Aging, Housing, and Macroeconomic Inefficiency

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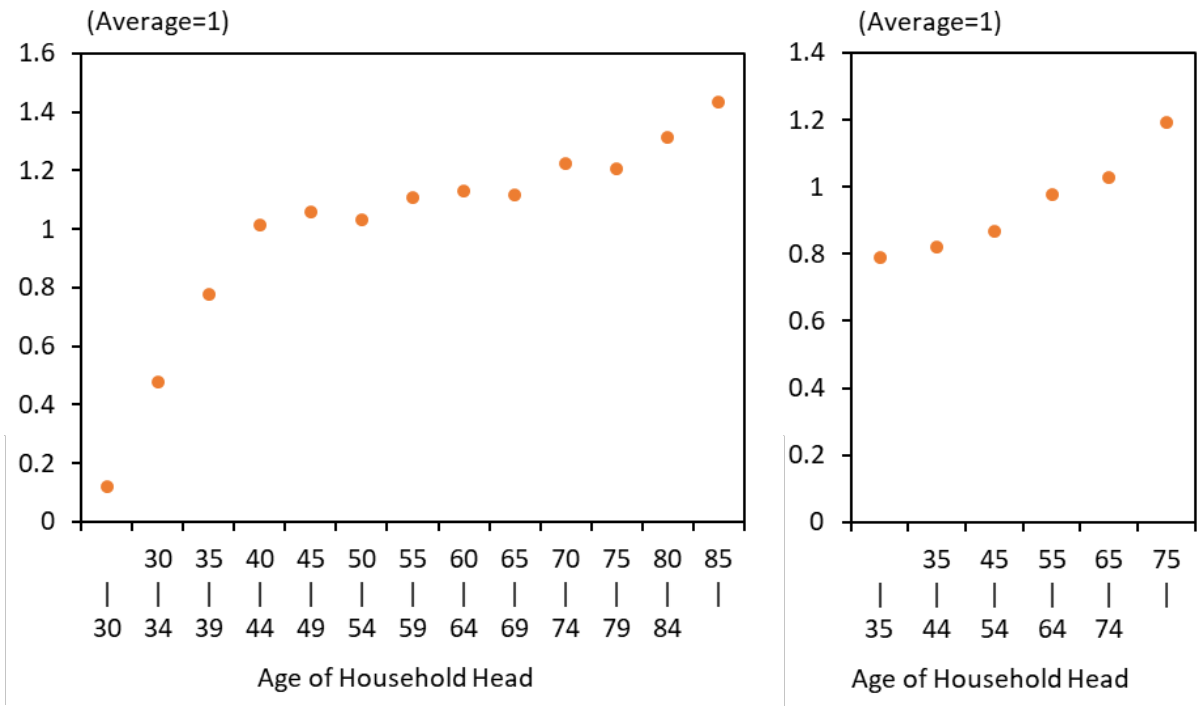
Outline

Motivating Micro Evidence

Older households in Japan have more housing assets, even within the homeowner sample. Seko et al. (2023) attribute this tendency to bequest motives.

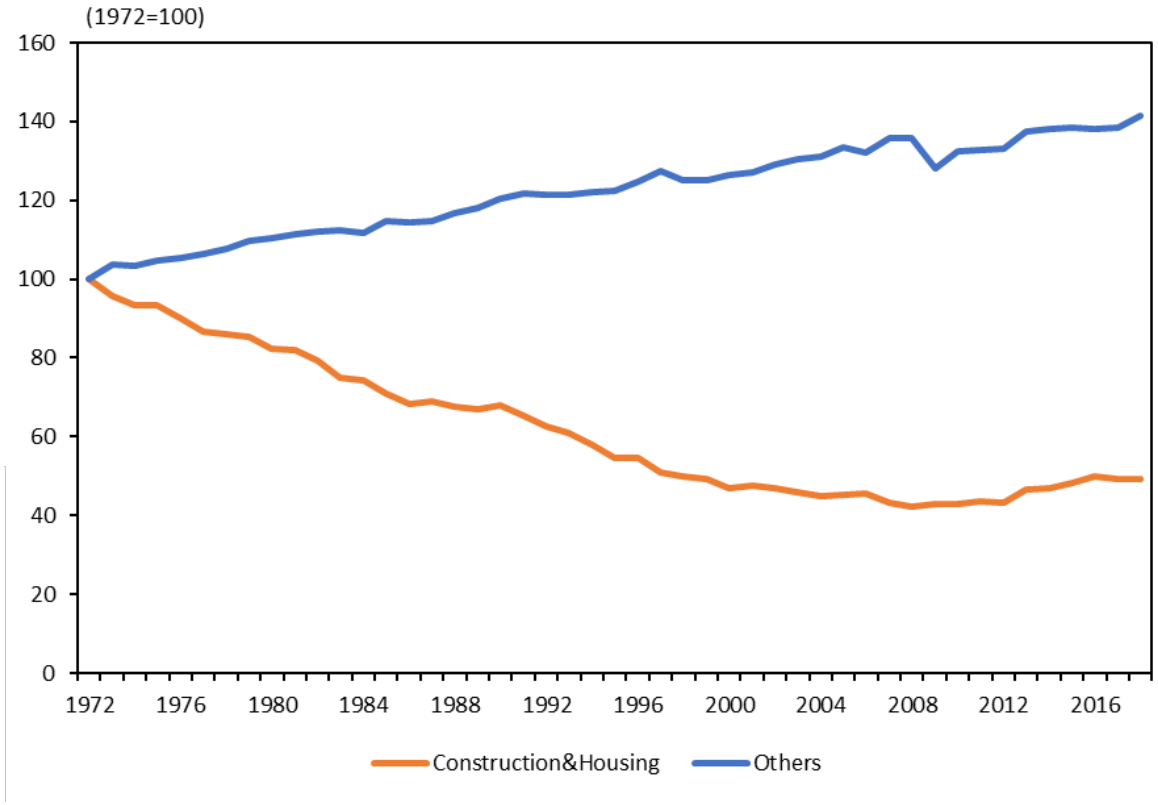


Housing Assets by Age (2019) For Homeowners

Source: National Survey of Family Income and Expenditure.

Motivating Macro Evidence

Productivity of construction and housing sector has been decreasing over the past 50 years in Japan.

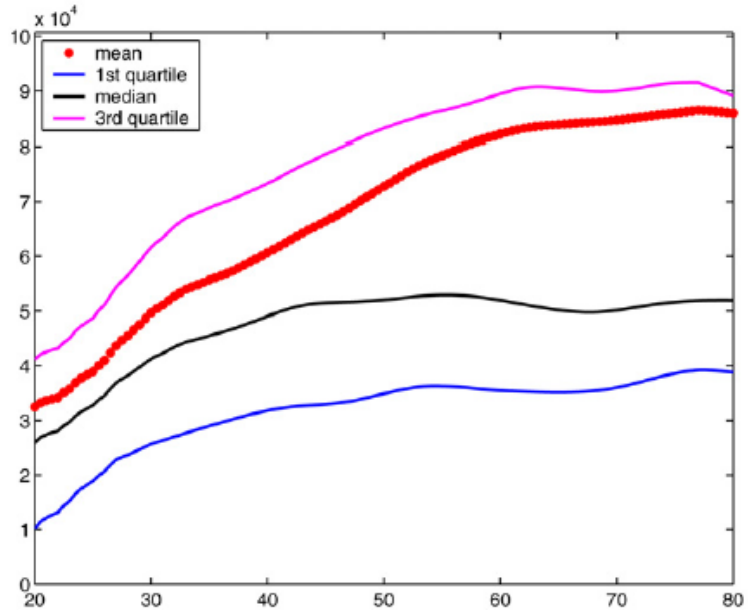


TFP Level in Japan

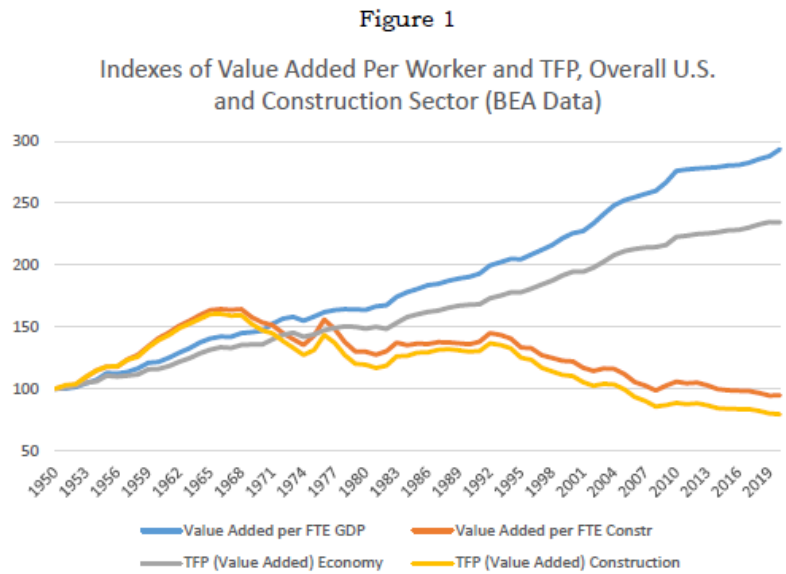
Source: JIP database. Note: TFP is gauged from the market production and housing is also an element of home production.

Global Implications

Also, in the US and other countries, housing consumption is increasing in age, and the construction sector is less productive.



US Housing Consumption by Age (Yang, 2009)



US TFP Level (Goolsbee and Syverson, 2023)

Hypothesis and What We Do

As the aging population demands more housing, more resources are allocated to a less productive construction sector.
Impacts will be on: sector composition, productivity, interest rate, output, consumption, house prices, etc.

We calibrate a quantitative overlapping generations (OLG) model with housing bequest motives to the Japanese economy, and find that elderly households' ownership of large houses will:

- $\downarrow$ allocation to productive capital
- $\downarrow$ growth
- $\downarrow$ interest rates
- $\uparrow$ house prices

Outline

Literature Summary and Our Study

Our study is related to three strands of literature:

1. Population aging (Wise, 1989, & NBER Econ. of Aging)
2. Quantitative OLG models (Auerbach and Kotlikoff, 1987)
3. Macro models with housing and bequest motives (Artle and Varaiya, 1978; Galor, 1992)

Our novelty:

1. To propose a new channel through which population aging affects the economy (elderly households' housing).
2. To simulate the aging Japanese economy by incorporating bequest and housing into a quantitative OLG model.

Outline

Model Overview

A closed-economy OLG model
with:

- 85 generations
- age-specific labor productivity and mortality rates
- two sectors with a productivity gap (general and housing)
- bequest motives related to housing and financial assets
- income tax, inheritance tax, and a PAYG pension system

without:

- uncertainty (no precautionary saving or risk premia)
- behavioral biases (myopia, inertia, etc.)
- age-specific consumption (education, healthcare, etc.)
- frictions (borrowing constraints, adjustment costs)

Households: Utility Maximization

An agent from age 20 ($j = 1$) to 104 ($j = J = 85$) maximizes:

$$U_{j,t} = \sum_{i=0}^{J-j} \beta^i \left[\frac{N_{j+i,t+i}}{N_{j,t}} \left(\ln c_{j+i,t+i} + \chi \ln h_{j+i,t+i} \right) + \left(\frac{N_{j+i,t+i} - N_{j+i+1,t+i+1}}{N_{j,t}} \right) \psi \{ \nu \ln bi_{j+i,t+i} + (1-\nu) \ln h_{j+i,t+i} \} \right],$$

s.t.

$$c_{j,t} + a_{j,t} + bi_{j,t} + P_t^h hi_{j,t} = (1 + r_t)\, a_{j-1,t-1} + \mathbf{1}_{j \geq JR} pen_t + (1 - \mathbf{1}_{j \geq JR}) \left[(1 - T_t) \{ \sigma_j^g w_t^g \xi_j^g + \left(1 - \sigma_j^g\right) w_t^h \xi_j^h \} + (1 - T^a)\, i_t - T^h P_t^h i_t^h \right],$$

retirement at age 64 ($j = JR = 45$), wage w_t, labor productivity ξ_j

Households: Bequests and Inheritance

A working-age agent inherits financial and housing assets:

$$i_t = (1 + r_t) \frac{\sum_{j=1}^{J} (N_{j,t-1} - N_{j+1,t}) (a_{j,t-1} + b_{j,t-1})}{\sum_{j=1}^{JR} N_{j,t}}$$

$$i_t^h = (1 - \delta_h) \frac{\sum_{j=1}^{J} (N_{j,t-1} - N_{j+1,t}) h_{j,t-1}}{\sum_{j=1}^{JR} N_{j,t}}$$

Intentional bequest, housing, and vacant units accumulate:

$$\begin{aligned} b_{j,t} &= (1 + r_t) b_{j-1,t-1} + bi_{j,t}, \\ h_{j,t} &= (1 - \delta_h) h_{j-1,t-1} + hi_{j,t} + \phi (1 - \mathbf{1}_{j \geq JR}) i_t^h, \\ v_{j,t} &= (1 - \delta_h) v_{j-1,t-1} + (1 - \phi) (1 - \mathbf{1}_{j \geq JR}) i_t^h, \end{aligned}$$

ϕ: the utilization rate of inherited housing.

Production Sectors

Production of general goods and housing ($s = \{g, h\}$):

$$Y_t^s = \left(K_t^s\right)^{\alpha_s} \left(\zeta_t^s L_t^s\right)^{1-\alpha_s},$$

$\zeta_t^s = \left(1 + g_t^s\right) \zeta_{t-1}^s$ is labor-augmenting technology.

Productivity gap between g and h:

$$\theta_t \equiv 1 - \frac{\zeta_t^h}{\zeta_t^g}.$$

Periodic profits:

$$\pi_t^s = P_t^s Y_t^s - w_t^s L_t^s - \left(r_t + \delta_k^s\right) K_t^s.$$

Government

Budget constraint, given exogenous spending G_t, debt D_t, and inheritance tax rates T^h and T^a:

$$G_t + pen_t \sum_{j=JR}^{J} N_{j,t} + (1 + r_t) D_{t-1} =$$

$$D_t + \sum_{j=1}^{JR-1} N_{j,t} \left\{ T_t \left[\sigma_j^g w_t^g \xi_j^g + \left(1 - \sigma_j^g\right) w_t^h \xi_j^h \right] + \left(T^h P_t^h i_t^h + T^a i_t \right) \right\}.$$

Pensions:

$$pen_t = \rho_t \frac{w_t^g \sum_{j=1}^{JR-1} \sigma_j^g N_{j,t} \xi_j^g + w_t^h \sum_{j=1}^{JR-1} \left(1 - \sigma_j^g\right) N_{j,t} \xi_j^h}{\sum_{j=1}^{JR-1} N_{j,t}},$$

ρ_t is the replacement rate, σ_j^g is the labor share of general sector.

