# Aging, Factor Prices and Capital Flows

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August 6, 2018
Summer Workshop on Economic Theory (SWET)
Hokkaido University

# Big issue: aging, fiscal sustainability and capital flow

- A major challenge facing not only Japan, but also all economies, developed and developing, is aging of the populations, driven by
  - ➢ Rising longevity
  - ➢ Low fertility rates
  - → Rising old-age dependency ratios and fiscal tensions associated with old-age transfer programs.

# Big issue: aging, fiscal sustainability and capital flow

- But the countries and regions of the world differ in :

  - The timing and the severity of these demographic trends.
    → Advanced economies started aging earlier than emerging/developing regions.

  - Generosity of the age-dependent transfer programs and implicit debt.
    → Pension systems are less developed or generous in less developed economies, posing less fiscal challenges than in advanced economics.

# Big issue: aging, fiscal sustainability and capital flow

- The combination of **unsynchronized demographic aging** and **differences in social insurance institutions** has implications about capital-labor ratios, factor prices and capital flows (in an open-economy).
- They also matter for the timing and size of fiscal responses and for the achievement of fiscal sustainability, affecting macroeconomy.
- These issues are the most eminent and time-pressing in ***Japan.***

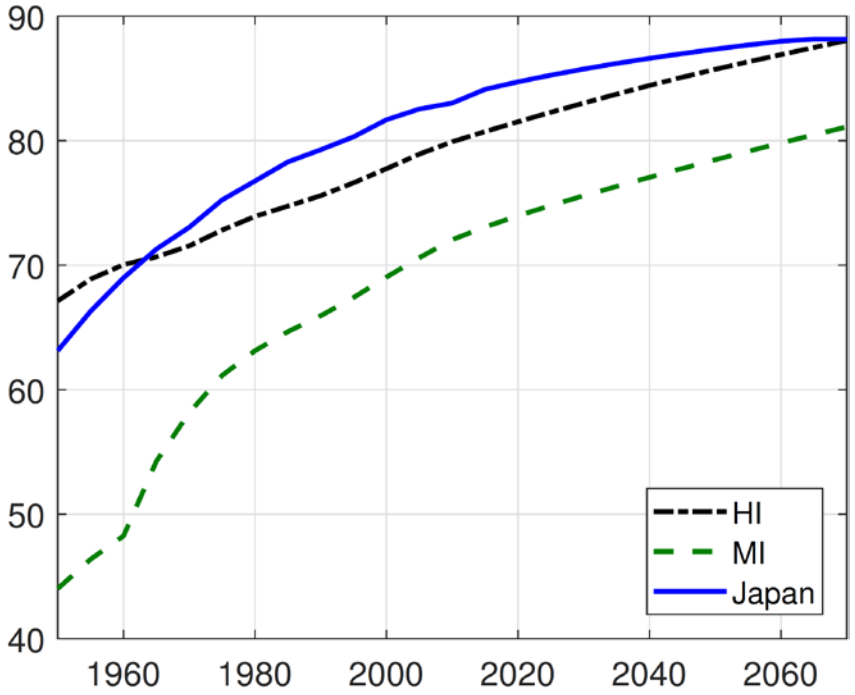
# A three-region model of the world

- To highlight the implications of the different demographic trends and social insurance institutions, we develop a three-region model of the world.
  - **High Income (HI) region:** United States, Canada, Europe (EU28), Australia and New Zealand.
  - **Middle Income (MI) region:** China, HK, Taiwan, South Korea, Singapore, Thailand, Indonesia, Malaysia, Philippines, Viet Nam, India, Mexico, Brazil, Russia, Saudi Arabia, UAE, South Africa and Turkey
  - **Japan ( J )**

# Demographic data and projections

- For HI and MI, use data from United Nations World Population Prospects: the 2017 Revision (2017)
  - Harmonized data and projections for all countries from 1950 to 2100
- For Japan, use 2017 estimates of the National Institute of Population and Social Security Research (IPSS).
  - The UN projections for Japan tend to be very optimistic.

# Demographic trends in the three regions




Life expectancy

Source: United Nation (2017) and IPSS (2017)

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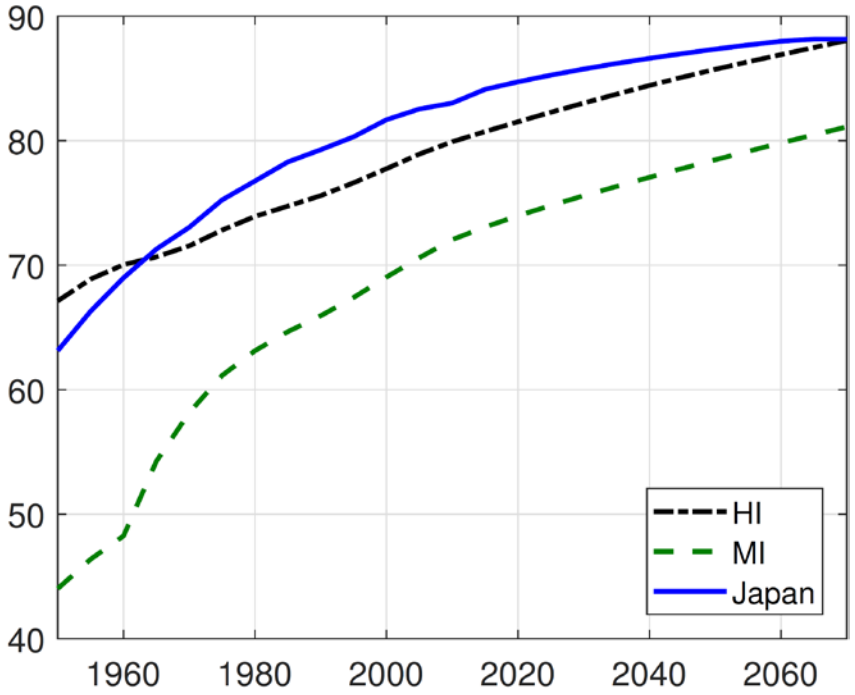


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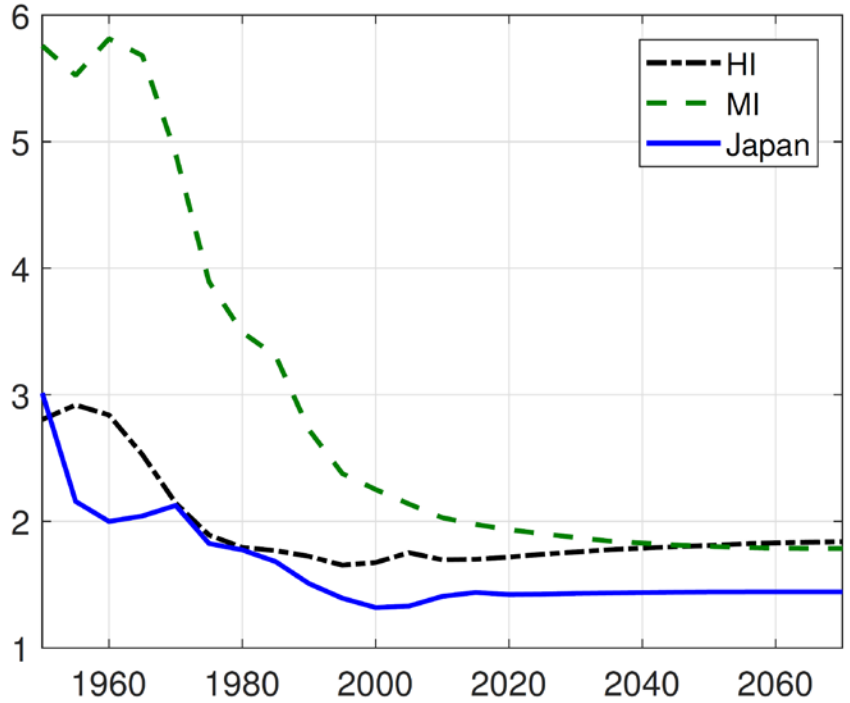
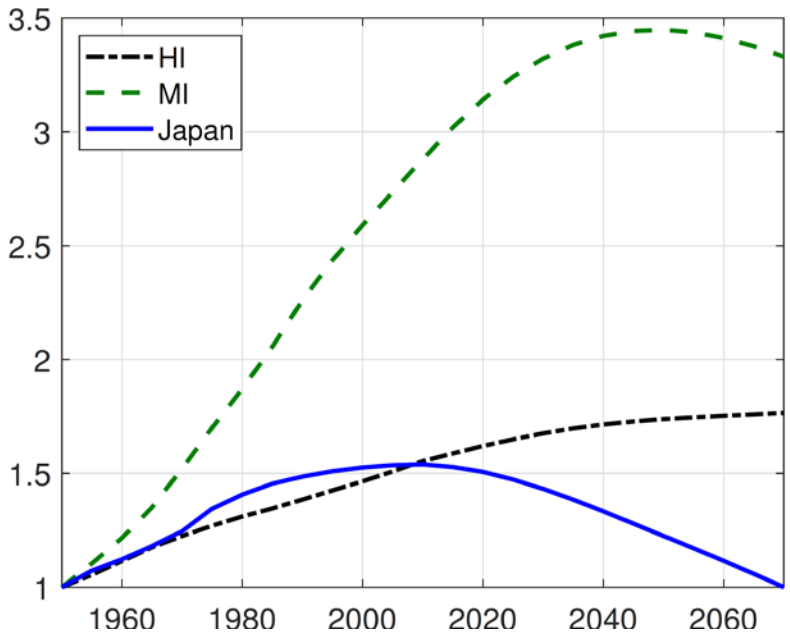



Total fertility rate

Source: United Nation (2017) and IPSS (2017)

# Demographic trends in the three regions




Normalized populations

Source: United Nation (2017) and IPSS (2017)

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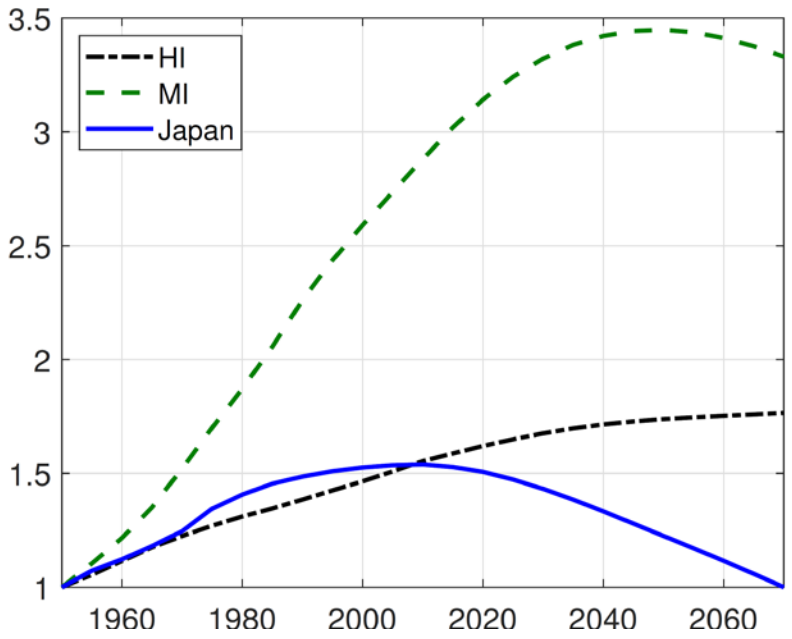


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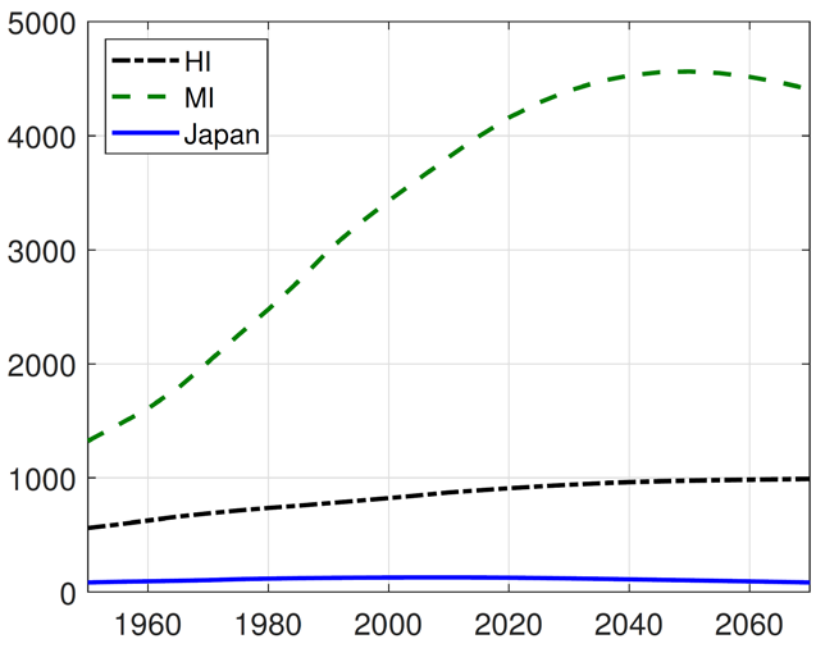


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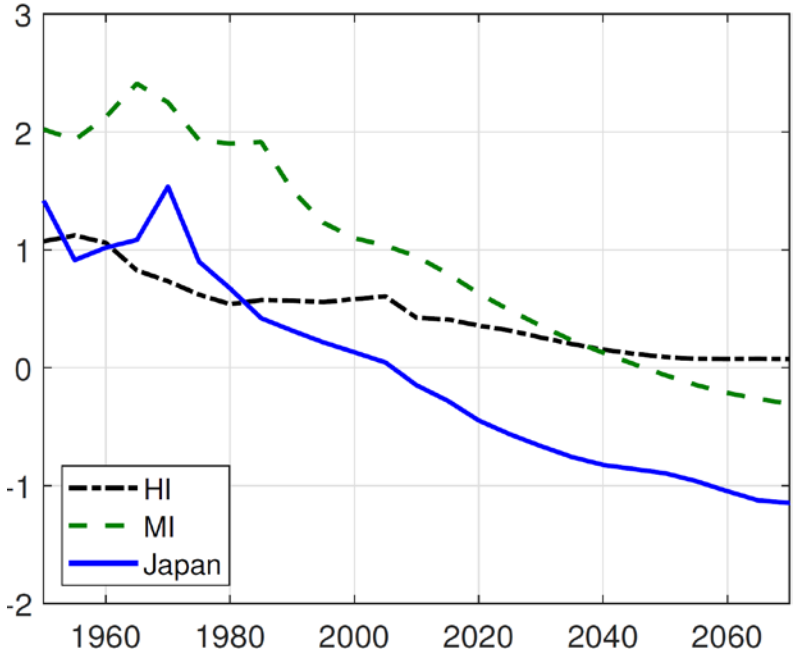
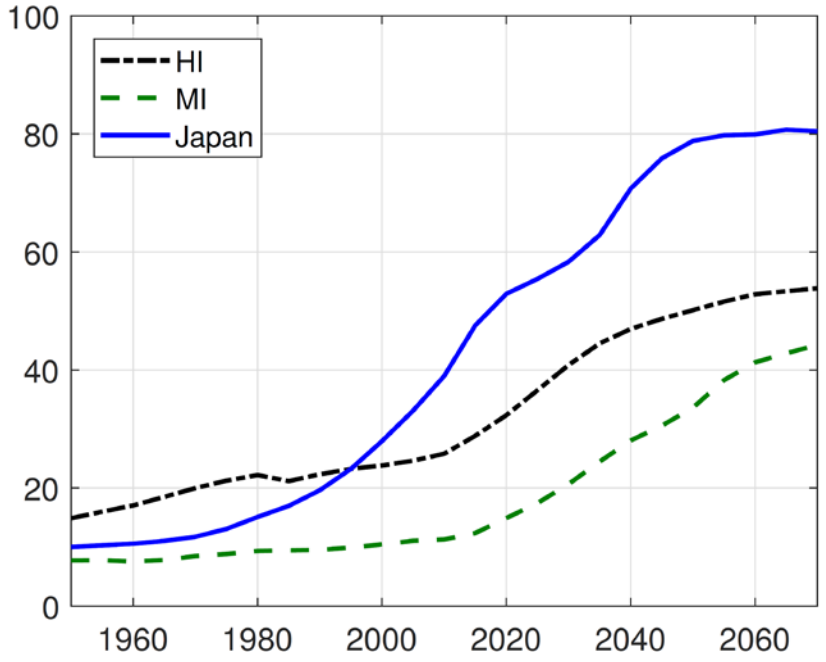



Population growth rates (%)




Old-age dependency ratios
(>=65/20-64, %)

Source: United Nation (2017) and IPSS (2017)

# Factor prices and capital flows

- These demographic trends and accompanying fiscal adjustments tend to raise the capital-labor ratio and reduce interest rates.
  - The force manifests in a closed economy, general equilibrium setting.
  - The mechanism may not be as strong in a small/large open economy, or does not exist in a partial equilibrium model.

