Aging, interest rates and deflation.

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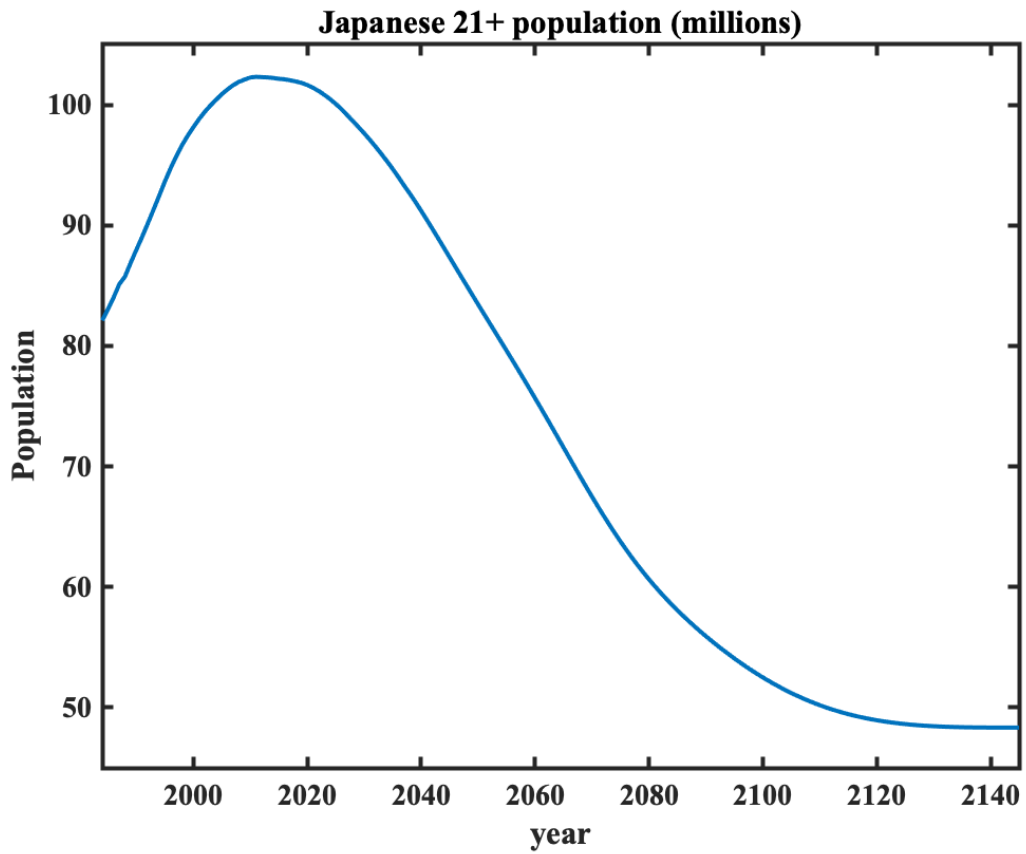
*These are the authors' personal views and not those of the Bank of Japan or Federal Reserve System.

Aging, interest rates and deflation (and secular stagnation).

- Common features of high income economies between 1990–2019.
  - Real interest rate has experienced steady declines (real return on physical capital and/or natural real interest rate).
  - The inflation rate has also experienced a slow but steady decline.
  - The nominal interest rate has declined to its effective lower bound.
  - Secular stagnation. Per capita output growth is persistently below previous trend.
- What forces are responsible for these secular patterns?

Advanced countries are experiencing large, persistent demographic transitions. Case of Japan.



- Aging of babyboomers, lower birth rates, longer life expectancy imply:
  - Japanese population is projected to decline by 40 million.
  - Peak old-age dependency ratio will exceed 70% (70 of 100 people older than age 68).