Market Clearing

The capital market:

$$D_t + K_t = A_t + B_t, \qquad K_{t-1} = K_t^g + K_t^h.$$

Labor markets:

$$L_t^g = \sum_{j=1}^{J} \sigma_j^g N_{j,t} \xi_j^g, \qquad L_t^h = \sum_{j=1}^{J} \left(1 - \sigma_j^g\right) N_{j,t} \xi_j^h.$$

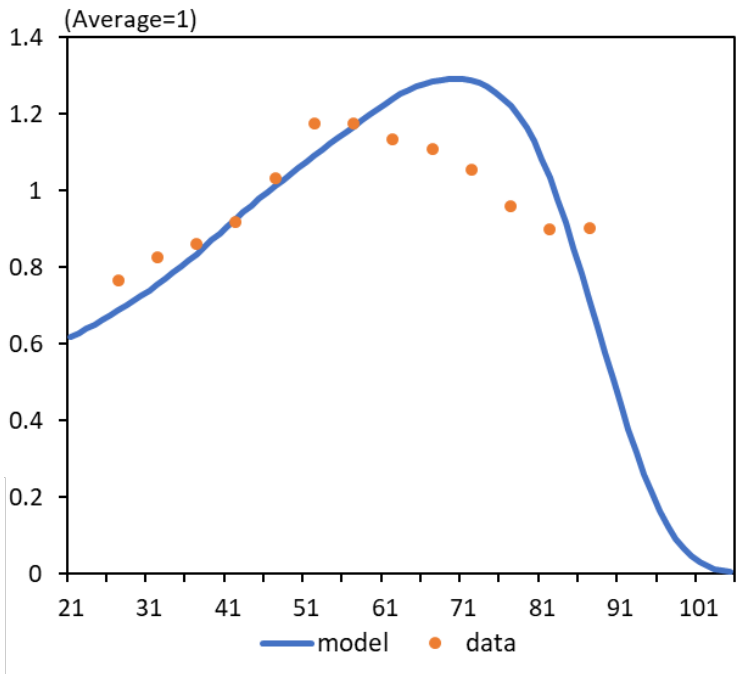
Goods and housing markets:

$$Y_t^g = \sum_{j=1}^{J} N_{j,t} c_{j,t} + K_t - (1 - \delta_k) K_{t-1} + G_t, \qquad Y_t^h = \sum_{j=1}^{J} N_{j,t} hi_{j,t}.$$

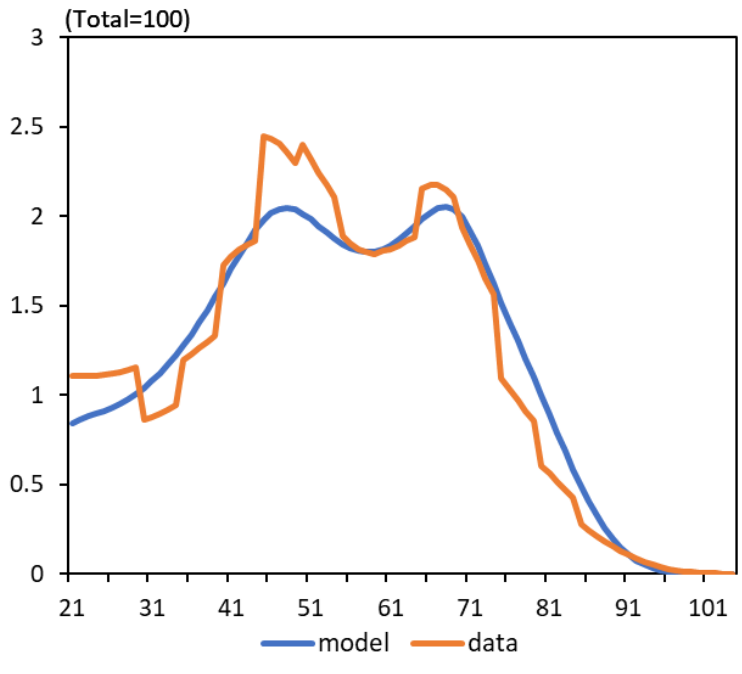
Key Equations and Age Profile: Consumption ($c_{j,2019}$)

The Euler equation: $\frac{c_{j+1,t+1}}{c_{j,t}} = \beta\,(1 + r_{t+1})\,(1 - \omega_{j,t})$.

Unlike the LCH/PIH, a hump-shaped age profile is replicated.



Per Capita Consumption



Aggregate Consumption

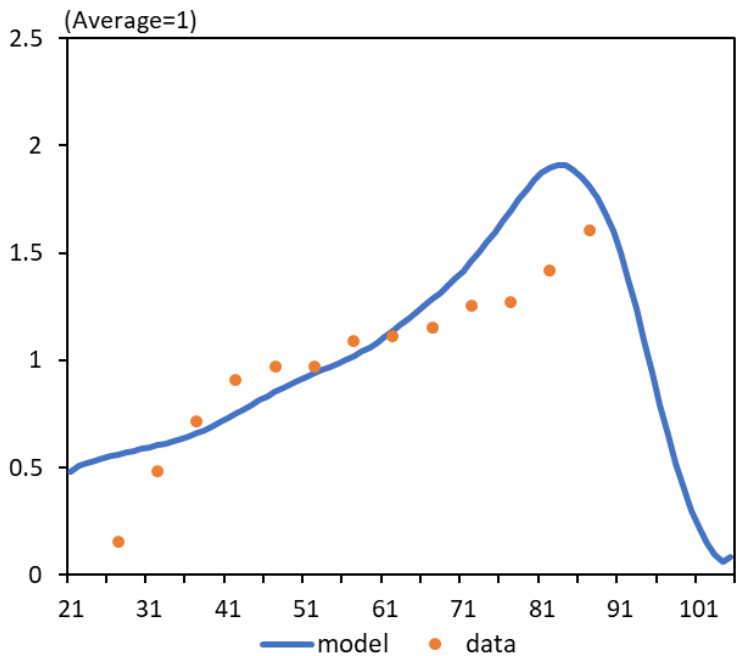
Source: National Survey of Family Income, Consumption, and Wealth.

Key Equations and Age Profile: Housing ($h_{j,2019}$)

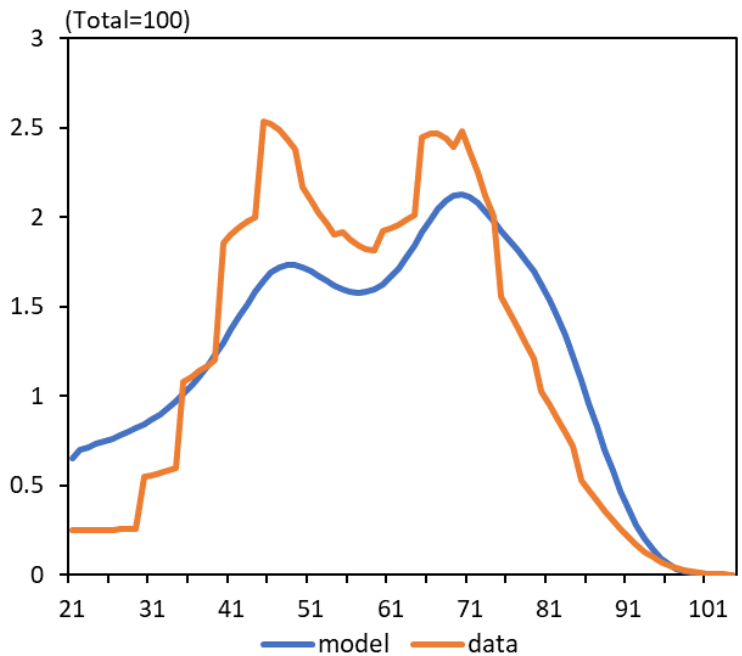
The intra-temporal $c - h$ relation:

$$\frac{h_{j,t}}{c_{j,t}} = [\chi + \psi (1 - \nu) \omega_{j,t}] \left[P_t^h - \frac{(1-\delta_h)}{(1+r_{t+1})} P_{t+1}^h \right]^{-1}.$$

An upward-sloping age profile is replicated.



Per Capita Housing



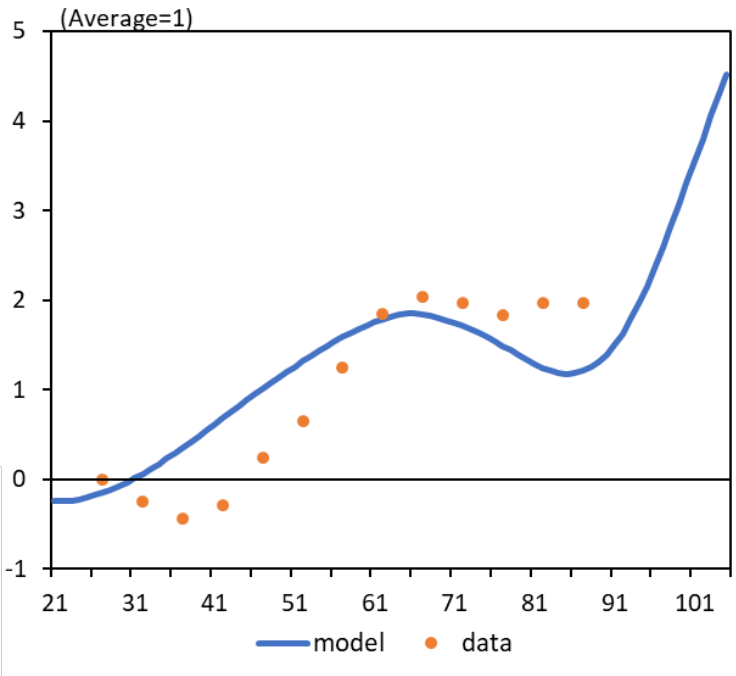
Aggregate Housing

Source: National Survey of Family Income, Consumption and Wealth.

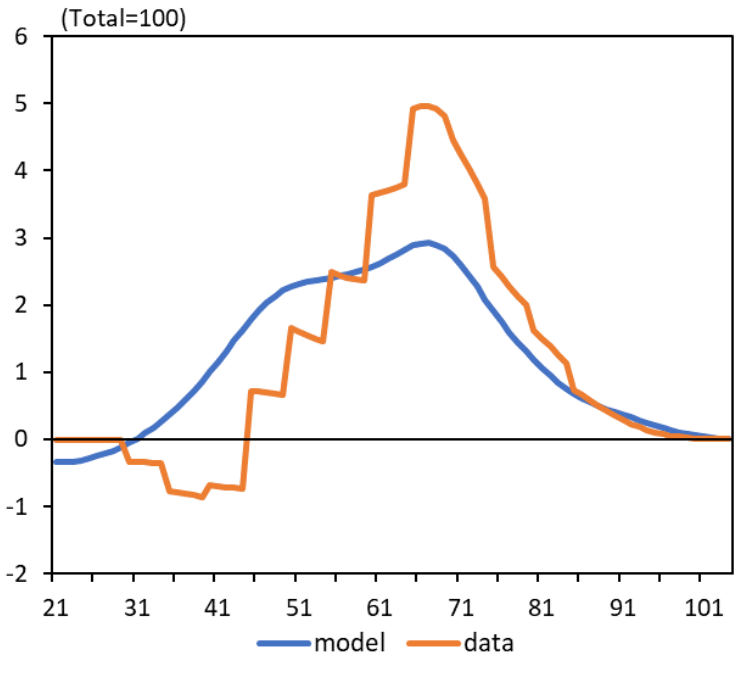
Key Equations and Age Profile: Fin. Asset ($a_{j,2019} + b_{j,2019}$)

The intra-temporal $c - bi$ relation: $\frac{bi_{j,t}}{c_{j,t}} = \psi\nu\omega_{j,t}$.

An upward-sloping age profile is replicated.



Per Capita Financial Assets



Aggregate Financial Assets

Source: National Survey of Family Income, Consumption and Wealth.

Outline

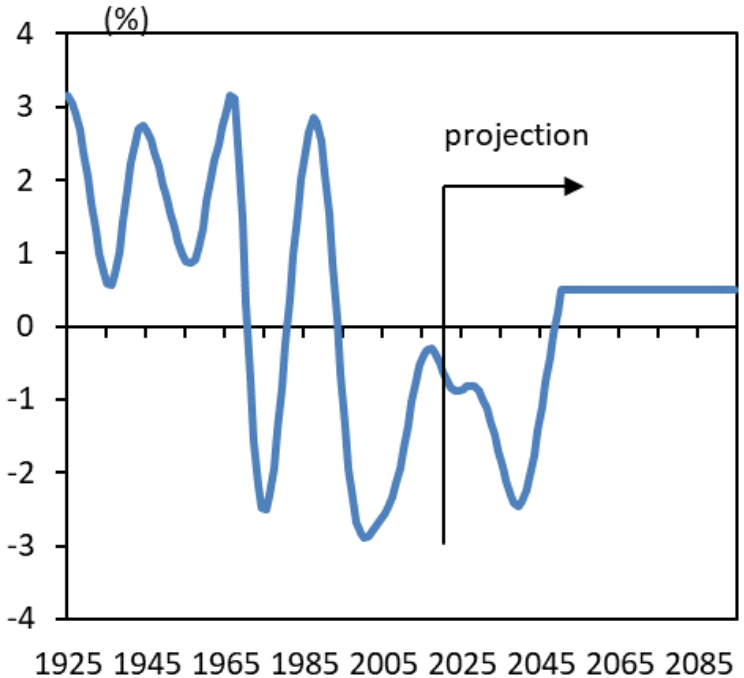
Exogenous Processes

The model economy is driven by the following exogenous processes.

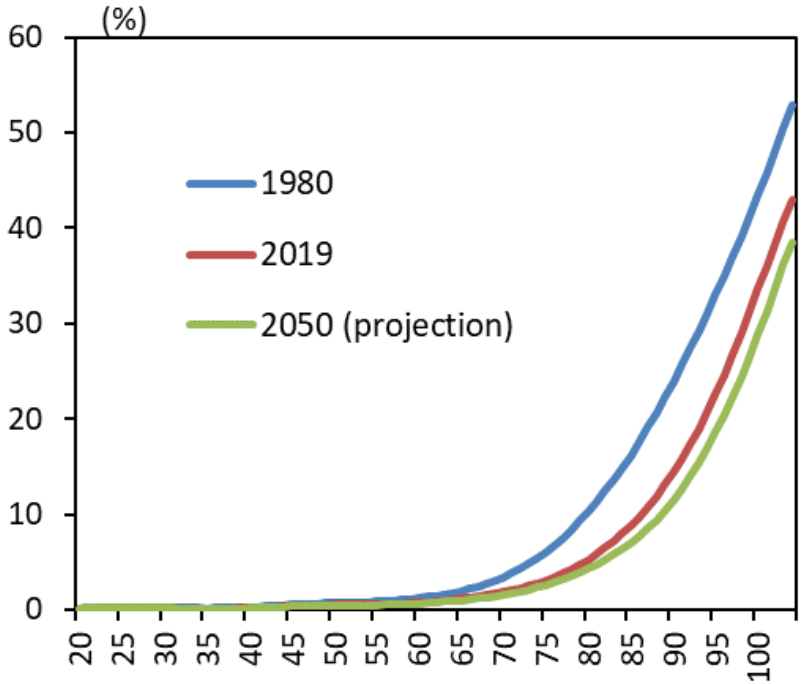
Name	Description	Type
$n_{1,t}$	Fertility rate (the growth rate of 20-year-old cohort)	periods x 1
$\omega_{j,t}$	Age-specific modified mortality rate	periods x cohorts
ζ_t^g	Labor-augumenting technology in general production sector	periods x 1
θ_t	Technology gap between the housing and general production sectors	periods x 1
$\mathbf{1}_{j \geq JR}$	Retirement indicator	periods x cohorts
ρ_t	Replacement rate	periods x 1
σ_j^g	Age-specific proportion for working in general production sector	cohorts x 1
ξ_j^g	Age-specific labor productivity in general production sector	cohorts x 1
ξ_j^h	Age-specific labor productivity in housing sector	cohorts x 1
$\overline{G/Y}$	Government spending ratio	periods x 1
$\overline{D/Y}$	Government debt ratio	periods x 1

List of Exogenous Variables

Exogenous Demographic Variables



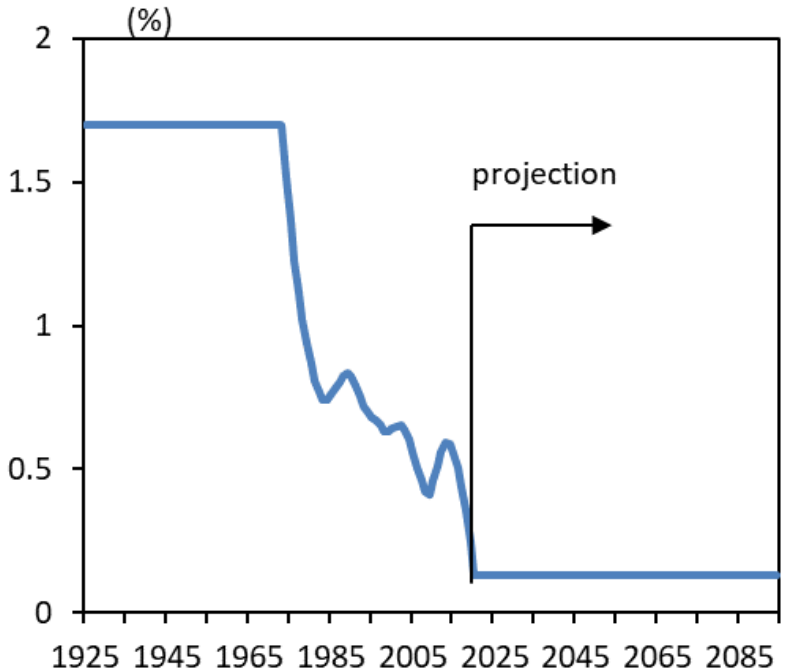
"Fertility Rate" at Age 20 ($n_{1,t}$)



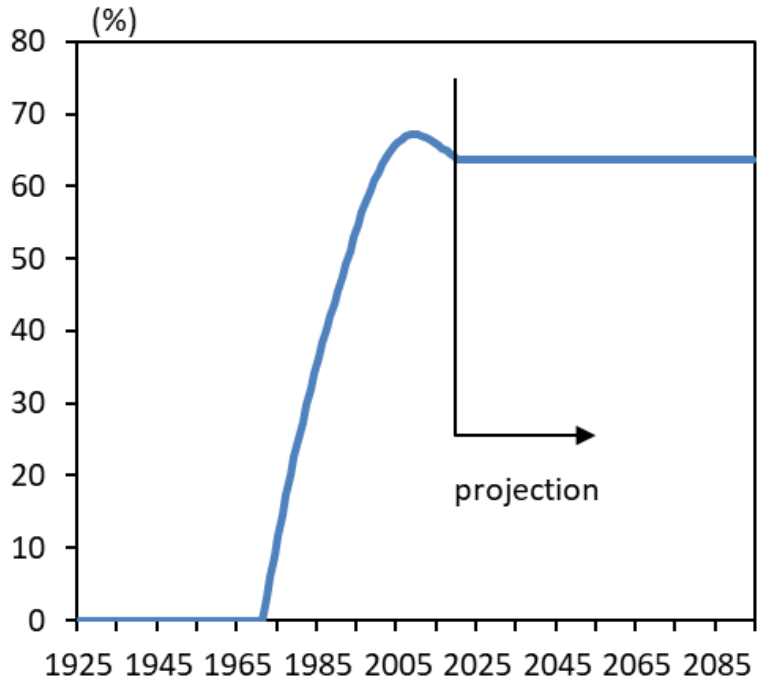
Mortality Rate ($\omega_{j,t}$)

Sources: Life Tables, Population Projection. Note: HP-filtered.

