2 percent joint tax lowered the wealth by 2.25 percent. Compared to the case without subsidy, the impact on wealth is less as the there are re-distribution from the homeowners to the renters. For variable interest rate, however, one percent tax on transaction lowered the wealth by 2.86 percent, while a one percent tax on holding housing property lowered the aggregate wealth by 0.20 percent.

r fixed		Transaction Tax		
		0%	1%	2%
Property Tax	0%	-	-0.41%	-0.20%
	1%	0%	-1.64%	-1.64%
	2%	-1.84%	-2.05%	-2.25%

Table 18. Percent Changes in Capital Output Ratio - Fixed Interest and Subsidy

r variable		Transaction Tax		
		0%	1%	2%
Property Tax	0%	-	-2.86%	+0.82%
	1%	-0.20%	-4.29%	-0.41%
	2%	-0.41%	-3.06%	-4.69%

Table 19. Percent Changes in Capital Output Ratio - Variable Interest and Subsidy

As for the aggregate welfare, the results were mostly positive for introducing taxes with redistribution of tax revenues to the renters. This is likely due to the fact that re-distribution affects renters who are mostly young households. The positive impact on aggregate welfare ranged from 0.06 percent to 0.56 percent for fixed interest rate. When the interest rate was adjusting to the introduction of taxes with redistribution of tax revenues to the renters, the effects were ambiguous. The impact on aggregate welfare ranged from -0.56 percent to 0.25 percent.

r fixed		Transaction Tax		
		0%	1%	2%
Property Tax	0%	-	-0.31%	+0.19%
	1%	+0.31%	+0.25%	+0.44%
	2%	+0.06%	+0.13%	+0.56%

Table 20. Percent Changes in Welfare - Fixed Interest and Subsidy

r variable		Transaction Tax		
		0%	1%	2%
Property Tax	0%	-	-0.38%	+0.25%
	1%	+0.13%	-0.56%	+0.13%
	2%	+0.06%	0%	-0.31%

Table 21. Percent Changes in Welfare - Variable Interest and Subsidy

7 Conclusion

In this paper, the wealth accumulation and asset portfolios of Korean households are investigated by setting up a quantitative model calibrated to reflect some key features of the Korean economy. The unique institutional features of the Korean housing market are highlighted and their roles are examined. The chonsae system, the unique rental arrangement in Korea, and the lack of mortgage system in Korea do play a significant role in accounting for the observed features of wealth accumulation and portfolio composition in Korea. Also, the various implications of recent policy changes are analyzed, such as expanding the current mortgage loan system and introducing social security system to the economy. An expansion of the mortgage system is expected to increase the average homeownership ratio significantly, especially for households in the 30-40 age group; whereas, introducing social security has the opposite effect. Expanding the mortgage system also shifts households' wealth portfolio toward housing assets, while the social security system does not affect the asset portfolio of households.

It is important to note that the model abstracts from several issues. First, the model does not incorporate the existence of inter-vivos transfers, which might explain why the model underestimates the level of wealth for the young households and is unable to match the age at which the profile of wealth peaks. In the data, Korean parents provide large financial support to

their children, especially when they become independent and buy a house. Given the high down payment ratio, children either save for an extended period of time or receive parental support in order to purchase a house. It is also reported that the average inter-vivos transfers received as a fraction of average income is higher in Korea than in the United States, especially for the younger households. This strengthens the importance of inter-vivos transfers in Korea and their implications on the accumulation of wealth over the lifecycle. Incorporating inter-vivos transfers in explaining the pattern of wealth accumulation in Korea raises several challenging questions for future research.

Second, the we use a lifecycle model to match a cross-section data, which was inevitable given the short span of the Korean household data. However, given that the new data sets have been published, it would be more feasible to look at a longer time series and construct a life cycle profile of wealth and homeownership for different cohorts. Further work on this data issue will be undertaken in the future.

References

[1] Ambrose, Brent W., and Sunwoong Kim. 2003. "Modeling the Korean Chonsei Lease Contract," Real Estate Economics, vol.31, pp. 53-74.

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

[3] Banks, James, Richard Blundell and James P. Smith. 2002. "Wealth Portfolios in the UK and the US," Working Paper No.9128, National Bureau of Economic Research, Cambridge, MA.

