Aging, Factor Prices and Capital Flows

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Basic Issue: Aging and Fiscal Sustainability in a World Economy: Implications on Capital Flows

- A major challenge facing all economies: Aging of the populations.
- Longevity has increased and fertility rates have decreased.
- However, the timing and the severity of these demographic trends are quite different across countries and regions of the world.
- Advanced economies such as United States, Japan, and those in the Eurozone have started aging much earlier and more significantly than emerging and developed countries.

Aging in an Economy with No Pensions

- A second difference between the advanced and less developed economies is that pension systems are less developed or generous in the less developed economies.
- In these developing economies, aging would have much less impact on government's budget as individuals would have to rely mostly on their life cycle saving to provide for their old age consumption.
- In advanced economies, on the other hand, pensions as well as public medical expenditures would rise significantly with the aging of their populations.
- Therefore the combination of differential aging and differences in social insurance institutions between advanced and developing countries has implications about capital flows and the timing and size of fiscal responses to achieve fiscal sustainability in advanced economies.

A Three Region Model of the World

- To highlight the implications of these different demographic trends and social insurance institutions, we develop a three region model of the world.
  - High Income (H) United States, Canada, Europe (EU 28), Australia, New Zealand
  - Middle Income (M) China, Hong-Kong, Taiwan, South Korea, Singapore, Thailand, Indonesia, Malaysia, Philippines, Vietnam, India, Saudi Arabia, United Arab Emirates, Turkey, Russia and South Africa
  - Japan (J)
- We take Japan separately because the aging has been and is projected to be the most severe among the H economies.

Latest Projections

- For H and M regions, we use data from United Nations World Population Prospects: The 2015 Edition Revision (2015).
- This publication provides harmonized data on population, fertility rate and life table projections for all countries from 1950 to 2100.
- For Japan, however, we rely on the most recent 2017 estimates and projections of the National Institute of Population and Social Security Research (IPSS).
- These projections have slightly higher fertility rates and are more optimistic than previous estimates.
- The UN projections for Japan tend to be very optimistic.

Demographic Trends in the Three Regions

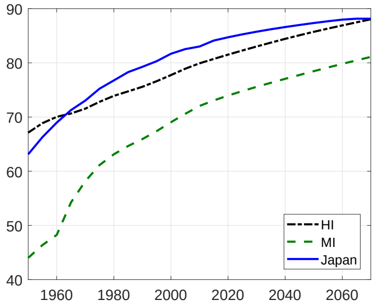

Figure: Life Expectancy

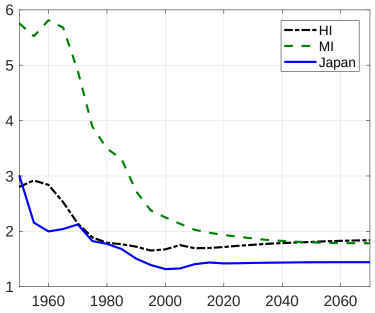

Figure: Total Fertility Rate

Demographic Trends in the Three Regions

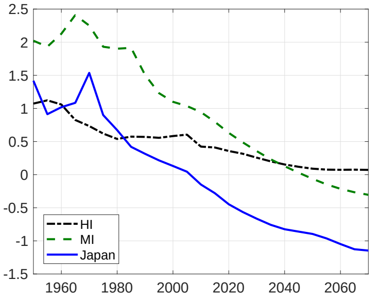

Figure: Population Growth Rates

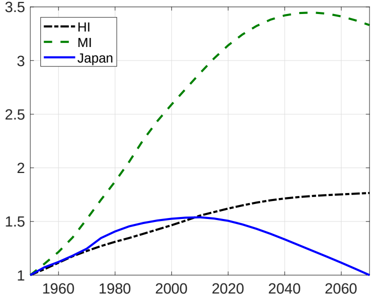

Figure: Normalized Populations

Higher Longevity and Lower Fertility

Dependency Ratio (65+/20-64)

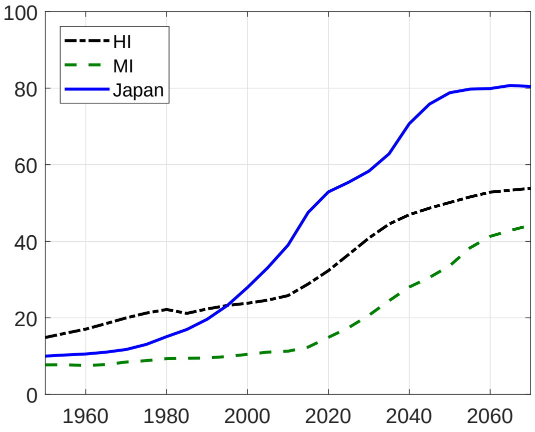

Figure: Old Age Dependency Ratios

Factor Prices and Capital Flows

- These large demographic trends and the accompanying monetary and fiscal adjustments tend to raise the capital labor ratio and reduce interest rates.
- This force is maximized in a closed economy, general equilibrium setting, with a direct link between the domestic capital labor ratio and factor rental rates.
- This mechanism is not as strong in a small, open economy, partial equilibrium model.
- Actual economies, however, are neither closed nor small, and depending on bilateral trade and capital flows, they may be closer to one extreme or the other.

What We Do

- Construct a general equilibrium model with 3 regions populated with overlapping generations of individuals
- Calibrate the model using UN, World Bank, OECD, IMF and Japanese data on demographics, capital stocks, labor income and efficiency, total factor productivity (TFP), pensions, tax rates, government expenditures and debt
- Incorporate the projected demographics and make assumptions on the future growth rates of TFP
- Compute two benchmark transition paths toward final balanced growth paths

What We Do

- One transition assumes that the 3 regions are closed economies
- An alternative transition assumes that the 3 regions are open economies with one integrated perfect capital market
- Numerically characterize the behavior of output, investment, saving, current account, net foreign asset position and other macroeconomic indicators in the 3 regions and compare them with those in the closed economy transition
- Describe the work to be done in the very near future (alternative fiscal adjustments, counterfactuals, welfare analysis on current and future cohorts, sensitivity computations, etc.)