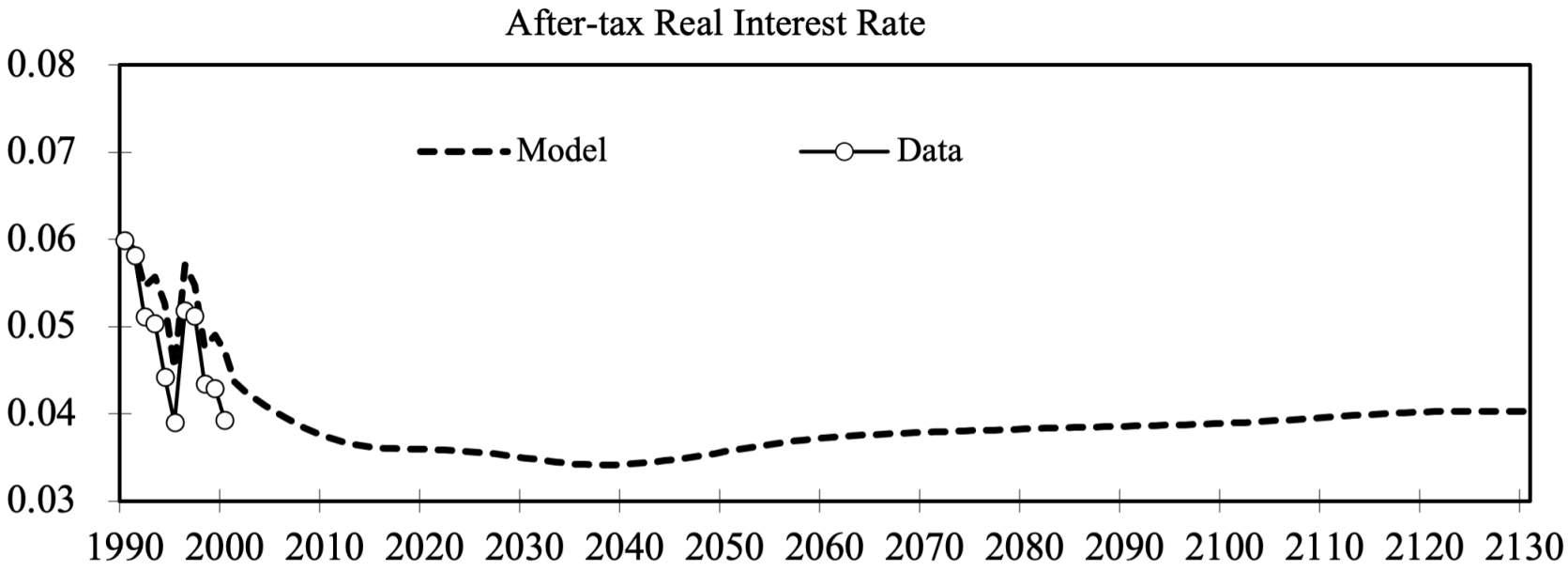
Our hypothesis

- Japan's demographic transition is putting steady significant downward pressure on:
  1. the real interest rate.
  2. the inflation rate.
  3. the nominal interest rate.
  4. growth rate of per capita output.
- We use the model of Braun and Ikeda (2021) to assess this hypothesis.

Our hypothesis is controversial among economists

1. Real interest rate Our claim is at odds with Mian, Straub and Sufi (2021) who assert secular decline in US natural interest rate is due to higher inequality.
2. Inflation rate Our claim is also inconsistent with standard theory (see e.g. Bullard, Garriga and Waller, 2014).
   - Modified golden rule: $f_k(k) - \delta - n = \rho$ where ρ is subjective rate of time preference.
   - A steady-state with lower population growth $n' < n$, implies a more aged population has $f_k(k') < f_k(k)$.
   - Real return on money is: $1/(1+\pi) = f_k(k) + 1 - \delta$
   - Thus, slower population growth, $n' < n$, should produce a higher inflation rate, $(\pi' > \pi)$.
3. nominal interest rate
   - Central bank targets the nominal interest rate. Response of monetary policy may matter too: $(1+R)/(1+\pi') = f'(k') + 1 - \delta$.

The case for aging: a lower real interest rate



Source: Braun, Ikeda and Joines (2008)

- Real interest rate projections for years 2001-2132 from a computational OG model using demographic projections from IPSS.
- Three channels of aging: lower fertility rates, higher life expectancy and aging of baby boomers.

Real interest rate co-movements with inflation are a puzzle for theory.

- Bullard, Garriga and Waller (2012) argue that aging can also produce a decline in the inflation rate.
- In their OG framework with capital, there is conflict between age groups about the appropriate value of the real interest rate.
  - Old prefer high real interest rate (low inflation rate).
  - Young prefer low real interest rate (high real wage and high inflation rate).
  - Slower population growth increases fraction of old and their influence in redistribution. Transition exhibits high real interest rate and low inflation rate.
- The puzzle. Aging is deflationary in their model only when the real interest rate is high (see also Katagiri, Konishi and Ueda, 2020).

$$1/(1+\pi) = f_k(k) + 1 - \delta$$

Today's talk

- Resolve the puzzle. Show that aging in the quantitative lifecycle framework of Braun and Ikeda (2021) predicts concurrent declines in: the real interest rate, the inflation rate and the nominal interest rate.
- Secular stagnation. Show that aging also produces below trend growth in per capita GDP in our model.
- Key insight. Price level and inflation are determined by the private sector's net demand for liquid assets and the real return on capital is only one factor that influences net demand for liquid assets. Dynamics of age distribution, monetary and fiscal policy also matter!
- Methodology Feed a demographic transition through the model and assess how the real interest rate, the inflation rate and the nominal interest rate evolve over time.

Quick summary of Braun and Ikeda (2021)

- Measurement Construct household age profiles of net-worth, liquid assets and illiquid assets.
- Theory Propose a computable OLG NK model that
  1. reproduces Japanese age profiles of earnings, net worth and its composition.
- Main results
  1. The **sign** and **persistence** of a household's consumption response MP depends on its age.
  2. Modeling the lifecycle enhances the empirical performance of the model's aggregate responses to MP relative to HANK.

The model: overview

- Finite lifetimes (individuals aged 21-120) with age dependent variation in:
  - family scale (one adult, age dependent fraction of children)
  - efficiency of labor
  - public pension income
  - survival risk.
- Overlapping generations
- Fiscal and monetary authorities
  - Nominal debt.
  - Inflation.
  - Redistribution
- General equilibrium (closed economy).