Exogenous Technologies



Technology Growth in General Sector (g_t^g)



Technology Gap Between the Housing and General Sectors (θ_t)

Sources: JIP database. Note: HP-filtered.

Calibration

Name	Description	Value	How to decide
β	Discount factor	0.996	Litereture
χ	Importance of housing	0.45	Match the average $P^h h/c$ ratio among age 20-64
ψ	Importance of bequest	24	Match the average $P^h h/c$ ratio among age 65-104
ν	Relative importance of financial bequest	0.56	Match the average $(a+b)/c$ ratio among age 65-104
δ_g	Capital depreciation rate	0.15	Litereture
δ_h	Housing depreciation rate	0.075	Litereture
ϕ	Resusable rate of inherit housing	0.2	Match the average h/v ratio
T^a	Tax rate for the financial bequest	0.4	Litereture
T^h	Tax rate for the housing bequest	0	Litereture
α_g	Capital share in general production sector	0.37	Calibrate with JSNA
α_h	Capital share in housing sector	0.31	Calibrate with JSNA

List of Structural Parameters

Variable	Target Value	Model Value
Average $P^h h/c$ ratio among age 20-64	5.3	5.3
Average $P^h h/c$ ratio among age 65-104	8.4	8.4
Average $(a+b)/c$ ratio among age 65-104	6.4	17.6
Average h/v ratio	5.0	6.1

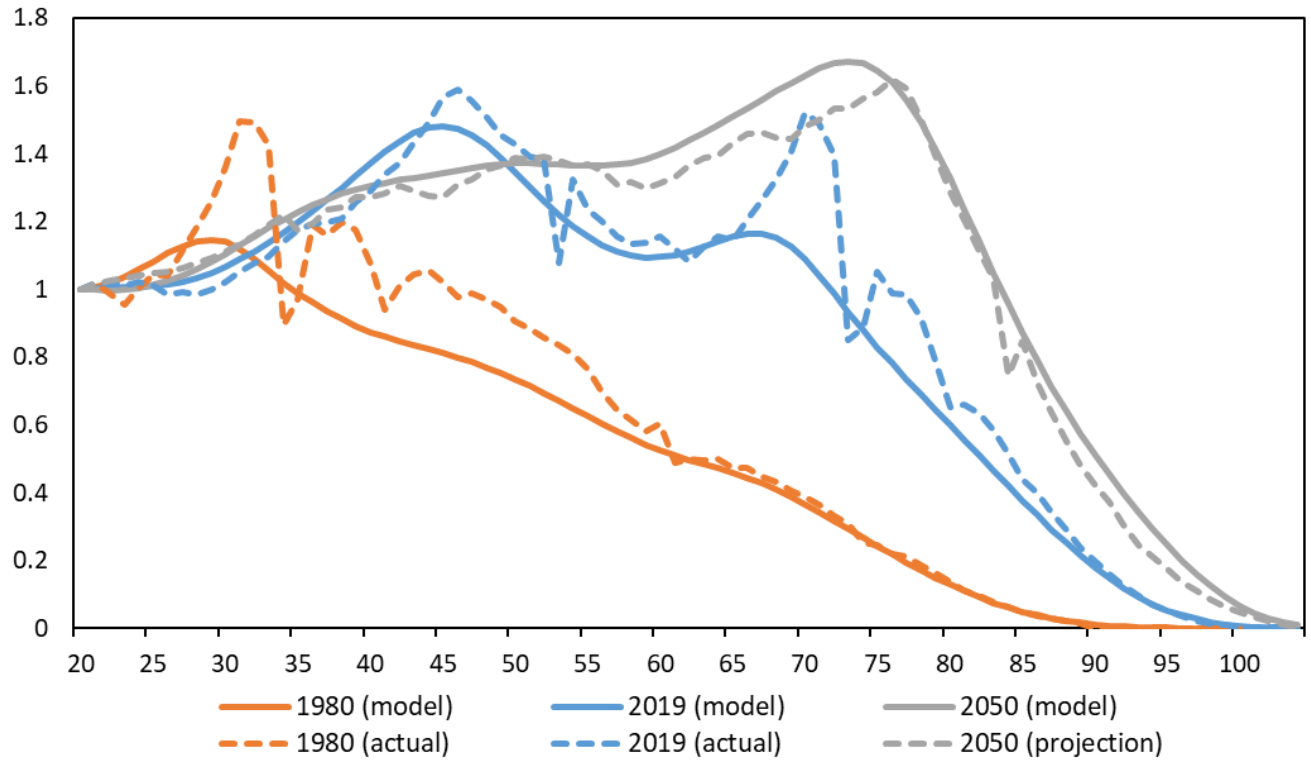
Calibration Results

Solution method

- We first estimate the steady-state values with constant exogenous variables for the initial (1925) and terminal (2095) states (▸ Algorithm).
- Then, we do our deterministic simulation (with perfect foresight) using Matlab and Dynare.
- We solve for an equilibrium path from 1925 to 2095 and focus on the trajectory from 1980 to 2050.

Age Profile: Demographics in 1980, 2019 & 2050

The model reproduces the actual demographics quite well.

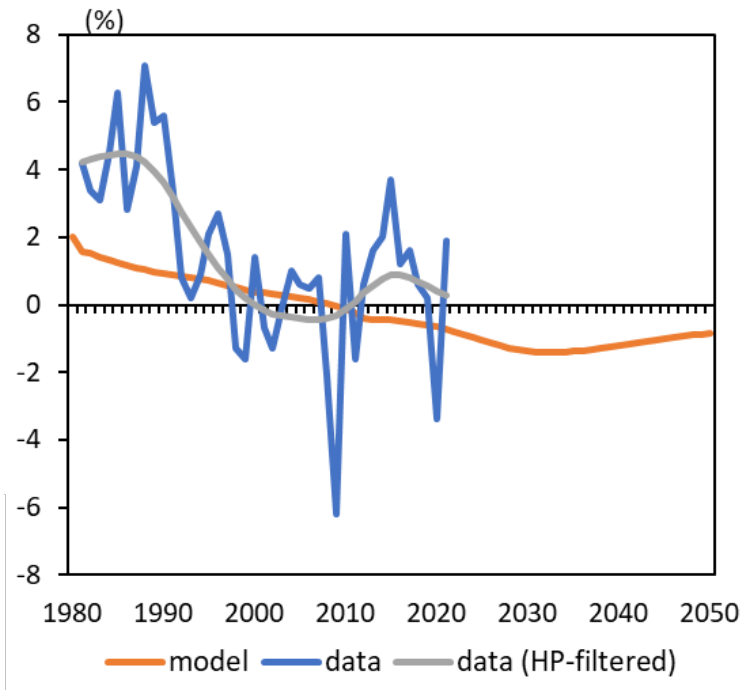


Demographics in 1980, 2019 & 2050

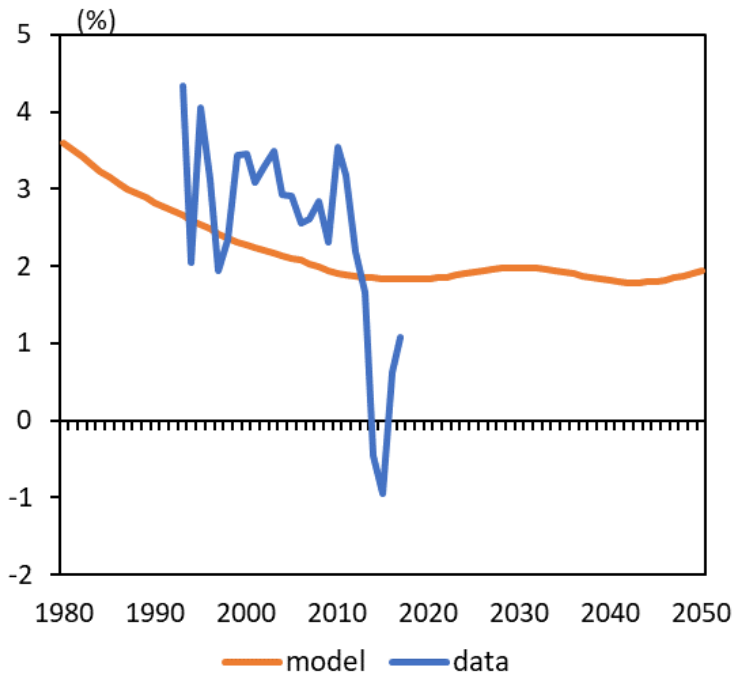
Sources: Population Estimates, Population Projection.

Aggregate Dynamics I

The model explains the downward trend of GDP growth and real interest rates.



GDP Growth

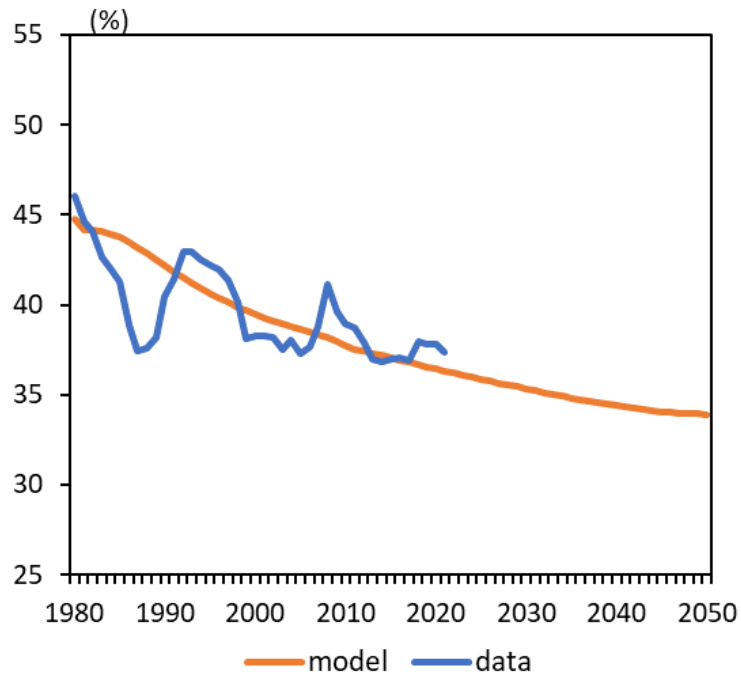


Real Interest Rate

Source: JSNA and World Development Indicators.

Aggregate Dynamics II

The model also explains the ratio of capital stock to household asset well.

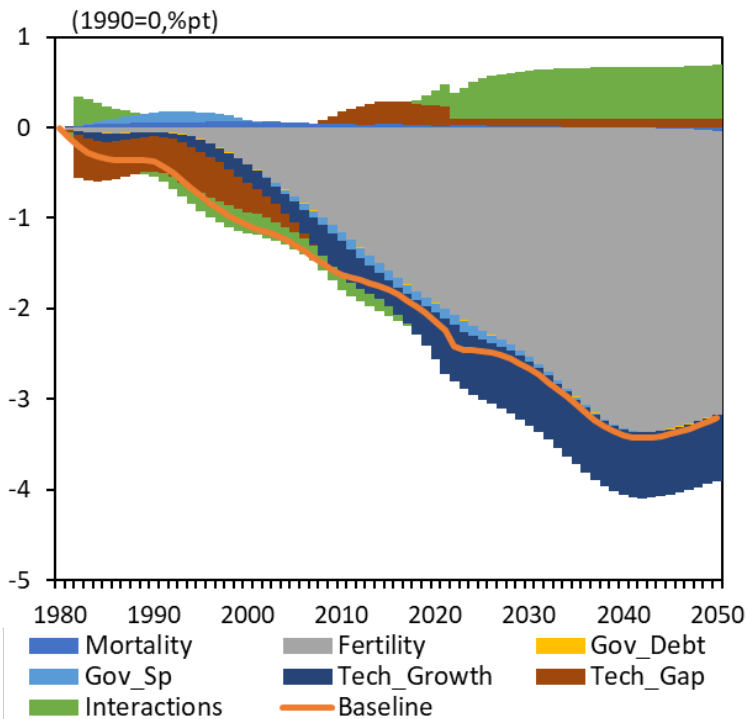


Ratio of Capital Stock to Householsd Asset

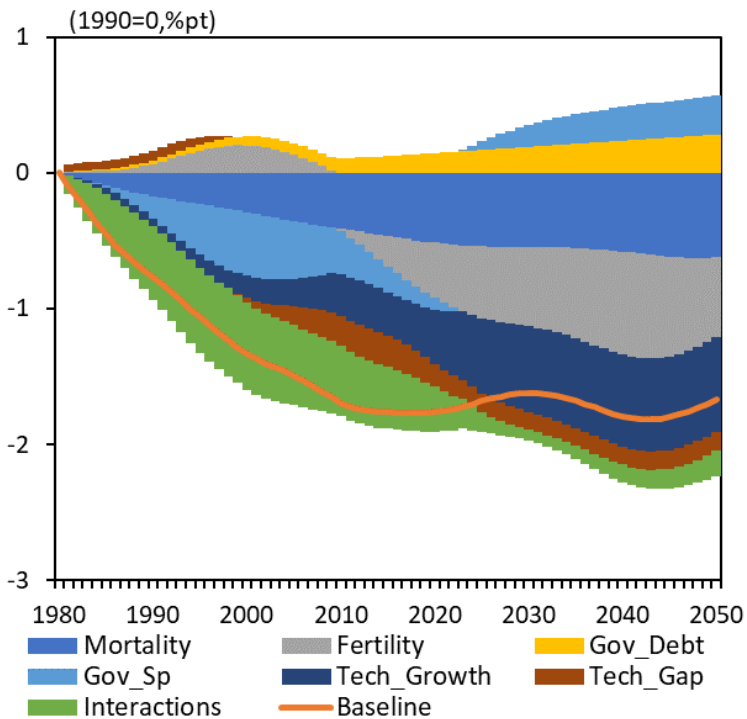
Source: JSNA and World Development Indicators. Note: Ratio of capital stock to household asset is calculated as $K_t/(A_t + (H_t + V_t)P_t^h)$.