The Japanese Context

- In the absence of reform of any kind, how high would the consumption tax rate go to achieve fiscal sustainability, given the projected aging and related public expenditures?
- Hansen and İmrohoroğlu (2016): 40-60% (labor income tax rate, much worse)
- İmrohoroğlu, Kitao, and Yamada (2016): Higher consumption tax, higher FLFP, and pension reform needed
- Braun and Joines (2015): 50% (retiree co-pay reform needed)
- Kitao (2015): 45% (pension reform needed)

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Related Literature

- Quantitative life cycle models and demographic shocks
  - Auerbach and Kotlikoff (1987), Huang, İmrohoroğlu and Sargent (1997), De Nardi, İmrohoroğlu, and Sargent (1999), ...
- Demographics and Capital Flows
  - Krueger and Ludwig (2007), Attanasio, Kitao and Violante (2007), Domeij and Floden (2006), Börsch-Supan, Ludwig, and Winter (2006), Backus, Cooley, and Henrikson (2014), Lisack, Sajedi, and Thwaites (2017), ...
- Secular Stagnation
  - Eggertsson, Mehrotra, and Robbins (2017), Gagnon, Johnson, and Lopez-Salido (2016), Carvalho, Ferrero, and Nechio (2016), Ikeda and Saito (2014), ...

Preliminaries

- Our model consists of Japan (J) and two regions; High-income (H) and Middle-income (M) regions.
- The two regions and Japan differ in their demographic trends, total factor productivity, and fiscal institutions.
- Our approach is to calculate a perfect foresight equilibrium transition path for the world economy from 1990 to a distant future steady state.
- Let t denote time, j a household's age, and r the regions, with $r = J, H, M$.

Technology

- In each region r, a constant returns to scale, aggregate production function $F(Z_t^r, K_t^r, N_t^r)$ produces output of a final good Y_t^r which can be used for consumption C_t^r or investment I_t^r.
- Z_t^r: total factor productivity level in region r at time t
- N_t^r: aggregate labor supply in efficiency units
- K_t^r: aggregate stock of physical capital used in production.
- Physical capital depreciates at the same rate δ each period in all regions.
- The level of technology in region r grows exogenously at rate λ_t^r between t and $t+1$.
- Growth rates differ across regions during the transition, but in the long-run all regions grow at the same constant rate λ.

Demographics

- Each region in the economy is populated by overlapping generations of ex-ante identical households who become active economically at age $j = 1$ and may live for a maximum of J periods.
- For households born in region r, $s^r_{j,t}$ denotes the probability of survival until age j at time t, conditional on being alive at time $t-1$.
- Hence, in region r, the unconditional probability of surviving j periods up to time t is given by

$$S^r_{j,t} = \prod_{k=1}^{j} s^r_{k,t+(k-j)},$$

  where $S^r_{1,t} = s^r_{1,t} \equiv 1$ for all t by definition.
- We denote by $\mu^r_{j,t}$ the size of the population of age j at time t in region r.

Household Preferences

- Households of age j at time t in region r make consumption allocation decisions based on the instantaneous utility function

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

where $c_{j,t}$ denotes consumption of a household of age j at time t.

- The intertemporal preference ordering for households born at adult-age $j = 1$ at time t is given by

$$U^r = \sum_{j=1}^{J} \beta^{j-1} S^r_{j,t+j-1} \frac{c_{j,t+j-1}^{1-\theta}}{1-\theta}, \tag{2}$$

where β is the subjective discount factor.

Household Preferences, continued

- There is no explicit bequest motive driven by altruism. Accidental bequests left by the deceased are distributed as a lump-sum transfer, denoted as b_t^r.

Household Endowments

- Households exogenously supply labor and derive no utility from leisure.
- At age J_R^r, households are subject to compulsory retirement from any working activity.
- Households of age j at time t in region r are endowed with $\varepsilon_{j,t}^r$ efficiency units of labor for each unit of time worked in the market.
- Finally, we assume that the initial asset holdings of each household is zero, i.e. $a_{1,t} = 0$ for any t in both regions.

Household Budget Constraint

- Let $a^r_{j,t}$ be the net asset holding of a household j at time t in region r.

$$\left(1+\tau^r_{c,t}\right) c^r_{j,t} + a^r_{j+1,t+1} = y^r_{j,t} + \left[1+\left(1-\tau^r_{a,t}\right) r_t\right]\left(a^r_{j,t} + b^r_t\right) + p^r_{j,t}.$$

We require households to die with non-negative wealth once they reach age J, but otherwise impose no borrowing constraint during their life.

Household Budget Constraint, continued

- Net earnings $y^r_{j,t}$ accruing to households of age j in region r at time t are defined as

$$y^r_{j,t} = \begin{cases} \left(1 - \tau^r_{w,t}\right) w^r_t \varepsilon^r_{j,t} = \left(1 - \tau^r_{w,t}\right) \tilde{y}^r_{j,t} & \text{if } j < J^r_R, \\ 0 & \text{if } j \geq J^r_R, \end{cases}$$

where w^r_t is the market wage rate, $\varepsilon^r_{j,t}$ is the efficiency units of labor of a household of age j, and $\tilde{y}^r_{j,t}$ is the before-tax labor income.

Household Budget Constraint, continued

- $p^r_{j,t}$ is pension income and takes a positive value for eligible individuals at and above social security's retirement age $j \geq j^r_{SS}$ and zero otherwise.
- Households pay proportional taxes at the rate of $\tau^r_{c,t}$ on consumption, $\tau^r_{a,t}$ on capital income, and $\tau^r_{w,t}$ on labor income. Residents of region r pay capital income taxes in region r, independently of where capital was invested.
- Social security benefits are given by the formula

$$p^r_{j,t} = \kappa^r_t \frac{W^r_{j,t}}{J^r_{SS} - 1},$$

where κ^r_t is the replacement ratio of average past earnings.

