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on Households' Lifetime Utility[†]

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Abstract

This study estimates the impact of the dramatic changes in housing prices during Japan's bubble from the late 1980s to the 1990s on households' asset accumulation and utility over the life-cycle. We construct a life-cycle model explaining households' consumption/saving and housing decisions under collateral and borrowing constraints. We estimate this model using data from the *Family Income and Expenditure Survey* (FIES), which includes data on households' housing wealth estimated from objective information. Using the estimated model, we then conduct a counter-factual simulation in which we assume that housing price remained constant during the bubble period. Doing so allows us to quantify the gains/losses of lifetime utility due to the housing price boom and bust. We find that 38.6% of households experienced an increase in lifetime utility, which averaged 3.3%, while 61.4% experienced a decrease in lifetime utility, which averaged 2.4%. On average, Japan's housing price boom and bust caused a 0.2% loss in lifetime utility, which is equivalent to 1.3% of lifetime income.

Keywords: Asset Bubbles, Housing
JEL classifications: D12, D31, R21

1. Introduction

What is the most expensive good that households purchase? The answer, for most Japanese households, is a house. To buy a house, it is quite common for households to save money to make a down-payment and borrow five to eight times their annual income. Moreover, the value of a house tends to affect how much the bank will lend. Therefore, fluctuations in housing prices over time can have a significant impact on households' lifetime resources.

The fluctuations in housing prices during Japan's bubble were dramatic. Figure 1 shows the average housing wealth held by Japanese households.[1] As can be seen from the figure, housing wealth increased rapidly, especially in the Tokyo area, from the late 1980s to the early 1990s. Households' housing wealth almost doubled within five years and then gradually declined over ten years. This dramatic change in housing wealth primarily reflects changes in land prices, which are shown in Figure 2. Since in Japan residential real estate prices primarily reflect the price of the land on which a house sits, the dramatic changes in housing wealth were largely driven by changes in land prices. Land prices are depicted in Figure 2 and show a similarly steep rise in the late 1980s and gradual decline in the 1990s.

How did Japanese households react to such dramatic changes in housing prices? Figure 3 presents home-ownership rates by age across different cohorts. Homeownership increases by age, and a typical Japanese household buys a house when the head is aged between 35 and 45. The larger markers in Figure 3 are for observations falling into Japan's bubble period (1988-1992). The figure suggests that homeownership rates did not change in response to the boom and bust of housing prices. That is, despite the dramatic increase in housing prices, there was no discernible change in the life-stage (age of the household head) at which households typically buy a house.

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[1] We construct the data on households' housing assets using the FIES and other data. The specific procedure is explained in Section 4.

Therefore, instead of delaying buying a house, households may have reduced consumption or settled for a lower-quality house, receiving poorer housing services for a prolonged period. Since most Japanese households tend to prefer a new house and the average price of a house is five to eight times households' income (see, e.g., Ito, 1991), Japan's housing price boom and bust may have had a significant impact on households' lifetime utility.

The goal of this study is to quantify the impact of Japan's housing price boom and bust on Japanese households using household data. Specifically, we use data from the *Family Income and Expenditure Survey* (FIES) conducted by the Statistics Bureau, Ministry of Internal Affairs and Communications. The FIES data contains detailed information about households' consumption, income, and financial assets. Moreover, it provides information about household dwellings, such as the location, size, and type (apartment or house). We combine the FIES data with other datasets to estimate the objective value of households' housing wealth. To concentrate on households that were most likely to be affected by the fluctuations in housing prices, we focus on households with a head born between 1951 and 1955 and living in the Tokyo Urban Employment Area (UEA). We construct a structural model that describes the consumption/saving and housing behavior of these households and estimate the model using the indirect inference method. Using the estimated model, we then conduct a counter-factual simulation in which housing prices are held constant from 1987 to 1999. The simulation result indicates that 38.6% of the households experienced a lifetime utility gain, which averaged 3.3%, while the remaining 61.4% experienced a lifetime utility loss, which averaged 2.4%. On average, Japan's housing price boom and bust caused a 0.2% loss in lifetime utility, which is equivalent to 1.3% of lifetime income.

The remainder of this paper is organized as follows. Section 2 outlines the background to our study and provides an overview of the previous literature. Section 3 then presents the structural model that we estimate, while Section 4 describes the dataset we employ and Section 5 discusses

the empirical methods. Next, Sections 6 and 7 respectively present the results of the estimation and the counter-factual simulation. Finally, Section 8 concludes.

2. Background and Related Literature

How can we assess the impact of temporal fluctuations in housing prices? The easiest way would be to evaluate the impact on the basis of capital gains/losses. If, for example, a household paid $500,000 for a house during the bubble period and the price of the house dropped to $300,000, the bubble caused a loss of $200,000. The problem with this approach is that the endogeneity of housing choice is ignored: even if there had been no bubble, the household might have paid $500,000 but would have got a better house for that money.

Another approach is to take advantage of the information about the relationship between households' housing wealth and consumption. According to the life-cycle/permanent income hypothesis (LC-PIH), households' consumption reflects changes in their available life-cycle resources. Attanasio and Weber (1994) proposed an approach to analyze how households' consumption responds to changes in housing prices. Hori and Niizeki (2017) applied the same approach to FIES data to estimate the marginal propensity to consume by regressing consumption on housing wealth. This approach is useful for examining whether housing wealth should be regarded as life-cycle assets and whether the LC-PIH holds. However, it is unclear by what margin life-time utility is increased or decreased due to the boom and bust of housing prices. If, for example, a household changed only the quality of the house it purchased in response to the change in housing prices, consumption may not reflect the change in life-time utility. Therefore, to assess the long-term impact of the housing price boom and bust, we employ a so-called "structural" approach, estimating a structural model to conduct counter-factual simulations. Such an approach

has at least two advantages. First, counter-factual simulations are not subject to the Lucas critique. And second, we can evaluate the impact of the housing price boom and bust on the basis of households' lifetime utility.

We estimate a life-cycle model using the indirect inference method. Indirect inference is a simulation-based technique that has been employed in numerous studies estimating a structural model. Simulation-based estimation techniques were first used to estimate the life-cycle model by Gourinchas and Parker (2002) in their pioneering study using the method of simulated moments (McFadden, 1989). Similar estimation methods have been employed by French (2005), Laibson et al. (2007), and French and Jones (2011), among others.[2]

The estimation of life-cycle models with housing wealth, on the other hand, is not very common, since the model structure becomes complex when housing wealth is incorporated. One of the few studies to do so is that by Attanasio et al. (2012), who, using U.K. data, construct and estimate a life-cycle model that incorporates households' housing choice under borrowing and collateral constraints. Another study is that by Li et al. (2016), who, using U.S. data, estimate a life-cycle model with housing wealth to measure the elasticity of substitution between non-durable and housing goods. Our study is the first to employ this approach to examine the long-term impact of a housing price boom and bust on households' lifetime utility.

Theoretical studies on economic bubbles (e.g., Hirano and Yanagawa, 2017) find that financial deregulation can result in the emergence of a bubble. This means that policy makers potentially face a trade-off between the benefits of financial deregulation and the risk of a bubble. Against this background, understanding the impact of Japan's housing price boom and bust on households' lifetime utility can provide important insights on the consequences of asset price bubbles.

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[2] A study applying this approach to Japanese data to estimate a life-cycle model is that by Abe and Yamada (2009).

3. Life-cycle Model

We construct a life-cycle model that incorporates consumption/savings and housing decisions under realistic borrowing and collateral constraints. The basic setup of the model, especially the budget constraint, is based on Attanasio et al.'s (2012) model.