The Model: environment

- Model period 1 year, physical capital, labor and time–varying population–age distribution,
- Demographic distribution, $N_t^j, j = 1, ..., J, t = 0, 1, 2, 3...$ is determined by:
  1. Initial age-distribution $N_0^j, j = 1, ...J$
  2. Sequence of survival probabilities ψ_t^j
  3. Sequence of birth rates $N_t^0, t = 1, 2, 3, ...$

Firms

1. Intermediate goods (monopolistic competition)
   - face quadratic price adjustment costs.
   - rent labor and physical capital
   - produce heterogenous intermediate goods.
2. Final goods (perfect competition)
   - Purchase all varieties of intermediate goods.
   - Produce homogenous final good (consumption and investment).
3. Mutual funds (perfect competition)
   - Own market portfolio of physical capital and shares in intermediate good firms.
   - Sell shares of mutual fund to households.

Government

- Fiscal authority
  - Taxes consumption, labor and assets.
  - Issues constant amount of *nominally* denominated debt each period.
  - Government purchases
  - Lumpsum transfers adjust to close the government budget constraint.
  - Pay-as-you-go public pension plan.
- Monetary authority
  - Sets the *nominal interest rate* on government debt and other liquid securities (private iou's).
  - Nominal interest rate targeting rule:

$$\log\left(\frac{R_t}{R}\right) = \rho_r \log\left(\frac{R_{t-1}}{R}\right) + (1-\rho_r)\phi_\pi \log(\pi_t) + \epsilon_t$$

Overview of household problem

- Uninsured idiosyncratic risk.
  - Only idiosyncratic risk is mortality risk. Observe death event at beginning of the period.
  - Two types of households in any age group.
- Aggregate risk.
  - Don't anticipate aggregate shocks. Innovation to demographic distribution is a MIT shock.
- Asset allocation problem: save or borrow liquid assets, save using illiquid assets.
- Labor supply varies with aggregate state but is not an individual choice variable.
- State-dependent convex costs of adjusting a household's holdings of illiquid assets.
- No bequest motive.

Consumption-Savings

$$U_j(a_{j-1,t-1}, d_{j-1,t-1}, z_{j,t}) = \max_{\{c_{j,t}, a_{j,t}, d_{j,t}\}} \Big\{ u(c_{j,t}, h_t; \eta_j) + \beta z_{j,t} \left[(1-\psi_{j+1}) U_{j+1}(a_{j,t}, d_{j,t}, 0) + \psi_{j+1} U_{j+1}(a_{j,t}, d_{j,t}, 1) \right] \Big\},$$

For survivors ($z_{j,t} = 1$) s.t.

$$(1+\tau^c)c_{j,t} + a_{j,t} + \chi(a_{j,t}, a_{j-1,t-1}, 1) + d_{j,t} \leqslant \tilde{R}_t^a a_{j-1,t-1} + \frac{\tilde{R}_{t-1}}{\pi_t} d_{j-1,t-1} + (1-\tau^w) w_t \epsilon_j h_t + b_{j,t} + \xi_t,$$

In death year ($z_{j,t} = 0$) s.t.

$$(1+\tau^c)c_{j,t} = \tilde{R}_t^a a_{j-1,t-1} + \frac{\tilde{R}_{t-1}}{\pi_t} d_{j-1,t-1} + (1-\tau^w) w_t \epsilon_j h_t + b_t + \xi_t - \chi(0, a_{j-1,t-1}, 0).$$

Notes on consumption-savings decisions

- Households purchase shares in mutual funds, $a_{j,t}$ that hold the market portfolio of illiquid assets:
  - equity in intermediate good firms,
  - physical capital.
- Natural borrowing constraint on $d_{j,t}$.
- Liquidity premium. In most situations $a_{j,t} > 0$
- No utility from illiquid assets.

Labor Supply

- Efficiency units of labor, ϵ_j, depend on age.
- Hours worked are set by benevolent labor unions.
- Hours worked are identical for workers of all ages 21–67 and set according to:

$$(1-\tau^w)\bar{\epsilon}w_t = \theta_w \upsilon \bar{\lambda}_t^{-1} h_t^{\frac{1}{\nu}}.$$

- hours h_t vary with the aggregate state.
- Mandatory retirement at age 68.

A novel feature of general equilibrium

Price level is determined in equilibrium and both fiscal and monetary policy both influence it.

- Fiscal policy
  - Ricardian equivalence doesn't obtain in our economy. Government debt is net wealth from the perspective of the private sector (Barro, 1974).
  - A change in the stock of nominally denominated government debt affects real allocations and the price level (Hagedorn, 2018).

$$D^g/P_t = \sum_j d^p_{j,t} N_{j,t}$$

- Monetary policy A surprise increase in the nominal interest rate (constant stock of nominal government debt), crowds out private capital formation, pushes down the price level and increases the real interest rate on government debt (Hu, Ma, Qiao and Wallace, 2019).