[4] Bell, F. C., Wade, A. H., and Goss, S. C. 1992. "Life tables for the United States social security area: 1900-2080," Actuarial Study No. 107. Washington DC: U.S. Department of Health and Human Services.

[5] Campbell, John Y and Joao Cocco. 2003. "Household Risk Management and Optimal Mortgage Choice," Working Paper, Harvard University. Cambridge, MA.

[6] Caroll, Christopher D. and Wendy E. Dunn. 1997. "Unemployment Expectations, Jumping (S,s) Triggers, and Household Balance Sheets," NBER Macroeconomics Annual 1997.

[7] Chambers, Matthew, Carlos Garriga and Don E. Schlagenhauf. 2004. "Accounting for Changes in the Homeownership Rate," Working paper, Florida State University.

[8] Chen, Kaiji. 2004. "The Welfare Implications of Social Security for Homeowners," Job Market Paper, University of Southern California, CA.

[9] Cho, Dongchul. 2005. "Interest Rate, Inflation, and Housing Price: With an Emphasis on Chonsei Price in Korea," Working Paper 11054, National Bureau of Economic Research, Cambridge, MA.

[10] Cocco, Joao. 2004. "Portfolio Choice in the Presence of Housing," accepted to Review of Financial Studies.

[11] De Nardi, Mariacristina. 2004. "Wealth Inequality and Intergenerational Links," Review of Economic Studies, 71, 734-768.

[12] Díaz, Antonia and María J. Luengo-Prado. 2002. "Precautionary Saving and Wealth Distribution with Durable Goods," Working paper, Northeastern University.

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

[14] Flavin, Marjorie and Takashi Yamashita. 2002. "Owner-Occupied Housing and the Composition of the Household Portfolio Over the Life Cycle," American Economic Review, 92, 345-362.

[15] Gervais, Martin. 2002. "Housing Taxation and Capital Accumulation," Journal of Monetary Economics, 49, 1461-1489.

[16] Glaeser, Edward L. and Jesse M. Shapiro. 2002. "The Benefits Of The Home Mortgage Interest Deduction," Working Paper No.9284, National Bureau of Economic Research, Cambridge, MA.

[17] Goetzmann, William N., and Matthew Spiegel, 2002, "The Policy Implications of Portfolio Choice in Underserved Mortgage Markets," Low-Income Ownership, Joint Center for Housing Studies, Brookings Institution Press, Washington D.C.. Eds. Retsinas and Belsky.

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

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

[20] Guiso, Luigi, Michael Haliassos and Tullio Japelli, eds. 2002. *Household Portfolios*, MIT Press, Cambridge, MA

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

[22] Haurin, Donald, Wenli Li and Rui Yao. 2004. "A Life-Cycle Model of Housing and Mortgage Choices with Labor Income and House Price Risks," *mimeo*

[23] Horioka, Charles Yuji, Hideki Fujisaki, Wako Watanabe, and Takassugu Kouno. 2000. "Are Americans More Altruistic Than The Japanese? A U.S.-Japan Comparison of Saving and Bequest Motives," Working Paper No.7463, National Bureau of Economic Research, Cambridge, MA.

[24] Hu, Xiaoqing. 2003. "Portfolio Choices for Homeowners," mimeo.

[25] Huggett, Mark. 1996. "Wealth distribution in life-cycle economies," Journal of Monetary Economics, Vol. 38(3), 469-494.

[26] Iwaisako, Takuo. 2003. "Household Portfolios in Japan," Working Paper No.9647, National Bureau of Economic Research, Cambridge, MA.

[27] Jappelli, Tullio and Marco Pagano. 1994. "Saving, Growth, and Liquidity Constraints," The Quarterly Journal of Economics, Vol. 109(1), 83-109.

[28] Kennickell, Arthur. 2003. "A Rolling Tide: Changes in the Distribution of Wealth in the U.S., 1989-2001," SCF Working Paper, Federal Reserve Board.

[29] Keister, Lisa. 2000. *Wealth in America : Trends in Wealth Inequality*, Cambridge University Press, Cambridge, MA.