Household Budget Constraint, continued

- Cumulated past gross earnings $W_{j,t}^r$ are defined recursively as

$$W_{j,t}^r = \begin{cases} \tilde{y}_{1,t}^r & \text{if } j = 1 \\ \tilde{y}_{j,t}^r + W_{j-1,t-1}^r & \text{if } 1 < j < J_{SS}^r \\ W_{j-1,t-1}^r & \text{if } j \geq J_{SS}^r. \end{cases}$$

Government Budget Constraint

- In each region r, public expenditures and social security program are administered by the government under a unique consolidated intertemporal budget constraint.
- The government can raise revenues by: taxes on consumption, labor income, and capital income, and can issue one-period risk-free debt, B_t^r.
- These finance a stream of expenditures G_t^r and the PAYG social-security program described above. The consolidated government budget constraint:
-

$$G_t^r + (1 + r_t)\, B_t^r + \sum_{j=J_{SS}^r}^{J} p_{j,t}^r \mu_{j,t}^r =$$
$$\tau_{w,t}^r w_t^r \sum_{j=1}^{J_R^r - 1} \mu_{j,t}^r \varepsilon_{j,t}^r + \sum_{j=1}^{J} \mu_{j,t}^r \tau_{a,t}^r r_t \left(a_{j,t}^r + b_t^r \right)$$
$$+ \sum_{j=1}^{J} \mu_{j,t}^r \tau_{c,t}^r c_{j,t}^r + B_{t+1}^r .$$

Market Structure

- There are three goods in the economy: a final good which can be used either for consumption or investment, the services of labor, and the services of capital.
- The price of the final good (homogeneous across the three regions) is used as the world numeraire.
- Labor is immobile, thus wages are determined independently in regional labor markets.
- In the open economy, we assume that physical capital is perfectly mobile across the three regions, so there is one world market for capital.

Market Structure

- 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.
- A negative value indicates ownership of capital used for production in the region but owned by households of other regions.
- The sum of positive and negative external wealth across regions is zero in equilibrium, satisfying the condition $\sum_r X_t^r = 0$ at any time t.
- Goods and asset markets are perfectly competitive.
- A no-arbitrage condition implies that the return on regional bonds is equal to the return on physical capital, as we have already implicitly assumed when we wrote the budget constraints of the government and households.

Competitive Equilibrium (CE) of the Multi-Region Economy

A CE, for a given sequence of region-specific demographics, TFP levels $\{Z_t^r\}_{t=1}^{\infty}$, and fiscal variables $\{G_t^r, \kappa_t^r, \tau_{a,t}^r, \tau_{c,t}^r, B_t^r\}_{t=1}^{\infty}$, is a sequence of: (i) households' choices $\left\{\left\{c_{j,t}^r, a_{j,t}^r\right\}_{j=1}^{J}\right\}_{t=1}^{\infty}$, (ii) labor income tax rates $\{\tau_{w,t}^r\}_{t=1}^{\infty}$, (iii) wage rates $\{w_t^r\}_{t=1}^{\infty}$, (iv) aggregate variables $\{K_t^r, N_t^r, I_t^r, C_t^r\}_{t=1}^{\infty}$ in each region r, (v) world interest rates $\{r_t\}_{t=1}^{\infty}$, and (vi) external wealth positions $\{X_t^r\}_{t=1}^{\infty}$ such that:

CE of the Multi-Region Economy, continued

- Households choose optimally consumption and wealth sequences $\left\{\left\{c_{j,t}^{r}, a_{j,t}^{r}\right\}_{j=1}^{J}\right\}_{t=1}^{\infty}$,maximizing the objective function subject to the budget constraint, and the income process, and the time allocation constraint.
- Firms in each region maximize profits by setting the marginal product of each input equal to its price, i.e.

$$w_t^r = F_N(Z_t^r, K_t^r, N_t^r), \text{ for all } r, \tag{3}$$

$$r_t + \delta = F_K(Z_t^r, K_t^r, N_t^r). \tag{4}$$

CE of the Multi-Region Economy, continued

- The lump-sum transfer of accidental bequests equals the amount of assets left by the deceased, distributed equally to all households of the region.

$$b_t^r = \frac{\sum_{j=1}^{J-1} a_{j,t}^r (1 - s_{j+1,t}^r) \mu_{j,t-1}^r}{\sum_{j=1}^{J} \mu_{j,t}^r}$$

- The regional labor markets clear at wage w_t^r and aggregate labor supply in each region is given by

$$N_t^r = \sum_{j=1}^{J_R^r - 1} \mu_{j,t}^r \varepsilon_{j,t}^r .$$

CE of the Multi-Region Economy, continued

- The regional bond markets and the world capital market clear at the world interest rate r_t, and the aggregate stocks of capital in the three regions satisfy

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

- $\left\{\tau_{w,t}^r\right\}_{t=1}^{\infty}$ satisfy the budget constraint in each region.
- The allocations are feasible in each region,

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

CE of the Multi-Region Economy, continued

- Aggregate gross investments in region r are given by

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

- Aggregate (private plus public) savings in the three regions are,

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

- As a result, the current account balances of the three regions equal their respective net asset positions, and, are given by,

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

- The sum of these current account balances is zero.

Calibration

- The calibration strategy is to match a set of moments in the data with the model's counterparts in the *closed economy* equilibrium.
- We calibrate the initial steady-state using demographic and economic variables for the period 1990-2015 in the three regions.
- We assume that demographic parameters and TFP growth rates in the three regions converge to the same values in the very long run, by 2200, and all regions eventually reach a balanced growth path some time after 2200. We then let our world economy transit between the two steady-states. The model's period is set to 5 years.

Calibration

Economies of the Three Regions

- High Income (H)
  - North America (United States and Canada), Europe, Australia, and New Zealand; for Europe, we include 28 countries that are members of European Union.
- Middle Income (M)
  - Economies in Asia (China, Hong Kong, Taiwan, Korea, Singapore, Thailand, Indonesia, Malaysia, Philippines, Viet Nam, and India), Mexico, Brazil, Russia, Saudi Arabia, U.A.E., South Africa, and Turkey.
- Japan (J).

Calibration

Technology Parameters

- We assume a constant returns to scale production function

$$F(Z_t^r, K_t^r, N_t^r) = Z_t^r (K_t^r)^\alpha (N_t^r)^{1-\alpha},$$

  with capital share $\alpha = 0.35$ in three regions.
- Using World Bank's *World Development Indicators* (WDI), growth rates of output per capita in the three regions from 1990-2015:
  - 1.1% in Japan, 1.4% in H region and 3.9% in M region.
- The growth rate of TFP λ^r in each region is set so that the region achieves the target average per-capita output growth rate during the same period.

Calibration

Technology Parameters

- After 2015, we let λ_t^r of all regions converge smoothly to the common long-run growth rate of TFP, 1%.
- We assume that the growth rate of Middle-income region converges over the next 30 years, by 2045, and those of Japan and High-income region by 2100.
- The TFP level in the long-run will differ across regions and the levels of Japan and Middle-income region will be around 0.75 of that of the High-income region.

