Demographic Change and Government Debt: The Impact of Bond Purchases by the Bank of Japan

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Figure: Net Debt to GNP Ratio
Hansen and Imrohoroglu (2016) use general equilibrium growth model to evaluate the fiscal implications of aging in Japan.

Government expenditures from 2011 to 2050 attributable to an aging population estimated by Fukawa and Sato (2009).

Finding: Projected expenditures will lead to Japanese debt relative to output to exceed 250 percent in 2021.

Tax increase in the range of 30 to 40 percent of aggregate consumption needed to achieve fiscal sustainability.
This Paper

Why has Japan been successful in stabilizing debt?

Consider more recent data (2011-2019).

Factors:

- Spending temporarily below forecasts from Fukawa and Sato (2009).
- Interest rates on government debt below that in Hansen and Imrohoroglu (2016).
- BOJ purchases of government debt means interest payments returned to government.
BOJ Purchases of JGB’s

Figure: BOJ Holdings of JGBs
Outline of Presentation

1. Related Literature
2. Government Expenditures and Total Factor Productivity: Assumed vs. Reality
3. Model (modified to allow for BOJ purchases of JGB’s)
4. Data and Calibration (income tax rates different)
5. Results
6. Conclusion (stabilization is temporary)
Implications of Fukawa and Sato (2009)
- Increases in health care and pension spending resulting from aging.
- A 7 percent increase in government spending to output from 2010 to 2050.

Literature associated with Broda and Weinstein (2005)
- Use spending estimates that are considerably more optimistic.
- Find that current tax rates are close to being sufficient to stabilize debt.
- Doi (2008), Doi, Hoshi and Okimoto (2011) and Bamba and Weinstein (2021).
Life cycle model with details of Japanese pension and health care programs to endogenously compute the fiscal costs associated with an aging Japan.

- Find spending increases due to aging similar to Fukawa and Sato (2009).
Total Factor Productivity

\[ TFP_t = \frac{Y_t}{(K_t^\theta h_t^{1-\theta})}, \text{ where } \theta = 0.3783 \]
Higher than anticipated TFP growth cannot explain success in stabilizing debt.
Government Purchases and Transfer Payments

- Purchases were higher than forecasted in 2011-2019.
- Transfer payments were lower than forecasted.
Japan spent less from 2012 to 2018 than predicted.

2019 implies lower spending may have been temporary.
Model Features

- One sector neoclassical growth model. No uncertainty.
- Bonds in utility function.
  - Captures convenience yield as in Krishnamurthy and Vissing-Jorgensen (2012).
- BOJ is agency external to the model that purchases JGB's and returns interest payments to government.
  - Balance sheet of central bank not modeled.
  - Inflation not modeled.
- Government collects tax revenue, purchases goods ($G_t$), makes transfer payments ($TR_t$), and issues debt ($B_{t+1}$) to satisfy its budget constraint.
Model Features—continued

Exogenous variables:

- $A_t$ TFP, $\gamma_t$ associated growth factor.
- $N_t$ population, $\eta_t$ associated growth factor.
- $G_t$ and $TR_t$
- Tax rates, $\tau_{c,t}$, $\tau_{k,t}$, $\tau_{h,t}$ and $\tau_{b}$
- $\lambda_t$ fraction of government debt held by central bank.

Endogenous variables:

- $B_{t+1}$ government bonds, $q_t$ associated price.
- $D_t$ lumps sum tax to retire debt when $B_t / Y_t$ becomes too large.
- $h_t$, $K_{t+1}$, $C_t$ and $Y_t$.
- $W_t$ and $r_t$ – wage rate and return to capital.
Government Budget

- $B_{t+1} = B_{t+1}^h + B_{t+1}^c$.
- $B_t^h = (1 - \lambda_t)B_t$ and $B_t^c = \lambda_t B_t$
- Government budget constraint:

$$G_t + TR_t + B_t = \eta_t q_t B_{t+1} + \tau_{c,t} C_t + \tau_{h,t} W_t h_t + \tau_{k,t} (r_t - \delta) K_t + (\tau_{b,t} (1 - \lambda_t) + \lambda_t) (1 - q_{t-1}) B_t + D_t.$$
Debt Sustainability Rule