[30] Kim, Kyung-Hwan. 2004. "Housing and the Korean Economy," Journal of Housing Economics, Vol. 13, 321-341.

[31] Lam, Eddie. 2002. "A Primer for Investors in the Korean MBS Market," Journal of Real Estate Portfolio Management, Vol. 8, No. 2.

[32] Lazear, Edward P. and Michael, Robert T. 1980. "Real Income Equivalence among One-Earner and Two-Earner Families," American Economic Review, Vol. 70(2), 203-08.

[33] Lee, Jungwoo and Sunglim Lee. 2001. "Estimation of Wealth Inequality in Korea (in Korean)," Journal of Korean Development Economics, 7-1.

[34] Li, Wenli and Rui Yao. 2005. "The Life-Cycle Effects of House Price Changes," Working Paper No.05-7, Federal Reserve Bank of Philadelphia, Philadelphia, PA.

[35] Lucas, Jr., Robert E. 1987.*Models of Business Cycles*, Basil Blackwell, New York.

[36] McCarthy, David. 2004. "Household Portfolio Allocation: A Review of the Literature," mimeo.

[37] Miles, David, Aleš Černý and Lubomir Schmidt. 2004. "A Calibrated Model of Saving, Portfolio Allocation and Housing Choices for Japanese Households," mimeo.

[38] Ortalo-Magné, François and Sven Rady. 1998. "Housing Market Fluctuations in a Life-Cycle Economy with Credit Constraints," working paper, Graduate School of Business, Stanford University.

[39] Platania, Jennifer and Don E. Schlagenhauf. 2002. "Housing and Asset Holding in a Dynamic General Equilibrium Model," Working Paper, Florida State University.

[40] Shimono, Keiko, Hideaki Otsuki and Miho Ishikawa. 1999. "Estimating the Size and Distribution of Bequests in Japan," mimeo, Institute of Economic Research, Nagoya City University, Nagoya, Japan.

[41] Silos, Pedro. 2005. "Housing Tenure and Wealth Distribution in Life-Cycle Economies," Working Paper 2005-25, Federal Reserve Bank of Atlanta.

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

[43] Yang, Fang. 2005. "Consumption Along the Life Cycle? How Different Is Housing?" Working Paper No. 635, Federal Reserve Bank of Minneapolis, Minneapolis, MN.

[44] Yao, Rui and Harold H. Zhang. 2003. "Optimal Consumption and Portfolio Choices with Risky Housing and Borrowing Constraints," Working Paper, University of North Carolina.

8 Appendix: Value Functions Corresponding to the US Economy

8.0.7 Homeowners selling and buying a new house: V^1_{us}, $(I, I') = (1, 1)$

In the beginning of period t, households have a position on the housing capital and pay maintenance costs as well as transaction costs for selling. In net, household receives $(1 - \delta^h - \phi^s)h$. Households also receive financial net worth with realized riskfree returns, $(1 + r)a$. Given the available resources, the households then chooses consumption of non-durable goods, c, next period financial net worth, a', and buys a new house with transaction costs, $(1 + \phi^b)h'$. In case the retired households do not survive until the next period, all assets are left as bequest. As the household stays as a homeowner, the minimum housing size constraint holds and the household can borrow up to a certain fraction of the value of the house. The problem for homeowners selling and buying a new house can be formed recursively as follows:

$$
\begin{aligned}
V^1_{us}(j, h, a, I, y) &= \max_{c,h',a'} \left[U(c, h, n) + s\beta E(V_{us}(j + 1, h', a', I', y')) + (1 - s)\varphi(q)\right] \\
&\text{subject to} \\
c + a' + (1 + \phi^b)h' &\leq E + (1 + r)a + (1 - \delta^h - \phi^s)h \\
c &\geq 0 \\
a' &\geq -\kappa h' \\
q &= a' + h' \\
h' &\geq \underline{H}
\end{aligned}
$$