Steady–state asset allocation by age model and data in Braun and Ikeda (2021)

Net worth, liquid and illiquid asset holdings by age relative to income of households aged 50–59

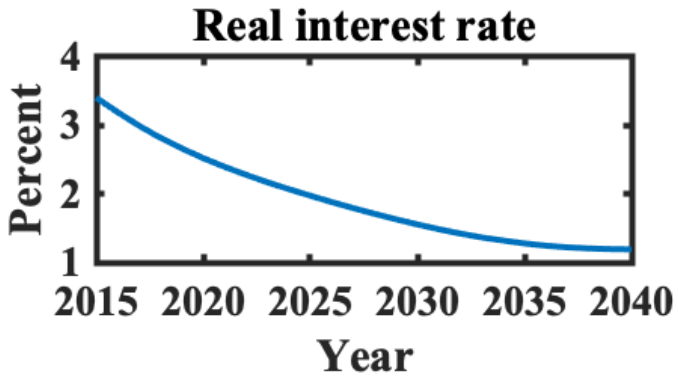
	Net Worth		Liquid assets		Illiquid assets	
Age	Model	Data	Model	Data	Model	Data
Under 30	0.01	0.65	-0.63	-0.08	0.64	0.73
30–39	0.88	1.60	-0.85	-0.58	1.73	2.18
40–49	2.85	2.58	0.19	-0.31	2.65	2.90
50–59	5.54	4.52	2.23	0.76	3.31	3.76
60–69	7.27	6.29	3.63	1.70	3.64	4.60
70+	4.16	6.01	0.94	1.77	3.22	4.25

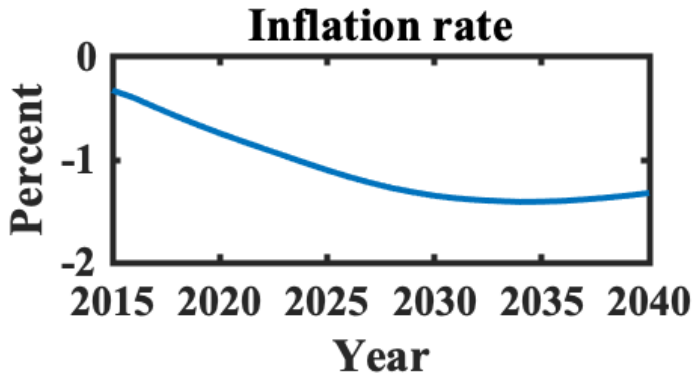
Data source: Our computations from 2014 NSFIE.

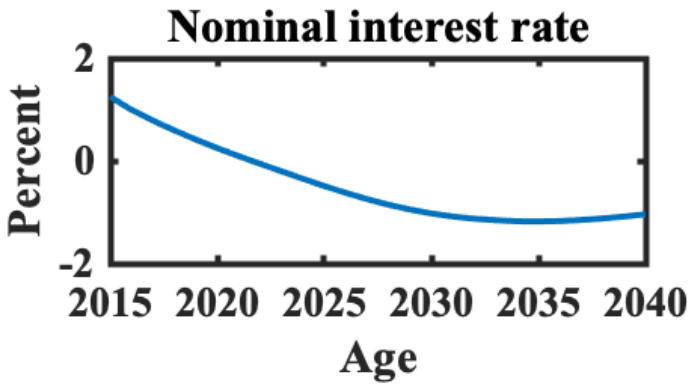
Data and conditioning assumptions for demographic transition

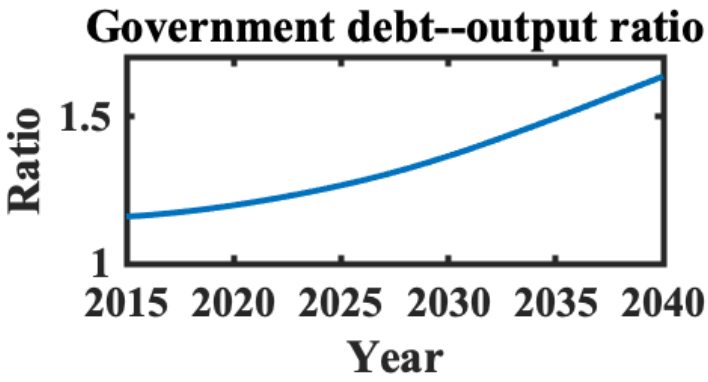
- Population by age for years 2014–2060 from IPSS.
  1. Initial age distribution.
  2. Future birth rates
  3. Future survival probabilities.
- Other conditioning assumptions
  - Nominal per-capita government debt fixed in all periods.
  - Government budget constraint closed by adjusting the lumpsum tax each period.
  - Monetary authority: nominal interest rate targeting rule with an autoregressive coefficient of 0.35 and inflation coefficient of 2

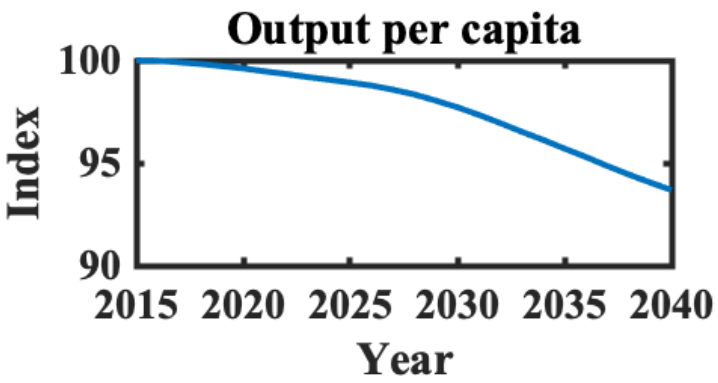
Main Result: Aging, inflation and interest rates











Intuition for low interest rates and inflation: asset demand

In this economy the price level is determined by the private sector's aggregate net demand for liquid assets:
$D_t^g/P_t = s_t^h - d_t^h$
where assets are per capita and,
D_t^g, Aggregate nominal government debt
P_t, Price level
s_t^h, real household aggregate savings in liquid securities
s_t^h, real household aggregate debt in liquid securities