- Actual economies are neither closed nor small-open. Depending on bilateral trade and capital flows, they may be closer to one extreme or the other.

# What we do

- Build a general equilibrium model with 3 regions, each populated with overlapping generations of individuals.

- Calibrate the model to the UN, World Bank, OECD, IMF and Japanese data on demographics and macro/fiscal variables (capital stock, growth, pensions, tax rates, government expenditures and debt). Use micro data on labor productivity.

# What we do

- Compute two benchmark transition paths
  - Three regions are closed economies
  - Three regions are open economies with one integrated capital market
- Numerically characterize the path of macro and microeconomic indicators (such as $Y$, $I$, $S$, $CA$, net foreign asset, life-cycle consumption and saving) in the three regions in closed vs open economies.
- Simulate various counterfactuals, sensitivity analysis and policy experiments.

# Aging and fiscal issues: the Japanese context

- In the absence of reform, how high would the fiscal burden be to achieve fiscal sustainability given the projected aging and related public expenditures?
  - Hansen and Imrohoroglu (2016): 40-60% in consumption taxes.
  - Braun and Joines (2015): 50%, health insurance reform needed.
  - Kitao (2015, 2018): 45%, pension reform needed, better done sooner than later.
- All in a closed-economy model.

# Related literature

- Quantitative life cycle models and demographic shocks
  - Auerbach and Kotlikoff (1987), De Nardi, Imrohoroglu and Sargent (1999), Imorhoroglu and Nishiyama (2018), …
- Demographics and capital flows
  - Attanasio, Kitao and Violante (2006, 2007), Domeij and Floden (2006), Krueger and Ludwig (2007), Backus, Cooley and Henriksen (2014), …

# Model

# Preliminaries

- The model consists of Japan ($J$) and two regions: High Income ($HI$) and Middle Income ($MI$) regions.
  - The three differ in their demographics, productivity and fiscal institutions.

- Calculate a perfect foresight equilibrium transition path for the world economy from 1990 to a distant future steady state.
  - Compute closed and open economy transitions

- Let $t$ denote time, $j$ a household's age, and $r$ the region with $r = J, HI, MI$.

# Technology

- Output is produced according to the CRS production function $F(Z_t^r, K_t^r, N_t^r)$ in each region $r$
  - $Z_t^r$ total factor productivity level
  - $K_t^r$ aggregate capital stock used in production
  - $N_t^r$ aggregate labor supply in efficiency units

- TFP in region $r$ grows at rate $\lambda_t^r$ between $t$ and $t+1$

# Demographics

- Each region is populated by overlapping generations of households of adult age $j = 1, \cdots, J$ (max age)
- Households of age $j$ face probability $s_{j,t}^{r}$ to survive till next period. Unconditional survival probability is given by $S_{j,t}^{r} \equiv \prod_{k=1}^{j} s_{k,t+(k-j)}^{r}$.
- Let $\mu_{j,t}^{r}$ denote the size of population of age $j$ at time $t$ in region $r$.

# Household preferences

- Instantaneous utility function

$$u(c_{j,t}) = \frac{c_{j,t}^{1-\theta}}{1-\theta}$$

- Intertemporal preference ordering

$$U^r = \sum_{j=1}^{J} \beta^{j-1} S_{j,t+j-1}^r \frac{c_{j,t+j-1}^{1-\theta}}{1-\theta}$$

- Accidental bequests left by the deceased are distributed as a lump-sum transfer, $b_t^r$, to all surviving households.

# Household endowments

- Households enter the market with zero initial asset, $a_{1,t}^{r} = 0$ and supply labor exogenously. Exit the labor force at age $J_{R}^{r}$.

- Households of age $j$ at time $t$ in region $r$ are endowed with $\varepsilon_{j,t}^{r}$ efficiency units of labor.

# Household budget constraint (1)

$$\left(1+\tau_{c,t}^{r}\right)c_{j,t}^{r}+a_{j+1,t+1}^{r}=y_{j,t}^{r}+\left[1+\left(1-\tau_{a,t}^{r}\right)r_{t}\right]\left(a_{j,t}^{r}+b_{t}^{r}\right)+p_{j,t}^{r}$$

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- Net earnings $y_{j,t}^{r}$ accruing to households of age $j$ in region $r$

$$y_{j,t}^{r}=\left(1-\tau_{w,t}^{r}\right)w_{t}^{r}\,\varepsilon_{j,t}^{r}$$

- $w_{t}^{r}$ is the market wage rate, $\varepsilon_{j,t}^{r}$ is the efficiency units of labor.

# Household budget constraint (2)

$$\left(1+\tau_{c,t}^{r}\right)c_{j,t}^{r}+a_{j+1,t+1}^{r}=y_{j,t}^{r}+\left[1+\left(1-\tau_{a,t}^{r}\right)r_{t}\right]\left(a_{j,t}^{r}+b_{t}^{r}\right)+p_{j,t}^{r}$$

- $p_{j,t}^{r}$ is the pension income for those above the pension eligibility age $j \geq J_{SS}^{r}$, given by the formula

$$p_{j,t}^{r}=\kappa_{j,t}^{r}\frac{W_{j,t}^{r}}{J_{SS}^{r}-1}$$

where $\kappa_{j,t}^{r}$ is the replacement rate of average past earnings. $W_{j,t}^{r}$ denotes cumulated past gross earnings, updated recursively.

# Government budget constraint

- In each region, the government can raise revenues by taxes on consumption at $\tau_{c,t}^{r}$, labor income at $\tau_{w,t}^{r}$, and capital income at $\tau_{a,t}^{r}$, and lump-sum tax $\tau_{ls,t}^{r}$, and can issue one-period risk-free debt $B_{t+1}^{r}$.

- Revenues finance a stream of expenditures $G_t^r$, debt services $(1+r_t)B_t^r$ and benefits of the PAYGO social security program $\sum_{j=J_{SS}^r}^{J} p_{j,t}^r \mu_{j,t}^r$.

$$G_t^r + (1+r_t)B_t^r + \sum_{j=J_{SS}^r}^{J} p_{j,t}^r \mu_{j,t}^r =$$

$$\tau_{w,t}^r w_t^r \sum_{j=1}^{J_R^r-1} \mu_{j,t}^r \varepsilon_{j,t}^r + \sum_{j=1}^{J} \mu_{j,t}^r \left[\tau_{a,t}^r r_t \left(a_{j,t}^r + b_{j,t}^r\right) + \tau_{c,t}^r c_{j,t}^r + \tau_{ls,t}^r\right] + B_{t+1}^r$$

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Adjusted to balance budget

$$G_t^r + (1+r_t)B_t^r + \sum_{j=J_{SS}^r}^{J} p_{j,t}^r \mu_{j,t}^r =$$

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# Market structure (1) : openness

- In the baseline open economy, we assume that physical capital is perfectly mobile without any friction across the three regions. There exists one world market for capital. (Later introduce frictions.)

- Labor is immobile and wages are determined independently in regional markets.

# Market structure (2)

- Let $X_t^r$ denote the external wealth of region $r$ at time $t$, that is, the stock of capital used in production in other regions and owned by households of region $r$.
- In equilibrium, $\sum_r X_t^r = 0$ at any time $t$.
- The world interest rate clears the world capital market.
  - A no-arbitrage condition implies the return on regional bonds and capital market equals the world interest rate. Households' wealth is allocated to $K_t^r, X_t^r, B_t^r$, with the same return.

$$K_t^r + X_t^r + B_t^r = \sum_{j=1}^{J} \mu_{j-1,t-1}^r \left(a_{j,t}^r + b_t^r\right).$$

# Competitive equilibrium of the multi-region economy

- A competitive equilibrium, for given paths of demographics, TFP, fiscal variables, is a sequence of
  1. Household choices
  2. Lump-sum taxes
  3. Factor prices: wage rates in each region and world interest rate
  4. Aggregate variables in each region

  such that

# Competitive equilibrium of the multi-region economy

- Households optimally choose consumption and wealth sequence subject to the budget constraint.
- Firms in each region maximize profits.

$$w_t^r = F_N(Z_t^r, K_t^r, N_t^r) \text{ for all region,}$$
$$r_t = F_K(Z_t^r, K_t^r, N_t^r) - \delta.$$

- The lump-sum transfer of accidental bequests equals the amount of assets left by the deceased, distributed equally to all surviving households of the region.
- The regional labor markets clear and aggregate labor supply equals the labor $N_t^r = \sum_{j=1}^{J_R^r - 1} \mu_{j,t}^r \, \varepsilon_{j,t}^r$

# Competitive equilibrium of the multi-region economy

- The world capital market clears at the world interest rate $r_t$. At interest rate $r_t$, the aggregate stock of capital in each region satisfies

$$K_t^r + X_t^r + B_t^r = \sum_{j=1}^{J} \mu_{j-1,t-1}^r \left(a_{j,t}^r + b_t^r\right).$$

- The lump-sum taxes satisfy the government budget constraint of each region.

## Competitive equilibrium of the multi-region economy

- The allocations are feasible in each region, that is, they satisfy aggregate resource constraints.

$$K_{t+1}^r - (1-\delta)K_t^r + X_{t+1}^r - (1+r_t)X_t^r = F(Z_t^r, K_t^r, N_t^r) - C_t^r - G_t^r$$

# Some equations

- From the aggregate resource constraint

$$K_{t+1}^r - (1-\delta)K_t^r + X_{t+1}^r - (1+r_t)X_t^r = F(Z_t^r, K_t^r, N_t^r) - C_t^r - G_t^r$$

# Some equations

- From the aggregate resource constraint

$$\underbrace{K_{t+1}^r - (1-\delta)K_t^r}_{I_t^r} + X_{t+1}^r - (1+\underbrace{r_t}) X_t^r = \underbrace{F(Z_t^r, K_t^r, N_t^r) - C_t^r - G_t^r}_{S_t^r} \quad (1)$$

# Some equations

- From the aggregate resource constraint

$$\underbrace{K_{t+1}^r - (1-\delta)K_t^r}_{I_t^r} + X_{t+1}^r - \underbrace{(1+r_t)X_t^r}_{} = \underbrace{F(Z_t^r, K_t^r, N_t^r) - C_t^r - G_t^r}_{S_t^r} \quad (1)$$

- Aggregate gross investment in region $r$ is given as

$$I_t^r = K_{t+1}^r - (1-\delta)K_t^r \quad (2)$$

- Aggregate saving (public and private) is given as

$$S_t^r = F(Z_t^r, K_t^r, N_t^r) + r_t X_t^r - C_t^r - G_t^r \quad (3)$$

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- (2) and (3) in (1), the current account is given as

$$S_t^r - I_t^r = CA_t^r = X_{t+1}^r - X_t^r$$

# Calibration

# Calibration: basic strategy

- Match a set of moments in the data with the model's counterparts in the closed-economy equilibrium.
  - Target economic variables for the period of 1990-2015.
- Compute the initial and final steady states and compute the transition between the two steady states.
  - Use the actual age distribution in the initial steady state (non-stationary demographics)
- Let demographic parameters and TFP growth rates in the three regions converge in the long run, by 2200, and all regions reach a BGP sometime after 2200.
- Model frequency : 1 year

# Calibration: technology

- TFP growth rates in 1990-2015 are set to match the per-capita GDP growth during the same periods of each region.
- Initial TFP levels are set to match the per-capita GDP (level) in 2015.

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| Region | GDP pc growth 1990-2015 (Target) | TFP growth rate 1990-2015 (Calibrated) | GDP per capita level, WDI 2015 (Target) | Initial TFP level (Calibrated) |
|---|---|---|---|---|
| Japan | 1.1% | 0.825% | $40,763 (1.00) | 0.56 |
| High income | 1.4% | 0.850% | $45,373(1.11) | 0.73 |
| Middle income | 3.9% | 2.060% | $12,696(0.31) | 0.29 |

- After 2015, we let the growth rate of TFP in the three regions converge smoothly to the common long-run growth rate of 1% by 2100.

# Calibration: demographics

- For HI and MI, use estimates of the United Nations (2017). For Japan, use data and projections of the IPSS (2017).
- Households enter the economy at age 20 and live up to 100 years old.
- Age to exit the labor force 65.

# Calibration: preference and endowment

- Common preferences across regions
  - CRRA set at 2 and discount factor at 1.0552 to match the target interest rate of 4% in Japan in 1990.
- Labor productivity
  - Basic Survey on Wage Structure (BSWS) for Japan
  - Consumer Expenditures Survey (CEX) of the U.S. for HI
  - ENIGH of Mexico for MI

# Calibration: Government

- Debt $B_t$ and expenditures $G_t$ to GDP using IMF's World Economic Outlook (WEO) database
  - $G_t$ : 33% in HI and 21% in MI, 26% in Japan.
  - $B_t$ : 51% in HI and 31% in MI. For Japan, varies from 14% in 1990-1995 to 120% in 2010-2015. Set 100%.

- Pension data from OECD Pensions at a Glance (2014)
  - The replacement rate is 48%, 27% and 39% for HI, MI and J.
  - The statutory retirement age is 66, 56 and 65 for HI, MI and J.

# Calibration: Government

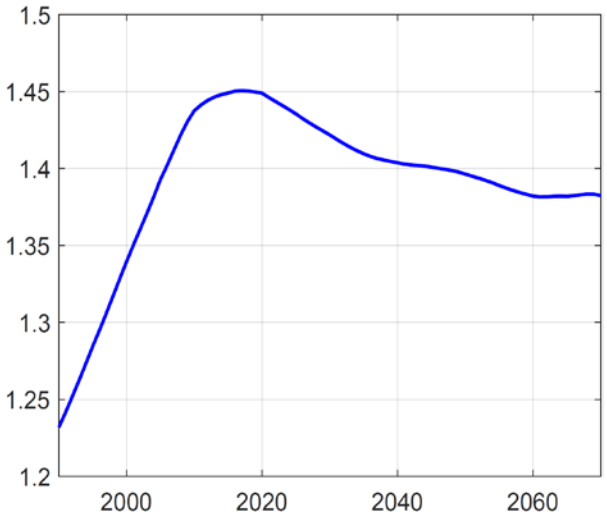
- Effective tax rates are computed using OECD Revenue Statistics and UN National Account Statistics, following the method of Mendoza, Razin and Tesar (1994).
  - Capital tax: 34.1% in HI, 18.8% in MI and 34.7% in Japan.
  - Labor income tax: 32.8% in HI, 17.0% in MI and 29.8% in Japan.
  - Consumption tax 10.9% in HI and 12.7% in MI. 3%→5%→8%→10% in 2019 in Japan.
  - Lump-sum tax is adjusted each year in each region to satisfy government budget constraint

# Numerical results

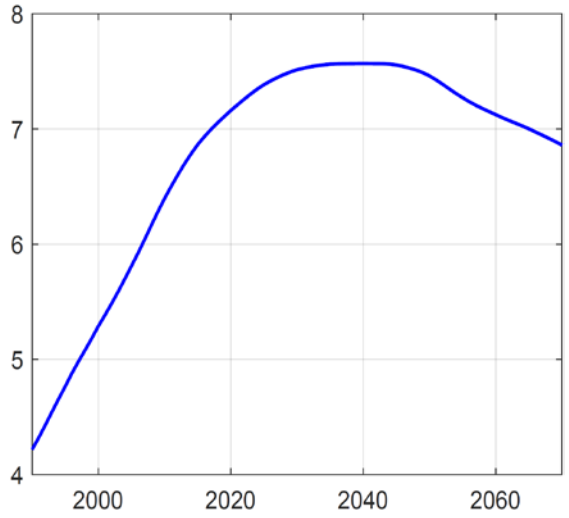
# Numerical results: methodology

- Characterize the equilibrium transition path from 1990 to 2065 (or 2100).
- Two extreme assumptions on the openness of the economics: closed and open.
  - First, study closed-economy transition paths of the three regions and study the open economy.
  - Then focus on the Japanese economy, closed vs open.
- Individuals and firms have the "perfect foresight" and make optimal decisions taking into account paths of demographics, fiscal institutions, macroeconomic variables.