8.0.8 Homeowners maintaining existing house: V^2_{us}, $(I, I') = (1, 1)$

In the beginning of period t, households have a position on the housing capital and pay maintenance costs. In net, household receives $(1 - \delta^h)h$. Households also receive financial net worth with realized riskfree returns, $(1 + r)a$. Given the available resources, the households then chooses consumption of non-durable goods, c, next period financial net worth, a', and maintains the same housing size ($h' = h$). In case the retired households do not survive until the next period, the sum of the housing and financial assets are left as bequest. As the household stays as a homeowner and does not change the housing size, the minimum housing size constraint holds

automatically, and the household can borrow up to a certain fraction of the value of the house as collateral. The problem for homeowners maintaining their existing houses can be formed recursively as follows:

$$
\begin{aligned}
V^2_{us}(j,h,a,I,y) &= \max_{c,h',a'} \left[U(c,h,n) + s\beta E(V_{us}(j+1,h',a',I',y')) + (1-s)\varphi(q)\right] && (61)\\
&\text{subject to} \\
c + a' + h' &\leq E + (1+r)a + (1-\delta^h)h && (62)\\
c &\geq 0 && (63)\\
a' &\geq -\kappa h' && (64)\\
q &= a' + h' && (65)\\
h' &\geq \underline{H} && (66)\\
h' &= h && (67)
\end{aligned}
$$

8.0.9 Homeowners selling house and renting: V^3_{us}, $(I, I') = (1, 0)$

As the homeowner is selling the house in the current period, the right hand side of the budget constraint is identical to the one shown in V^1_{us}. Given the available resources, the household then chooses consumption of non-durable goods, c, next period financial net worth, a', and pays rent, which is priced at $\tilde{p}$ per unit of rental service flow $f(h')$. The household also incurs transaction cost for moving into rental property and pays security deposit which is ι fraction of the rental property. This is denoted as $(\phi^b + \iota)h'$. As the household becomes a renter, the household does not have any collateral and thus cannot borrow. In case the retired household does not survive until the next period, all assets are left as bequest. The problem for homeowners selling their houses and renting can be formed recursively as follows:

$$
\begin{aligned}
V^3_{us}(j,h,a,I,y) &= \max_{c,h',a'} \left[U(c,h,n) + s\beta E(V_{us}(j+1,h',a',I',y')) + (1-s)\varphi(q)\right] && (68)\\
&\text{subject to} \\
c + a' + \tilde{p}f(h') + (\phi^b + \iota)h' &\leq E + (1+r)a + (1-\delta^h - \phi^s)h && (69)\\
c &\geq 0 && (70)\\
a' &\geq 0 && (71)\\
q &= a' + \iota h' && (72)
\end{aligned}
$$

8.0.10 Renters buying a house: V^4_{us},$(I, I') = (0, 1)$

In the beginning of period t, households receive the security deposit paid in the last period with interest payment. Since the renter is moving out of the rental property to buy a new

house, there is a cost of moving out proportional to the size of the rental property occupied. In net, the household receives $((1+r)\iota - \phi^s)h$. Households also receive financial net worth with realized riskfree returns, $(1+r)a$. Given the available resources, the household then chooses consumption of non-durable goods, c, next period financial net worth, a', and buys a new house with transaction costs involving the purchase $(1+\phi^b)h'$. In case a retired household does not survive until the next period, all assets are left as bequest. As the household becomes a homeowner, the minimum housing size constraint holds and the household can borrow up to a certain fraction of the value of the new house. The problem for renters buying a new house can be formed recursively as follows:

$$
\begin{aligned}
V^4_{us}(j,h,a,I,y) &= \max_{c,h',a'} \left[U(c,h,n) + s\beta E(V_{us}(j+1,h',a',I',y')) + (1-s)\varphi(q)\right] && (73)\\
&\text{subject to} \\
c + a' + (1+\phi^b)h' &\leq E + (1+r)a + ((1+r)\iota - \phi^s)h && (74)\\
c &\geq 0 && (75)\\
a' &\geq -\kappa h' && (76)\\
q &= a' + h' && (77)\\
h' &\geq \underline{H} && (78)
\end{aligned}
$$