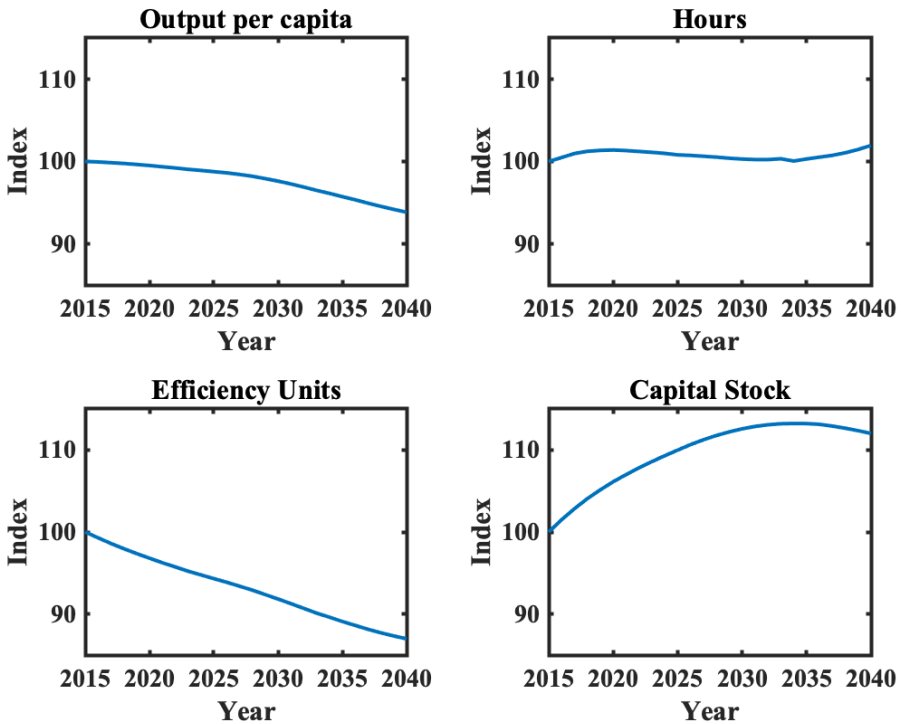
During the demographic transition household net demand for liquid securities goes up over time.

Intuition for low inflation and interest rates: Fisher equation

What is wrong with standard theory?

- Standard theory:
  $(1 + R')/(1 + \pi') = f_k(k') + 1 - \delta$
- In this model we have (approximately):
  $\frac{1+R'}{1+\pi'} = \frac{f_k(k')+1-\delta+\gamma_a \Delta a_{j+1,t+1}}{1+\gamma_a \Delta a_{j,t}}$
  - γ_a governs the cost of adjusting illiquid assets.
  - $a_{j,t}$ is holdings of illiquid assets by a household of age j in period t.
  - Wedge between household demand for liquid and illiquid assets, depends on it's age and date (survival risk, liquidity premium).
  - Fraction of different aged households varies by date.

Secular Stagnation



- Hours per worker flat.
- Hours in efficiency units exhibit steady decline due to aging.
- Capital deepening (real interest rate declines).

Contributing Factors: demographics

- Recall: age distribution depends on three factors.
  1. Aging of baby boomers (initial age distribution).
  2. Longer life expectancy
  3. Lower birth rates.
- What is the role of each factor in producing deflation and secular stagnation?