Calibration

Technology Parameters

- Initial value of the Japanese TFP, Z_0^J is chosen to normalize income per capita in Japan to 1 in 2015.
- Based upon the WDI, income per capita in 2015:
  - H: 1.11 ($45,373)
  - M: 0.31 ($12,696)
  - J: 1.00 ($40,763)
  - Z_0^H and Z_0^M set to match these ratios.
- The depreciation rate of capital is set to 6% per year.

Calibration
Demographic Parameters

- Population data for H and M: Estimates of the United Nations (2015).
- Population data for J: Data and projections of the National Institute of Population and Social Security Research (IPSS) (2017).
- Population in 1990 (initial year of transition):
  - J: 122 million
  - H: 778 million
  - M: 2,976 million
- The survival probabilities are computed based on the population data and projections by age for each region.
- The population dynamics thereafter follow the projections of the United Nations and the IPSS.

Calibration

Demographic Parameters

- Each model-period corresponds to five years
- Households enter the economy at age $j = 1$, which corresponds to 22 years old (age 20-24), and live up to the maximum age of $J = 16$, or for the maximum of 80 years, up to age 97 (95-99 years old).
- Age to exit the labor force $J_R^r = 10$; 67 years old (65-69).
- Note that the age to exit the labor force J_R^r, which is assumed to be exogenous in the model, can be different from the retirement age for the purpose of the social system. The latter is a policy parameter. We set the two at the same age in Japan and H region, but the retirement age is lower in M region as discussed below.

Calibration

Preference and Endowment Parameters

- Preferences are common across regions.
- We set $\theta = 2$ based on the estimates in the literature.
- We set the subjective discount factor β =1.0552 to match the target interest rate of 4% in Japan on an annual basis in 1990, the initial year of the transition.
- The age-efficiency profile for Japan is based on the earnings data from the BSWS in 2010.
- For H region, we use weekly wage data from the *Consumer Expenditure Survey* (CEX) for the period 1982-1999.
- For M region, we use an age-efficiency profile on Mexican data—precisely from the *Encuesta Nacional de Ingreso y Gasto de los Hogares* (ENIGH), which is the equivalent of the U.S. CEX, using the 1989, 1992, 1994, 1996, 1998, and 2000 waves.

Age Efficiency Profiles

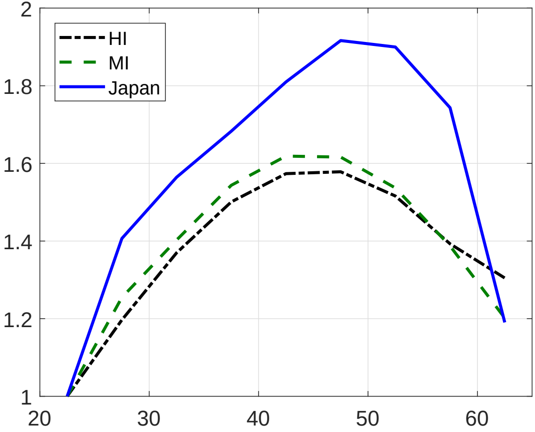

Figure: Net External Wealth to Output Ratio

Calibration

Government Debt to GDP Ratios

- Government debt and expenditures as a fraction of GDP for H and M regions are computed from the IMF's World Economic Outlook database (WEO, 2017) as time-averages over the period 1990-2015.
- The WEO data yield a ratio of government expenditures to GDP at 35%, 41% and 25% for J, H, and M regions, respectively, in 1990-2015.
- These expenditures contain all expenditures including interest payments on the government debt and transfers such as social security benefits.
- We calibrate the ratio of the government expenditures in our model, G_t^r, to GDP to match these data and they turn out to be 26% in Japan, 33% in H and 21% in M region.

Calibration

Government Debt to GDP Ratios

- The ratio of government debt B_t^r to GDP in 1990-2015 was 51% and 31% in H and M regions, respectively, based on the WEO database.
- The debt level of the Japanese government greatly fluctuated during the period and rose from 14% of GDP in 1990-1995 to approximately 120% in 2010-2015 and we set the ratio to 100%.

Calibration

Public Pension Replacement Rates

- Pension replacement rates for the three regions are calculated using OECD Pensions at a Glance (2014).
- In particular, we compute ‘coverage adjusted’ net replacement rates (NRRs) by multiplying NRRs by active coverage (defined as total number of contributors divided by labor force), available from the World Bank Pensions database (2014).
- The GDP (current PPP) weighted, coverage adjusted NRRs are 47.8%, 26.8%, and 38.5% for High and Middle-income regions and Japan, respectively.

Calibration

Public Pension Replacement Rates

- The statutory retirement age is 65, 66 and 56 in Japan, H and M regions, respectively, based on the population-weighted average of the World Bank's database.
- Based on these, in the model, the retirement age J^r_{SS} in Japan and H region is set at 10, which corresponds to 67 years old (65-69) and that of M region at 8, corresponding to 57 years old (55-59).

Calibration
Tax Rates

- Tax rates on consumption and assets are computed using the revenue data from the OECD Revenue Statistics, OECD National Accounts Statistics and UN National Account Statistics, following the method of Mendoza, Razin and Tesar (1994).
- τ_a^r is set at 34.7%, 34.1% and 18.8% in Japan, H and M regions, respectively.
- Consumption tax rates are 10.9% and 12.7% for H and M regions.
- The Japanese consumption tax rate had been zero until 1989, when it was set to 3% and raised to 5% in 1997 and 8% in 2014.
- We let $\tau_{c,t}^J$ increase accordingly and assume that it stays constant after 2015.

Calibration

Tax Rates

- We adjust labor income tax rates τ_w^r to satisfy the government budget constraint in each period and region. The paths of endogenously determined labor income tax rates are reported later on.