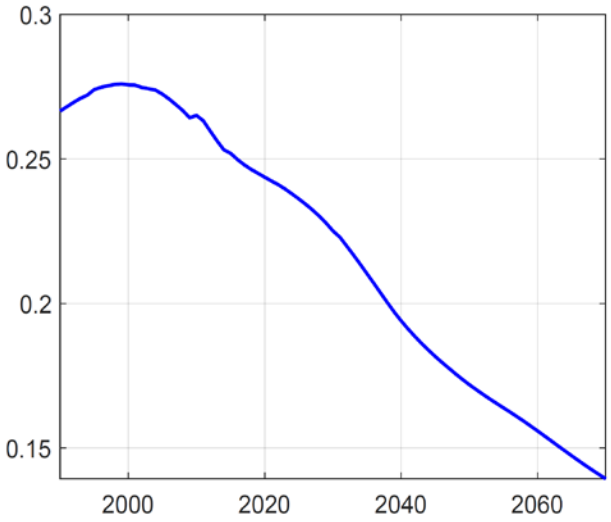
# Labor supply: exogenous




High income

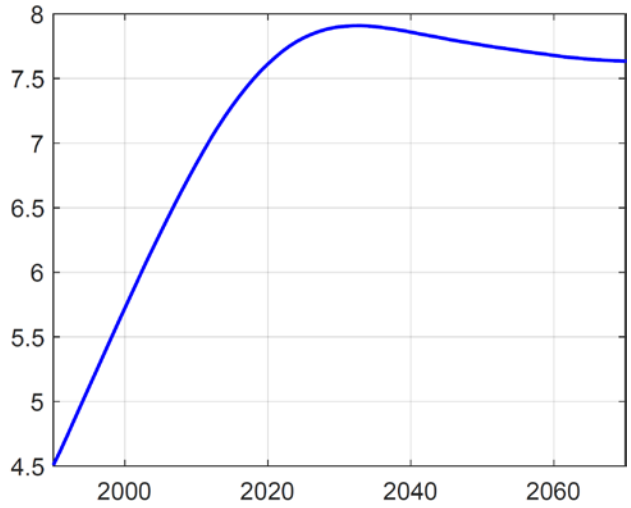



Middle income

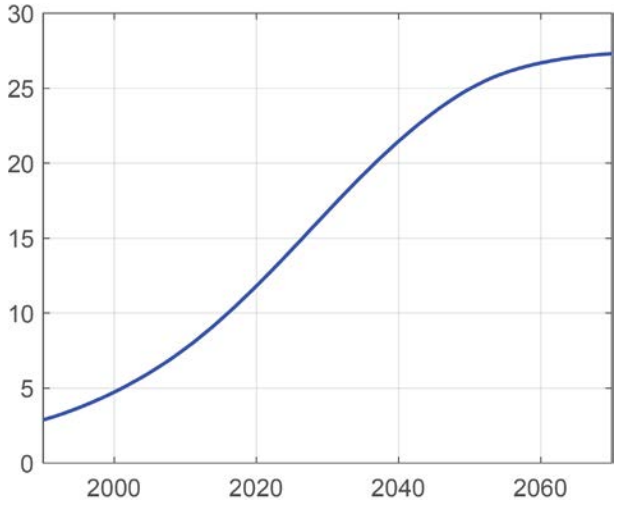



Japan

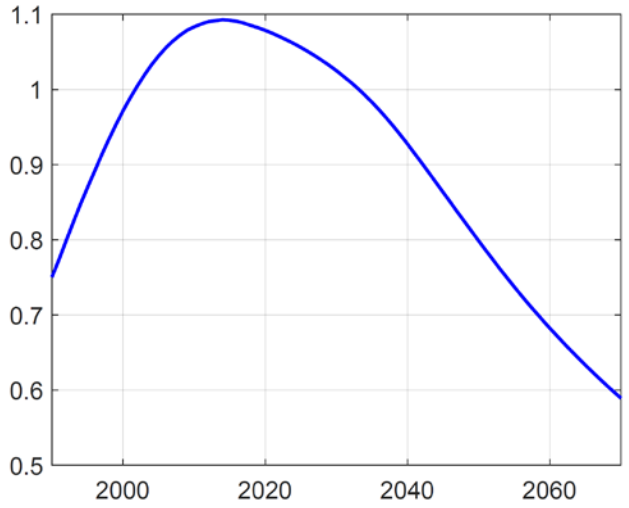
# Capital stock: closed economy




High income

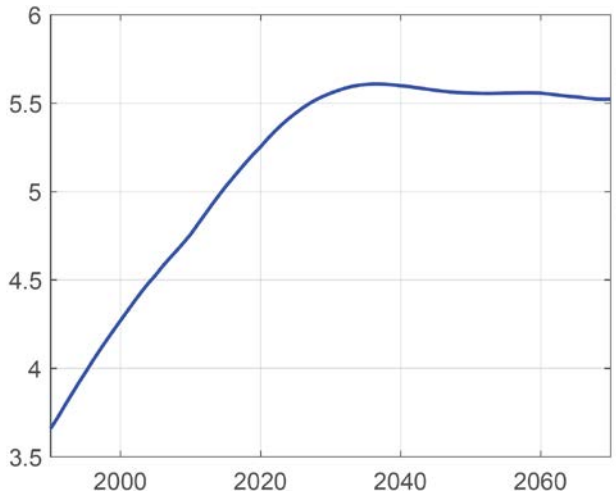



Middle income




Japan

# Capital-labor ratio: closed economy

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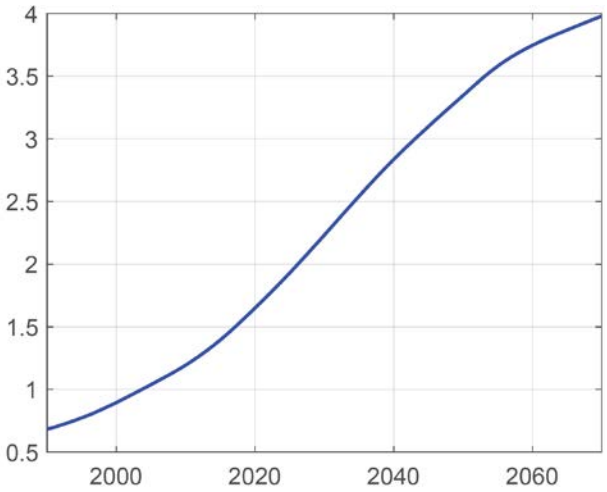
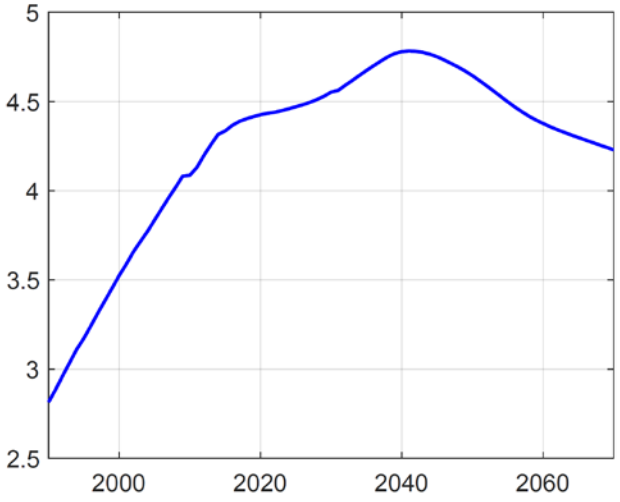
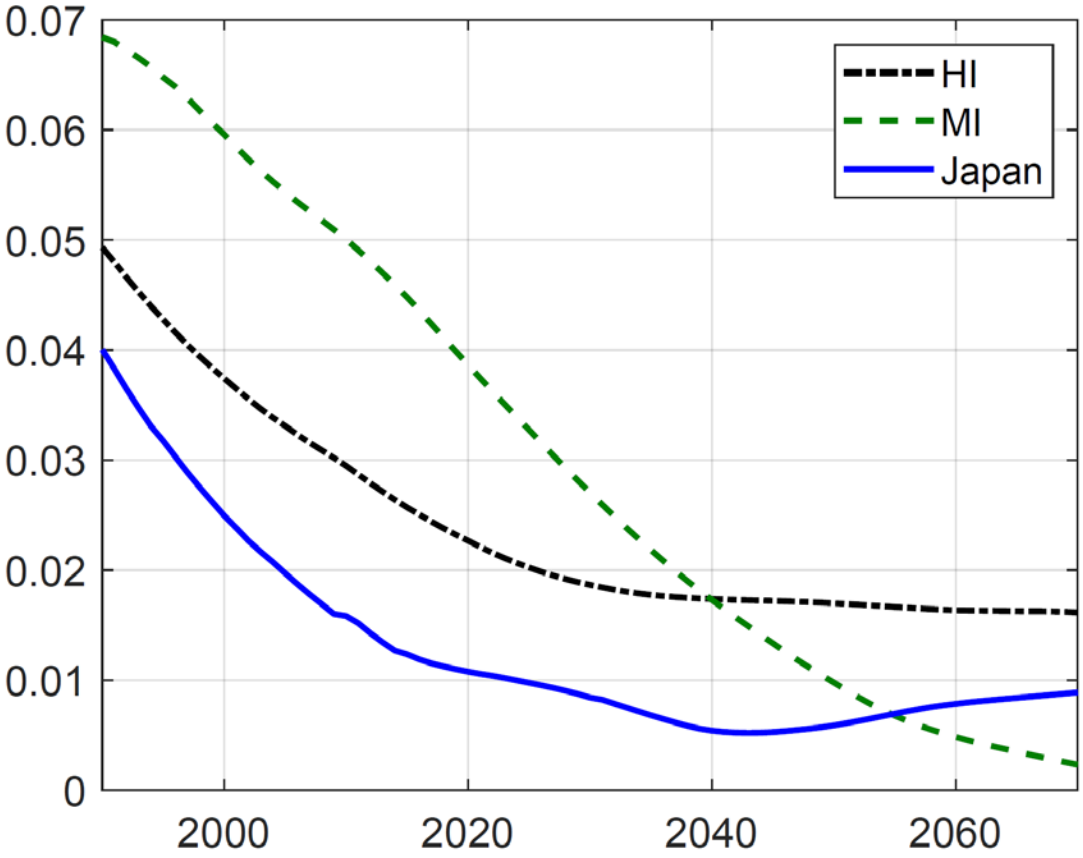