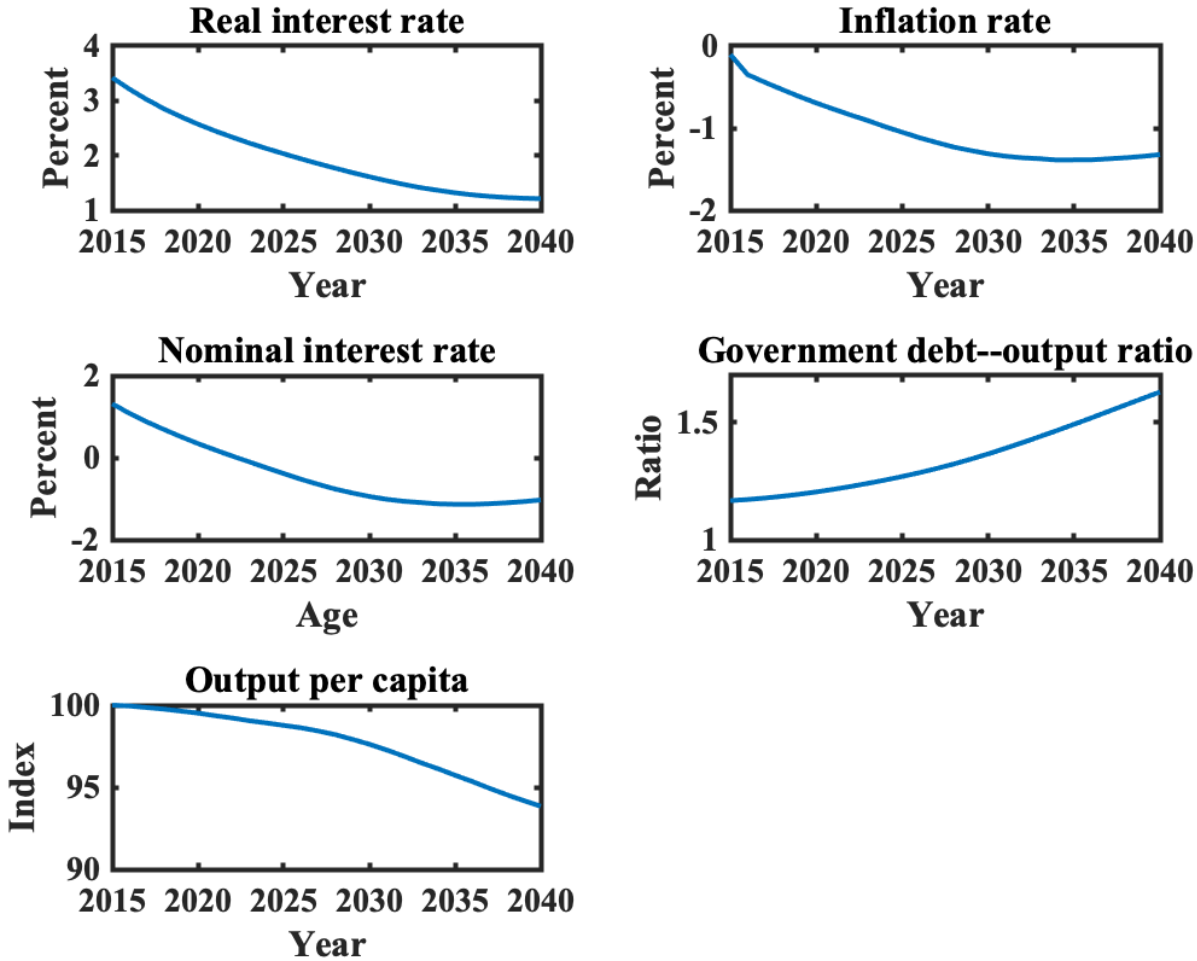
	Babyboomers	Longer Lifespans	Lower Births	Overall
r_k (p.p. change)	-2.025	-0.08	-0.59	-1.85
π (p.p. change)	-0.93	-0.12	-0.51	-1.03
R (p.p. change)	-1.66	-0.26	-0.96	-2.27
y (% change)	-4.49	-0.64	1.47	-2.29
d/y (change)	0.25	-0.01	0.04	0.22
ξ/y (change)	-0.04	0.00	-0.01	-0.02

*Changes between the years 2015 and 2030. ξ- lumpsum transfers.

- Compare with Katagiri, Konishi and Ueda (2020).

Contributing factors: Nominal rigidities?

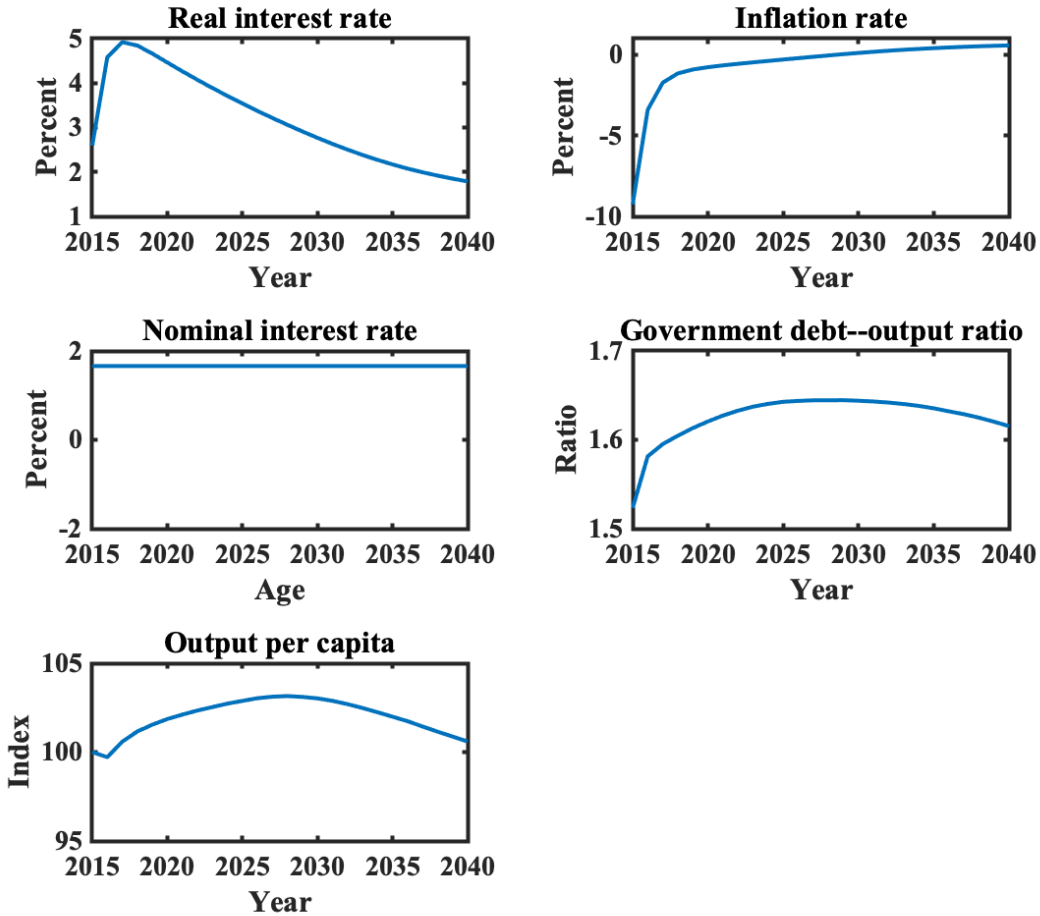
Demographic transition with flexible prices.