Households live T periods. Since the number of periods considerably affects the time it takes to compute the model, we set one period in the model to three years in order to save computation time. We assume that the initial period starts at age 25-27 and household members live until age 82-84 ($T = 20$). In each period, households make decisions about consumption c_t and housing h_t to maximize their lifetime utility:

$$\max_{c_t, h_t} \sum_{t=1}^{T} \beta^{t-1} E[u(c_t, h_t)].$$

For simplicity, we assume that the choice of dwelling is discrete. Households can choose not to own a dwelling ($h_t = 1$), to own a low-quality dwelling ($h_t = 2$), to own a medium-quality dwelling ($h_t = 3$), or to own a high-quality dwelling ($h_t = 4$). The quality of houses is defined on the basis of their value in each period, and we do not distinguish between houses and apartments. For simplicity, we assume that a household can own at most one house and has no bequest motive.

The current payoff depends on consumption c_t and housing choice h_t and is given by

$$u(c_t, h_t) = \gamma\big[\ln c_t + \phi \ln f(h_t) - F1[h_t \neq h_{t-1}]\big] + \eta(h_t) \tag{1}$$

where $f(h_t)$ is the utility derived from housing, F is the cost of moving, and $\eta(h_t)$ is an idiosyncratic utility shock that takes different values for each housing choice, following the type

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1 extreme value distribution.[3] The utility from housing is given by

$$f(h_t) = \begin{cases} 1 & if \ \ h_t = 1 \\ 1 + 0.25\mu & if \ \ h_t = 2 \\ 1 + 0.5\mu & if \ \ h_t = 3 \\ 1 + 0.75\mu & if \ \ h_t = 4 \end{cases}.$$

Households' budget constraint depends on their homeownership status. If a household does not own a home, the budget constraint is written as

$$A_{t+1} = R_{t+1}\left[A_t + w_t - c_t - q_t d_{1t} - \sum_{j \in \{l,m,h\}} p_t^{(j)} d_{jt}\right] \tag{2}$$

where A_{t+1} represents the household's financial assets at the beginning of period $t + 1$ (assets carried over from period t), R_{t+1} is the gross mortgage/interest rate, w_t stands for the household's income, q_t is the housing rent, d_{jt} $(j = 1,2,3,4)$ are dummy variables that take a value of one if $h_t = j$ and zero otherwise, and $p_t^{(j)}$ are the prices of low-, medium-, and high-quality houses ($j \in \{l,m,h\}$). The gross interest rate that a household pays or receives, R_{t+1}, depends on the amount of financial assets the household holds at the end of period t. If the household carries over negative financial assets into the next period, R_{t+1} is the mortgage rate $\left(R_{t+1} = R_{t+1}^{(b)}\right)$; if the household carries over positive financial assets, R_{t+1} is the interest rate on bank deposits $\left(R_{t+1} = R_{t+1}^{(d)}\right)$.

When a household owns a j-quality house ($j \in \{l,m,h\}$), the budget constraint can be written as

$$A_{t+1} = R_{t+1}\left[A_t + w_t - c_t - q_t d_{1t} - \sum_{k \neq j} p_t^{(k)} d_{kt} + p_t^{(j)}(1 - d_{jt})\right]. \tag{3}$$

Let s_t denote a household's savings or financial assets at the end of period t, that is, $s_t \equiv \frac{A_{t+1}}{R_{t+1}}$.

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[3] We incorporate idiosyncratic utility shocks to randomize the housing choice. The reason is that the randomness from the idiosyncratic income shocks is not sufficient to replicate the observed pattern of housing asset accumulation.

For simplicity, we assume that mortgage payments m_t are not fixed and given by

$$m_t = (R_t - 1)s_{t-1}. \tag{4}$$

If a household owns a j-quality house ($j \in \{l, m, h\}$) at the beginning of period t and chooses to continue to live in that house, the household does not pay any housing costs except the mortgage payments m_t. In this case, the household's savings s_t can be written as

$$s_t = A_t + w_t - c_t. \tag{5}$$

If a household that owns a j-quality house ($j \in \{l, m, h\}$) at the beginning of period t buys a k-quality house ($k \neq j$), it has to sell the existing (j-quality) house at the beginning of period t and pay for a new house:

$$s_t = A_t + w_t - c_t + p_t^{(j)} - p_t^{(k)}. \tag{6}$$

If a household that owns a j-quality house ($j \in \{l, m, h\}$) at the beginning of period t wants to sell the house and not buy a new one (renting a house instead), the budget constraint can be written as

$$s_t = A_t + w_t - c_t + p_t^{(j)} - q_t. \tag{7}$$

We assume that a household's borrowing limit depends on the value of the dwelling it owns:

$$s_t \geq 0 \qquad \text{if } h_t = 0 \tag{8}$$

$$s_t \geq -\lambda_h p_t^{(j)} \quad \text{if } h_t = j, j \in \{l, m, h\} \tag{9}$$

where $0 < \lambda_h < 1$. Equation (8) indicates that borrowing is allowed only when the household owns a dwelling.[4] Equation (9) represents the collateral constraint, that is, the purchased house is pledged as collateral and the household makes down payment $(1 - \lambda_h)p_t^{(j)}$. Furthermore, we impose the assumption that the borrowing limit depends on the household's annual income, that is,

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[4] Since in Japan the majority of households' debt consists of housing loans, this assumption is not as strong as it may appear.

$$s_t \geq -\lambda_w w_t. \tag{10}$$

Moreover, we assume that households are not allowed to die in debt, that is, $s_T \geq 0$. Thus, there is a natural debt limit at each period as an implicit constraint.

Household income w_t depends only on the age of the household head:

$$\ln w_t = \alpha_0 + \alpha_1 t + \alpha_2 t^2 + \nu_t, \qquad \nu_t = \nu_{t-1} + \xi_t \tag{11}$$

where $\xi_t \sim N(0, \sigma_\xi^2)$ and $\nu_1 \sim N(0, \sigma_{\nu_1}^2)$. Note that ν_t follows a random walk and ξ_t is an idiosyncratic permanent income shock. Although the income function is simple, persistent household characteristics, such as the household head's educational attainment, are captured by ν_t.

The income process differs across households, while households are faced with the same housing price and mortgage rate (interest rates). The price of a medium-quality house $p_t^{(m)}$ is also assumed to be exogenous and follows a random walk:

$$\ln p_t^{(m)} = \ln p_{t-1}^{(m)} + \epsilon_t^p \tag{12}$$

The house price shock ϵ_t^p follows normal distribution $\epsilon_t^p \sim N(0, \sigma_p^2)$. Since we discretize the state variable and solve households' utility maximization problem at each state point, the number of continuous state variables we use is an important determinant of the time it takes to compute the model. To keep the number of continuous state variables small, we therefore assume thatthe prices of low- and high-quality houses form a log-linear relationship with the price of medium-quality houses:

$$\ln p_t^{(l)} = \zeta_0^{(l)} + \zeta_1^{(l)} \ln p_t^{(m)} \tag{13}$$

$$\ln p_t^{(h)} = \zeta_0^{(h)} + \zeta_1^{(h)} \ln p_t^{(m)}. \tag{14}$$

In theory, one would expect housing rents to be related to housing prices. In practice, however, this does not appear to be the case. Figure 4 shows housing rents in the Tokyo UEA. The figure indicates that housing rents remained relatively constant even during the bubble period. We

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therefore assume that housing rents depend only on time:

$$q_t = \zeta_0^{(q)} + \zeta_1^{(q)} t + \zeta_2^{(q)} t^2 \qquad (15)$$

As shown in Figure 5, mortgage rates changed dramatically during the bubble period. If we assume deterministic mortgage and interest rates, households in the model would behave as if they knew in advance that mortgage rates would suddenly drop. We therefore incorporate uncertainty about mortgage and interest rates in the model, i.e.:

$$\ln R_t^{(b)} = \ln R_t^{(b)} + \epsilon_t^{(R)} \qquad (16)$$

We assume that shocks to mortgage rates follows normal distribution $\epsilon_t^{(R)} \sim N(0, \sigma_R^2)$. So as not to increase the number of continuous state variable, we assume that the interest rate on savings is determined by the mortgage rate:

$$\ln R_t^{(d)} = \zeta_1^{(d)} + \zeta_1^{(d)} \ln R_t^{(d)}. \qquad (17)$$

4. Data

We use the FIES data to estimate the model. The FIES is a monthly survey currently covering about 9,000 households per month. We use data for the period from 1983 to 2012 containing observations on 500,000 households in total. The survey tracks each household for three months in the case of one-person households and six months in the case of two or more-person households.[5] Respondents keep a diary on their monthly income and expenditures. The FIES data is designed to provide basic information needed to construct the consumer price index (CPI) and other important statistics related to consumption and the prices of goods. As mentioned earlier, we focus on individuals born between 1950 and 1955 who lived in the Tokyo UEA during the

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[5] The FIES has a panel structure, but the information about assets is available only for the first period. We therefore cannot take advantage of the panel structure and use the data as cross-sectional data.

observation period. Furthermore, we focus on households with two or more members, because information about financial assets is not available for one-person households. In the model, households accumulate financial assets and borrow money to buy a house on their own; that is, obtaining a house through inheritance is not included in the model. We therefore drop those living with a household member older than the head, because those living with their parents are likely to share and inherit their house.