Factor Decomposition: GDP growth and Real Interest Rates

GDP growth rates decrease by 3 pp due to low fertility rates.
Real interest rates decrease by 1.7 pp due to demographics and low technology growth.



GDP Growth

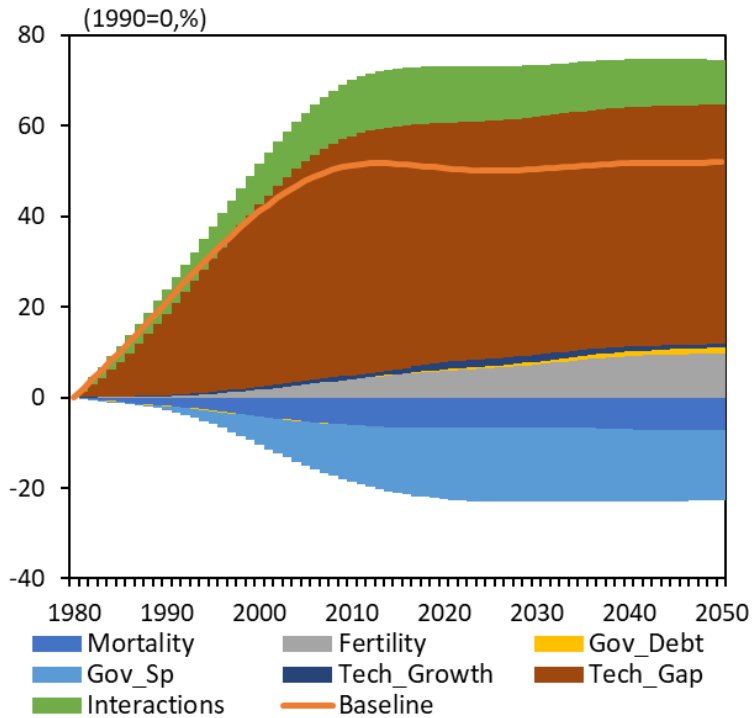


Real Interest Rate

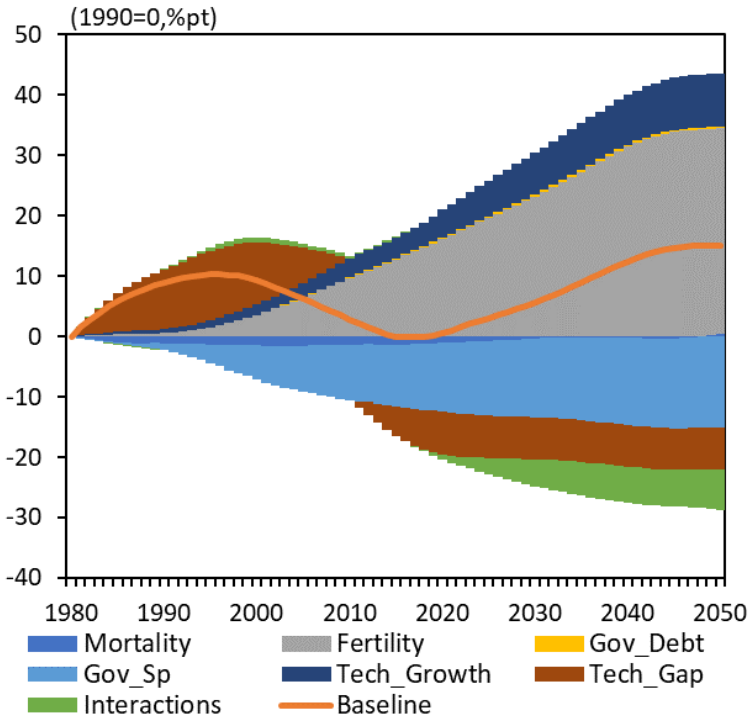
Note: Decomposition by the effect of keeping one factor at the 1990 value.

Factor Decomposition: House Prices

House Prices increase by 51% due to the productivity gap and level off, consistent with the post-bubble prices. Per capita housing value is affected by competing effects of aging and tax burden.



House Prices



Per Capita Housing Value

Outline

Counterfactual Analysis

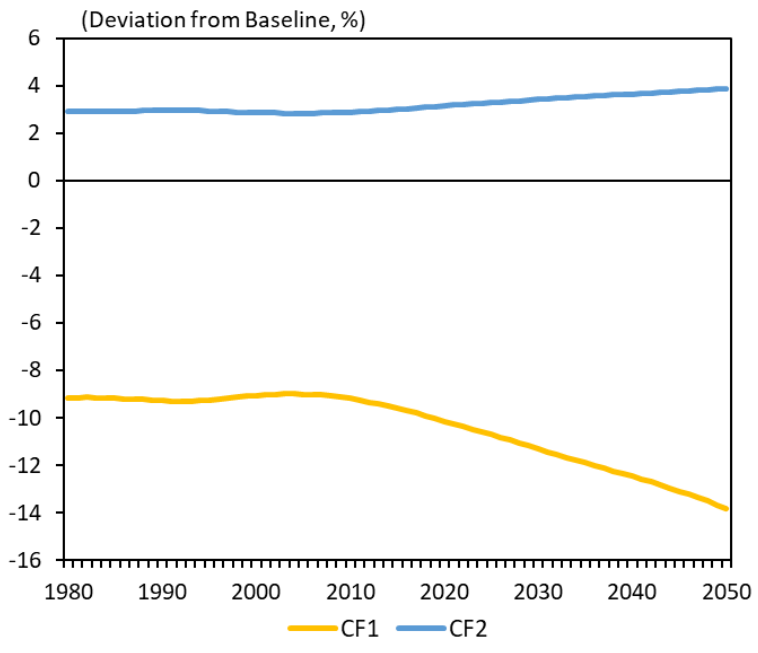
We conduct eight counterfactual simulations.

Name	Description	Baseline	CF1	CF2	CF3	CF4	CF5	CF6	CF7	CF8
ψ	Importance of bequest	24	0	36	-	-	-	-	-	-
ν	Relative importance of financial bequest	0.56	-	-	0.2	0.8	-	-	-	-
ϕ	Resusable rate of inherit housing	0.2	-	-	-	-	0	1	-	-
T^a	Tax rate for the financial bequest	0.4	-	-	-	-	-	-	0	0.4
T^h	Tax rate for the housing bequest	0	-	-	-	-	-	-	0	0.4
β	Discount factor	0.996	-	-	-	-	-	-	-	-
χ	Importance of housing	0.45	-	-	-	-	-	-	-	-
δ_g	Capital depreciation rate	0.15	-	-	-	-	-	-	-	-
δ_h	Housing depreciation rate	0.075	-	-	-	-	-	-	-	-
α_g	Capital share in general production sector	0.37	-	-	-	-	-	-	-	-
α_h	Capital share in housing sector	0.31	-	-	-	-	-	-	-	-

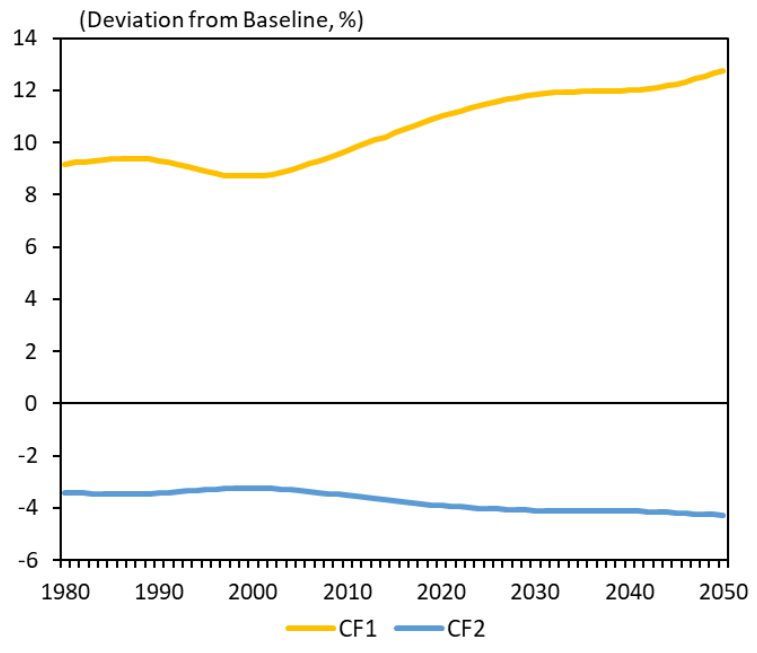
Table: List of Parameters' Value

Bequest Motives: GDP and Aggregate Consumption

The removal of bequest motives decreases GDP by 14% but increases consumption by 13% because of less housing demand solely based on flow utility.



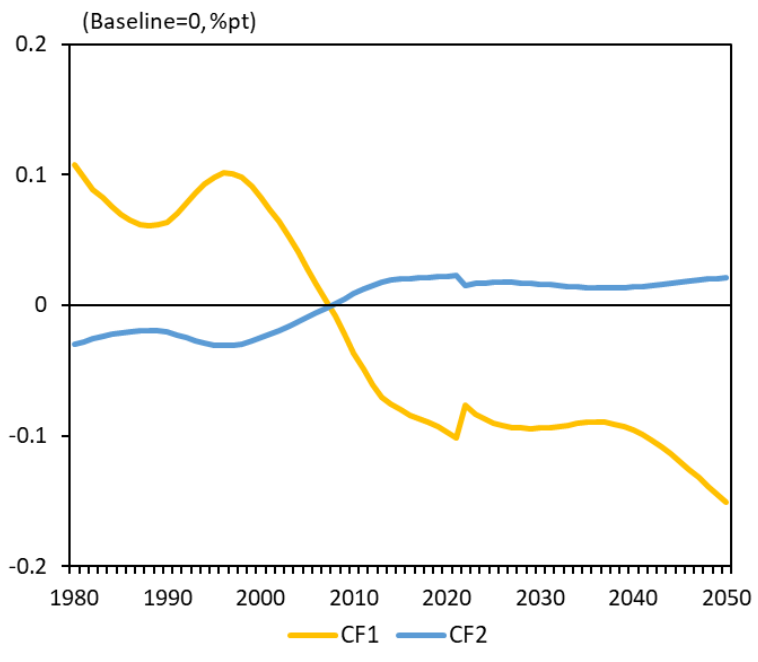
GDP Level



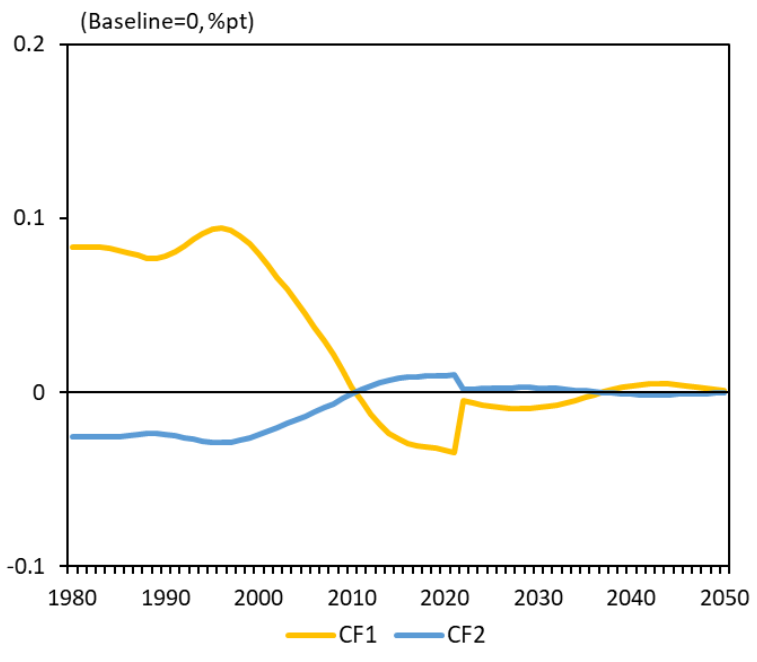
Consumption Level

Bequest Motives: GDP and TFP Growth

Without bequest motives, the growth rate of GDP and TFP would have been higher until the 2000s because of lower technological growth in the construction sector. After 2010, aging suppresses GDP growth.



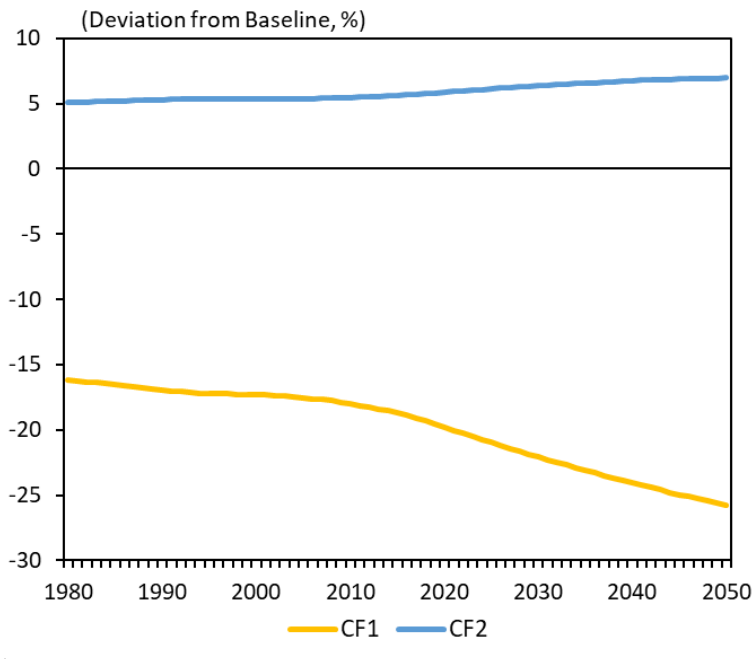
GDP Growth



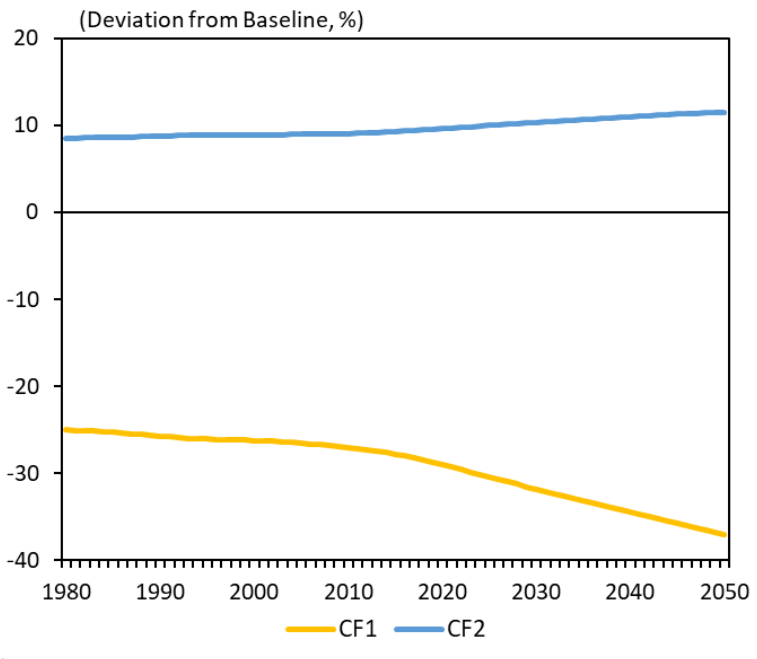
Total TFP Growth

Bequest Motives: House Prices and Aggregate Housing

Without bequest motives, house prices will be 26% lower; ie, the current house prices are inflated by bequest motives. Similarly, the equilibrium quantity of housing stock will also be smaller.