Calibration

Table: Demographic Parameters

Parameter and description		Value, source
$s^r_{j,t}$	Survival rates	United Nations (2015) and IPSS
n^r_t	Cohort growth rates	United Nations (2015) and IPSS
J^r_R	Age to retire from the labor force	10 (65-69 yrs)
J	Maximum age	16 (95-99 yrs)

Calibration

Table: Calibrated Parameters (annual values)

Parameter	and description	Value	Target, source
β	Subj. discount factor	1.055	Interest rate in Japan in 1990
θ	Risk aversion	2.0	Attanasio (1999)
ε_j^r	Wage profile	—	see text
α	Capital share	0.35	Holmes, McGrattan and Prescott (2015)
δ	Depreciation rate	0.06	Holmes, McGrattan and Prescott (2015)
Government			
D_t/Y_t	Debt to GDP ratio		IMF World Economic Outlook (2017)
G_t/Y_t	Gov. purch. to GDP ratio		IMF World Economic Outlook (2017)
κ_t^r	Pension replacement rate		OECD Pension at a Glance (2014)
J_{ss}^r	Pension retirement age e		10 (65-69 yrs) in J and H, 8 (55-59 yrs) in M World Bank Pensions database
$\tau_{c,t}^r$	Consumption tax		OECD Revenue Stat., OECD/National Acct. Stat., Mendoza, Razin and Tesar (1994)
$\tau_{a,t}^r$	Capital income tax		OECD Revenue Stat., OECD/National Acct. Stat., Mendoza, Razin and Tesar (1994)
$\tau_{w,t}^r$	Labor income tax		Endogenous

Calibration

Table: Growth rate and level of TFP

Region	GDP per capita growth, WDI (1990-2015), target	TFP growth rate λ_t^r(1990-2015) calibrated	GDP per capita level, WDI 2015, target	Initial TFP level Z_0^r calibrated
Japan	1.1%	0.72%	$40,763 (1.00)	1.12
High Income	1.4%	0.82%	$45,373 (1.11)	1.38
Middle Income	3.9%	2.07%	$12,696 (0.31)	0.60

Summary of calibration targets

Parameter	Description	Target	Period	Value by region		
				Japan	HI[c]	MI[c]
Preferences and endowments						
β	Subj. discount factor	Interest rate in Japan, %	1990		4	
Production technology						
Z_0^r	TFP level (initial)	GDP per capita level, $ PPP	2015	40,763	45,373	12,696
λ_t^r	TFP growth rate	GDP per capita growth, %	1990-2015	1.1	1.4	3.9
Government						
D_t/Y_t	Debt to GDP ratio	General gov. net debt to GDP, %	1990-2015	100[a]	50.9	30.7
G_t/Y_t	Gov. purch. to GDP ratio	General gov. total expenditure to GDP, %	1990-2015	34.9	41.5	25.2
κ_t^r	Pension replacement rate	Net replacement rate, coverage adjusted	2014	38.5	47.8	26.8
τ_a^r	Capital income tax	Avg. eff. capital income tax, %	2000-2014	34.7	34.1	18.8
τ_c^r	Consumption tax	Avg. eff. consumption tax, %	2000-2014	3 – 8[b]	10.9	12.7

Notes: [a,b] See text for details on how targets were set; [c] High Income (HI): United States, Canada, Europe (UE 28), Australia, New Zealand; Middle Income (MI): China, Hong-Kong, Taiwan, South Korea, Singapore, Thailand, Indonesia, Malaysia, Philippines, Vietnam, India, Saudi Arabia, United Arab Emirates, Turkey, Russia and South Africa.

Dataset description (1)

Indicator	Period	Description	Sources
GDP per-capita (PPP, current international $)	2015	Gross domestic product divided by midyear population and converted to international dollars using purchasing power parity exchange rates. The target indicator by region is computed as a cross-country weighted mean, using GDP at current PPPs for weighting.	World Bank World Development Indicators (2017)
GDP per-capita growth (%)	1990-2015	The annual growth rate of GDP per-capita is calculated from GDP per-capita measured in constant local currency. The target indicator by region is a time average of the cross-country weighted mean. GDP at constant 2010 US$ is used for weighting.	World Bank World Development Indicators (2017)
General government total expenditure (% GDP)	1990-2015	Total spending of general government includes expenditures incurred by the central, state and local government, and social security funds. Total expenditure comprises current outlays, including interest payments on government debt and social transfers, and net investment in non-financial assets. The target total expenditure to GDP ratio by region is a time average of the cross-country weighted mean. GDP at constant 2010 US$ is used for within-region weighting.	IMF World Economic Outlook (2017)
General government net debt (% GDP)	1990-2015	Net debt of general government is given by gross debt minus financial assets corresponding to debt instruments (monetary gold and SDRs, currency and deposits, etc.). The target net debt to GDP ratio by region is a time average of the cross-country weighted mean. GDP at constant 2010 US$ is used for within-region weighting.	IMF World Economic Outlook (2017)

Dataset description (2)

Indicator	Period	Description	Sources
Capital income tax rate (%)	2000-2014	Average effective tax rate computed following the method by Mendoza, Razin and Tesar (1994). Tax revenue data and national account aggregates available from various sources. The target indicator by region is a time average of the cross-country weighted mean. GDP at constant 2010 US$ is used for within-region weighting.	OECD Revenue Statistics (2017), OECD National Accounts Statistics (2017), UN National Accounts Statistics (2017)
Consumption tax rate (%)	2000-2014	Average effective tax rate computed following the method by Mendoza, Razin and Tesar (1994). Tax revenue data and national account aggregates available from various sources. The target indicator by region is a time average of the cross-country weighted mean. GDP at constant 2010 US$ is used for within-region weighting.	OECD Revenue Statistics (2017), OECD National Accounts Statistics (2017), UN National Accounts Statistics (2017)
Net replacement rate, coverage adjusted (%)	2014	The net replacement rate (NRR) is given by net pension entitlements divided by net pre-retirement lifetime earnings, thus accounting for individual income tax and social contributions (for a mean male earner). The adjustment for coverage is done by multiplying the NRR by active coverage (defined as the number of contributors to the social security system divided by labor force). GDP at current PPPs is used for within-region weighting.	OECD Pensions at a Glance (2014), World Bank Pensions Database (2014)
Pension retirement age	2013	It is the statutory retirement age (mean of females and males if they differ) at which people eligible to old-age pension start receiving benefits. Total population is used for within-region weighting.	World Bank Pensions Database (2014)
Total population by age groups	1990-2100	Historical data and projections (medium variant). Total population is used for within region weighting.	UN World Population Prospects (Rev. 2015)
Age-specific fertility rate	1990-2100	The age-specific fertility rate is the number of births to women in a particular age group divided by the number of women in that group. Historical data and projections (medium variant). Total population is used for within-region weighting.	UN World Population Prospects (Rev. 2015)