As a result of dropping observations based on these criteria, our sample consists of 4,478 households. Because one period in the model corresponds to three years, we divide the observation period overall into 10 subperiods. The sample size for each subperiod ranges from 300 to 550 households.

4.1   Household income

Although the FIES data is panel data, each household is tracked for six months only, so that the monthly income data is subject to seasonality. Moreover, the seasonally adjusted income data is quite noisy, and the fit of the income function regression is poor. Therefore, we use the previous year's income, multiplied by the average ratio of households' disposable income to pretax income.[6]

Figure 6 shows the mean household disposable income by age across the three cohorts shown in Figure 3. We can see that life-cycle income is hump-shaped and that the shape differs across cohorts. As previous studies (e.g., Hamaaki et al., 2012) have pointed out, the life-cycle income path of younger cohorts in Japan is flatter than that of older cohorts. This pattern may reflect the collapse of the traditional Japanese seniority wage system,

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[6] We calculate the ratio of disposable income to pretax income from seasonally adjusted monthly income. Specifically, we calculate this ratio for each household as the average over the six month-period the household is tracked and used this as the disposable income of the household.

4.2 Financial assets

Figure 7 shows the mean of financial assets by household heads' age across the three cohorts. Larger markers indicate the period of the asset price bubble (1988-1992). The figure suggests that households' financial asset holdings did not change much during the asset price bubble. This is perhaps because the majority of financial assets held by Japanese households are bank deposits. For this reason, we do not investigate the effect of the bubble in financial markets on households' life-time utility and exclusively focus on the bubble in housing prices.

4.3 Housing wealth

While the FIES provides rich information about households' characteristics, income, consumption, and financial assets, it unfortunately does not contain information on the value of households' housing wealth. However, the dataset does offer detailed information about the approximate address, type (apartment or house), age, land area, and floor space of households' dwellings. Combining this information with other data sets such as official land price data allows us to estimate the value of the dwelling in which a household lives and thus provides us with an objective estimate of households' housing wealth.[7] The benefit of these estimates over subjective housing asset values, if they were available, is that they likely more accurately reflect the housing price boom and bust. That is, those who bought their house before the bubble and were not interested in selling it may not have been aware of the dramatic change in the housing wealth they held.

To estimate land values, we use households' address and match this to the price of

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[7] Note that having to rely on this approach means that housing assets other than the household's home are not included in housing wealth.

residential land in the area. Land prices are taken from the "Land Market Value Publication" (*Chikakoji*) provided by the Ministry of Land, Infrastructure, Transport and Tourism. We multiply the land area by the unit land price of the closest point for which land prices are available.

We estimate house values using information about the type of dwelling, the age of the house, and the floor area. Information about the link between housing construction costs, the type of dwelling, the municipality, and the floor area are taken from the "Annual Report of Building Construction" (1953-2012). Employing such information, we estimate the price of a new house in a particular locality and then estimate its value at the time of the survey taking depreciation based on the age and type of dwelling into account.[8]

Figure 8 shows households' housing wealth by age across the three cohorts. The figure indicates that households accumulate housing wealth until age 45-48. The rapid increase in housing wealth for those in their 30s and 40s across all three cohorts reflects the increase in homeownership rates. In addition, for the two older cohorts, the house price boom during the bubble economy also contributed to the increase in their housing wealth, as indicated by the larger markers representing years during the bubble period. In the model, we discretize housing wealth into three levels: low-, medium-, and high-quality dwellings. We define low-quality dwellings as the 25th percentile, medium-quality dwellings as the median, and high-quality dwelling as the 75th percentile of the values of housing wealth. Thus, the prices of low-, medium-, and high-quality houses in the model correspond to the 25th, 50th, and 75th percentile of the housing wealth distribution. Note that households of other cohorts living in the Tokyo UEA are included when we calculate the value of housing wealth.

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[8] For more detailed information about the estimation procedure, see Hori and Niizeki (2017).

5. Estimation Procedure

This section describes our estimation procedure. It should be noted that some of the parameters in the model cannot be estimated from the data, so that we set them a priori. Specifically, the value of the slope parameter in the utility from housing, μ, is set to 1, because it is not clear whether or not it is separately identified from ϕ. We also need to set the two parameters associated with the borrowing limits. The first is the loan-to-value ratio $(1 - \lambda_h)$, which is set to 80%, a typical value in Japan (see e.g. Moriizumi, 1996). Moreover, since we do not have information about the limit of the debt-to-income ratio, we set it to 6.[9] We calculate the variances of the shocks to housing prices and mortgage rates directly from the FIES data. The parameters are summarized in Table 1.

5.1. Estimation of the parameters in the income, housing price, and mortgage rate processes

We assume that household income, housing prices, and interest rates are all exogenous. We therefore estimate the parameters in Equations (11), (13), (14), (15), and (17) directly from the data.

To estimate the household income function, we regress the log of annual disposable income on age and age squared. We then estimate the variance of the income shock, σ_ξ, and the initial variance of the error term, σ_{v_1}, using the residual from the log wage regression. Let $\hat{u}_{it}$ be the residual from the log wage regression of individual i in period t. It is typically observed that cross-sectional wage variation increases by age. Since, in our model, the increase in the cross-sectional variance of household income is attributable to the idiosyncratic income shock ξ, the variance of the error term of the household income function can be written as

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[9] We calculate the debt-to-income ratio using the FIES data and find that the 99th percentile of the debt-to-income ratio in the FIES data is approximately 6.

$$E\left(u_{it}^2 \mid Age\right) = \sigma_{v_1} + \sigma_\xi (Age - 24). \tag{18}$$

Thus, to estimate σ_ξ and σ_{v_1}, we regress the squared residuals $\hat{u}_{it}^2$ on a constant term and $Age - 24$. The coefficient on $Age - 24$ can be regarded as an estimate of the income shock variance. Since the initial period of the model starts at age 25, the constant term can be regarded as the variance of income in the initial period.

5.2. Estimation procedure of the structural parameters

Let us refer to the other parameters, such as discount factor β, as structural parameters. We estimate the structural parameters employing the method of indirect inference proposed by Gouriéroux et al. (1993), taking the parameters estimated directly from the data as given. The indirect inference estimator of the structural parameter minimizes the "distance" between the ordinary least squares (OLS) estimates of the following auxiliary model obtained from the FIES data and those from the data generated from the simulations with the structural model:

$$A_{it} = \sum_{t=1}^{10} \omega_t^{(A)} d_{it} + u_{it}^{(A)} \tag{19}$$

$$H_{it} = \sum_{t=1}^{10} \omega_t^{(H)} d_{it} + \omega_w w_{it} + u_{it}^{(H)}. \tag{20}$$

where A_{it} represents a household's financial wealth, d_{it} is a time dummy representing three-year intervals, H_{it} represents households' housing wealth, and w_{it} is households' income.