Let \( \overline{b} = \overline{B}_t / \overline{Y}_t \) be the steady state bond to output ratio:

\[
D_t = \begin{cases} 
\kappa(B_t - \overline{B}_t) & \text{if } B_s / Y_s \geq b_{\text{max}} \text{ for some } s \leq t, \\
0 & \text{otherwise.}
\end{cases}
\]

\( \kappa > 0 \) is chosen to be as small as possible so that \( B(t) / Y(t) \) converges to \( \overline{b} \).
Household’s Problem

Given $K_0$ and $B_0^h$, choose $\{C_t, h_t, K_{t+1}, B_{t+1}^h\}_{t=0}^{\infty}$ to

$$\max \sum_{t=0}^{\infty} \beta^t N_t [\log C_t - \alpha \frac{h_t^{1+1/\psi}}{1 + 1/\psi} + \phi \log(\mu_t + B_{t+1}^h)]$$

subject to

$$(1 + \tau_{c,t})C_t + \eta_t K_{t+1} + q_t \eta_t B_{t+1}^h = (1 - \tau_{h,t}) W_t h_t$$
$$+ [(1 + (1 - \tau_{k,t})(r_t - \delta)) \bar{K}_t$$
$$+ [1 - (1 - q_{t-1})\tau_{b,t}] B_t^h + TR_t - D_t,$$

and $\mu_t = \mu A_t^{1/(1-\theta)}$. 
Technology

A stand-in firm operates a constant returns to scale Cobb-Douglas production technology:

\[ Y_t = A_t K_t^\theta h_t^{1-\theta} \]

Capital depreciates at the rate \( \delta \).
Equilibrium

Given all exogenous sequences and a debt sustainability rule \( \{\kappa, \bar{b}, b_{\text{max}}\} \), a competitive equilibrium consists of an allocation \( \{C_t, h_t, K_{t+1}, B_{t+1}\}_{t=0}^{\infty} \), factor prices \( \{W_t, r_t\}_{t=0}^{\infty} \) and the bond price \( \{q_t\}_{t=0}^{\infty} \) such that

- the allocation solves the household’s problem,
- the allocation and factor prices satisfy:
  \[ W_t = (1 - \theta)A_t K_t^\theta h_t^{-\theta} \quad \text{and} \quad r_t = \theta A_t K_t^{\theta-1} h_t^{1-\theta}, \]
- the government budget is satisfied,
- the value of \( \kappa \) is sufficiently large to guarantee convergence of \( B_t/Y_t \) to \( \bar{b} \),
- the market for bonds clears, \( (1 - \lambda_{t+1})B_{t+1} = B^h_{t+1} \)
- and the goods market clears:
  \[ C_t + [\eta_t K_{t+1} - (1 - \delta)K_t] + G_t = Y_t. \]
Calibration Strategy

- Use methodology from Cooley and Prescott (1995) and more directly, Hayashi and Prescott (2002).
- Calibration would be identical to that paper except different tax rates are used and this affects other parameters.
  - Income tax rates computed using different method.
  - $\tau_c$ was supposed to increase to 10% in 2015. Instead was increased in 2020.
Data

- National income accounts are constructed as in Hayashi and Prescott (2002).
- $Y_t$ is Gross National Product, investment includes net exports with net factor payments from abroad.
- $N_t$ is working age population aged 20-69. Official projections used to extend to 2050 after which constant.
- $h_t$ is employment multiplied by average weekly hours divided by 98.
- $G_t$ includes all in kind transfers such as health care.
- $TR_t$ is mostly pensions and other net transfers minus net indirect taxes.
**Tax Rates**

- $\text{REV}_{\tau_h}$ is revenue from labor income taxes.
- $\text{REV}_{\tau_k}$ is revenue from corporate income taxes.
- $\text{REV}_{\tau_h} = \tau_h W h = \tau_h (1 - \theta) Y$
- $\text{REV}_{\tau_k} = \tau_k (r - \delta K) = \tau_k \left( \theta - \delta \frac{K}{Y} \right) Y$
- $\tau_{b,t} = 0.2$ for all $t$. 
\( \tau_h \) and \( \tau_k \) are constant at 2019 values from 2020 and beyond.
BOJ Holdings of Net Debt
Preference Parameters