Middle income

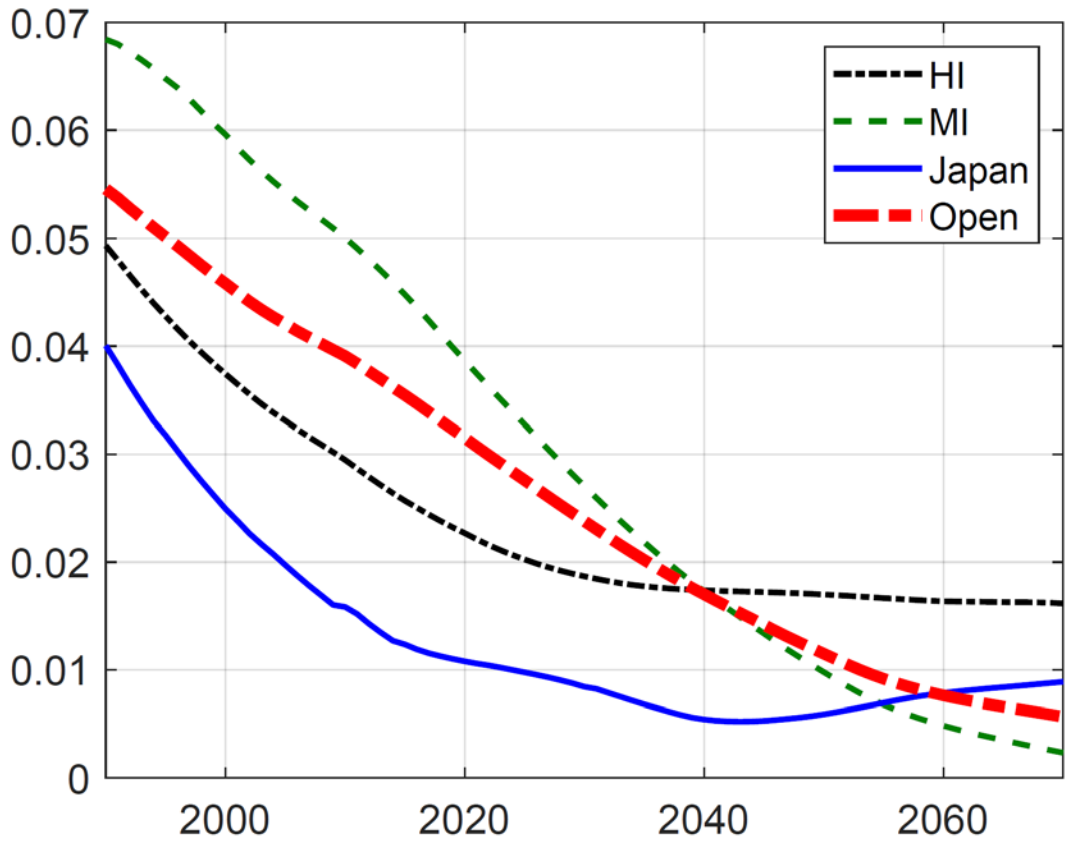



Japan

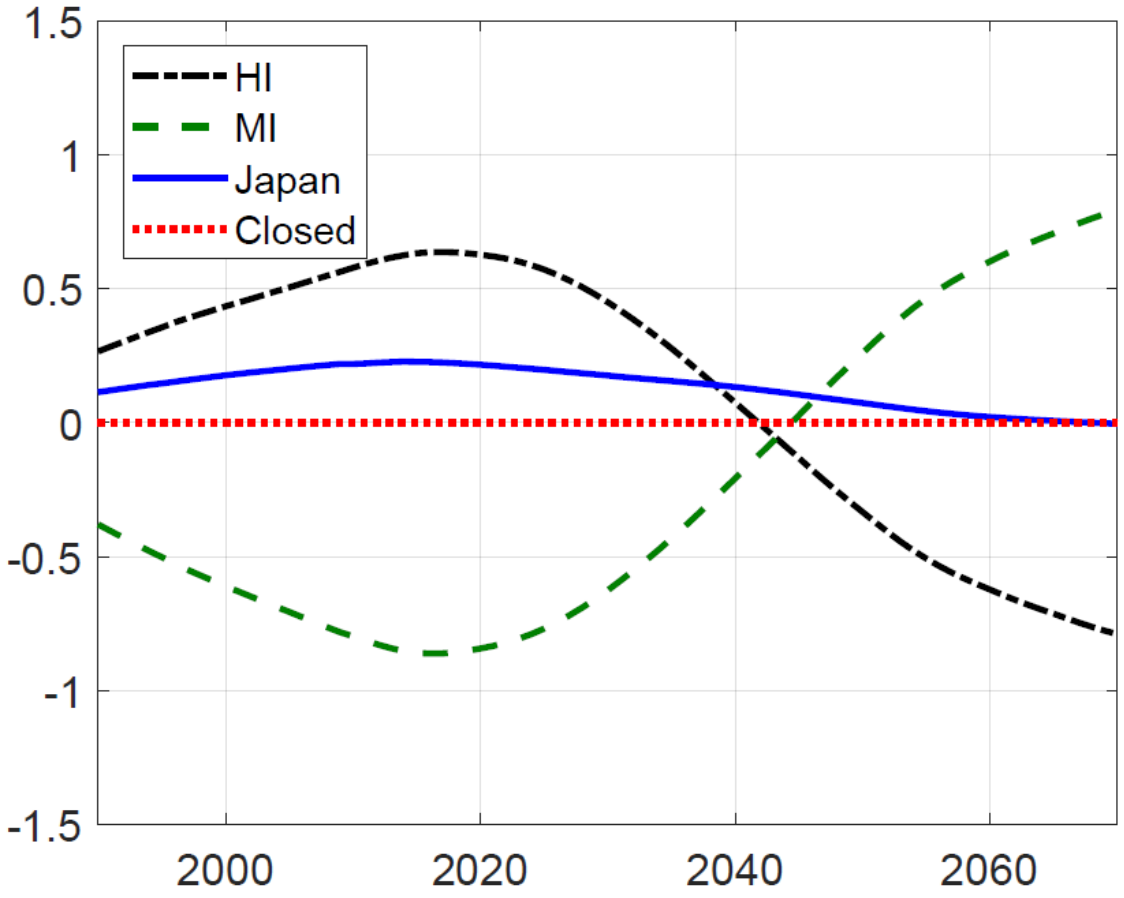
# Interest rates : closed economy



# Interest rates : closed & open

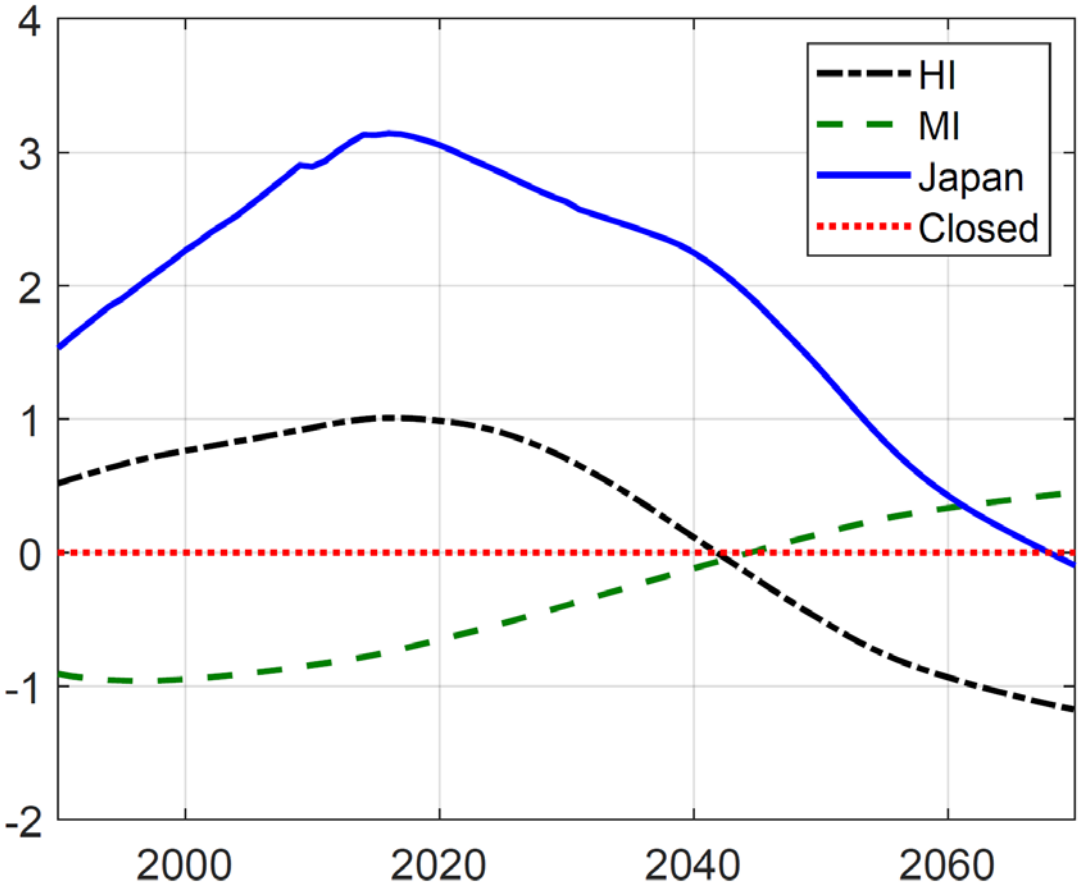


# External wealth




Normalized to the total GDP of the three regions in the initial year 1990.

# External wealth to GDP




Relative to GDP of each region.

# Some equations

- From the aggregate resource constraint

$$K_{t+1}^r - (1-\delta)K_t^r + X_{t+1}^r - (1+r_t)X_t^r = F(Z_t^r, K_t^r, N_t^r) - C_t^r - G_t^r \quad (1)$$

- Aggregate gross investment in region $r$ is given as

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- Aggregate saving (public and private) is given as

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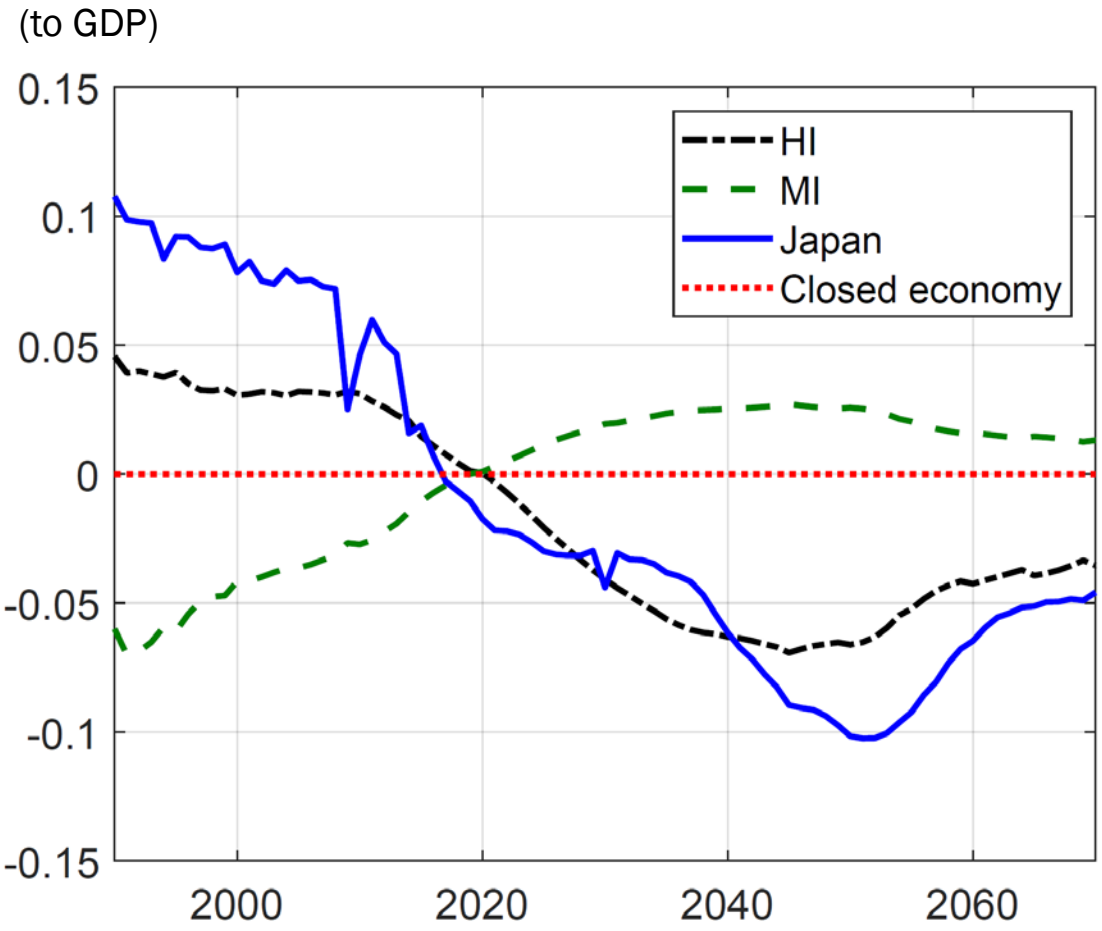
- (2) and (3) in (1), the **current account** is given as

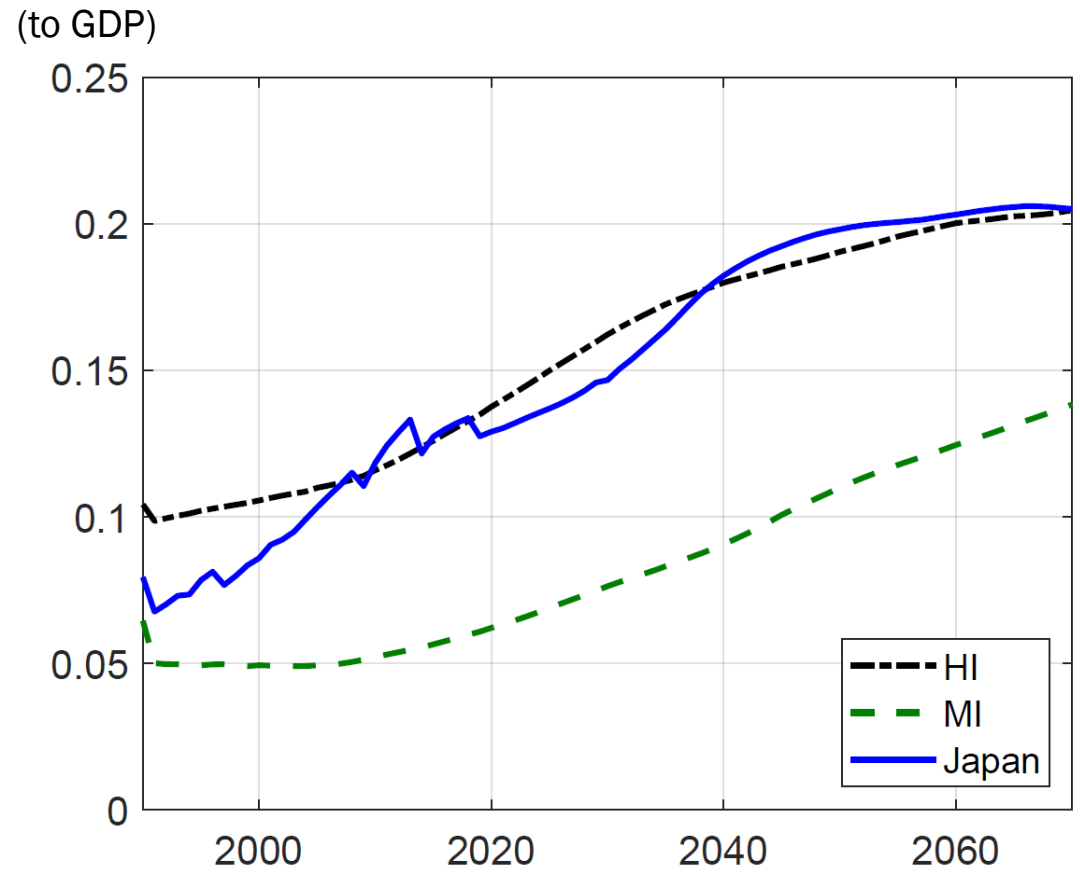
$$S_t^r - I_t^r = CA_t^r = X_{t+1}^r - X_t^r$$