Calibration and Data

Net Foreign Asset Position of Japan

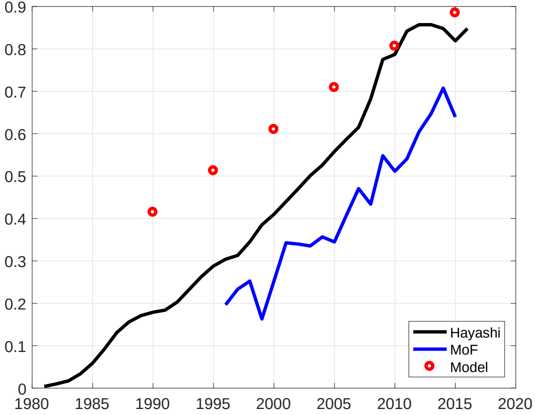

Figure: Net External Wealth to Output Ratio

Numerical Findings

Methodology

- Characterize equilibrium transition paths from the initial steady state to a final steady state in 2200, starting in 1990.
- These equilibrium paths are computed under the 'perfect foresight' assumption and are therefore deterministic.
- Previous research (authors' and others) suggest this is fine.
- All individuals and firms have perfect information on factor prices and fiscal policy parameters (tax rates, benefits, etc.) and make optimal decisions under new demographic variables and fiscal parameters and associated (endogenous) factor prices, given their asset holdings in the initial steady state.

Numerical Findings

Methodology

- Cohorts that survive to 1990 re-optimize given their new demographic and policy environments.
- Along the transition, like in the initial and final steady states, it is assumed that the labor income tax rate adjusts in each time period to satisfy the government's budget, given a constant debt to output ratio.

Numerical Findings

Methodology

- In most of the figures below, we will show the equilibrium transition paths under two separate assumptions on the openness of the economies.
- First, we compute the transitions under the assumption that each region has been a closed economy in the initial steady state and will remain closed along the transition path to the final steady state.
- Alternatively, in the open economy computations, we assume that there are three regions in the initial steady state and the transition path such that labor is immobile but capital is perfectly mobile across regions and there is one international capital market that helps determine the world interest rate.