\[ \beta_t = \frac{(1 + \tau_{c,t+1}) \gamma_t^{1/(1-\theta)} c_{t+1}}{(1 + \tau_{c,t}) c_t \left[ 1 + (1 - \tau_{k,t+1}) \left( \theta \frac{y_{t+1}}{k_{t+1}} - \delta \right) \right]} \]

\[ \alpha_t = \frac{h_t^{-1/\psi} (1 - \tau_{h,t}) (1 - \theta) y_t}{(1 + \tau_{c,t}) c_t h_t} \]

\[ \phi_t = \eta_t (\mu + b_{t+1}^h) \left[ \frac{q_t \gamma_t^{1/(1-\theta)}}{(1 + \tau_{c,t}) c_t} - \beta_t \frac{1 - (1 - q_t) \tau_{b,t+1}}{(1 + \tau_{c,t+1}) c_{t+1}} \right] . \]

- Need to recalibrate due to new tax rates.
- Need empirical counterpart to \( q \).
$F_t$ is GNP deflator and $P_t$ is interest payments.

$$q_t = \frac{B_{t+1}/F_t}{(B_{t+1} + P_{t+1})/F_{t+1}}.$$
## Parameter Values

**Table: Calibration of Structural Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Source/Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\gamma$</td>
<td>$1.015^{1-\theta}$</td>
<td></td>
</tr>
<tr>
<td>$\eta$</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>$\theta$</td>
<td>0.3783</td>
<td>Sample Average, 1981-2010</td>
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<tr>
<td>$\delta$</td>
<td>0.0842</td>
<td>Sample Average, 1981-2010</td>
</tr>
<tr>
<td>$\beta$</td>
<td>0.9502</td>
<td>Sample Average, 1981-2010</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>24.4438</td>
<td>Sample Average, 1981-2010</td>
</tr>
<tr>
<td>$\psi$</td>
<td>0.5</td>
<td>Chetty et al (2012)</td>
</tr>
<tr>
<td>$\phi$</td>
<td>0.1273</td>
<td>Sample Average, 1981-2010</td>
</tr>
<tr>
<td>$\mu$</td>
<td>1.1</td>
<td>Fit $q_t$ for 1981-2010</td>
</tr>
</tbody>
</table>
Government Revenue

Revenue from 2011 to 2019 is from forecasted tax rates.
Interest Payments on Government Debt

Figure: Net Interest Payments (% of GNP)
Experiments

- Experiment 0 – Forecasts of TFP, government expenditures and tax rates used for 2011-2019.
- Experiment 1 – Actual values of above in place of assumed values.
- Experiment 2 – Recalibrate $\phi$ using average from 2005-2019 when interest rates were low.
- Experiment 3 – BOJ holdings of debt introduced.
- Experiment 3A – Same as Experiment 3 except $\lambda$ stays constant at 2020 level.
- $\phi = 0.127$ in Ex. 0 & 1, $\phi = 0.167$ in Ex. 2, and $\phi = 0.143$ in Ex. 3.
Government Spending

**Figure:** $(G + TR)$ to GNP Ratios: 1981-2040
Debt to Output Ratios (Experiment 0)

Figure: Debt to GNP Ratios: 1981-2060

$B/Y$ reaches 250% in 2022.
Debt to Output Ratios (Experiment 1)

Figure: Debt to GNP Ratios: 1981-2060

$B/Y$ reaches 250% in 2025.
Debt to Output Ratios (Experiment 2)

Figure: Debt to GNP Ratios: 1981-2060

$B/Y$ reaches 250% in 2030.
Debt to Output Ratios (Experiment 3)

Figure: Debt to GNP Ratios: 1981-2060

$B/Y$ reaches 250% in 2039.
Interest Rates on JGB’s
Interest Payments on Debt

Figure: Interest Payments to GNP Ratios: 1981-2040
Hansen and Imrohoroglu (2016) (and other papers) found that government debt to output would reach unprecedented levels in the early 2020’s without significant spending reductions and/or tax increases.

Japan has been successful in stabilizing debt due to lower spending, low interest rates and a cooperative Bank of Japan.

We find that this stabilization (without further fiscal policy changes) can only be temporary.

Puzzle: Japanese debt was stable beginning in 2012. In our simulations, debt is stable beginning in 2014.