**A change in external wealth**

# Capital-flow (current account) to GDP

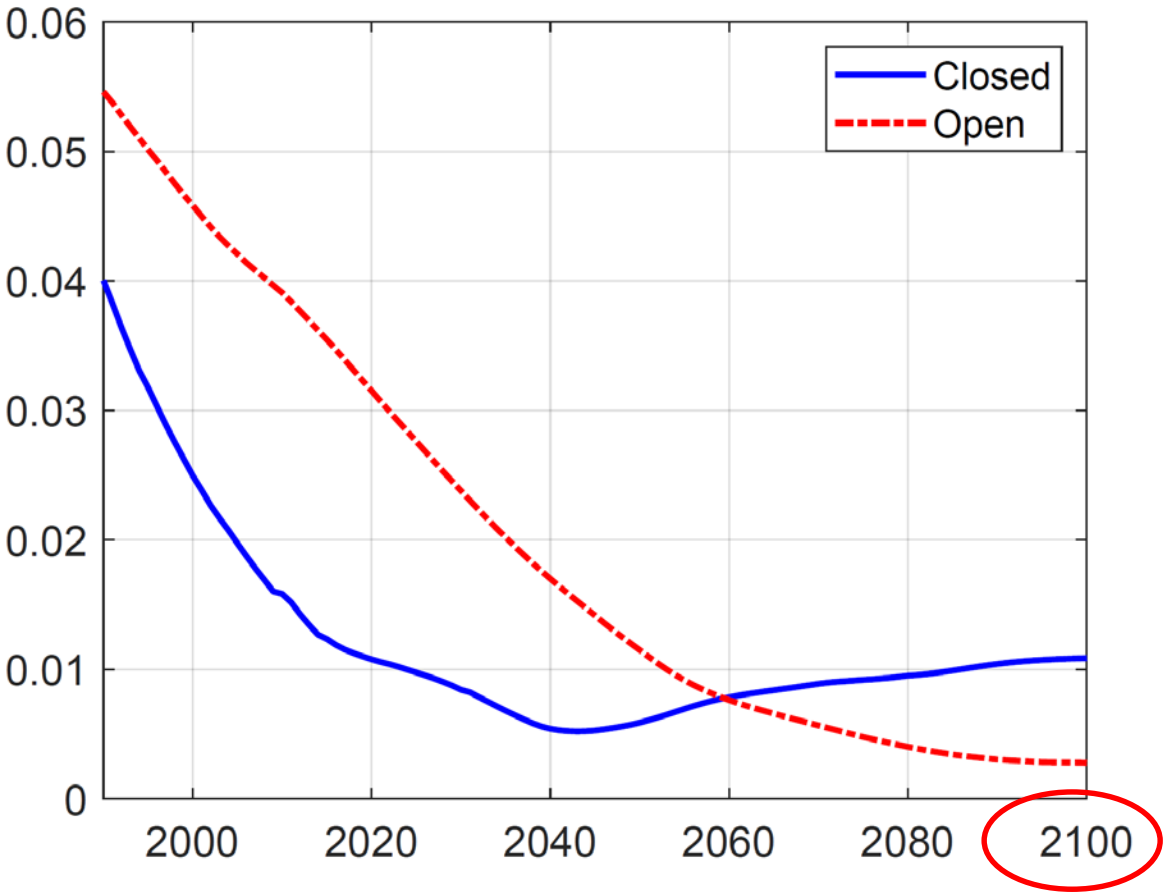


# Lump-sum taxes

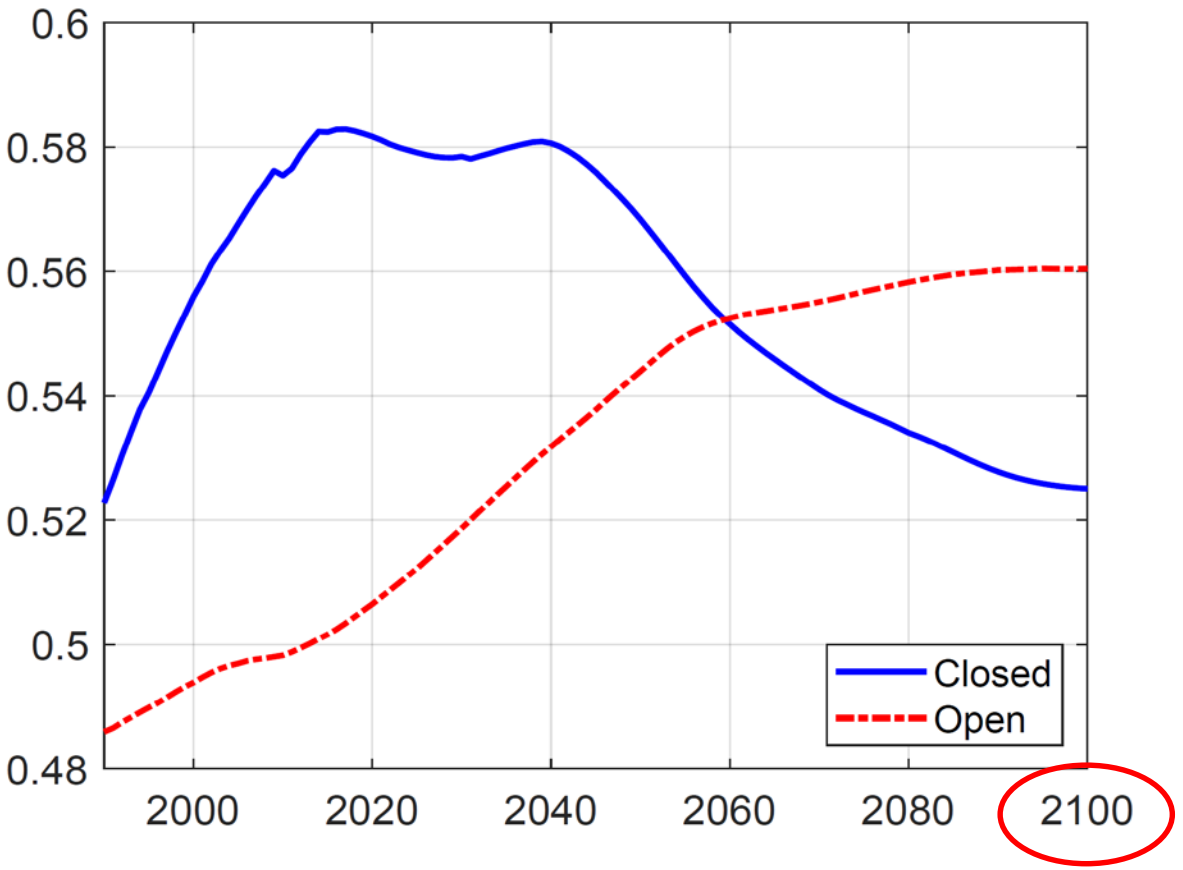


- Now focus on the transition paths in Japan
  - Closed vs open

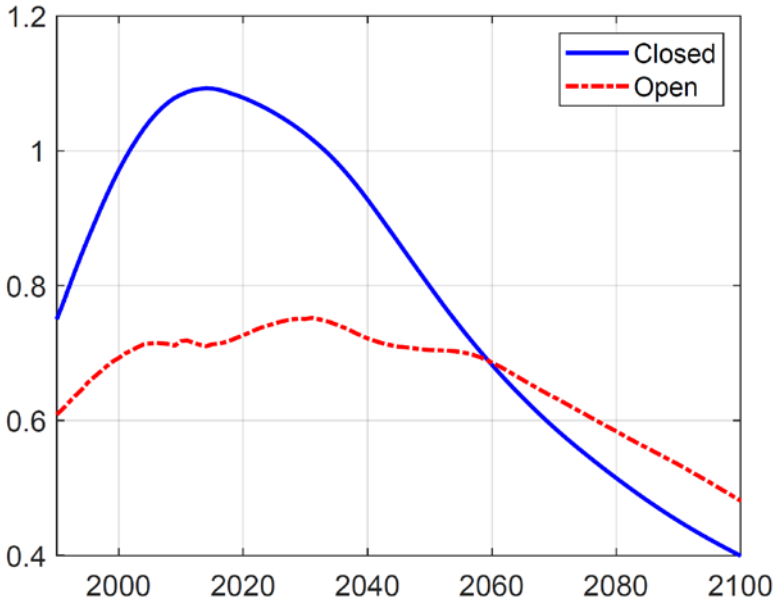
# Interest rates : Japan



# Wage rates : Japan

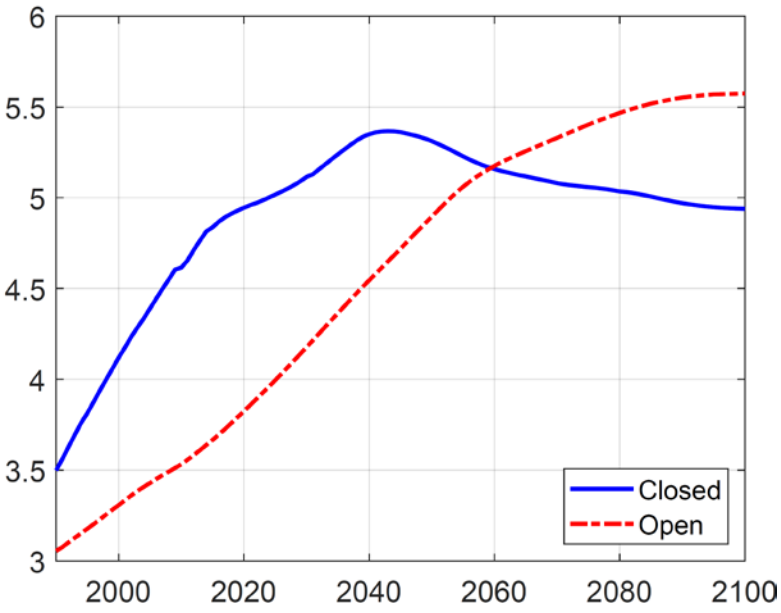


# Capital stock : Japan



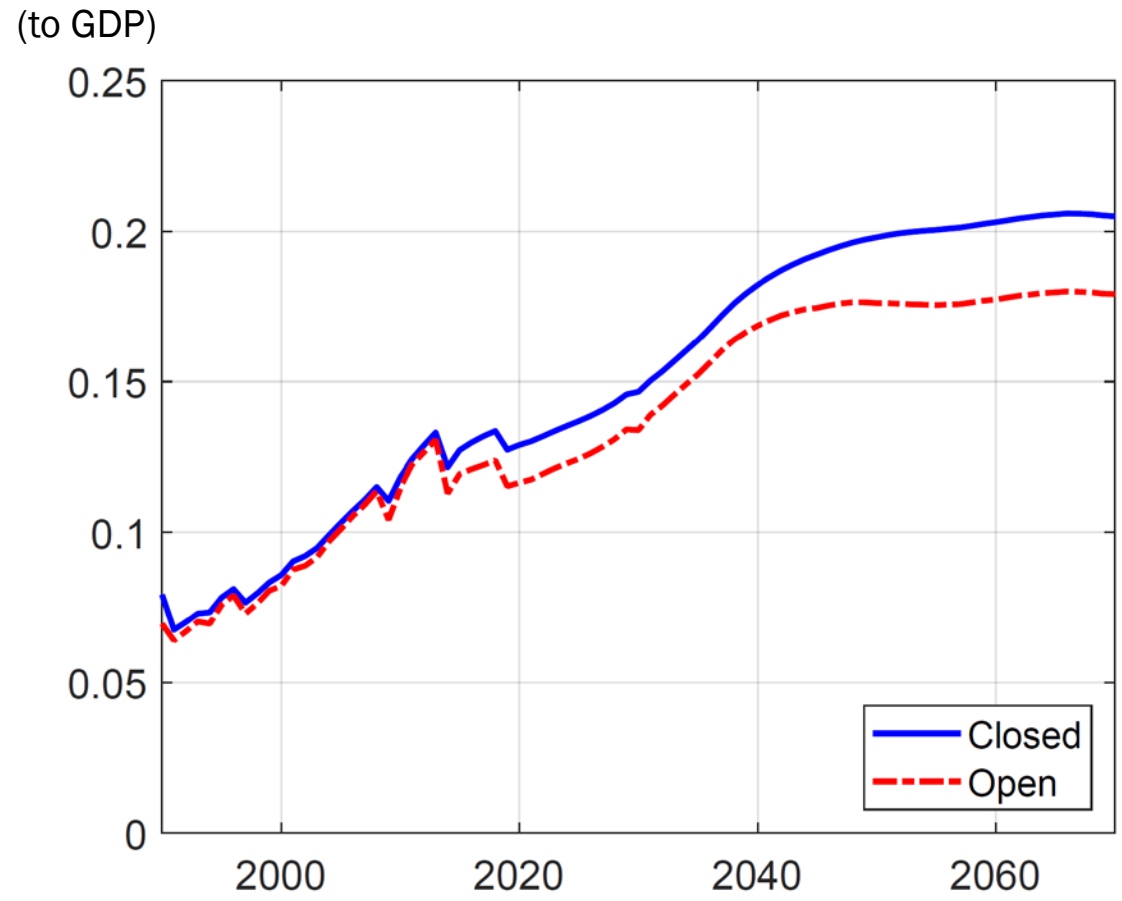

In levels

(to GDP)

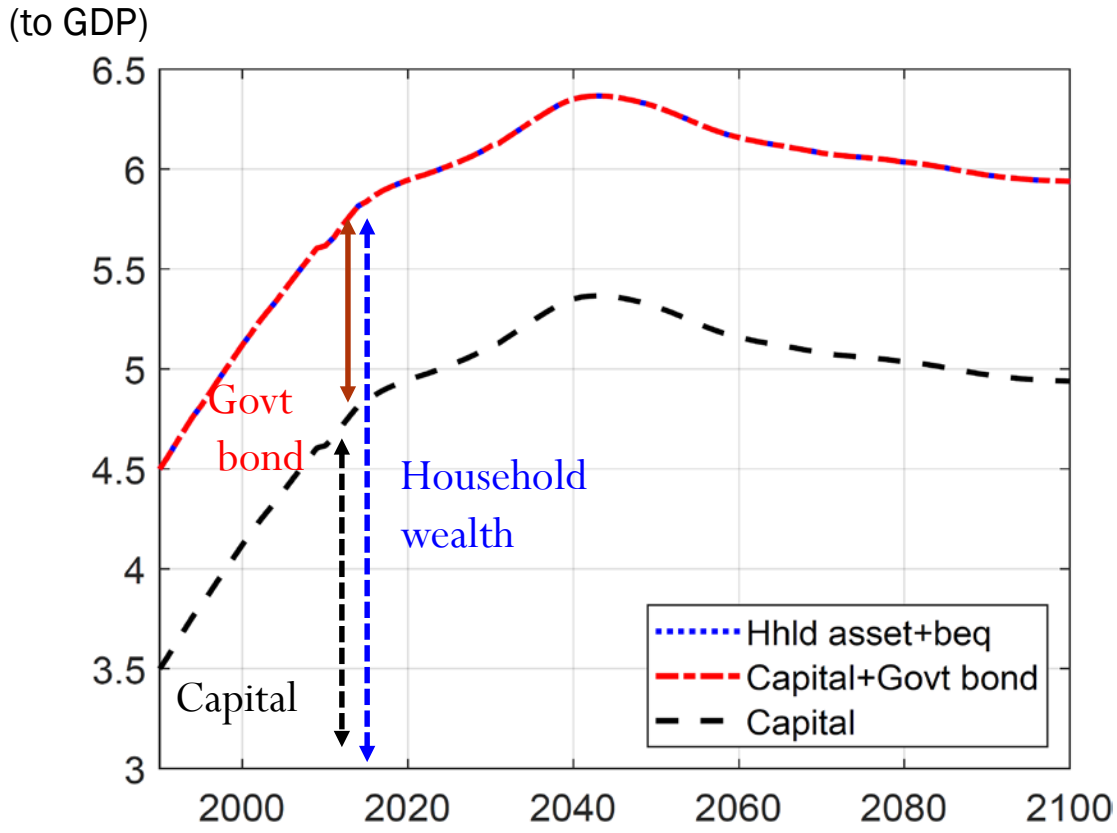



Relative to GDP

# Lump-sum tax : closed and open

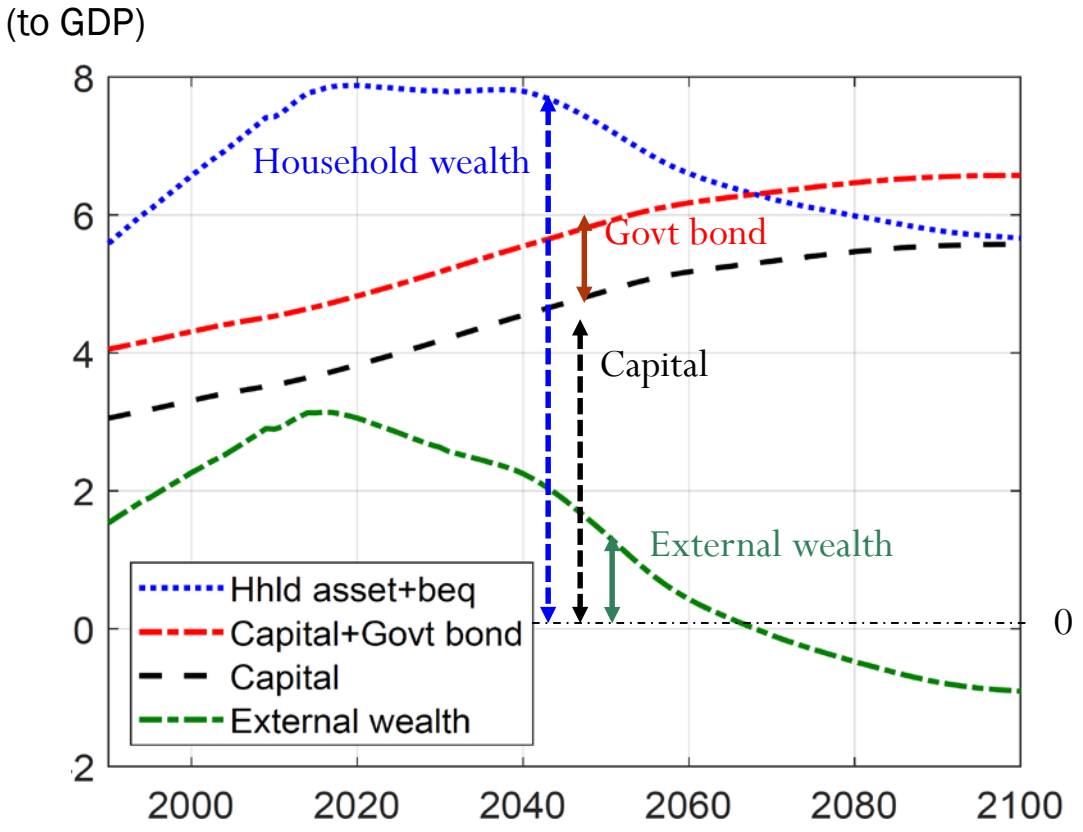


# Wealth decomposition of Japan : closed economy




**Household asset (incl. bequest)** = **Capital** + **Government bond**

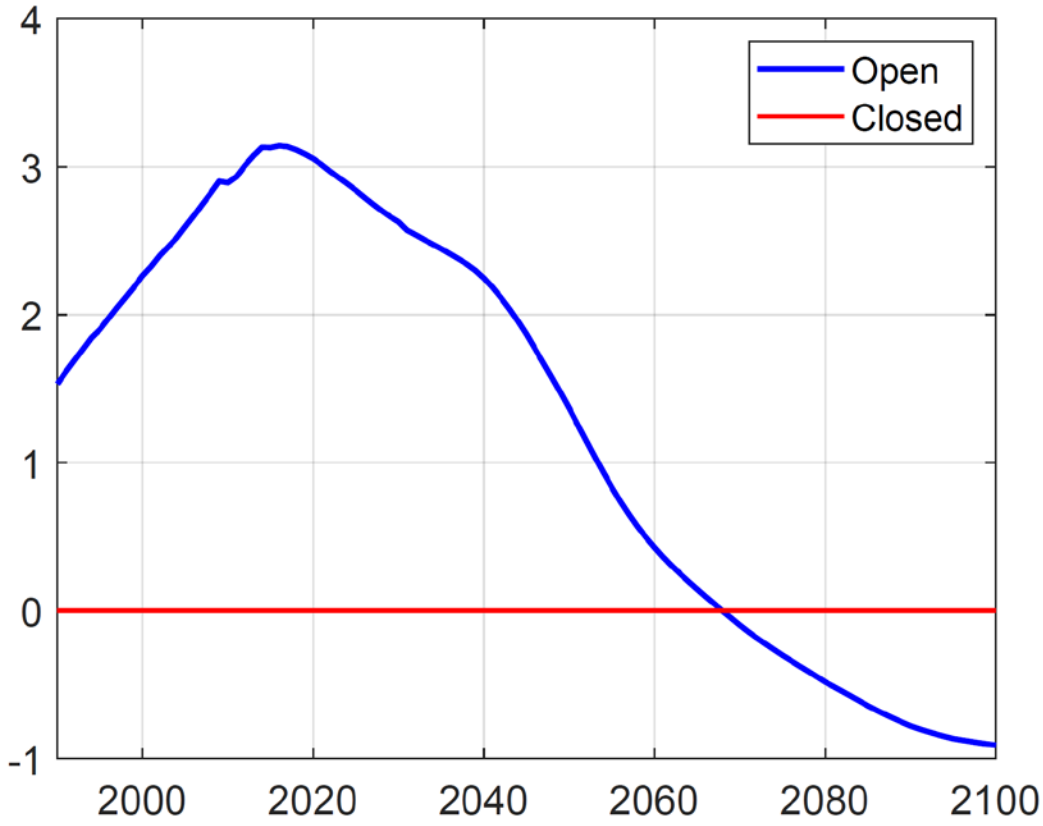
# Wealth decomposition of Japan : open economy