Numerical Findings

Labor Supply

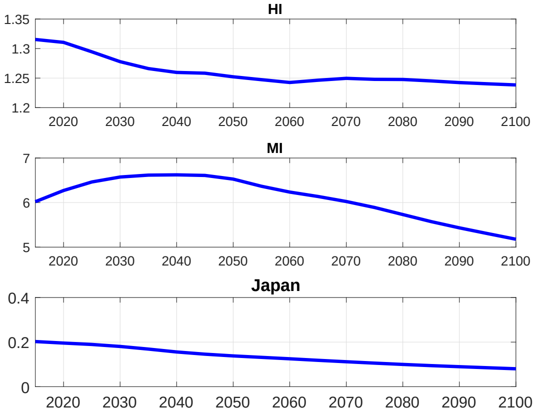

Figure: Labor Supply

Numerical Findings

Capital Stock

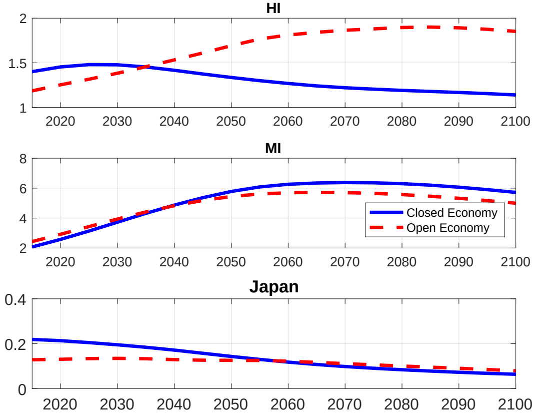

Figure: Capital Stock in the Closed and Open Economies

Numerical Findings
Capital Labor Ratio

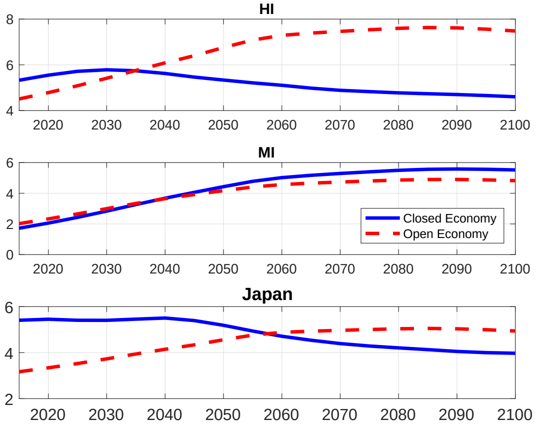

Figure: Capital Labor Ratio in the Closed and Open Economies

Numerical Findings

Interest Rates

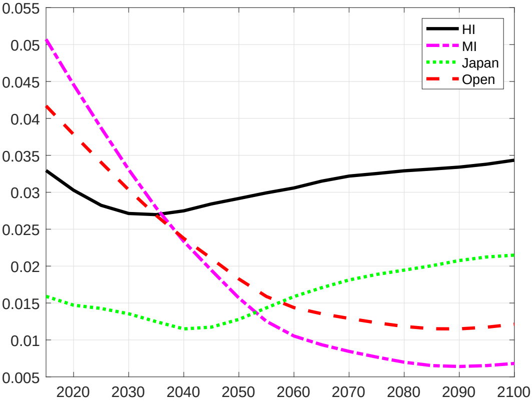

Figure: Return to Capital

Numerical Findings

Wages

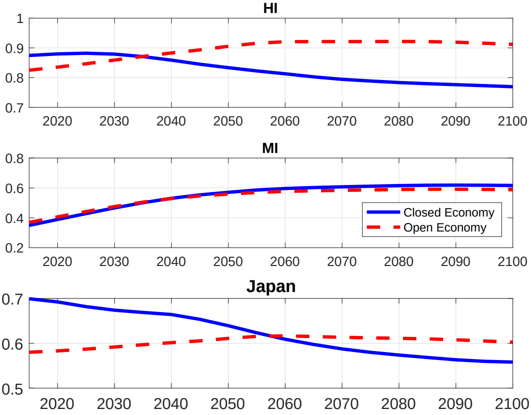

Figure: Wages

Numerical Findings

Tax Rates

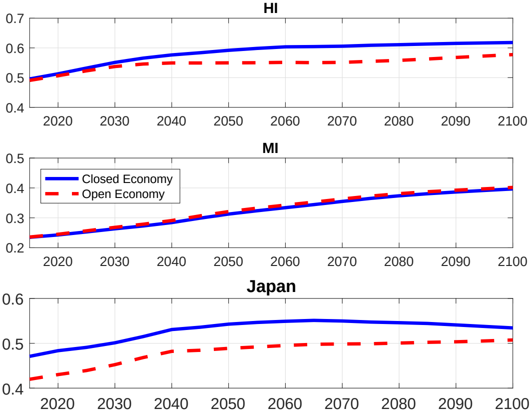

Figure: Labor Income Tax Rate

Numerical Findings
Current Account to GDP Ratio

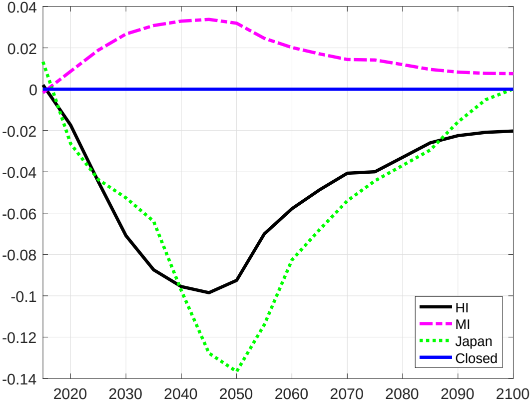

Figure: Current Account

Numerical Findings

Investment and Saving in Japan (closed)

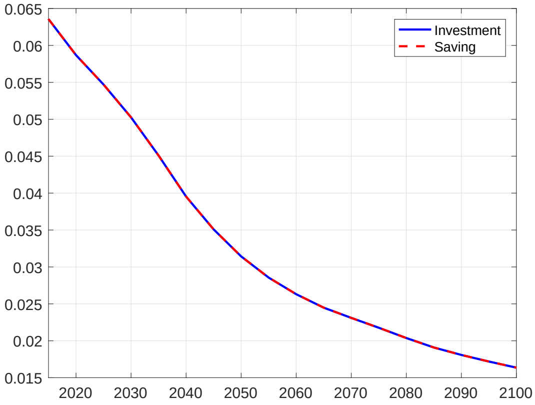

Figure: Investment and Saving in Japan (Closed)

Numerical Findings

Investment and Saving in Japan (open)

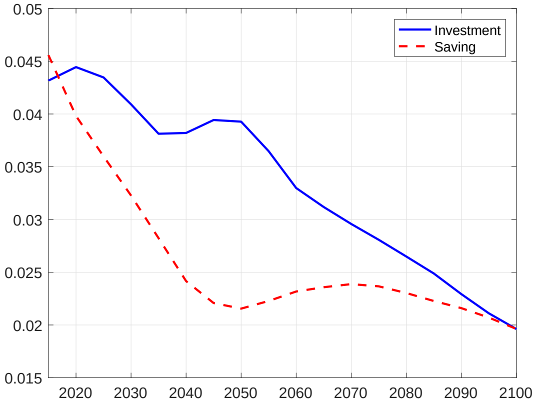

Figure: Investment and Saving in Japan (Open)

Numerical Findings

Investment and Saving in Japan (% of GDP)

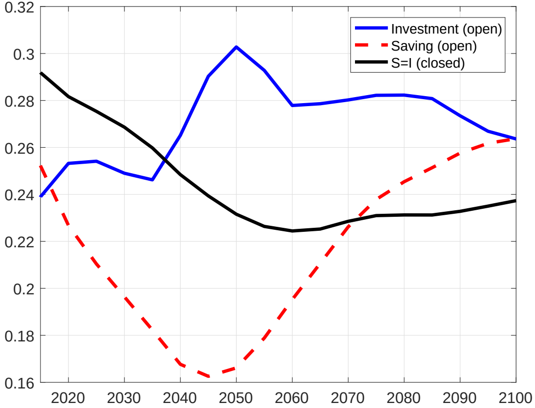

Figure: Investment and Saving in Japan

Numerical Findings

Net Asset Position to GDP Ratios

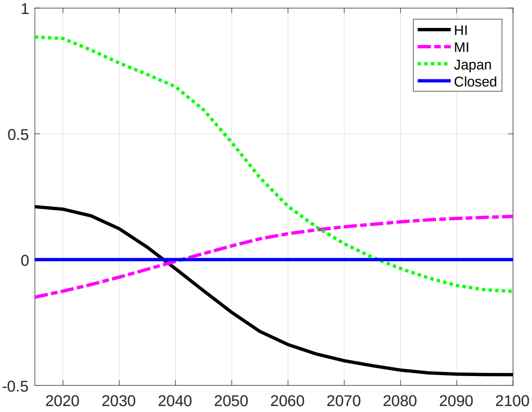

Figure: External Wealth

Numerical Findings
Output in Japan

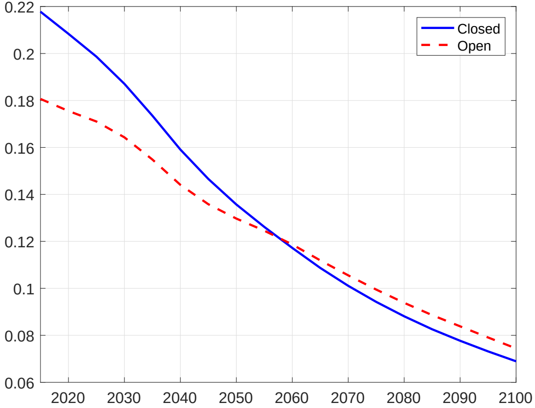

Figure: Output in Japan

Numerical Findings

Asset Profiles in Japan (closed)