8.0.11 Renters staying at the same rental property: V^5_{us}, $(I, I') = (0,0)$

In the beginning of period t, households receive the security deposit paid in the last period with interest payment. Households also receive financial net worth with realized riskfree returns, $(1+r)a$. Given the available resources, the household then chooses consumption of non-durable goods, c, next period financial net worth, a', and stays at the existing rental property ($h' = h$). In case a retired household does not survive until the next period, all assets are left as bequest. As the household remains as a renter, the household does not have any collateral to borrow. The problem for renters staying at the same rental property can be formed recursively as follows:

$$
\begin{aligned}
V^5_{us}(j,h,a,I,y) &= \max_{c,h',a'} \left[U(c,h,n) + s\beta E(V_{us}(j+1,h',a',I',y')) + (1-s)\varphi(q)\right] && (79)\\
&\text{subject to} \\
c + a' + \tilde{p}f(h') + \iota h' &\leq E + (1+r)a + (1+r)\iota h && (80)\\
c &\geq 0 && (81)\\
a' &\geq 0 && (82)\\
q &= a' + \iota h' && (83)\\
h' &= h && (84)
\end{aligned}
$$

8.0.12 Renters moving to a different rental property: V^6_{us}, $(I, I') = (0, 0)$

As the renter is moving out of current rental property in the current period, the right hand side of the budget constraint is identical to the one shown in V^4_{us}. Given the available resources, the household then chooses consumption of non-durable goods, c, next period financial net worth, a', and nd pays rent, which is priced at $\tilde{p}$ per unit of rental service flow $f(h')$. The household also incurs transaction cost for moving into rental property and pays security deposit which is ι fraction of the rental property. This is denoted as $(\phi^b + \iota)h'$. In case a retired household does not survive until the next period, all assets are left as bequest. As the household remains as a renter, the household does not have any collateral to borrow. The problem for renters moving to a different sized rental property can be formed recursively as follows:

$$V^6_{us}(j, h, a, I, y) = \max_{c,h',a'} \left[U(c, h, n) + s\beta E(V_{us}(j + 1, h', a', I', y')) + (1 - s)\varphi(q)\right] \quad (85)$$

subject to

$$c + a' + \tilde{p}f(h') + (\iota + \phi^b)h' \leq E + (1 + r)a + ((1 + r)\iota - \phi^s)h \quad (86)$$

$$c \geq 0 \quad (87)$$

$$a' \geq 0 \quad (88)$$

$$q = a' + \iota h' \quad (89)$$

-

9 Appendix: Computation of the Model

Since there is no closed form solution to the model, the stationary equilibrium of the model is solved numerically to work out optimal decision rules as a function of the state variables. The optimal decision rules were found by backward induction, starting at the terminal period J and working all the way recursively to the initial period.

In period J, the value functions coincide with the sum of the period utility function and the bequest function, and, given the realization of the state variables, the consumption and bequest choices are trivial. Based on the period J policy functions, in every period prior to J, the values associated with the different choices of housing in the next period were calculated, and consumption and asset portfolio choices conditional on different housing choices were obtained subsequently.

For choices of control variables that violate various constraints, a large negative utility is given so that an optimizing household would never opt for these choices. The realization of the earnings process are approximated using a Markov process following Tauchen and Hussey (1991) [**?**]. The state space for housing and financial assets were discretized into a finite number of grid points.

$$
\begin{aligned}
a &\in \{a_{min}, \ldots, 0, \ldots, a_{max}\} \\
h &\in \{0, \ldots, \underline{H}, \ldots, h_{max}\}
\end{aligned}
$$

Whenever the upper limit for the grids turned out to be binding in the solution to the problem, the upper and lower bounds were increased and the problem was solved again. In the end, the boundaries for the grids became sufficiently large and no longer imposed any constraint on the optimization process.

Solving for the stationary equilibrium, I take the following steps:

1. Guess the initial values of the interest rate r and solve for the rental deposit price p using the equilibrium conditions (8) and for the wage rate w using the equilibrium conditions in the factor market in (46).

2. Guess the initial level of transfers given to working households.

3. Solve for the individual household's recursive problem from the terminal period J and iterate backwards until the first period in life. This yields the policy functions and the value functions for all periods.

4. Using forward induction of the policy function, compute the stationary distribution of households m^*.

5. Given the stationary distribution and policy functions, compute the level of transfers. If the transfers converge, then go to the next step. If not, update the level of transfers and go back to step 2.

6. Given the stationary distribution and prices, compute aggregate capital and compute interest rate r using equation (45). Iterate until the interest rate r converges.