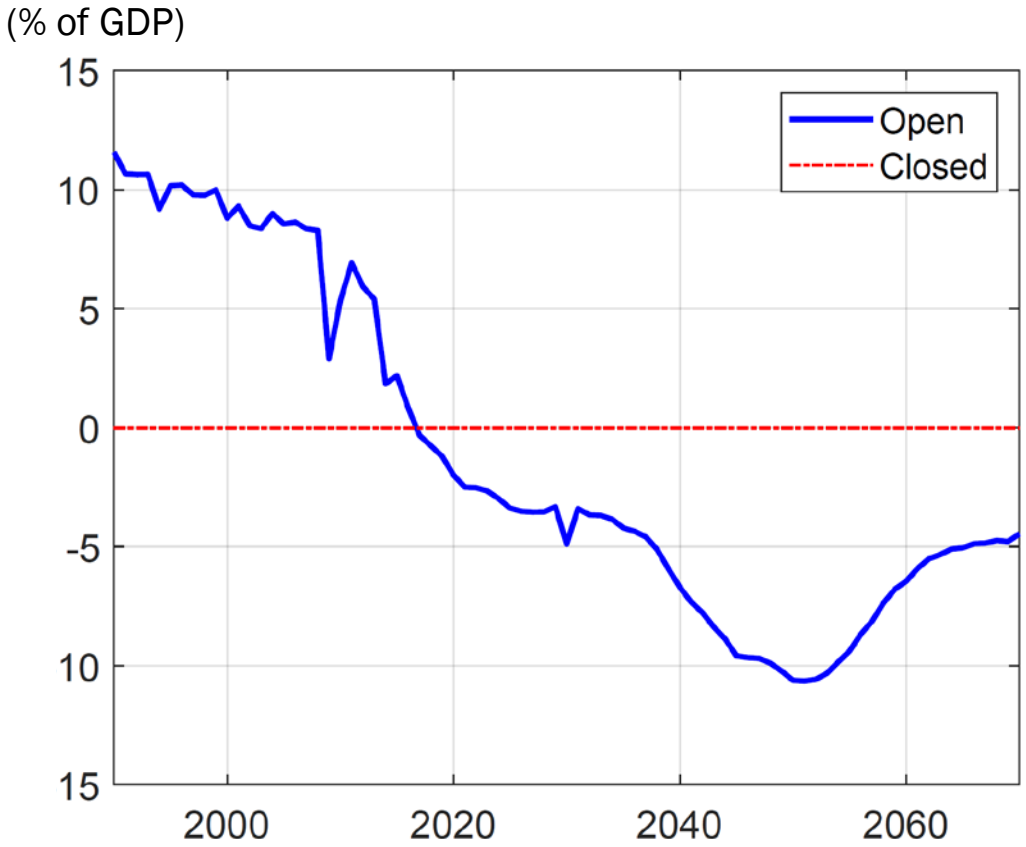

**Household asset (incl. bequest)** = **Capital** + **Government bond** + **External wealth**

# External wealth of Japan

(to GDP)



# Capital flow (current account)



# Some equations

- From the aggregate resource constraint

$$K_{t+1}^r - (1-\delta)K_t^r + X_{t+1}^r - (1+r_t)X_t^r = F(Z_t^r, K_t^r, N_t^r) - C_t^r - G_t^r \quad (1)$$

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- (2) and (3) in (1), the **current account** is given as

$$S_t^r - I_t^r = CA_t^r = X_{t+1}^r - X_t^r$$

**Saving - Investment**

# Some equations

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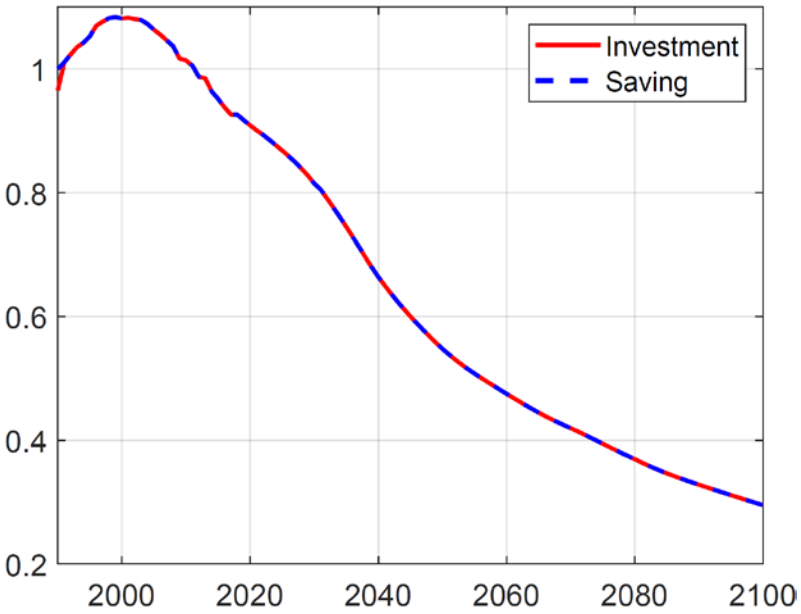
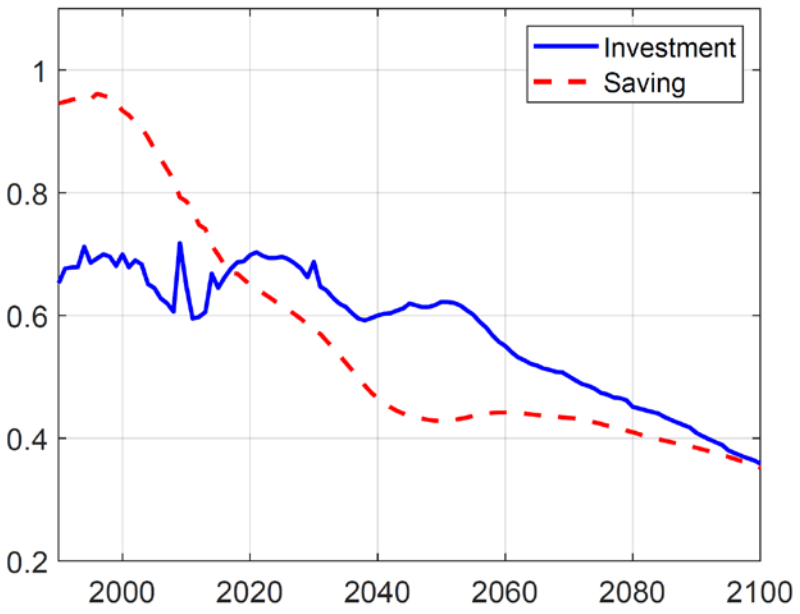
**Saving - Investment**

# Saving and investment in Japan

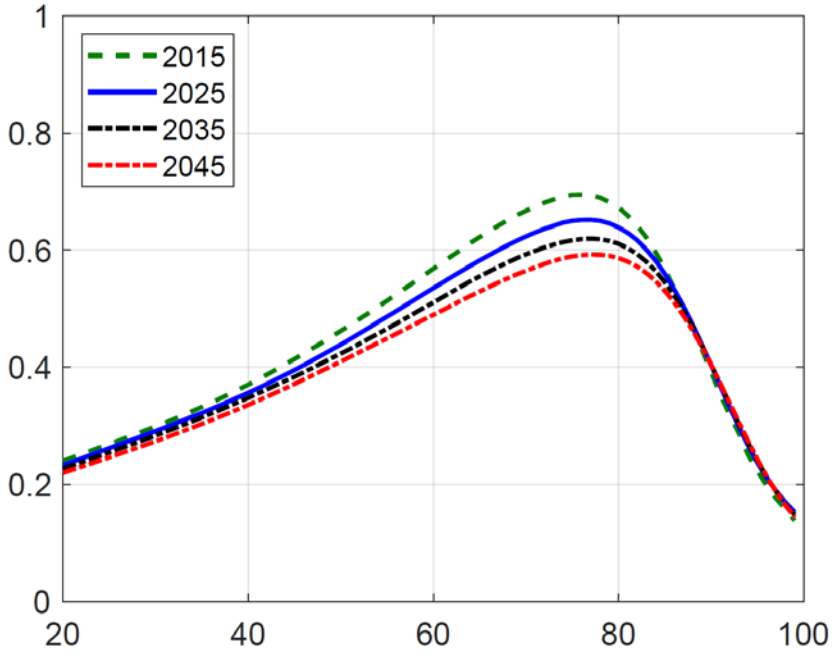



Closed economy

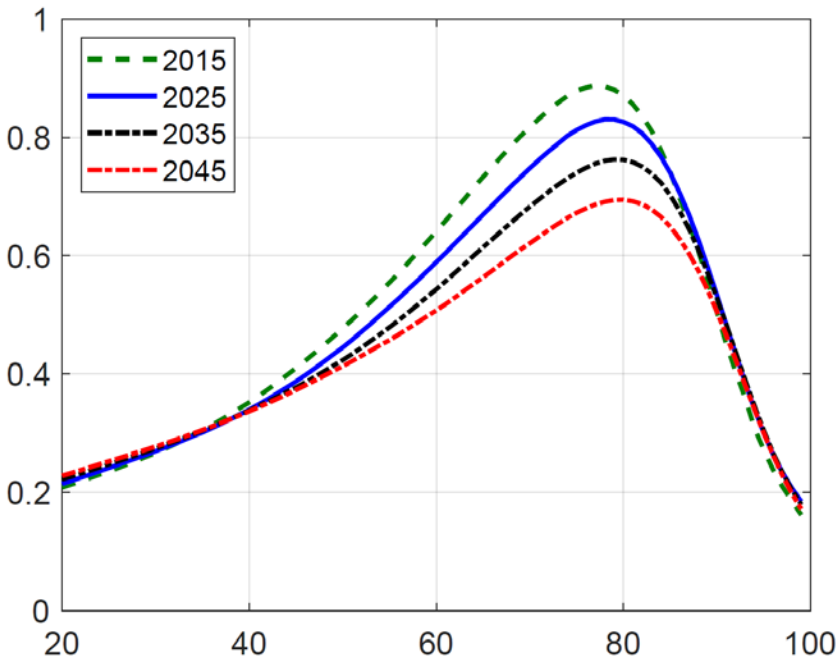



Open economy

# Life-cycle consumption in Japan




Closed economy




Open economy

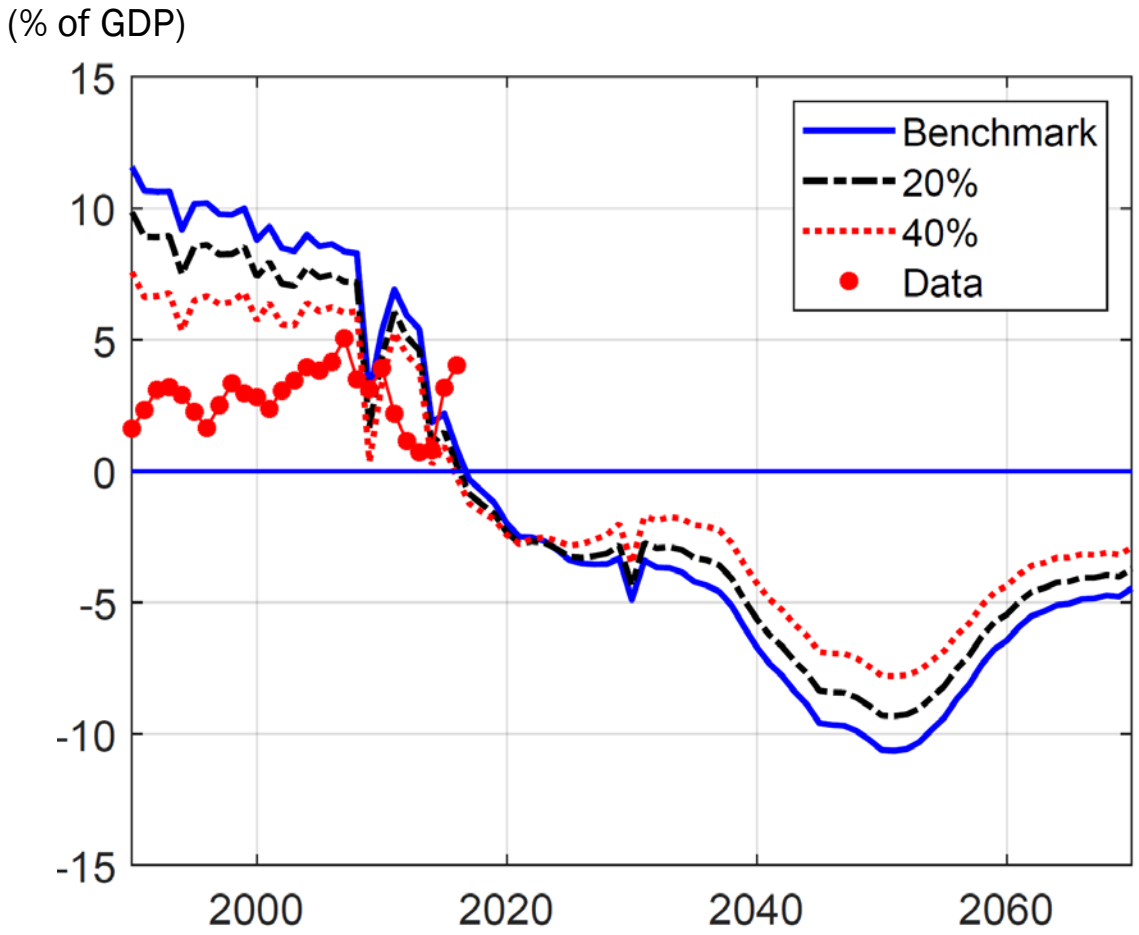
# Summary of the baseline transitions

- Aging demographics and a rise in government expenditures raise the tax burden in equilibrium and lower disposable income in the closed economy.
- In the open economy, capital initially flows from Japan to the MI with higher interest rates but the direction reverses by 2020, and the current account will turn negative. Japan will be a borrower against the world by mid-2060s.
- Next : sensitivity of the results to assumptions on the demographics projections, fiscal policy (pension generosity) in Japan and MI, transaction costs, etc…?