- Nominal rigidities are not important for these results.

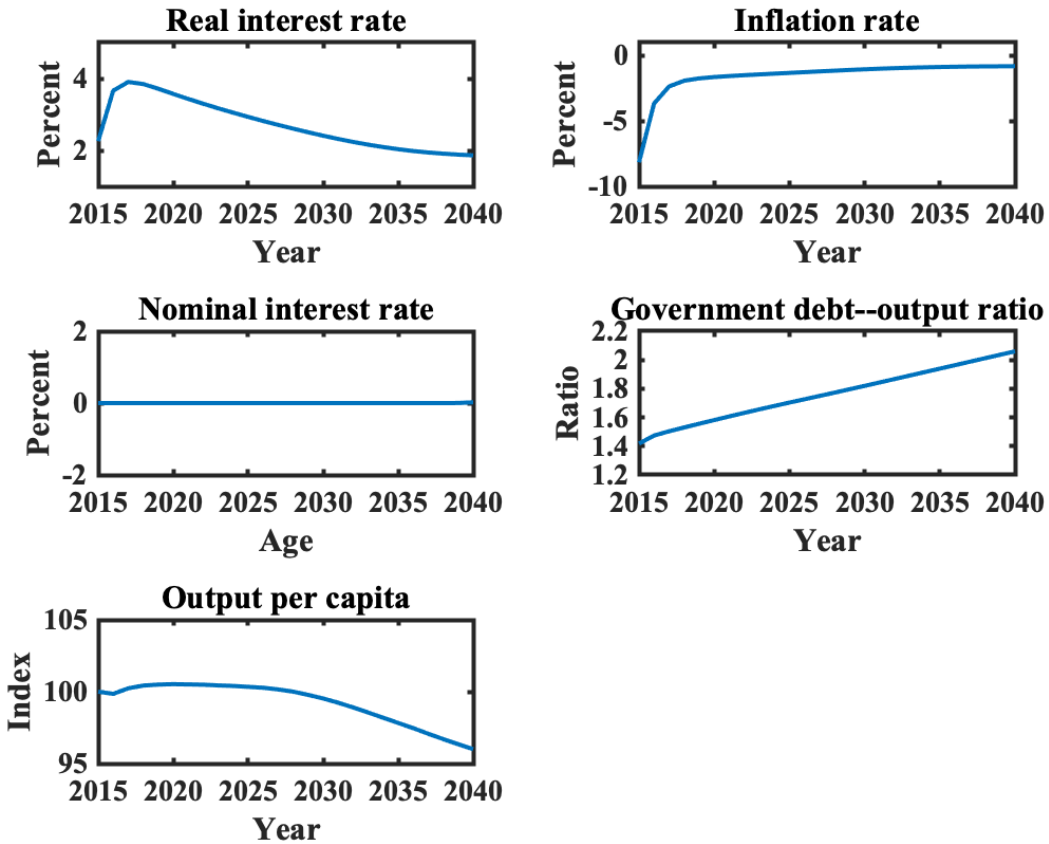
Contributing Factors: Monetary policy feedback rule

- Suppose instead nominal interest rate is fixed $\forall$ t.



- Negative correlation between real interest rate and inflation rate.

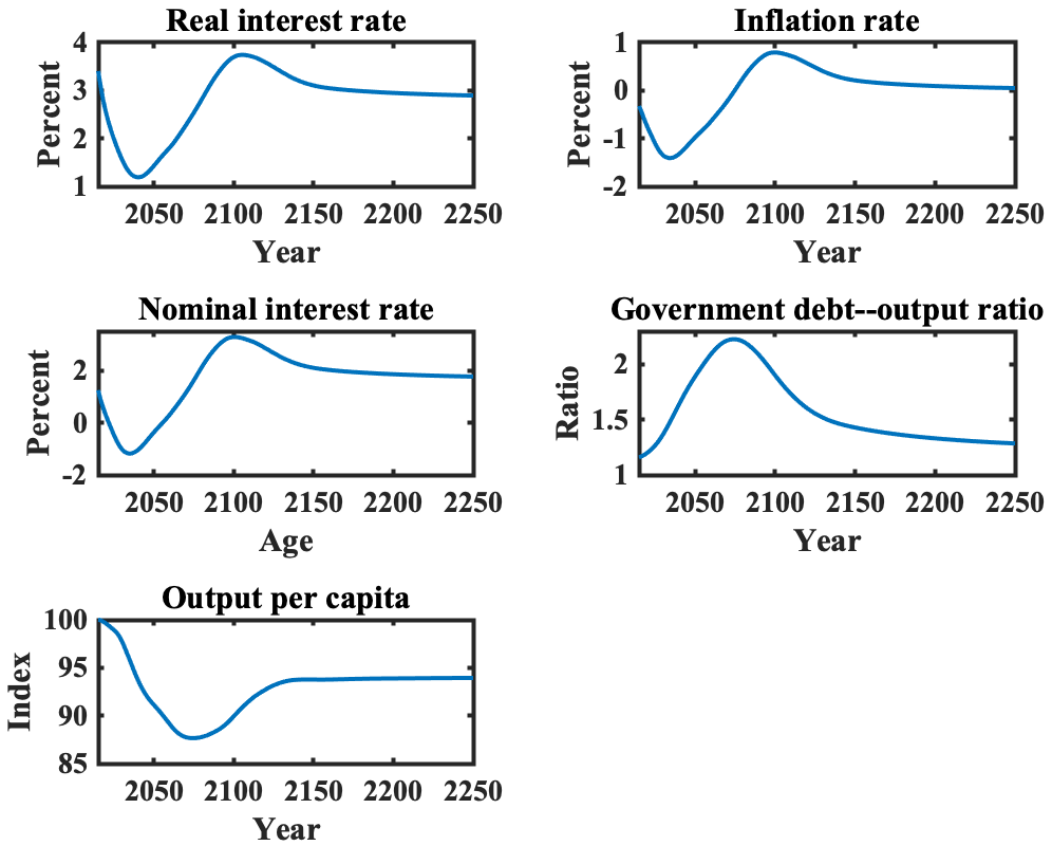
Monetary Feedback rule ZLB imposed.