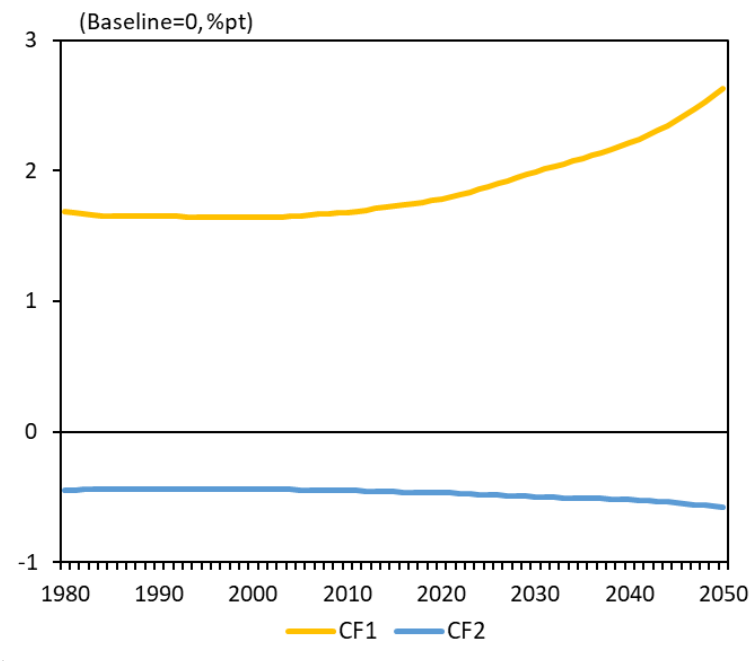
House Prices



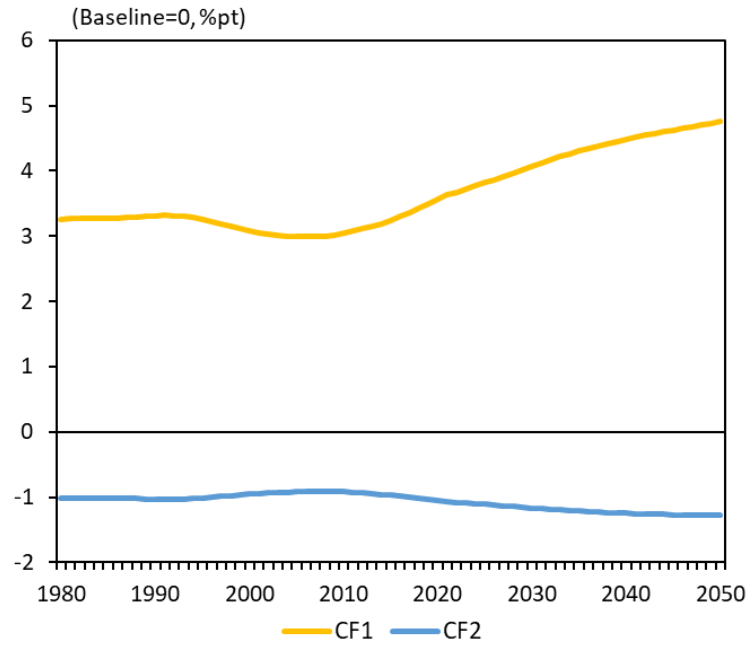
Per Capita Housing Value

Bequest Motives: Interest Rate and Stock Allocation

Without bequest motives, interest rates will be 2.6 pp higher than the benchmark rates, which range from -1% to -2%, because of higher MPK (a smaller production scale and higher aggregate TFP). Capital is shifted from housing to the general sector.



Real Interest Rate



Goods Sector Capital Share

Other Counterfactual Exercises

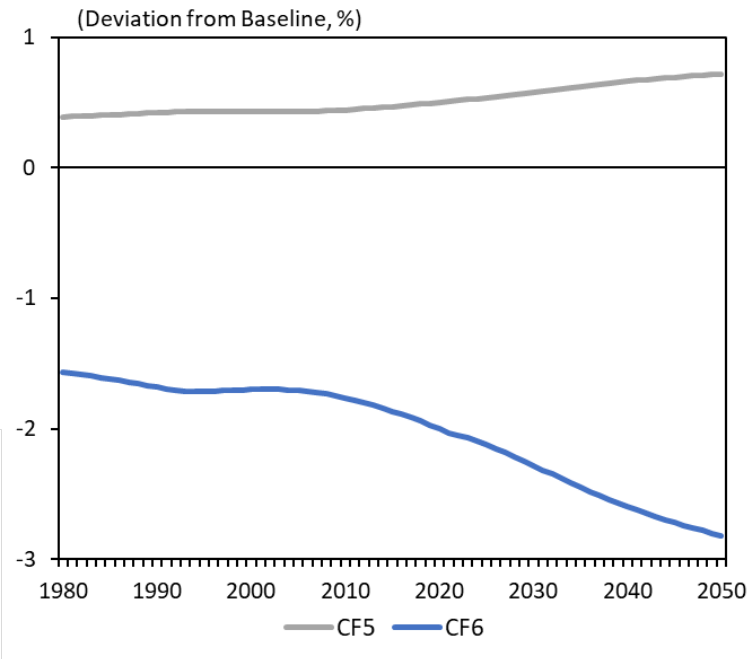
Weight on Financial Bequests (ν) ▸ Weight on Financial Bequests

Matching Efficiency (ϕ) ▸ Matching Efficiency

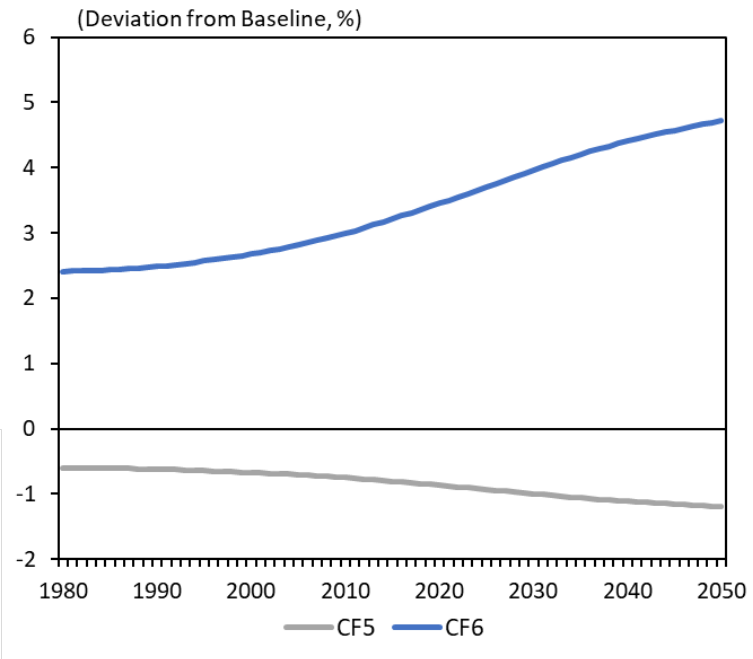
Inheritance Taxes (T^a and T^h) ▸ Inheritance Taxes

Matching Efficiency: GDP and Aggregate Consumption

A more sustainable society with efficient house matching (CF6) decreases GDP but increases consumption because less construction is needed.



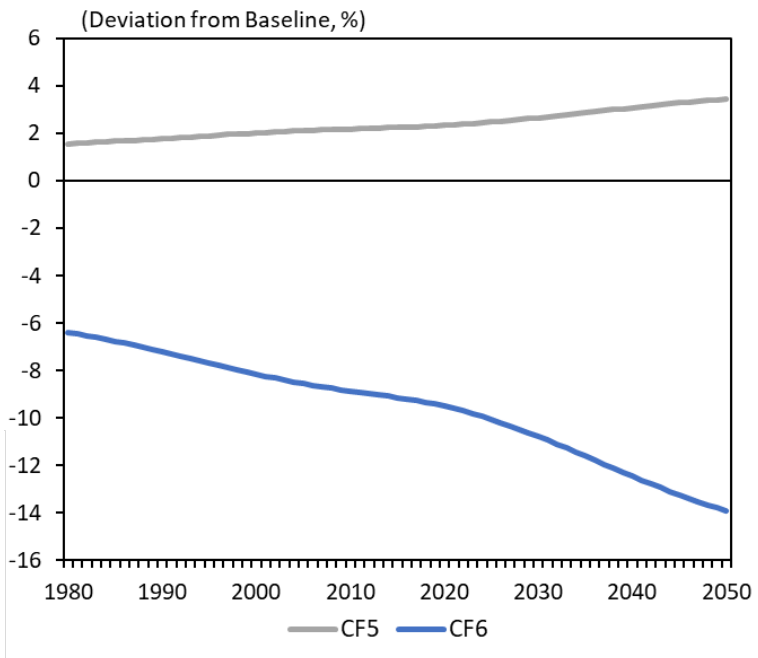
GDP Level



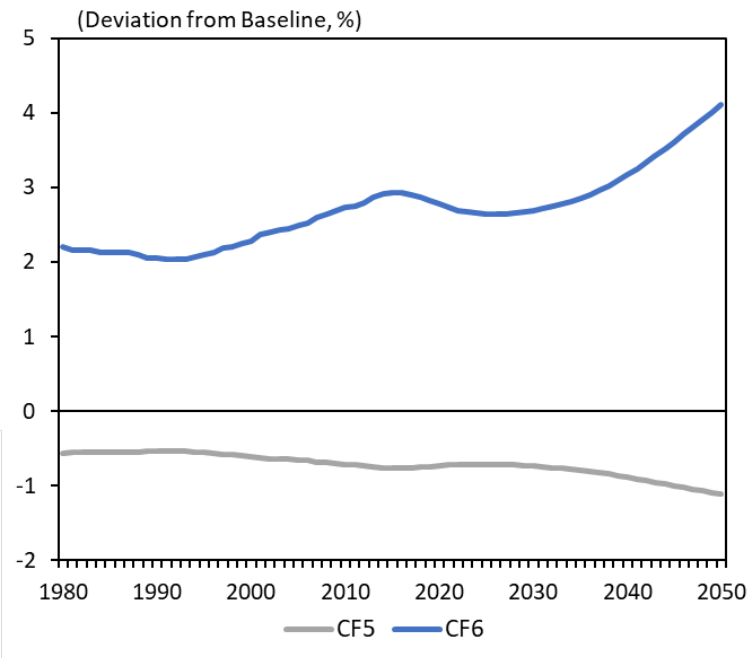
Consumption Level

Matching Efficiency: House Prices and Aggregate Housing

With efficient matching, house prices will be lower, but housing quantity will be larger; ie, efficient matching is a supply shift.



House Prices



Per Capita Housing Value

Outline

Conclusion

Population aging impacts the macroeconomy. We propose a new channel: Elderly households' ownership of large houses

- An OLG model calibrated to Japanese economy
- In an aging society, bequest-driven housing demand increases, and capital is put into housing.
- Housing bequest motives
  $\downarrow$ allocation to productive capital
  $\downarrow$ growth
  $\downarrow$ interest rates
  $\uparrow$ house prices
- Effects are exacerbated when inherited houses become vacant
- US and other countries face a similar situation (aging, homeownership, productivity, taxes)

Potential extensions

Short-term (for better calibration)

- Calibrating the model to the US economy

Medium-term

- Introducing land in housing production (DRS-lower MPK)
- Decomposing factors that increase housing
  - Utility function (substitution, myopic)
  - Moving/transaction costs
  - Family size parameter
- Heterogeneity
  - Household characteristics, geography

Long-term

- Endogenized labor share of sectors
- Environmental externalities
- TFP growth as a function of demographics

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Outline

Literature on Aging

- NBER Project on the Economics of Aging (Wise, 1989, 1990, 1992, 1994, 1996, 1998b,a, 2001, 2004, 2005, 2009, 2011, 2012, 2014, 2017).
- Weil (1997) and Lee (2016) review the effect of aging on the macro economy
  - increased capital intensity
  - higher wages
  - lower returns on capital
- The effect on output is
  - negative (e.g., Sheiner et al., 2007; Sheiner, 2014; Börsch-Supan et al., 2014; Gagnon et al., 2021; Maestas et al., 2023)
  - positive (e.g., Cutler et al., 1990)

Literature on Large-scale OLG models

- Seminal work by Auerbach and Kotlikoff (1987)
- Recent OLG models predict a downward trend of the real interest rate due to more savings (e.g., Bielecki et al., 2020; Papetti, 2021).
- Bielecki et al. (2020) (most closely related to our study) show that population aging explains approximately two thirds of the secular decline in the interest rate
- Eggertsson et al. (2019) and Gagnon et al. (2021) predict that GDP growth and interest rates will remain low in the U.S.
- Sudo and Takizuka (2018) and Braun and Ikeda (2022) predict that interest rate and inflation rate will remain low in Japan.
- Carvalho et al. (2016) identify competing three channels: larger savings driven by longevity, larger capital per-worker, and a lower savings rate.

Literature on Macroeconomic models with bequests

- Artle and Varaiya (1978) is an early study
- Hurd (1987) and Hurd (1989) argue that bequests are accidental and a motive is trivial
- Kopczuk and Lupton (2007) find that roughly three quarters of the elderly single population has a bequest motive and consumes less.
- Bernheim (1991) finds that the typical household maintains resources in bequeathable forms
- Intentional bequests can emerge either from altruism (Tomes, 1981) or self-interested exchange with one's heirs (Bernheim et al., 1985).
- Bequests are also incorporated in quantitative macro models (e.g., Hurd, 1989; Hviding and Mérette, 1998; Fougère and Mérette, 1999; Kraft and Munk, 2011).

Literature on Macroeconomic models with housing

- Real estate as a collateral (Kiyotaki and Moore, 1997; Bernanke et al., 1999; Wong, 2021)
- Asset pricing and portfolio choice (Flavin and Yamashita, 2002; Piazzesi et al., 2007).
- Iacoviello (2005) and Iacoviello and Neri (2010) incorporate housing in DSGE to show that housing is increasingly important in explaining consumption.
- More recent DSGE models (Liu et al., 2013; Garriga et al., 2021; Adam and Woodford, 2021)
- Housing in multi-sector OLG models (Galor, 1992; Farmer and Wendner, 2003; Yang, 2009; Kraft and Munk, 2011; Waters, 2020; Nakajima, 2020), but Nakajima (2020) focuses on the substitution between housing and non-housing capital and suggests a low optimal capital income tax rate.
- Cocco and Lopes (2020) study the role of housing wealth in retirement consumption and saving decisions by the elderly.

Algorithm to Calculate a Steady State

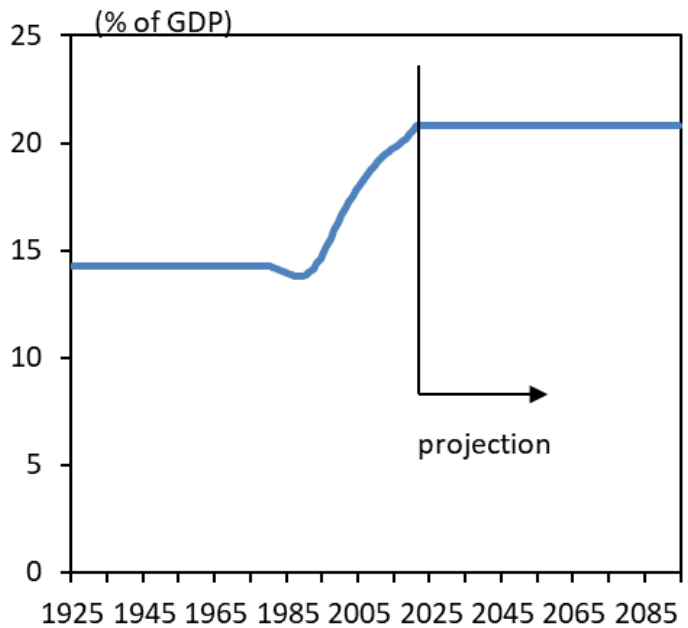
1. Set the initial value for the following aggregate variables.