The estimation procedure is as follows. First, we estimate the auxiliary model using the FIES data. Let $\overline{\omega}$ denote the parameter vector of the auxiliary model obtained from the FIES data. Second, we solve the dynamic programming problem of households by backward induction for the set of structural parameters $\Theta \equiv \{\beta, \phi, \gamma, F, \sigma_A\}$ to obtain the policy and value functions.[10]

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[10] To solve the dynamic programming problem, we discretize the continuous state variables and linearly interpolate

Using these functions, we conduct simulations to obtain simulated data. Using the simulated data, we then estimate the auxiliary model. Let $\boldsymbol{\omega}(\Theta)$ be the vector of OLS coefficients of the auxiliary model obtained from the simulated data. Finally, we calculate the distance between the coefficients obtained from the FIES data, $\overline{\boldsymbol{\omega}}$, and those obtained from the generated data, $\boldsymbol{\omega}(\Theta)$. The distance is defined by

$$[\overline{\boldsymbol{\omega}} - \boldsymbol{\omega}(\Theta)]'W[\overline{\boldsymbol{\omega}} - \boldsymbol{\omega}(\Theta)] \tag{21}$$

where W is a weighting matrix whose diagonal elements are the inverse of the variance of the corresponding elements of $\overline{\boldsymbol{\omega}} - \boldsymbol{\omega}(\Theta)$. The indirect inference estimator is the minimizer of Equation (21).

5.3. Identification of the structural parameters

We incorporate utility shock $\eta(h_t)$ (in Equation (1)) to randomize households' housing choices, while γ dictates the relative magnitude of the utility shock and utility from consumption and housing. A smaller γ indicates a weaker link between households' housing choice and state variables, and vice versa. This is why we include w_{it} in Equation (20). By matching the ω_w obtained from the FIES data with the ω_w from the simulated data, we ensure that γ is uniquely identified.

If we did not include utility shock $\eta(h_t)$, we would not need to include w_{it} in Equation (20). In that case, matching the coefficients in the auxiliary model is equivalent to matching the mean of financial and housing wealth in each period. Therefore, let us consider how the structural parameters other than γ are identified by matching the mean of financial and housing wealth in each period.

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the policy and value functions. Furthermore, to approximate the expected values with respect to the random shocks that follow a normal distribution, we use Gauss-Hermite quadrature. We use 20 sample points and impose the assumption that the shocks cannot be smaller than the smallest sample point.

We can identify the structural parameters, except for γ, if, in the model, the levels and growth rates of financial and housing wealth are determined when the values of these parameters are given. Let us consider the identification condition for each parameter. First, the standard deviation of financial assets in the initial period determines the levels of financial and housing wealth. Therefore, we can identify σ_{A_1} by matching the means of financial and housing wealth in the first or the first and second periods if the relative magnitudes of financial and housing wealth are determined by other parameters. Second, the relative magnitudes of financial and housing wealth are determined by the weight of utility from housing ϕ, where ϕ is identified from the levels of financial and housing wealth. Third, the discount factor β dictates the relative importance of consumption across different points in time. Thus, the value of β is determined when the growth rate of financial assets is given. Finally, the moving cost F dictates the frequency of house purchases and sales, and the frequency determines the growth rate of housing wealth. Therefore, the moving cost F is identified by matching the growth rates of housing wealth.

6. Estimation Results

6.1   Reduced-form estimation

This section presents our estimation results. We start with the reduced-form estimation. As mentioned above, parameters governing the exogenous processes that determine income, housing prices, and mortgage (interest) rates are estimated directly from the data. The values of these parameters are summarized in Table 1.

In order to graphically show the fit of the model, we draw the fitted regression lines of income and housing prices. Figure 9 shows estimated household income over the life-cycle. As can be seen from the figure, the predicted income captures the hump-shaped life-cycle income

well. Note that, in the model, household income halves at age 60 and remains constant thereafter.

Figure 10 shows the estimated prices of low- and high-quality housing. To save computation time, we assume that the prices of low- and high-quality housing form a log linear relationship with medium-quality housing. Although this may appear to be a strong assumption, the predicted prices of low- and high-quality houses are very close to the actual prices.

6.2 Structural estimation

The estimates of the structural parameters are summarized in Table 2. Note that the estimated discount factor β discounts the value for one period in the model. Since one period in the model is three years, the annual discount rate is approximately 3.14%.

To provide an overview of the fit of the structural model, we draw the means of assets held by actual and simulated households: Figure 11 shows the means of actual and predicted financial assets in each period, while Figure 12 shows the means of actual and simulated housing wealth in each period. Solid lines depict the means calculated from the FIES data, while dashed lines depict those calculated from the generated data. The model fit seems good for the most part, except for financial wealth at age 36 to 45. Since the sample consists of households that were aged 36 to 45 during the bubble, the estimated model underestimates households' financial asset holdings during the bubble period. Households in the FIES sample held more financial assets than simulated households during the bubble period, perhaps because some of the households inherited financial or housing wealth from their parents and did not borrow as much to purchase a house as the model predicts. Despite this discrepancy, overall the estimated model successfully replicates the pattern of financial and housing wealth accumulation.

In order to take a closer look at the housing behavior of households, we present the shares of renters as well as low-, medium-, and high-quality housing owners in Figure 13. As can be seen,

renters gradually tend to become home-owners, and the share of households living in better dwellings increases as households get older.

7. Counter-factual Simulation

To quantify the effect of the housing price boom and bust, we conduct a counter-factual simulation in which housing prices are held fixed from the first period (1983-85) to the 11th period (1998-2000). The actual and counter-factual housing prices of medium-quality housing are shown in Figure 14. In each period, households make decisions about their consumption/saving and housing based on the belief that housing prices are uncertain and follow a random walk. In the counter-factual simulation, however, the realized housing prices are constant over time. Moreover, in the simulation, the variance of housing price shocks is replaced with the variance of housing price shocks calculated from data before the housing price boom (1983-1986) and after the bust (1997-2012). Since housing price fluctuations were smaller during these periods before and after the bubble, the variability of shocks to housing prices is smaller than the actual variability. This means that in the counter-factual simulation, households are faced with less uncertainty and more stable housing prices.

Figures 15 and 16 present the results of the counter-factual simulation. They show households' accumulation of financial and housing wealth based on the counter-factual housing prices shown in Figure 14. Based on counter-factual housing prices, the housing wealth of households under 45 years of age is smaller than based on actual prices. Figure 17 shows the shares of renters and home-owners and indicates that the share of renters is lower in the counter-factual simulation and households tend to live in higher-quality housing. Thus, the gap in housing wealth of those aged under 45 between the simulations based on actual and counter-factual

housing prices is for the most part due to the gap in housing prices. As can be seen from Figure 15, under counter-factual housing prices, households tend to hold less financial wealth after age 30. Why do households hold more debt in the counter-factual simulation in which they can buy a house at a lower price? As can be seen from Figure 17, households buy a better house in the counter-factual simulation. Moreover, in the counter-factual simulation, consumption is 1.93% higher than in the simulation with actual housing prices. In summary, in the counter-factual simulation, households borrow more money to buy a better house and consume more.

As mentioned above, one of the greatest advantages of structural estimation is that we can assess the effect of the housing price boom and bust on the basis of households' utility. We find that the impact of the housing price boom and bust is heterogeneous across households. Japan's housing price boom and bust had a negative impact for 38.6% of households and a positive impact for 61.4%. The average utility gain for those that experienced a positive effect was 3.3%, while the average utility loss for those that experienced a negative impact was 2.4%. Moreover, consumption of those that benefited from the housing boom and bust increased by 1.4%, while consumption of those who experienced a utility loss decreased by 4.1%. On average, the lifetime utility from consumption and housing in the counter-factual simulation is 0.2% higher than in the simulation with actual housing prices. Thus, the loss in lifetime utility due to the housing price boom and bust is 0.2%. To lower lifetime utility by 0.2% in the no-bubble simulation, lifetime household income would need to decrease by 1.3%. Therefore, the loss of lifetime utility is equivalent to 1.3% of lifetime income.