# Numerical experiments

- A capital transaction cost
  - Return from capital in MI "reduced" by a given fraction (20-40-60%)
- Public pension reform
  - Replacement rate (RR): 47.8% in HI, 26.8% in MI, 38.5% in Japan
  1. R.R. in Japan falls to the level of MI
  2. R.R. in MI rises to the level of HI
- Demographic transition path
  - Fertility rates in Japan : low and high scenarios of the IPSS

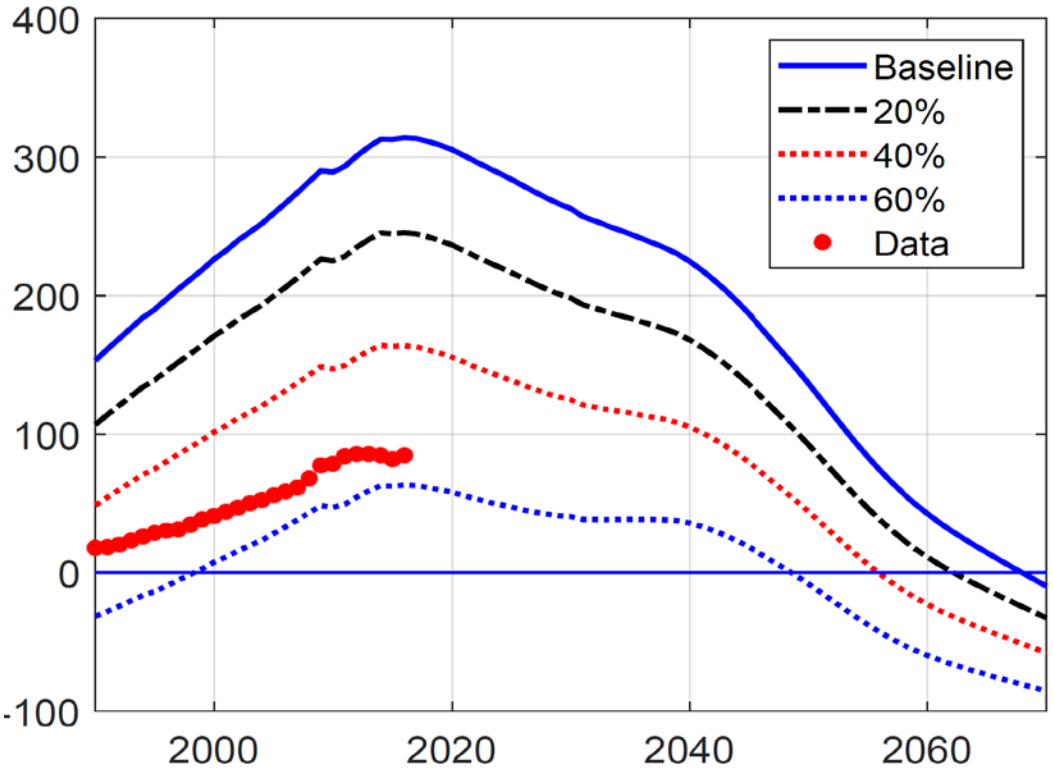
# Capital adjustment cost: current account of Japan




Data computed based on Hayashi and Prescott (2002) and the SNA

# Capital adjustment cost: external wealth of Japan

(% of GDP)

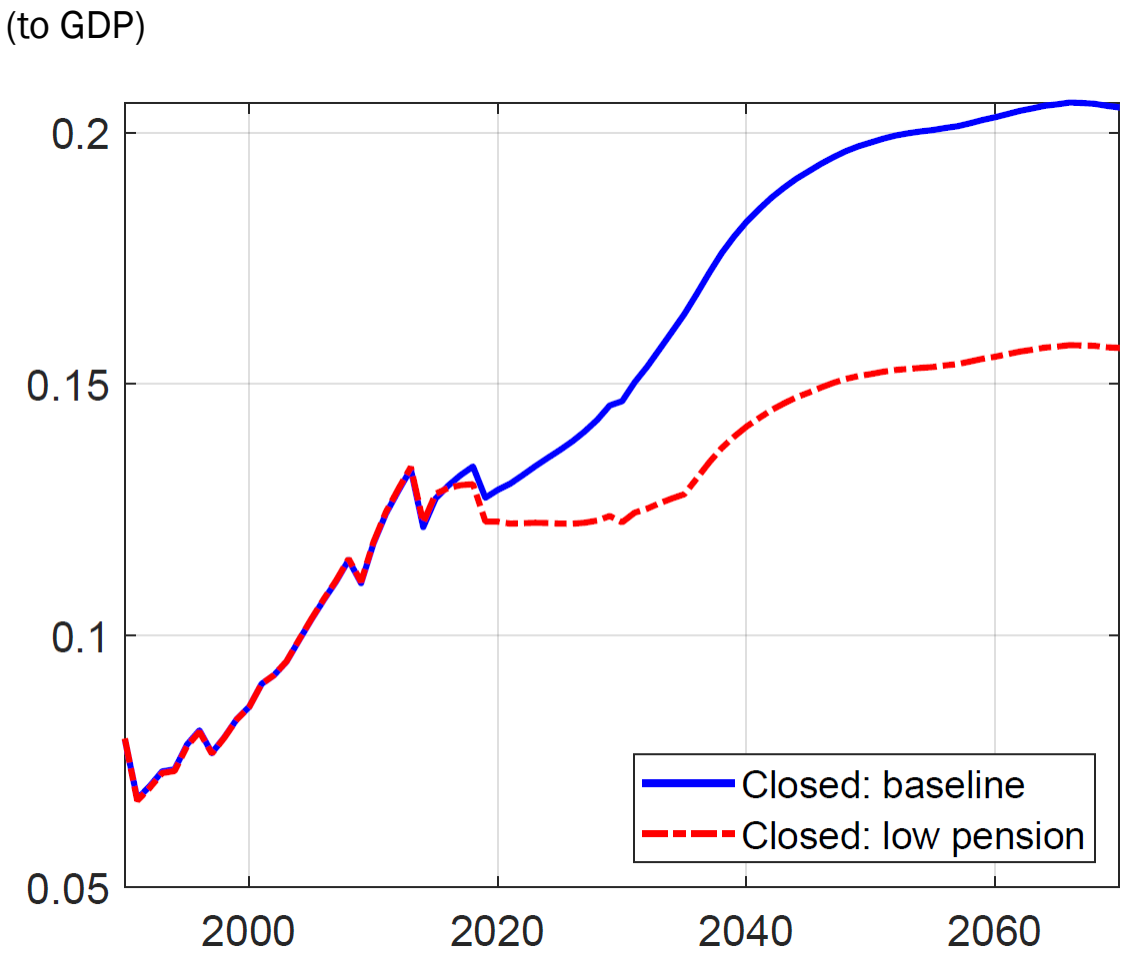



Data computed based on Hayashi and Prescott (2002) and the SNA

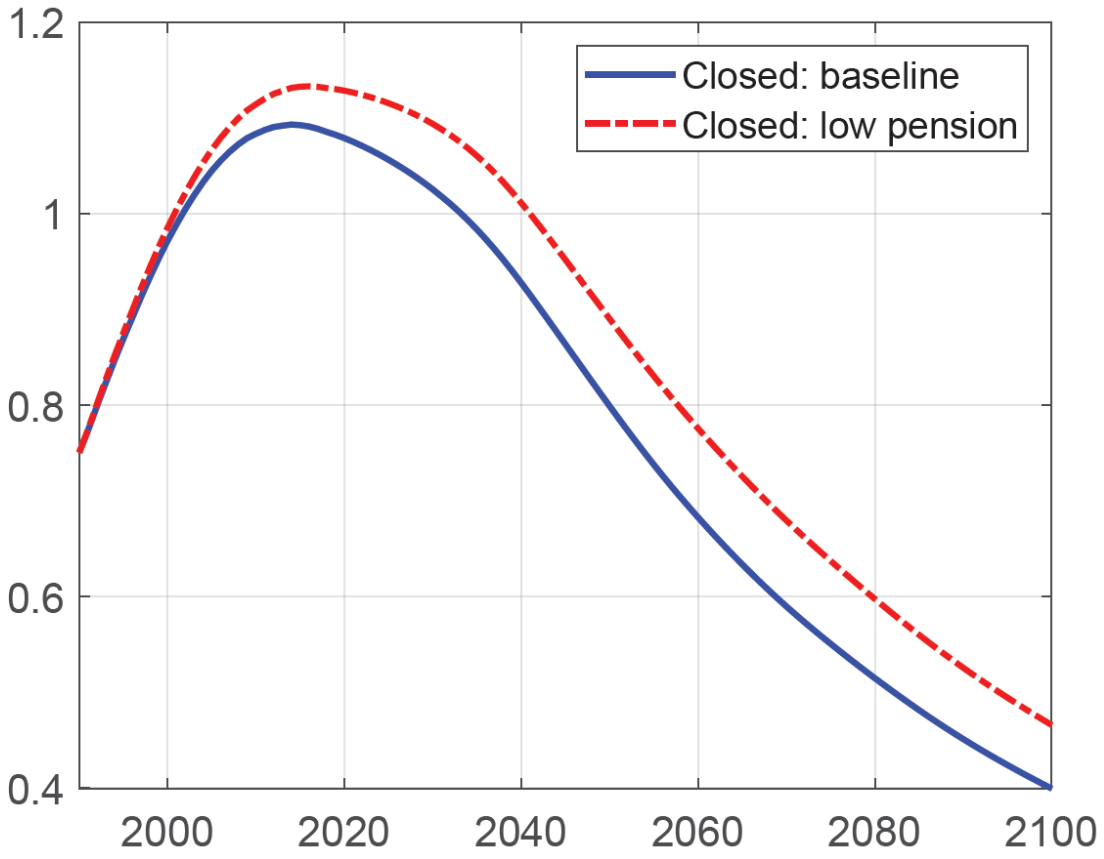
# Capital adjustment cost: remarks

- IF transaction costs associated with various risks of lower income countries (such as underdeveloped financial markets, political uncertainty and expropriation risks) explain the overprediction of the capital flow to the MI, they will be less relevant once the capital flow is reversed, since such risks are much lower in advanced economies.