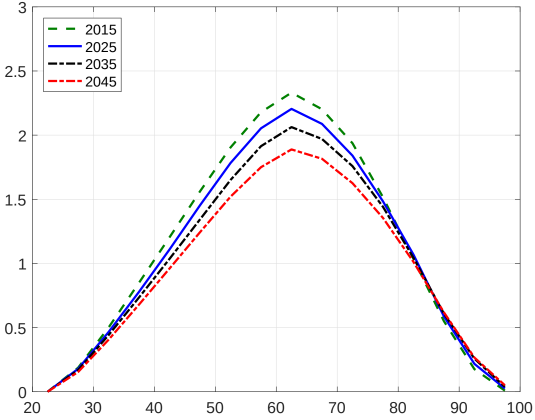

Figure: Asset Holdings by Age and Year in Japan (Closed)

Numerical Findings

Asset Profiles in Japan (open)

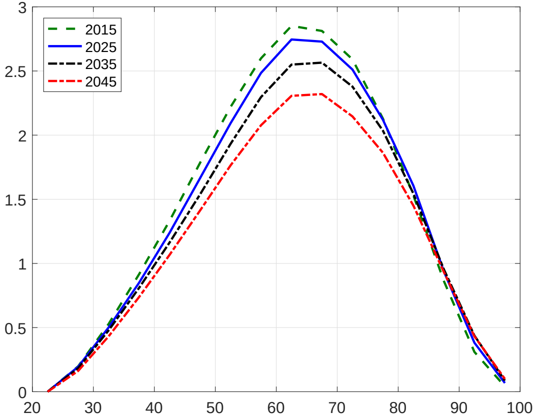

Figure: Asset Holdings by Age and Year in Japan (Open)

Numerical Findings

Living Standards

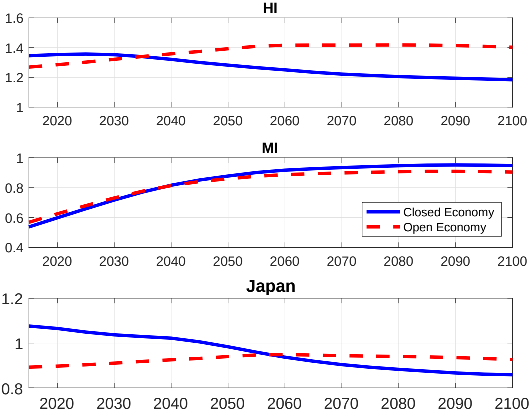

Figure: Output per Labor

Numerical Findings

CA in Japan: Data and Model Projections

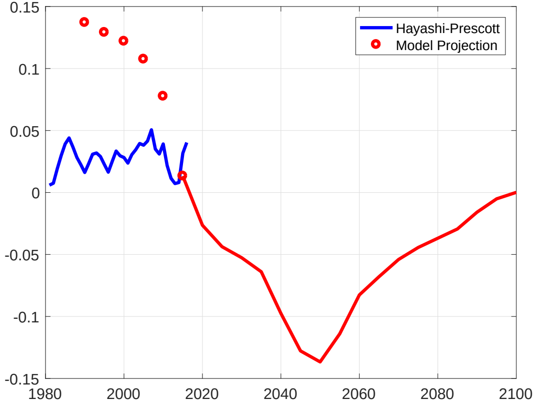

Figure: CA Balance as a % of GDP

Numerical Findings

Net Foreign Capital of Japan

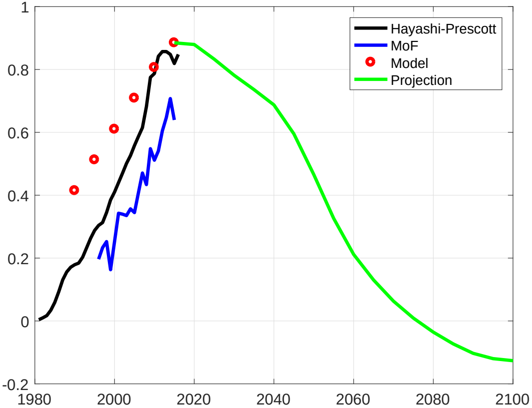

Figure: Output per Labor

Tentative Conclusions

- Aging has an ambiguous effect on saving and capital accumulation:
  - $K \uparrow$ as individuals save more for a longer retirement period (intensified in regions with less generous social insurance systems)
  - $K \downarrow$ because there are less savers (retirees) and more dissavers (workers)
- Aging decreases labor supply
- K/L likely to $\uparrow \Rightarrow w \uparrow, r \downarrow$
- In addition, there is unsynchronized aging
- What are the implication of this demographic projection on S, I, CA?
- Especially when there is a large, looming fiscal adjustment?
- Does it matter how fiscal sustainability is achieved to deal with aging?

Tentative Conclusions

- We developed a 3-region quantitative general equilibrium model, calibrated it to data from the UN, World Bank, OECD, IMF, CEX, ENIGH, BSWS, IPSS
- Generated numerical results under two different assumptions: closed economy vs world economy with a single, perfect capital market
- We demonstrated that
  - Labor suppy falls in H and J (a lot), flat inverse U-shape in M
  - Capital stock rises a bit in H but then falls, broadly rises in M, and monotonically falls in J
  - K/L largely follows this path and therefore r is flat in H and J (very low) and declining in M under closed economy
  - World r monotonically declines from 4% to 1%

Tentative Conclusions

Tax Rates

- Tax rates rise in all regions.
- In M, closed or open economy makes little difference.
- In H, there is an increasing difference, from about zero to about 5.5 percentage points eventually
- In J, there is a 5.5 percentage difference starting from 2015
- The level of tax rates is very high 50% or higher in H and J.

Tentative Conclusions

Current Account

- In both the H and J regions, there are current account deficits very soon; 2020 in J.
- These are persistent and lead to significant changes in the net foreign asset positions.
- In Japan, the reason for CA deficits is the sharp decline in national saving, starting in 2020.
- Japan becomes a net borrower in 2075.
- Japanese GDP shrinks due to the decline in labor supply
- Japanese living standards slowly rise as the decline in K is mitigated in the open economy simulation and hence GDP declines slower than that in labor supply.

Tentative Conclusions

Caveats and More Computations Needed

- We have a perfect world capital market; capital moves easily with no frictions; no role for exchange rate
- Pension or health reform in Japan (raise retirement age, effective macro slide, raise co-pay for the retirees ...)
- Increase in fertility in Japan
- Expanding social insurance systems in China and other M economies to levels similar to those at the H region
- Same return on government bonds as that with capital, both within and across regions
- Much more work to be done (consumption tax, sensitivity analysis, welfare analysis, ...)