8. Conclusion

We constructed a theoretical model illustrating households' financial and housing asset

accumulation over the life-cycle. In each period, households make decisions with regard to their consumption/saving and housing under realistic collateral and borrowing constraints and facing uncertainty about their income, housing prices, and interest rates. We estimate the model using the method of indirect inference, so that OLS estimates of the auxiliary model calculated from the simulated data mimic those calculated from the FIES data. The overall fit of the model is good, but the model under-estimates households' financial assets during the bubble period. Using the estimated model, we conducted a counter-factual simulation assuming that housing prices remained constant from the mid-1980s through the 1990s. Doing so enabled us to quantify the impact of Japan's housing price boom and bust on households' lifetime utility.

The estimated impact was heterogeneous across households: 38.6% of households experienced an increase in lifetime utility, which averaged 3.3%, while 61.4% experienced a decrease in lifetime utility, which average 2.4%. On average, Japan's housing price boom and bust caused a 0.2% loss of utility, which is equivalent to 1.3% of lifetime income. Moreover, we found that those who experienced an increase in lifetime utility experienced an increase in consumption as well, and vice versa. The amount of the changes in consumption and lifetime utility, however, are quite different. This indicates that the changes in consumption may not precisely reflect the changes in lifetime utility due to housing price fluctuations. Thus, for the purpose of evaluating the impact of housing price fluctuations on lifetime utility, a structural approach is more appropriate than a reduced-form approach that relies on the regression of consumption on housing wealth.

References

[1] Abe, N., & Yamada, T. (2009). Nonlinear income variance profiles and consumption inequality over the life cycle. *Journal of the Japanese and International Economies*, 23(3), 344-366.

[2] Attanasio, O. P., Bottazzi, R., Low, H. W., Nesheim, L., & Wakefield, M. (2012). Modelling the demand for housing over the life cycle. *Review of Economic Dynamics*, 15(1), 1-18.

[3] Attanasio, O. P., & Weber, G. (1994). The UK consumption boom of the late 1980s: aggregate implications of microeconomic evidence. *The Economic Journal*, 104(427), 1269-1302.

[4] French, E. (2005). The effects of health, wealth, and wages on labour supply and retirement behaviour. *The Review of Economic Studies*, 72(2), 395-427.

[5] French, E., & Jones, J. B. (2011). The effects of health insurance and self-insurance on retirement behavior. *Econometrica*, 79(3), 693-732.

[6] Gouriéroux, C., Monfort, A., & Renault, E. (1993). Indirect inference. *Journal of Applied Econometrics*, 8(S1), S85-S118.

[7] Gourinchas, P. O., & Parker, J. A. (2002). Consumption over the life cycle. *Econometrica*, 70(1), 47-89.

[8] Hamaaki, J., Hori, M., Maeda, S., & Murata, K. (2012). Changes in the Japanese employment system in the two lost decades. *ILR Review*, 65(4), 810-846.

[9] Hirano, T., & Yanagawa, N. (2016). Asset bubbles, endogenous growth, and financial frictions. *The Review of Economic Studies*, 84(1), 406-443.

[10] Hori, M., & Niizeki, T. (2017). Housing wealth effects in Japan: evidence based on household micro data. *ESRI Discussion Paper Series* No.339.

[11] Ito, T. (1991). *The Japanese Economy*. MIT Press.

[12] Laibson, D., Repetto, A., & Tobacman, J. (2007). Estimating discount functions with consumption choices over the lifecycle. *NBER Working Paper* No. w13314. National Bureau of Economic Research.

[13] Li, W., Liu, H., Yang, F., & Yao, R. (2016). Housing over time and over the life cycle: a structural estimation. *International Economic Review*, 57(4), 1237-1260.

[14] McFadden, D. (1989). A method of simulated moments for estimation of discrete response models without numerical integration. *Econometrica*, 57(5), 995-1026.

[15] Moriizumi, Y. (1996). Credit rationing and public housing loans in Japan. *Journal of Housing Economics*, 5(3), 227-246.

Table 1. Pre-set parameters

Slope parameter governing the utility from housing μ	1.0
Collateral constraint λ_h	0.8
Borrowing constraint λ_w	6
Standard deviations of shocks and disturbances	
Income shock σ_{xi}	0.0045
Initial income disturbance σ_{v_1}	0.0812
Housing price shock σ_p	0.1029
Housing price shock (no bubble case) σ_p	0.0565
Mortgage rate shock σ_R	0.1529
Parameters in household income function	
Constant α_0	-2.9045
Age of household head α_1	0.1902
Age of household head squared α_2	-0.0019
Parameters in housing equations	
Constant $\zeta_0^{(l)}$	-0.1069
Log of medium-quality house $\zeta_1^{(l)}$	0.8968
Constant $\zeta_0^{(h)}$	-0.0394
Log of medium-quality house $\zeta_1^{(h)}$	1.168
Parameters in housing rent function	
Constant $\zeta_0^{(q)}$	0.3213
Time variable (year - 1982) $\zeta_1^{(q)}$	0.0415
Time variable (year - 1982) squared $\zeta_1^{(q)}$	-0.0009
Parameters in the equation relating mortgage and interest rates	
Constant $\zeta_0^{(d)}$	-3.1297
Mortgage rate $\zeta_1^{(d)}$	1.3752

Table 2. Estimates of structural parameters

Discount factor β	0.9086
Weight on utility from housing ϕ	3.2378
Moving cost F	36.8319
Weight on deterministic part of utility function γ	0.0989
Std. dev. of initial distribution of financial assets σ_A	2.0524

Notes: The discount factor is for three years. Standard errors are not calculated, because it is computationally too burdensome.
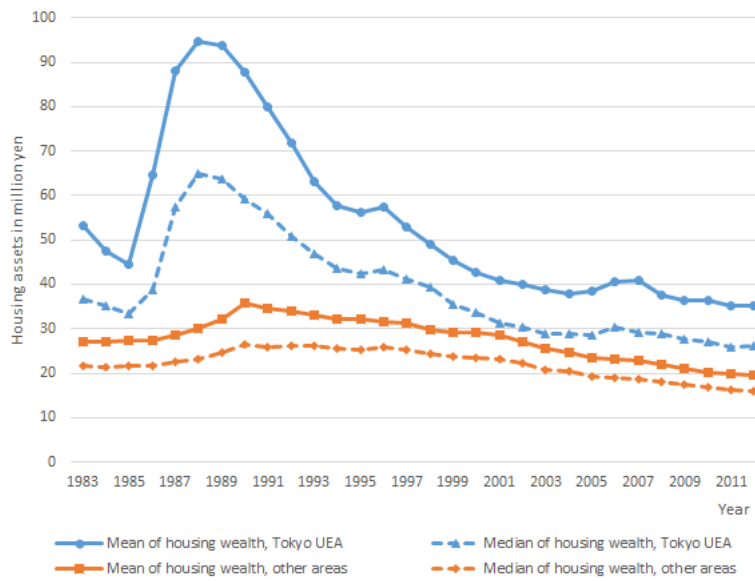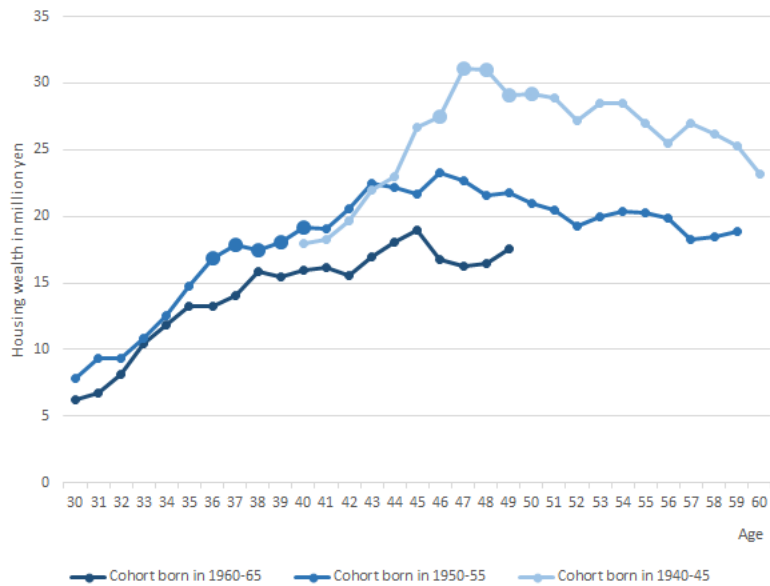
Figure 1: Households' housing wealth, 1983 to 2012