- Negative correlation of real rate and inflation rate.
- Deflation is now much more persistent.
- Response of debt-output ratio is much larger.
- Secular stagnation.

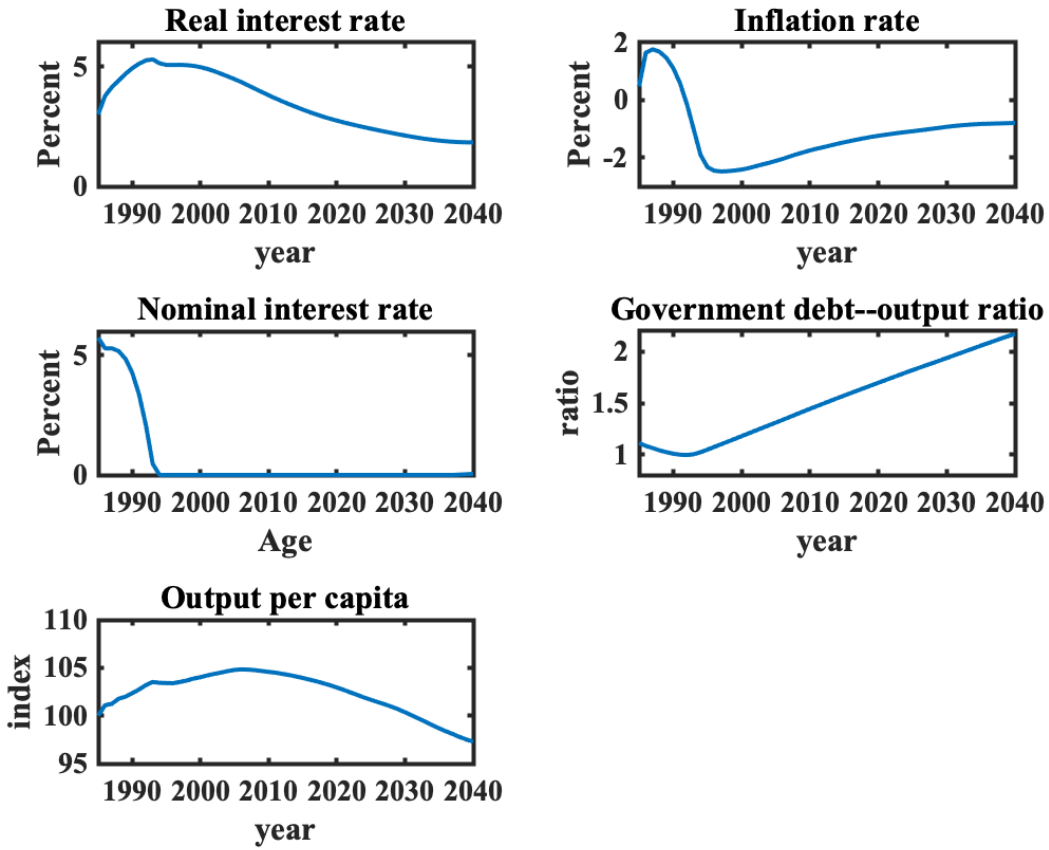
Unpleasant monetarist arithmetic

- Terminal condition assumes (P=1). Thus, deflation is followed by a period of inflation.



Robustness: Starting Year

- Demographic transition is starts from 1983 and ZLB is imposed.



Concluding Remarks

- In our model the choice of the monetary policy feedback rule has large macro effects during a demographic transition.
- Our current results are consistent with the following narrative:
  - Monetary policy has accommodated downward pressure on the real or "natural" interest rate induced by aging.
  - QE is been reasonably successful in undoing ZLB constraint.
- In our model the specification of the monetary policy feedback rule also has large and heterogenous impacts on the welfare of members of different cohorts.
- This is work in progress. Some outstanding issues:
  - fiscal policy.
  - expectations.