	$\frac{K^g}{L^g}$	$\frac{K^h}{L^h}$	i	i^h	pen
Initial values	3	1.5	2.0	4.0	0.2

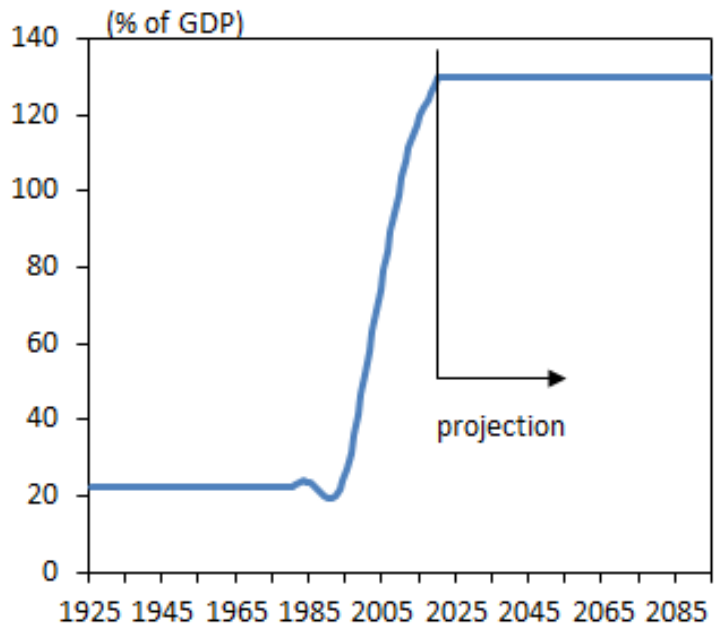
2. Calculate the steady-state prices and the tax rate: w^g, w^h, P^h, r and T.
3. Calculate the consumption for the youngest cohort as a function of the lifetime income.
4. Determine consumption and other variables for all cohorts: $\{N_j, c_j, a_j, h_j, hi_j\}_{j=1}^{J}$.
5. Evaluate the convergence of $\frac{K^g}{L^g}$, $\frac{K^h}{L^h}$, i, i^h and pen.
6. If not convergent, guess the next values and repeat the loop.

◂ Solution

Other Exogenous Drivers



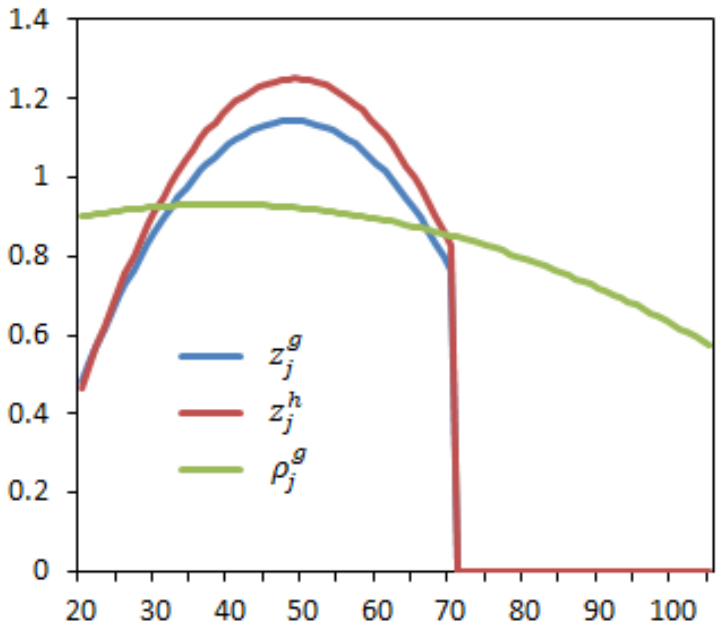
Government Spending $\overline{G/Y_t}$



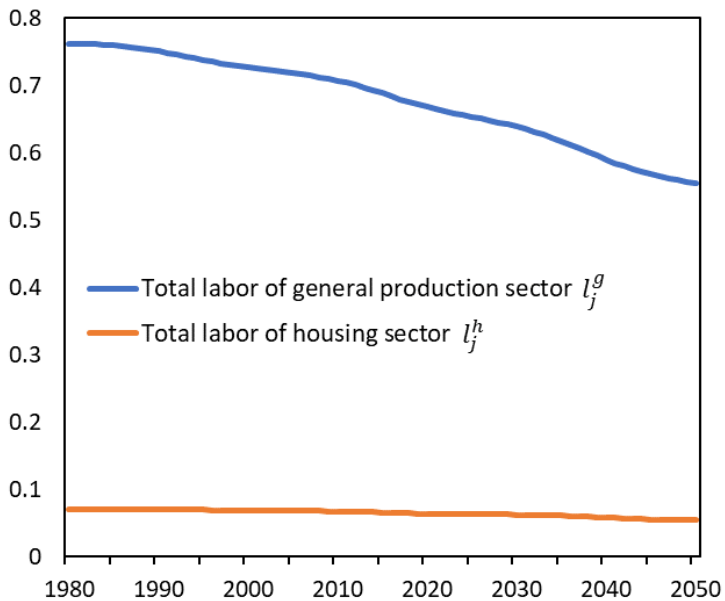
Government Debt $\overline{B/Y_t}$

Sources: JSNA. Note: HP-filtered.

Other Exogenous Drivers



Labor properties z_j^g, z_j^h, and ρ_j^g

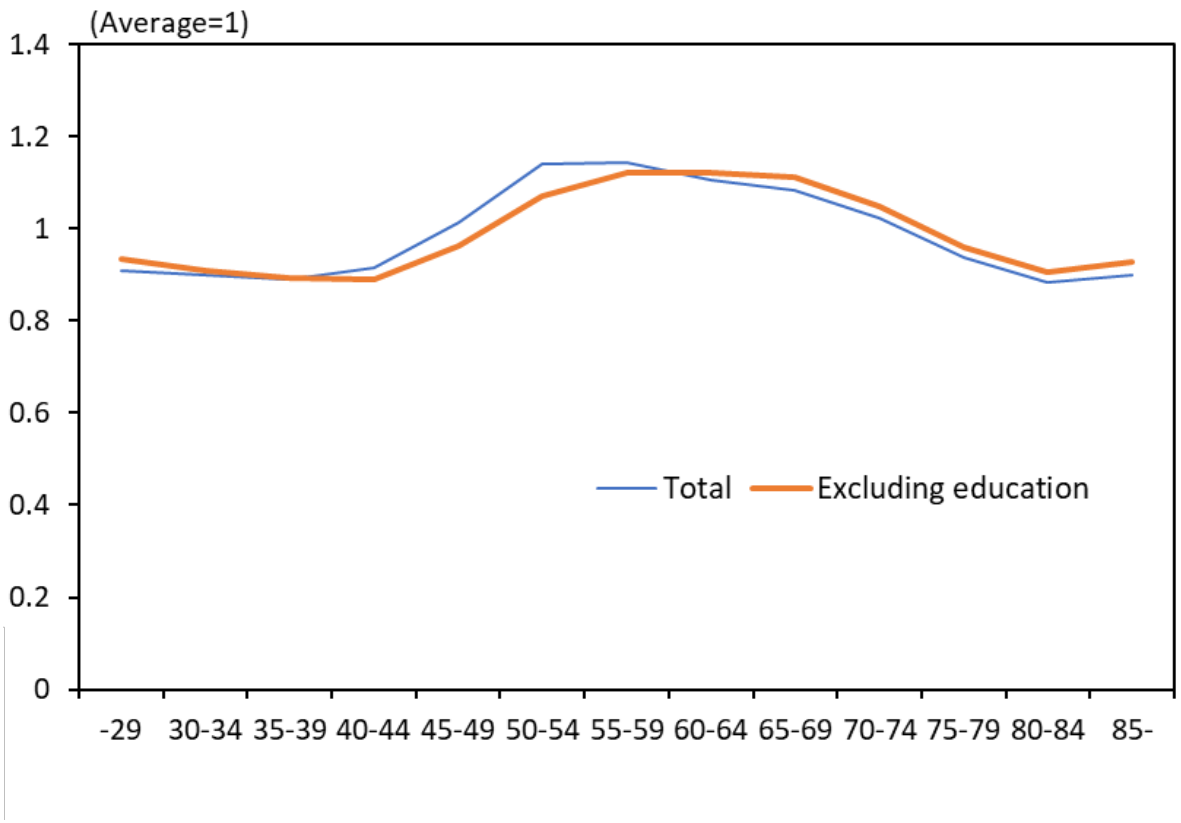


Total labor l_j^g, l_j^h

Sources: Basic Durvey on Wage Structure.

Age Profile of Consumption

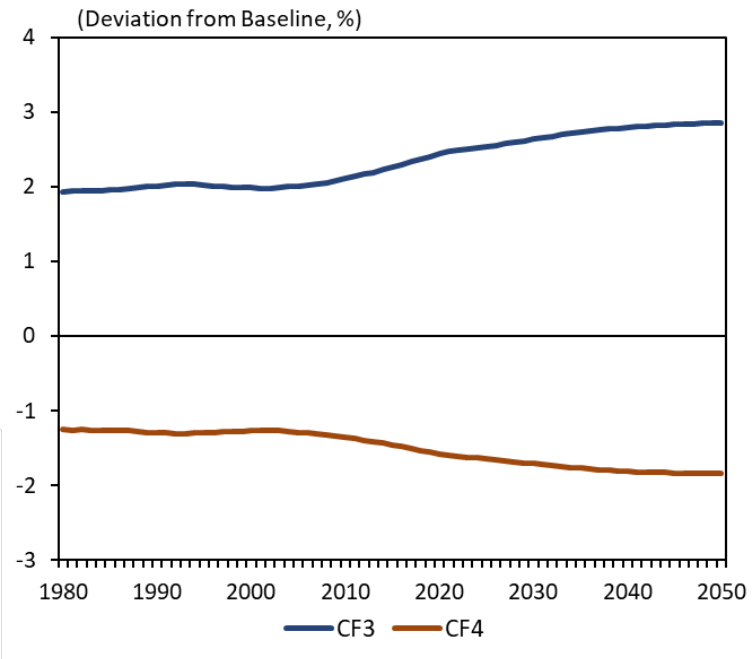
If the education consumption is excluded, the peak of age-profile of consumption is lagged slowly.



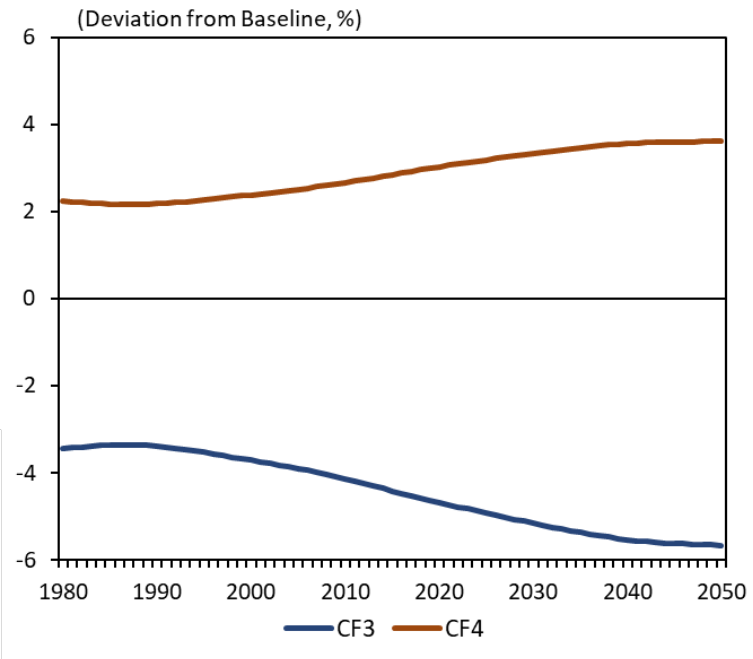
TFP Level in Japan

Weight on Financial Bequests: GDP and Aggregate Consumption

A larger weight on financial bequests (CF4) decreases GDP but increases consumption, similar to the removal of bequest motives.



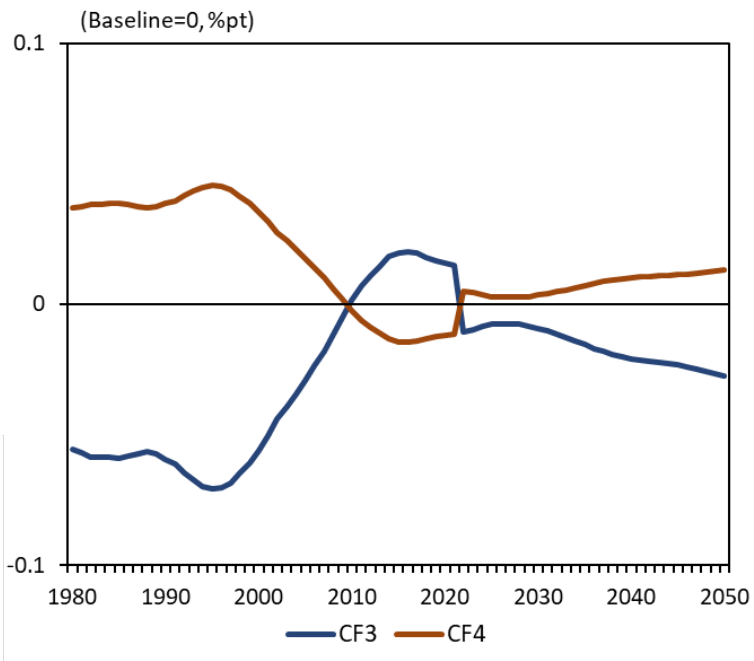
GDP Level



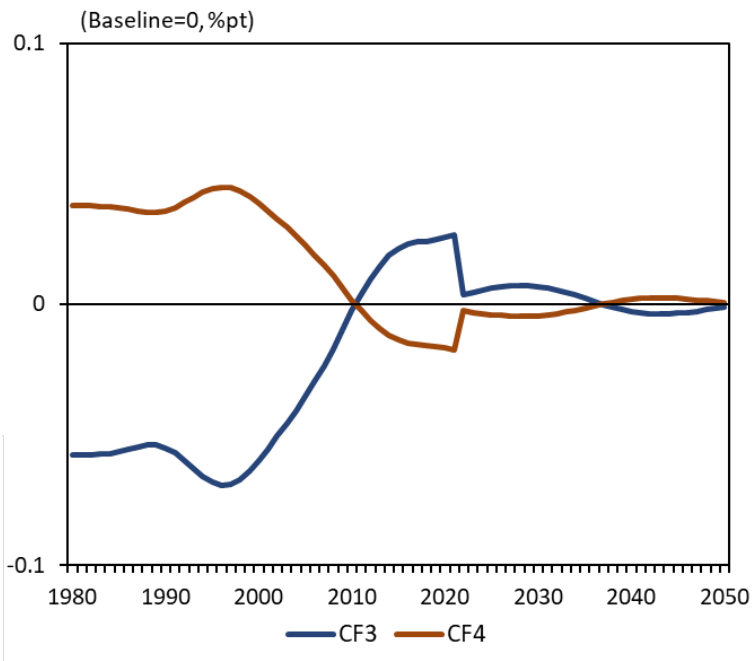
Consumption Level

Weight on Financial Bequests: GDP and TFP Growth

With a larger weight on financial bequests, the growth rate of GDP and TFP would have been higher until the 2000s because of reduced demand for housing. After 2010, aging suppresses GDP growth.