Source: Family Income and Expenditure Survey, Statistics Bureau, Ministry of Internal Affairs and Communications.
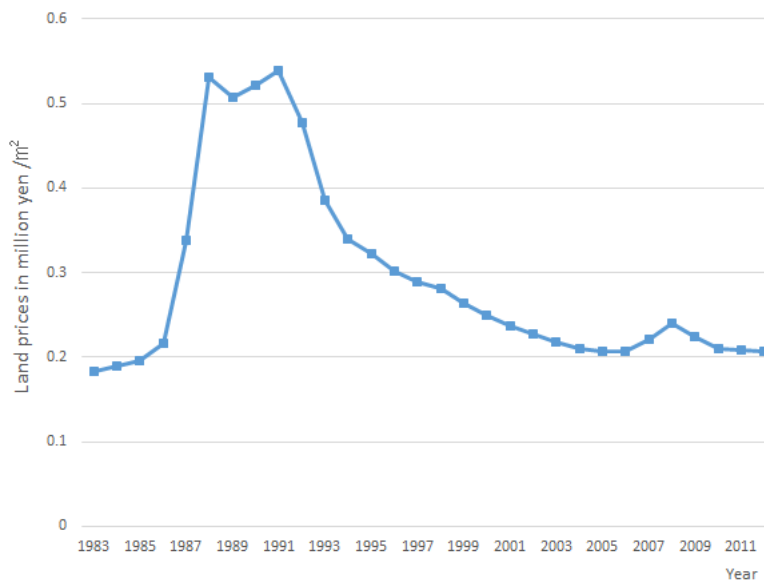
Figure 2: Land prices in residential areas, Tokyo, 1983 to 2012

Source: "Land Market Value Publication" (*Chikakoji*), Ministry of Land, Infrastructure, Transport and Tourism.
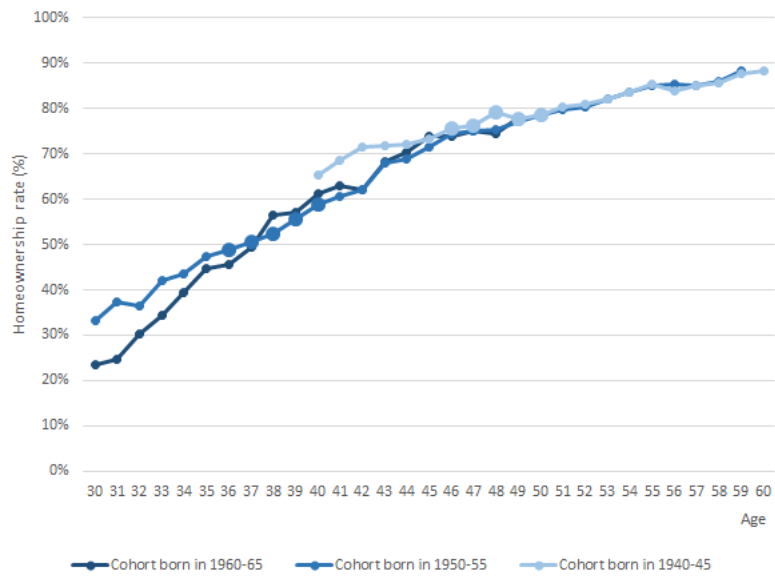
Figure 3. Homeownership rate, 1983 to 2012

Source: Family Income and Expenditure Survey, Statistics Bureau, Ministry of Internal Affairs and Communications.
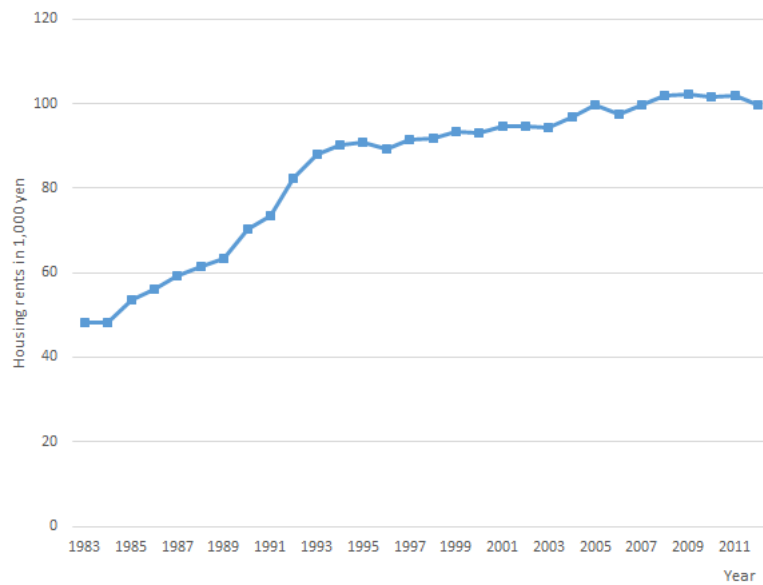
Figure 4. Housing rent

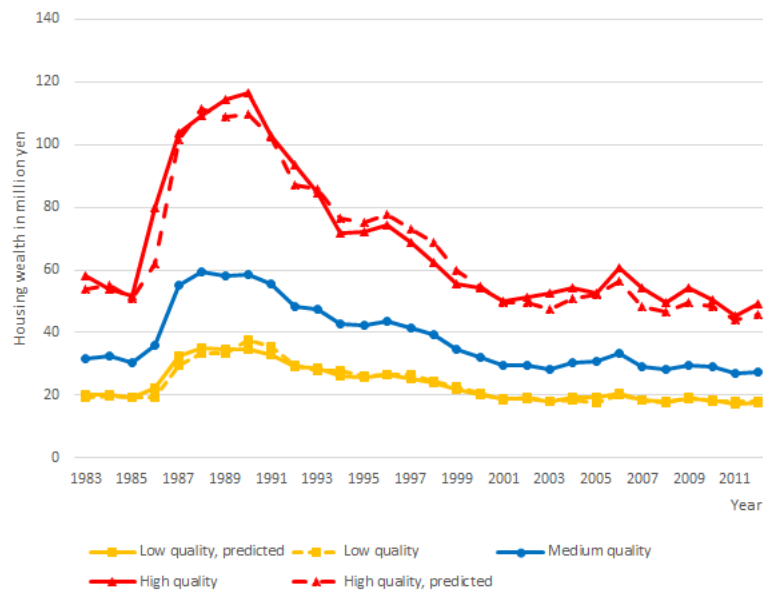Source: Family Income and Expenditure Survey, Statistics Bureau, Ministry of Internal Affairs and Communications.
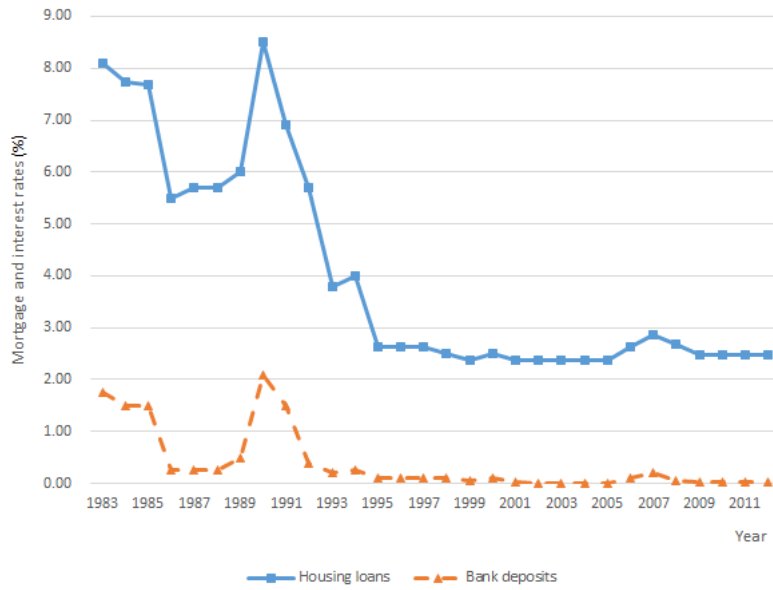
Figure 5. Mortgage and deposit interest rates, 1983 to 2012