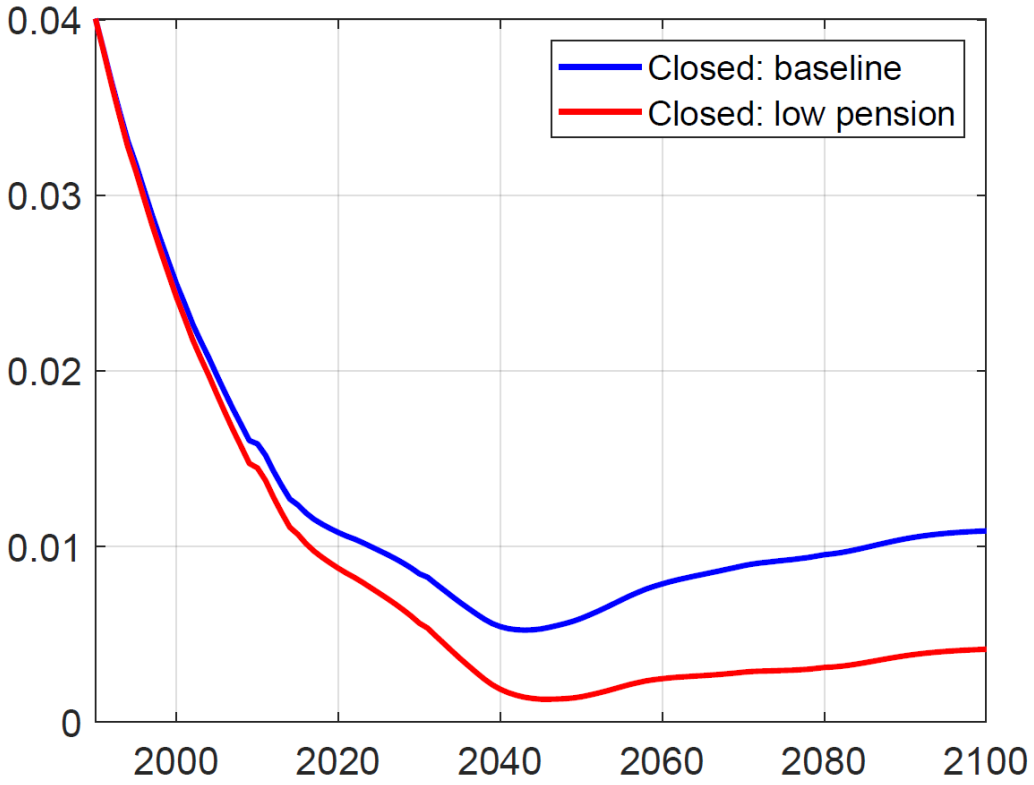
# Low pension in Japan: lump-sum tax



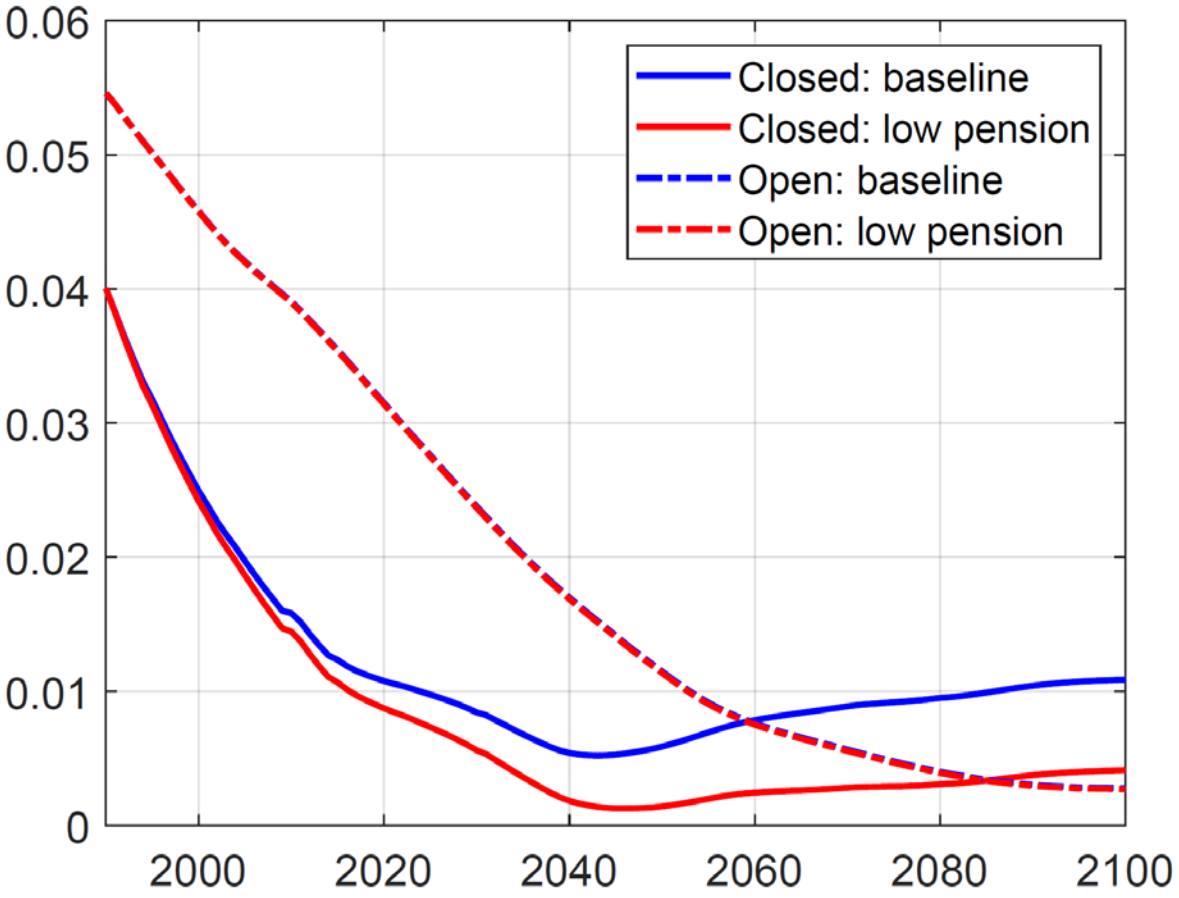
# Low pension in Japan: capital stock



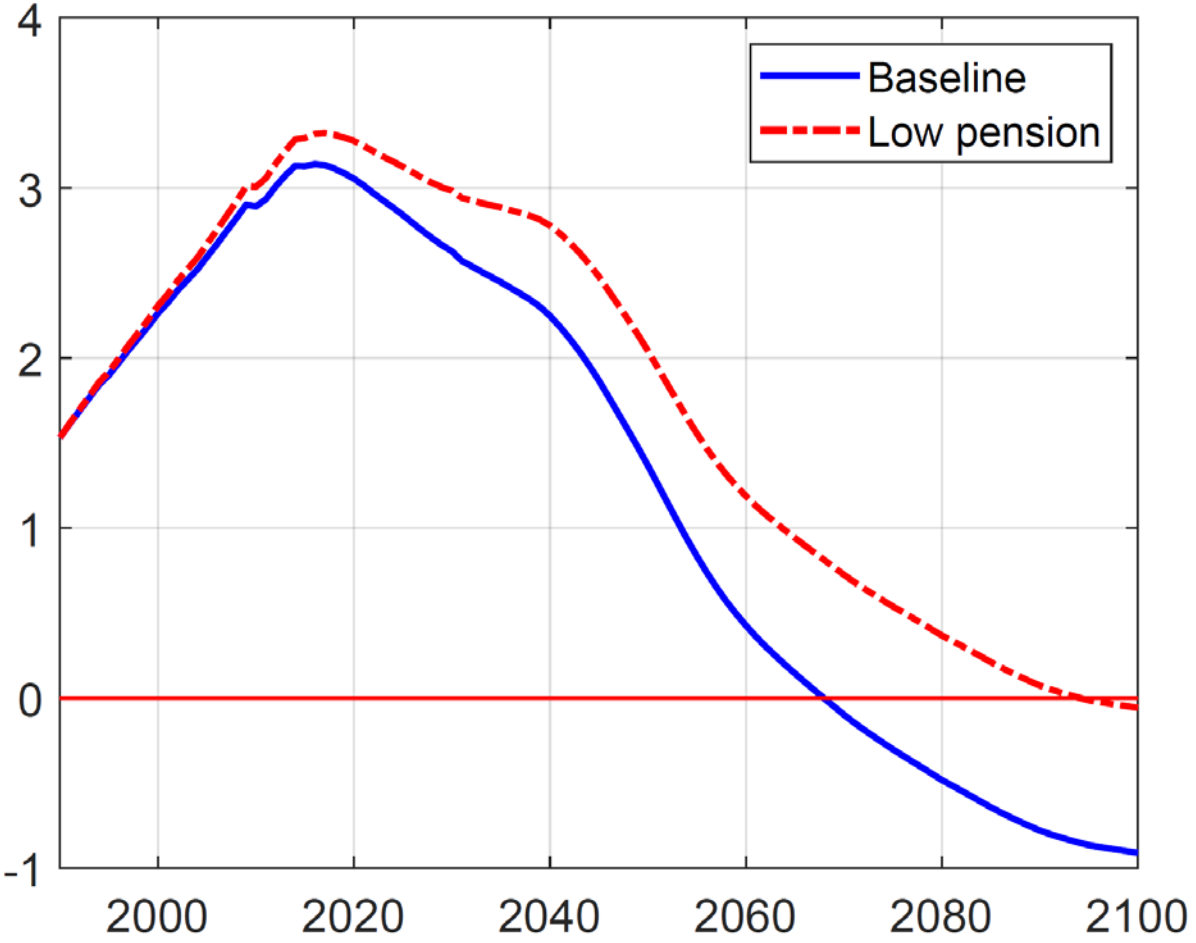
# Low pension in Japan: interest rate



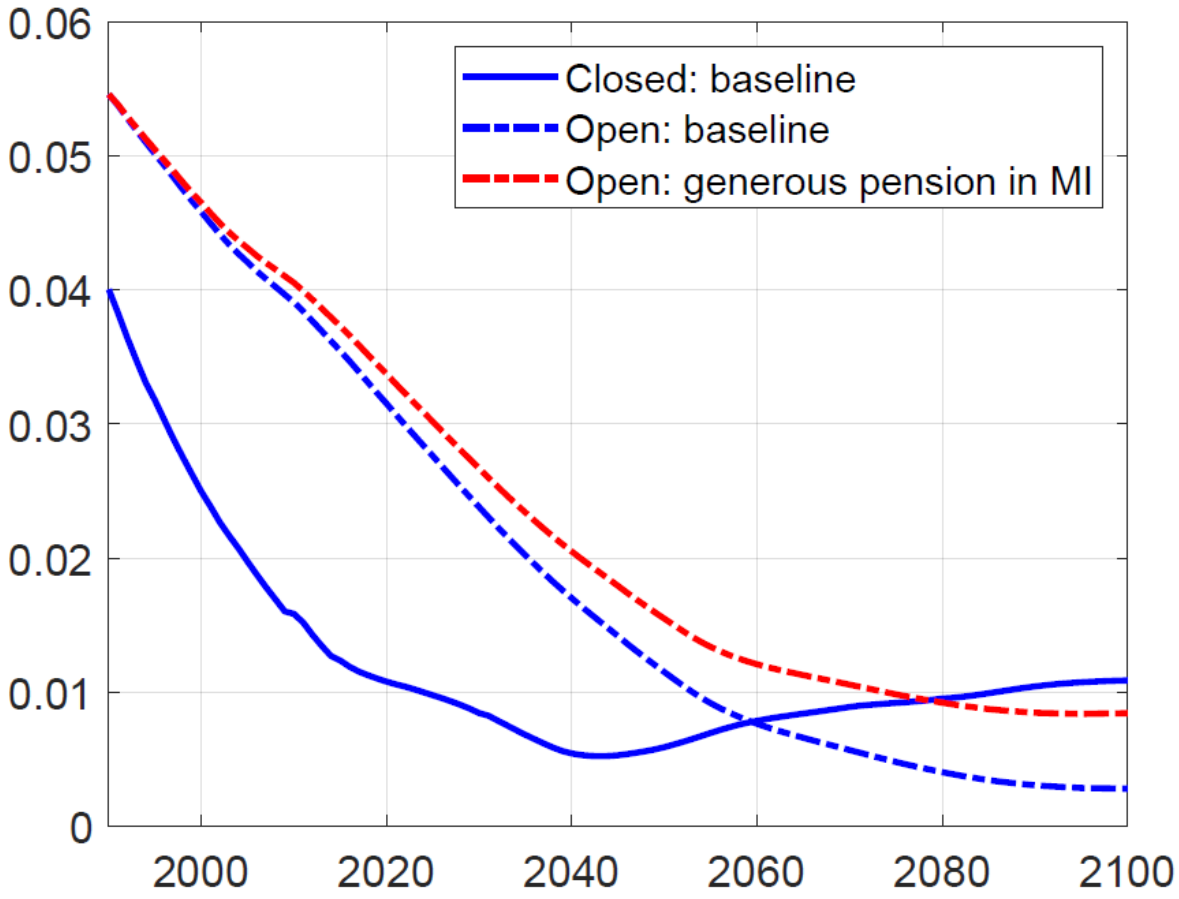
# Low pension in Japan: interest rate



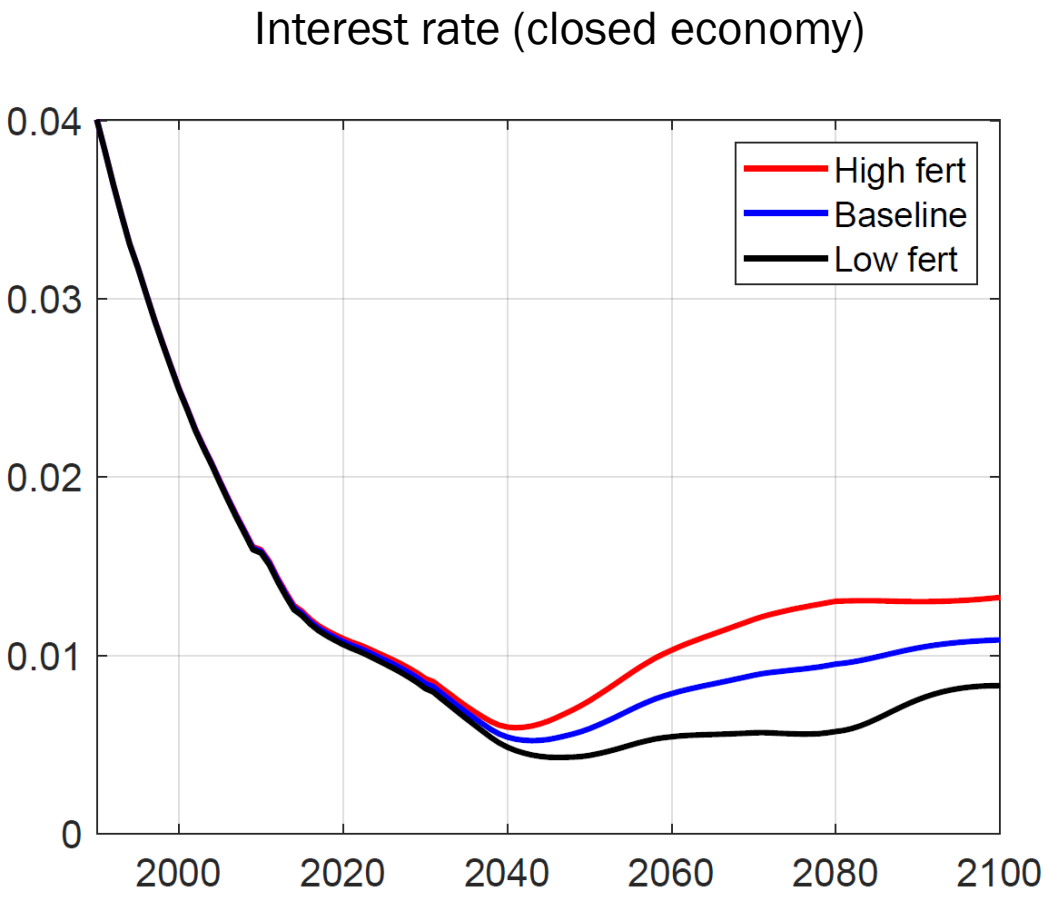
# Low pension in Japan: external wealth



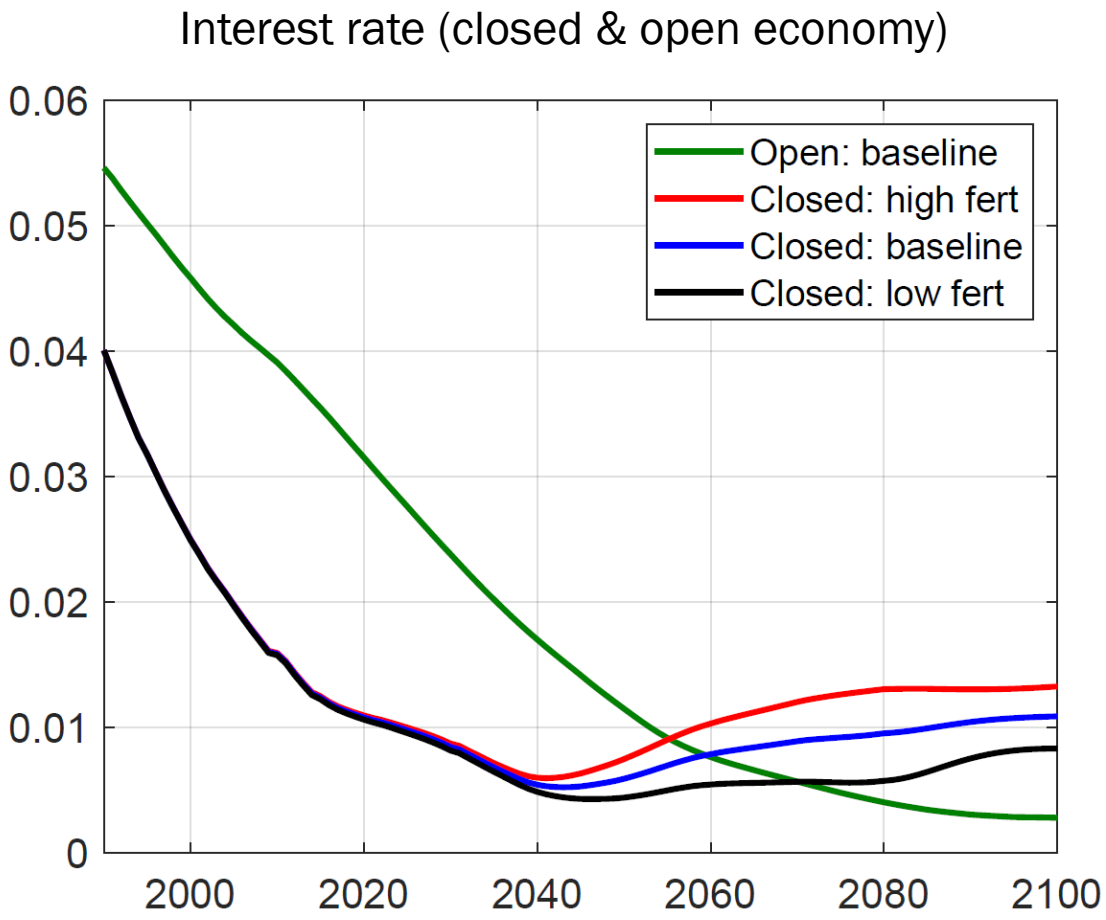
# More generous pension in MI: interest rate of Japan



# Low/high fertility rates in Japan

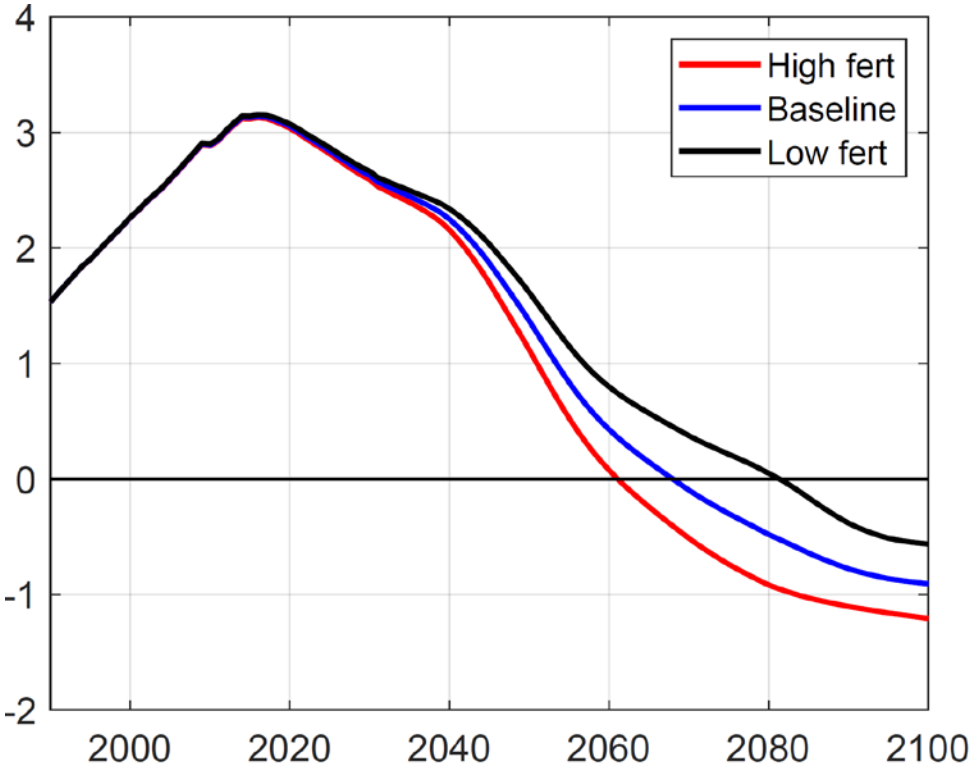


# Low/high fertility rates in Japan



# Low/high fertility rates in Japan

External wealth (to GDP)



# Remarks

- The unsynchronized demographic aging across regions and differences in the social security systems have induced capital to flow out of Japan but the direction may soon be reversed.
  - In the long-run, what implies lower closed-economy interest rates in the MI or higher interest rates in Japan will generate a greater capital flow into Japan and larger current account deficits.

- In the open economy, wages are higher and taxes are low due to the capital inflow to Japan, implying more benefits of more openness for future generations.