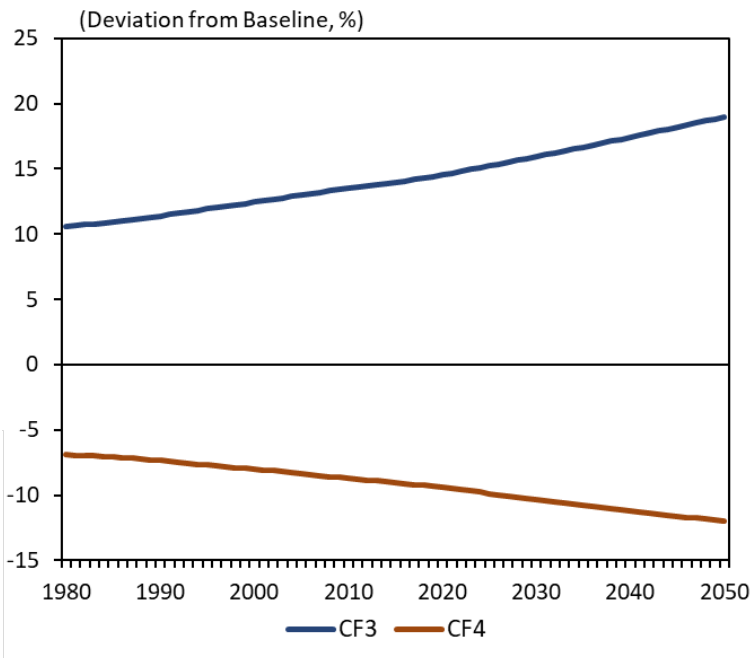
GDP Growth



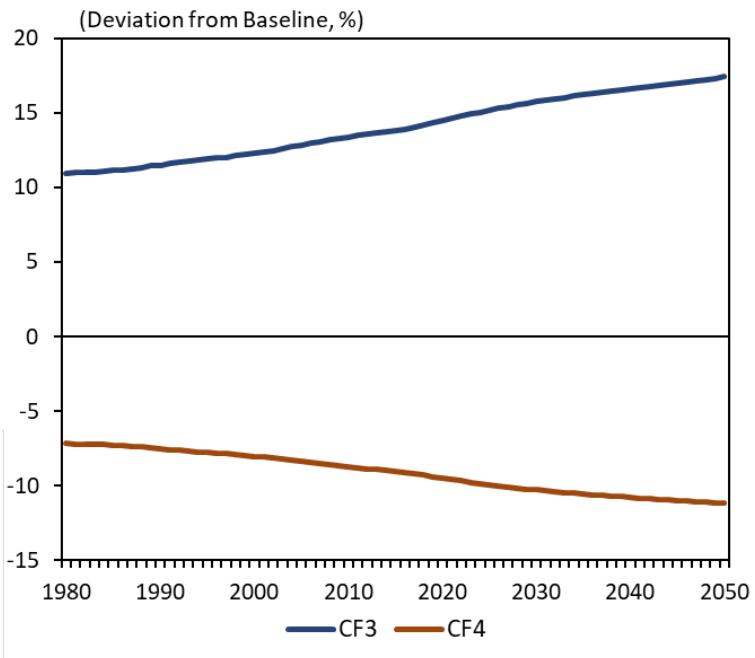
Total TFP Growth

Weight on Financial Bequests: House Prices and Aggregate Housing

With a larger weight on financial bequests, house prices will be lower; ie, the current house prices are inflated by housing bequest motives. Similarly, the equilibrium quantity of housing stock will also be smaller.



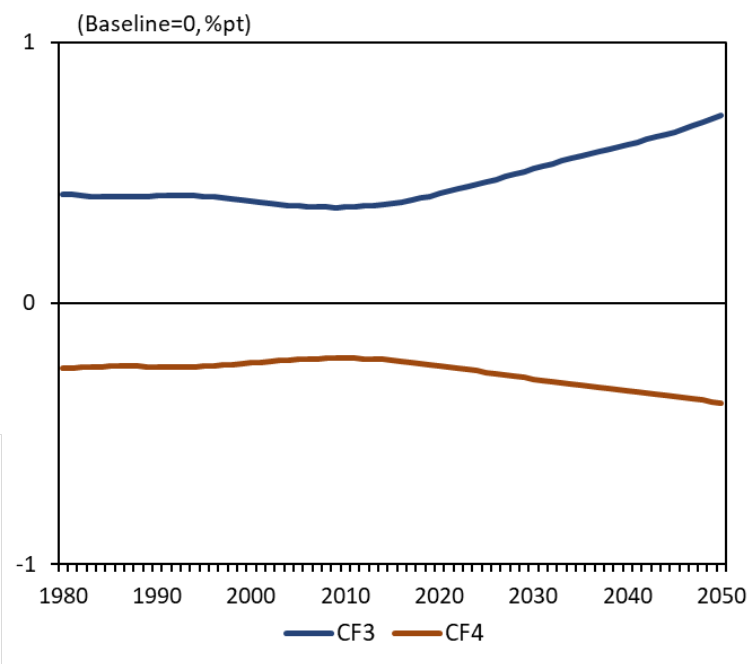
House Prices



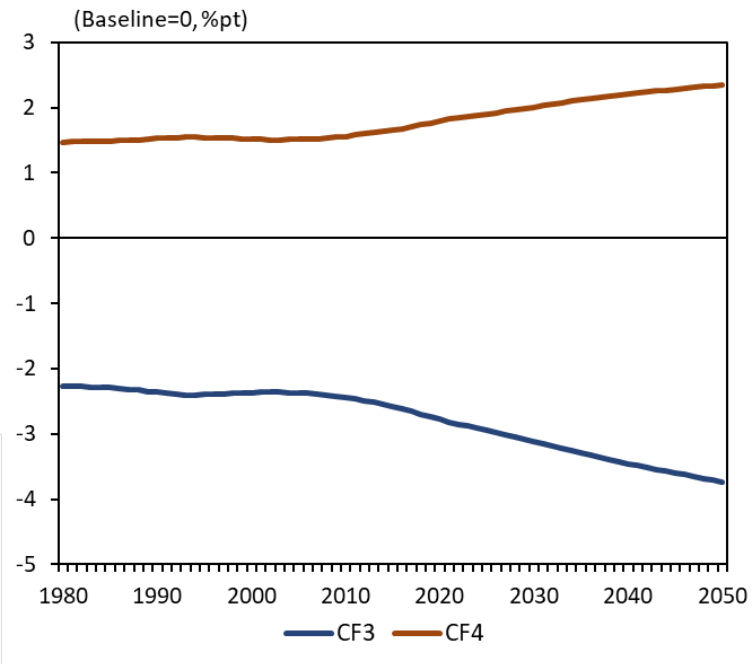
Per Capita Housing Value

Weight on Financial Bequests: Interest Rate and Stock Allocation

With a larger weight on financial bequests, interest rates will be slightly lower due to more savings. Capital is shifted from housing to the general sector.



Real Interest Rate

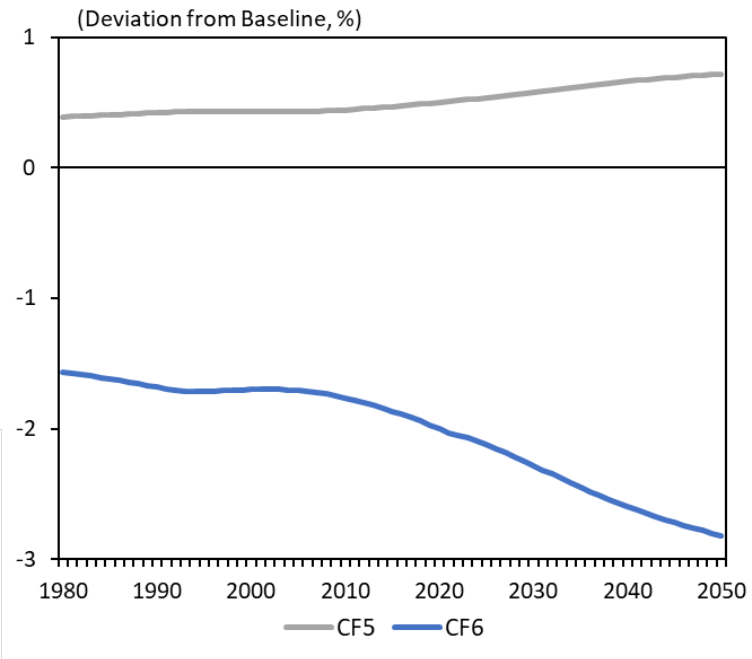


Goods Sector Capital Share

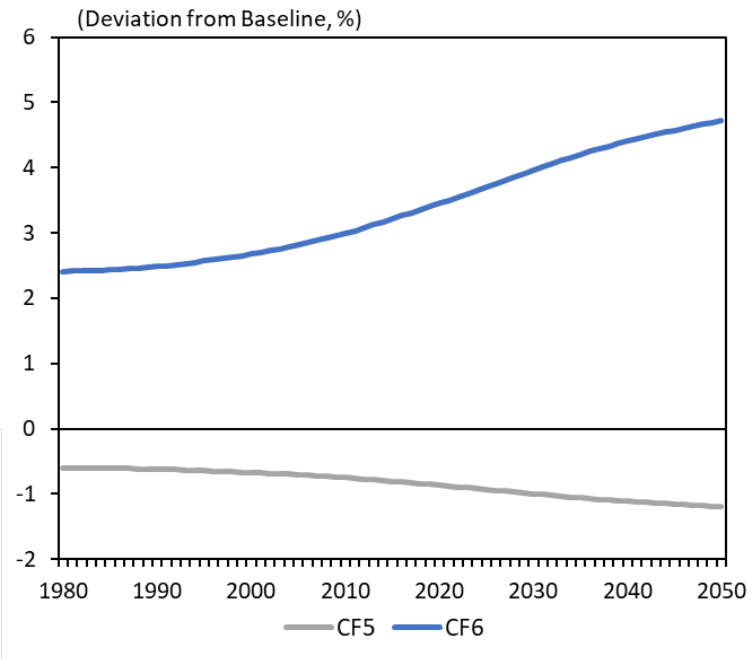
Back to Counterfactuals

Matching Efficiency: GDP and Aggregate Consumption

A more sustainable society with efficient house matching (CF6) decreases GDP but increases consumption because less construction is needed.



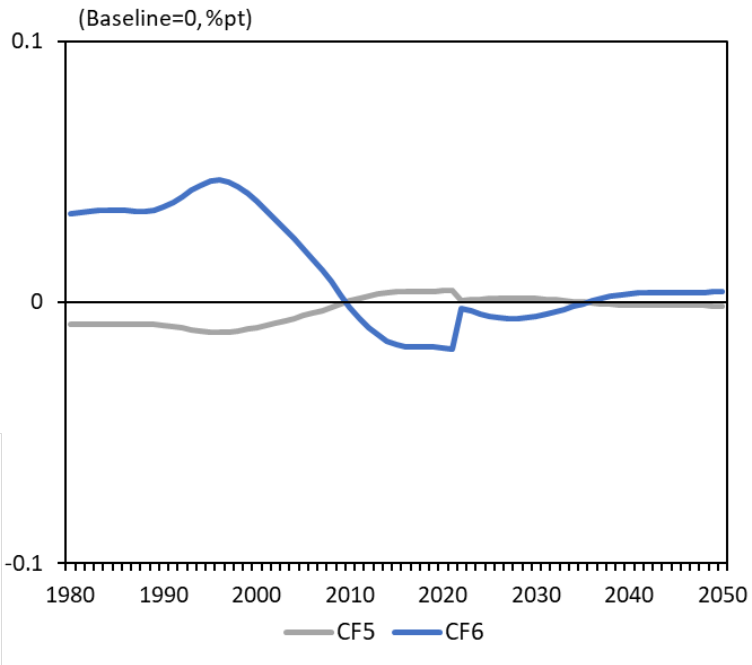
GDP Level



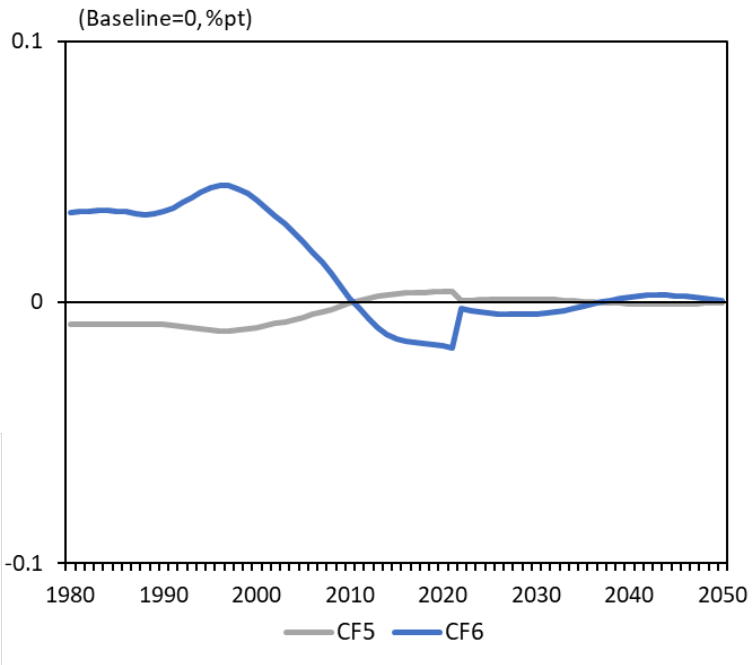
Consumption Level

Matching Efficiency: GDP and TFP Growth

With efficient matching, the growth rate of GDP and TFP would have been higher until the 2000s because of the smaller presence of the housing sector.



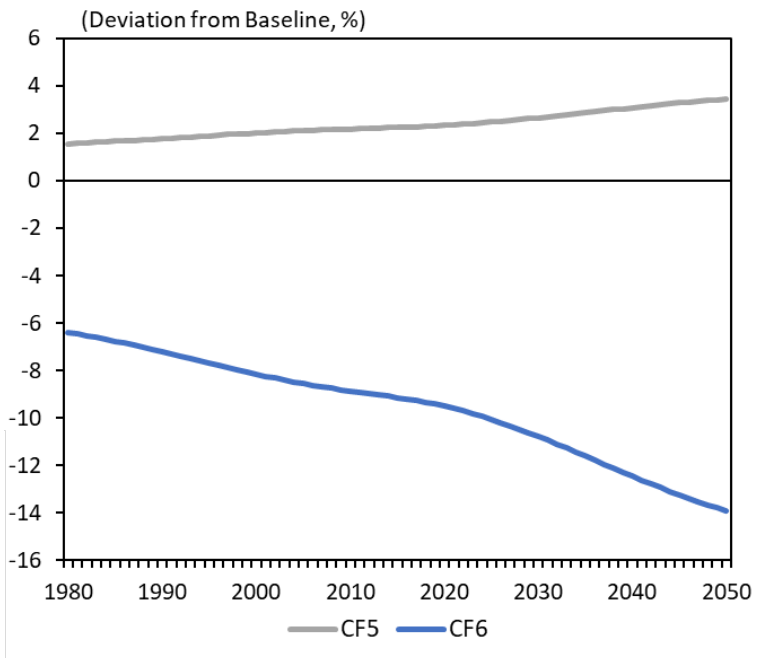
GDP Growth



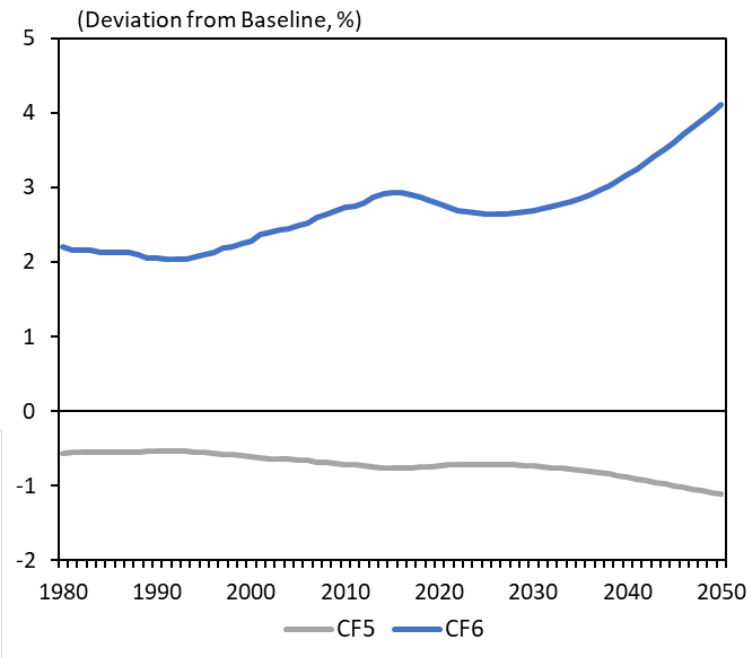
Total TFP Growth

Matching Efficiency: House Prices and Aggregate Housing

With efficient matching, house prices will be lower, but housing quantity will be larger; ie, efficient matching is a supply shift.