Source: Monthly Report of Recent Economic and Financial Developments, Bank of Japan.
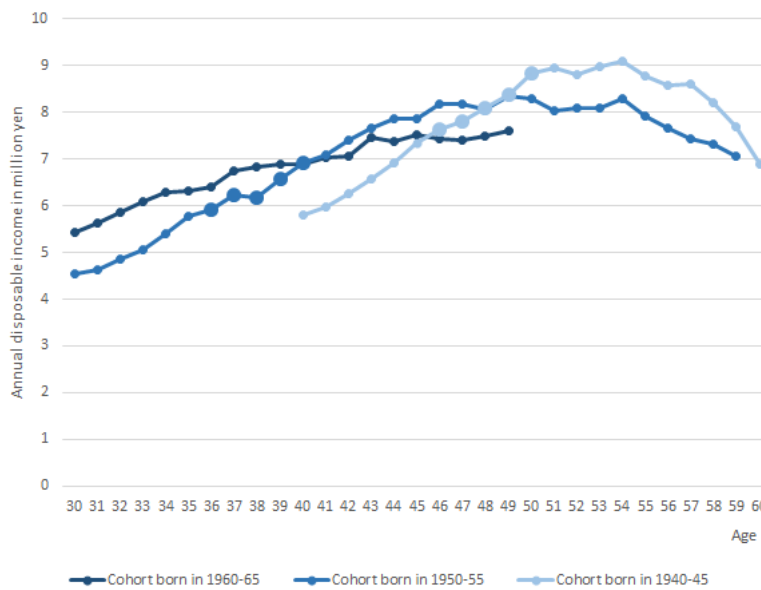
Figure 6. Annual disposable income, 1983 to 2012

Source: Family Income and Expenditure Survey, Statistics Bureau, Ministry of Internal Affairs and Communications.
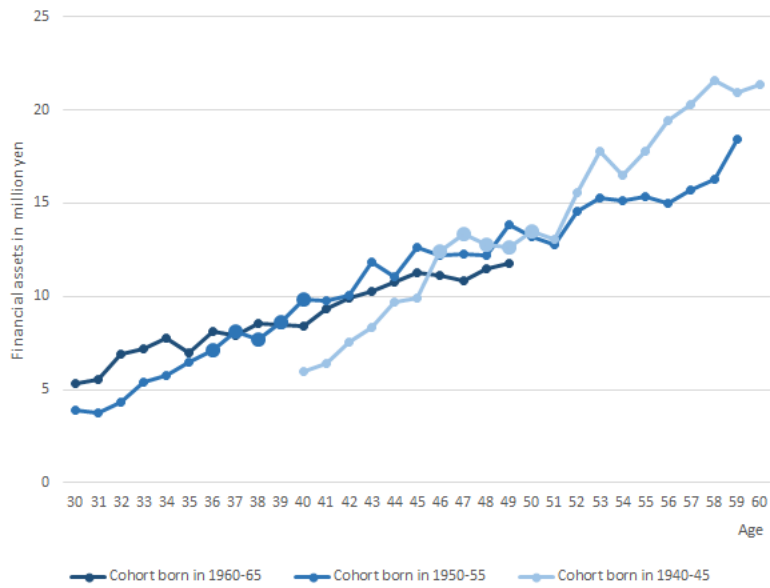
Figure 7. Household financial wealth, 1983 to 2012

Source: Family Income and Expenditure Survey, Statistics Bureau, Ministry of Internal Affairs and Communications.

Figure 8. Housing wealth, 1983 to 2012

Source: Family Income and Expenditure Survey, Statistics Bureau, Ministry of Internal Affairs and Communications.
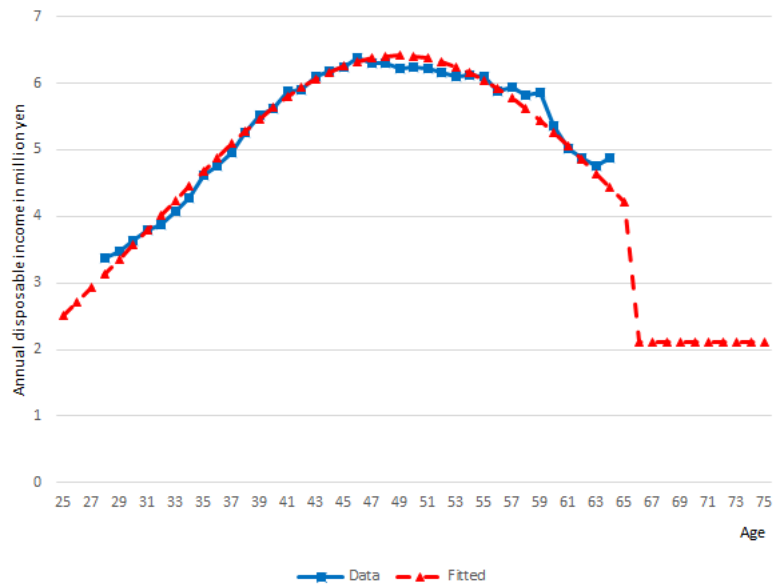
Figure 9. Model fit of household income function

Source: Family Income and Expenditure Survey, Statistics Bureau, Ministry of Internal Affairs and Communications.