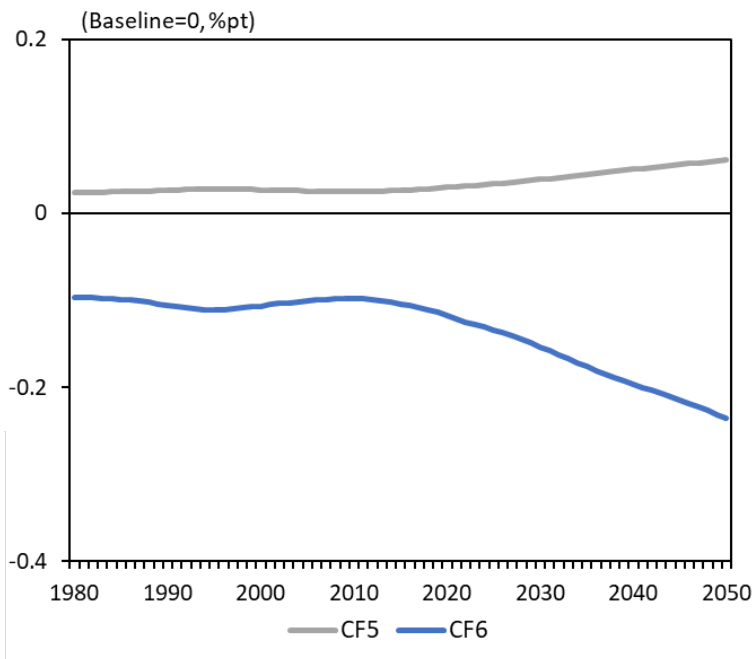
House Prices



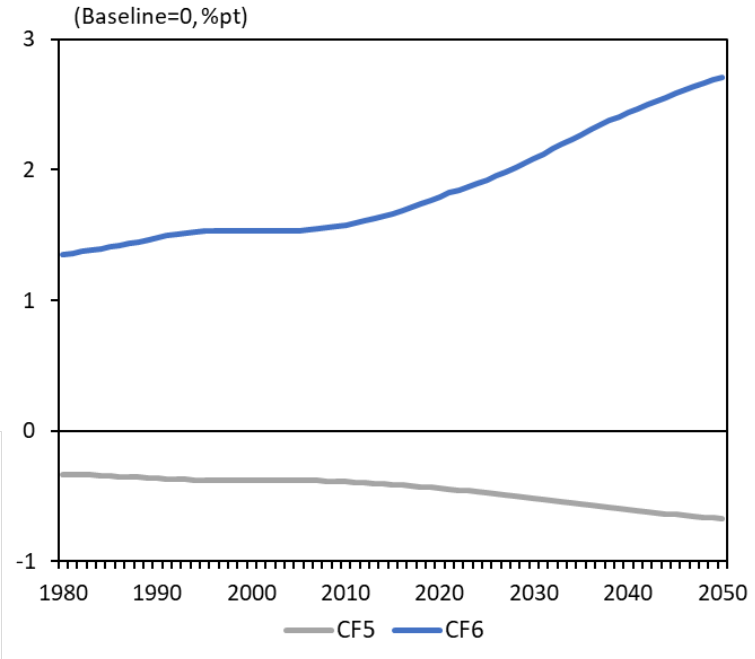
Per Capita Housing Value

Matching Efficiency: Interest Rate and Stock Allocation

With efficient matching, interest rates are lower because of more savings. Capital is shifted from housing to the general sector.



Real Interest Rate

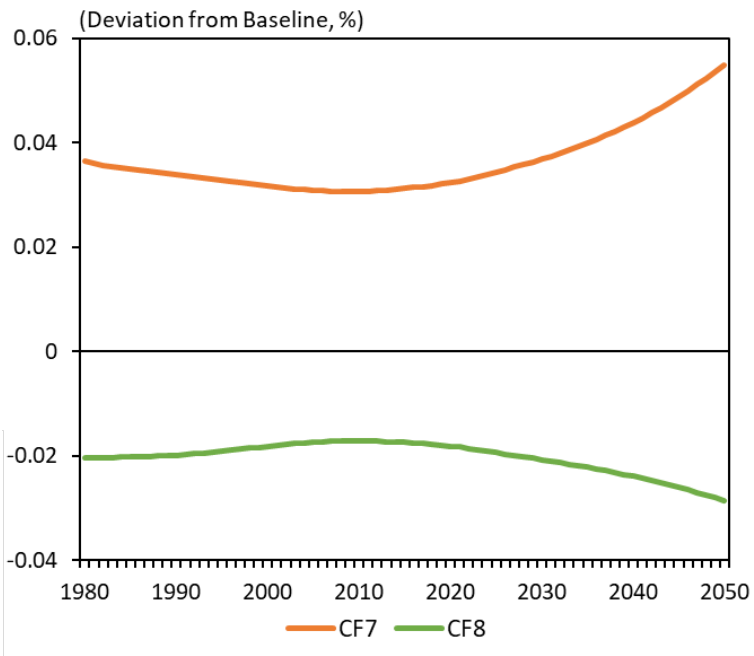


Goods Sector Capital Share

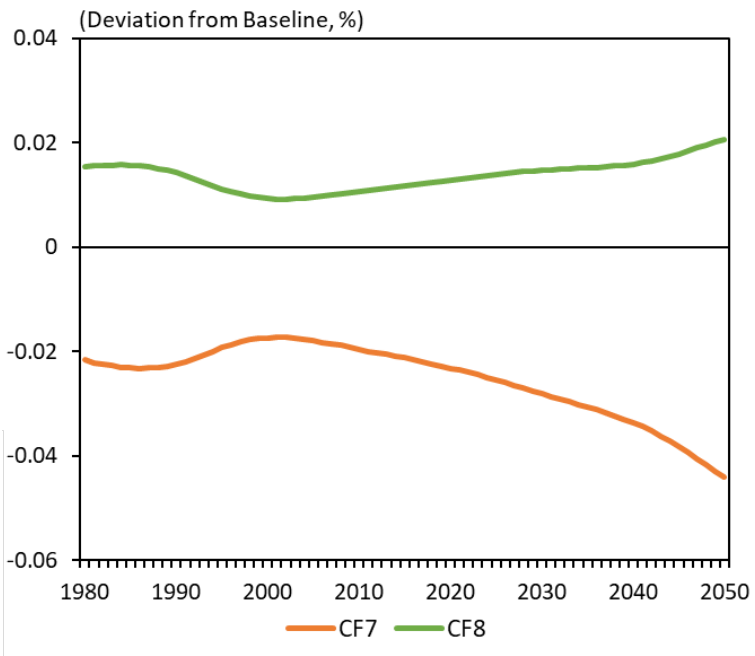
Back to Counterfactuals

Inheritance Tax Rates: GDP and Aggregate Consumption

The effect of inheritance taxes is negligible because these taxes are substitutes for income taxes for the government.



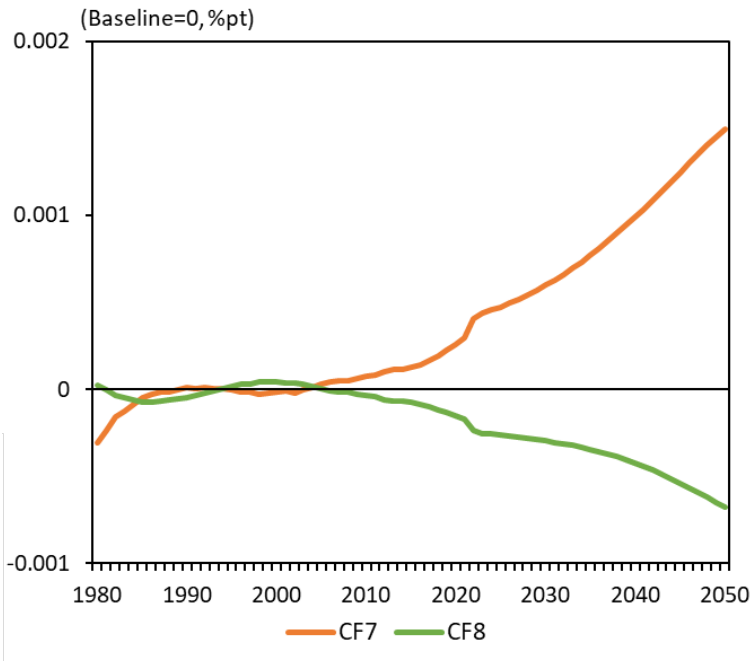
GDP Level



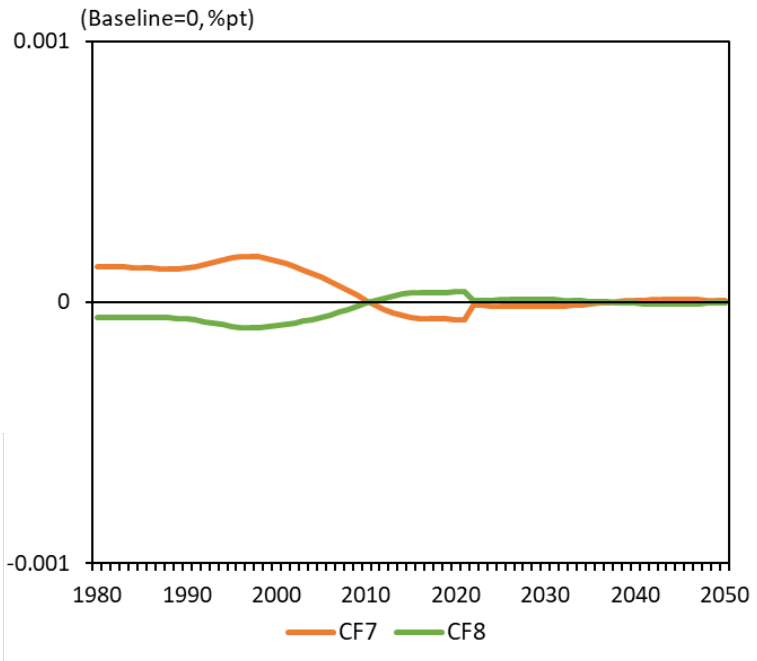
Consumption Level

Inheritance Tax Rates: GDP and TFP Growth

The effect of inheritance taxes is negligible because these taxes are substitutes for income taxes for the government.



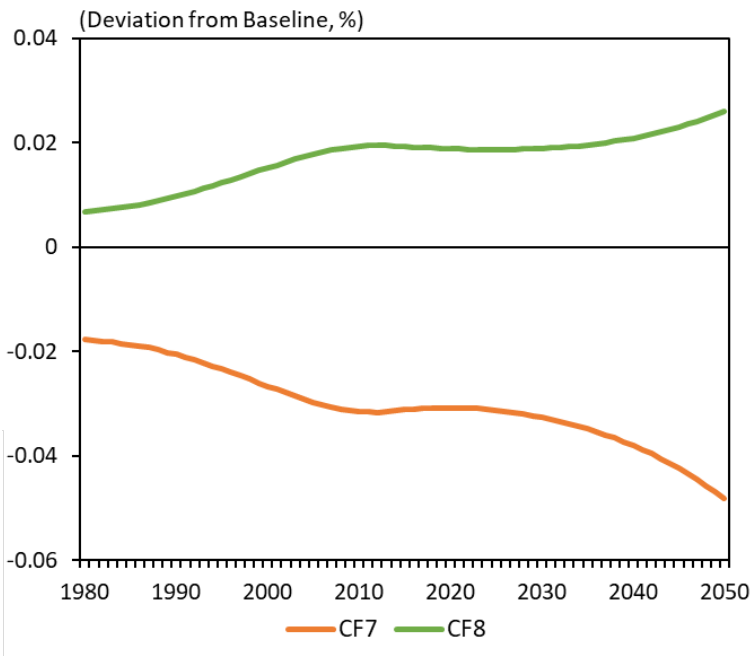
GDP Growth



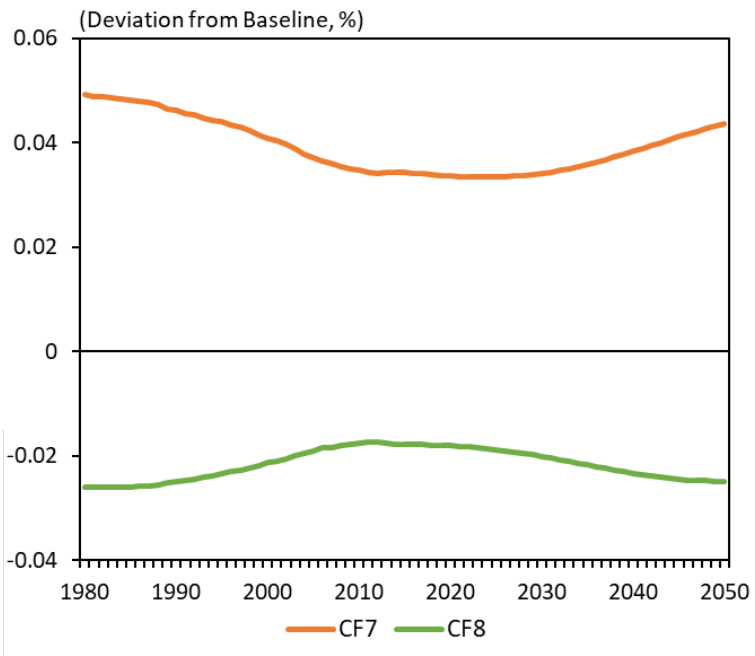
Total TFP Growth

Inheritance Tax Rates: House Prices and Aggregate Housing

The effect of inheritance taxes is negligible because these taxes are substitutes for income taxes for the government.



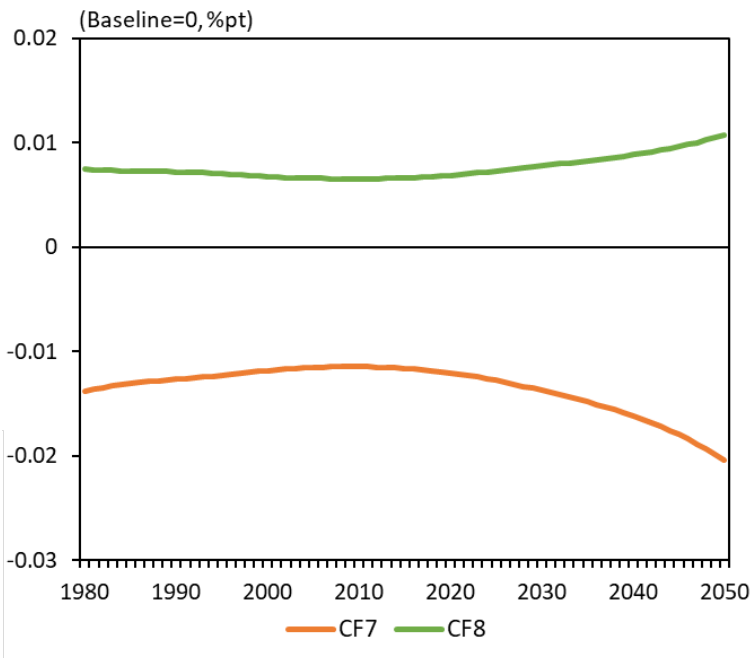
House Prices



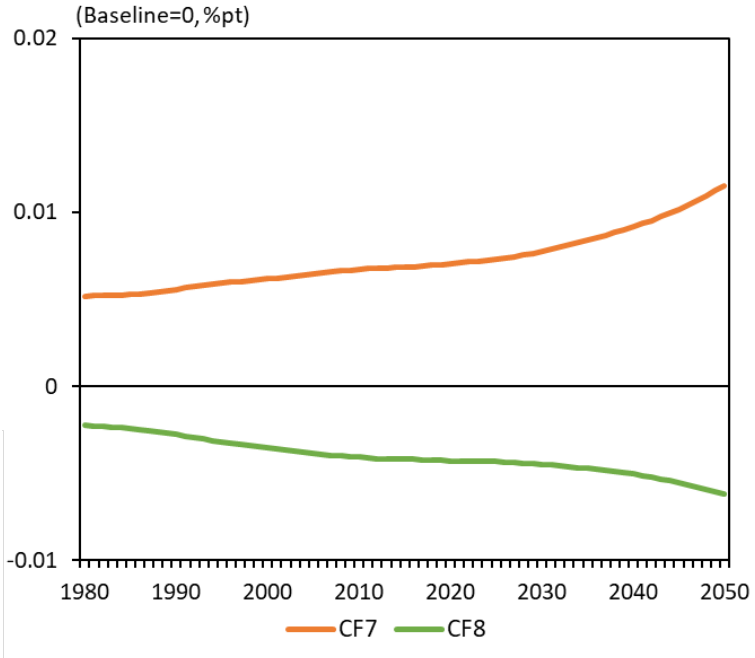
Per Capita Housing Value

Inheritance Tax Rates: Interest Rate and Stock Allocation

The effect of inheritance taxes is negligible because these taxes are substitutes for income taxes for the government.



Real Interest Rate



Goods Sector Capital Share

Back to Counterfactuals