Figure 10. Model fit of housing wealth values

Source: Family Income and Expenditure Survey, Statistics Bureau, Ministry of Internal Affairs and Communications.
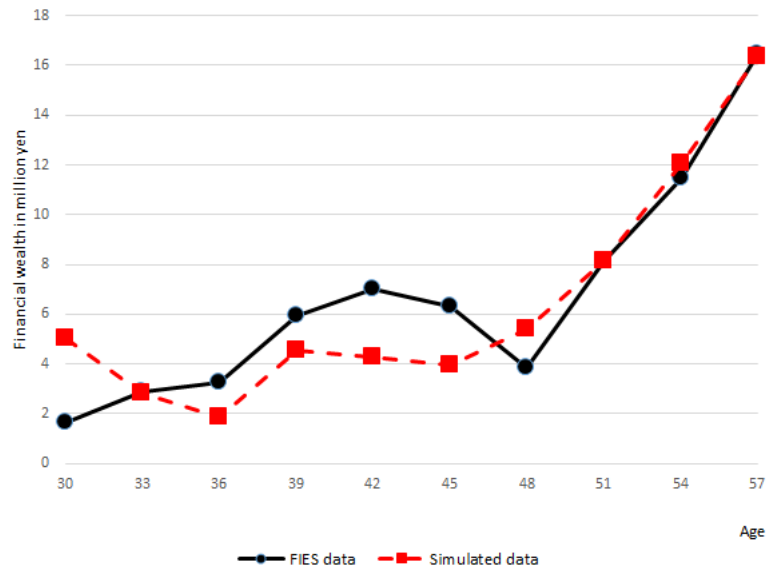
Figure 11. Model fit: financial assets
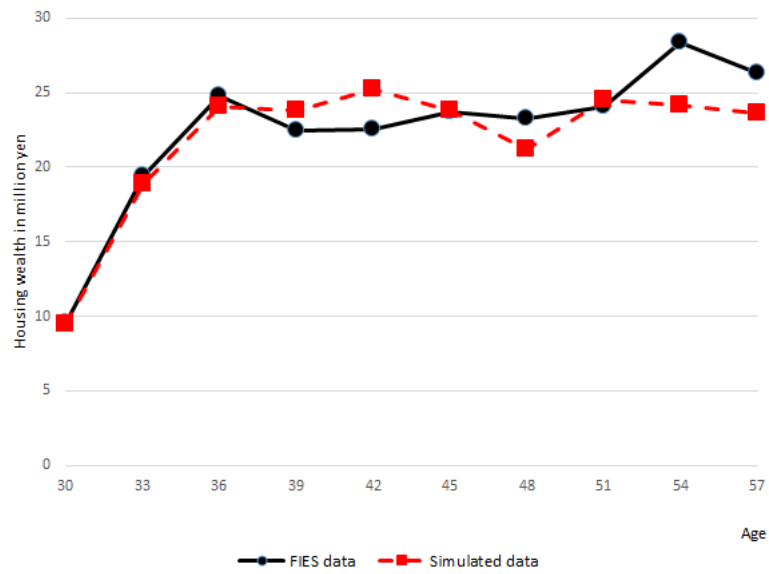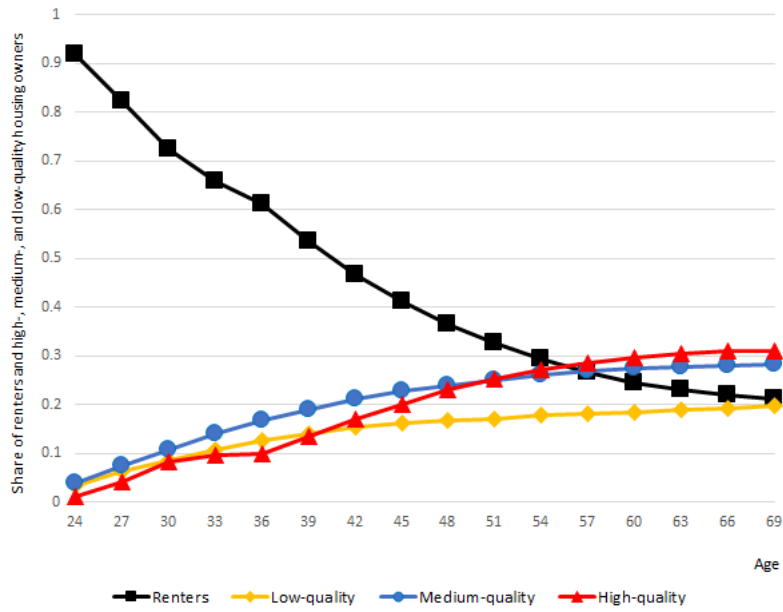

Figure 12. Model fit: housing wealth

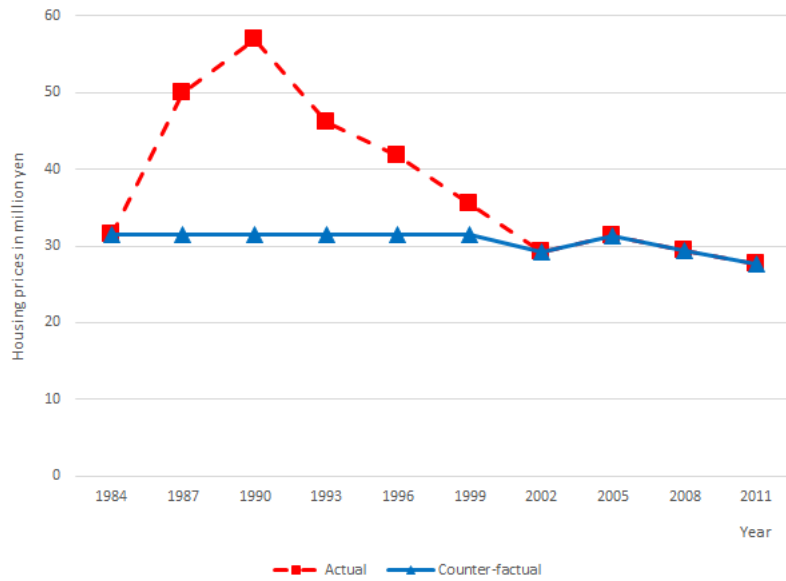Figure 13. Predicted share of renters and homeowners (by quality of housing)

Figure 14. Actual and counter-factual price of medium-quality housing

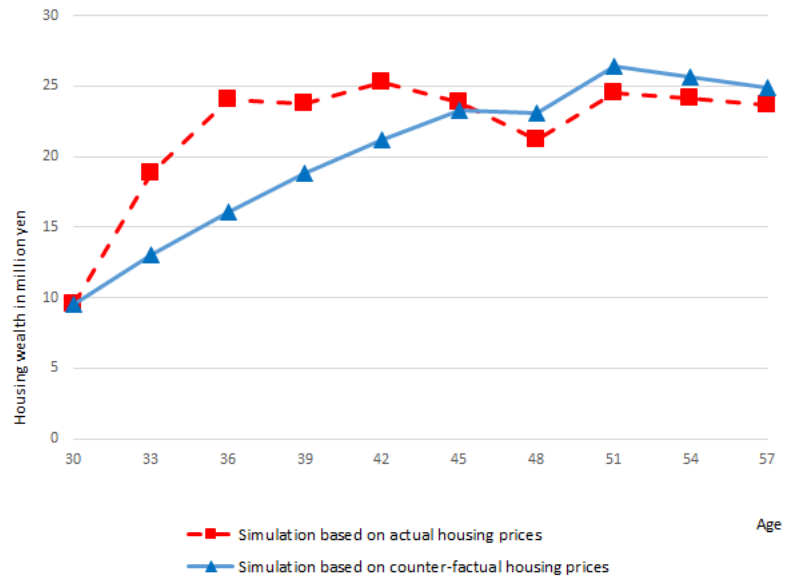Figure 15. Counter-factual simulation: financial assets
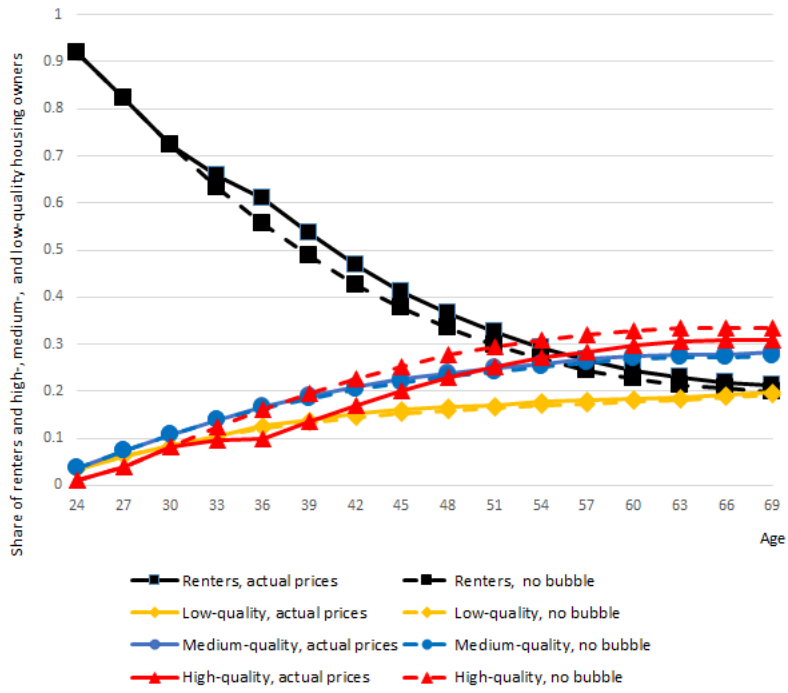

Figure 16. Counter-factual simulation: housing wealth

Figure 17. Counter-factual simulation: share of renters and homeowners