More gray, more volatile?
Aging and (optimal) monetary policy

Authors: Dániel Baksa and Zsuzsa Munkácsi
Presented by: Zsuzsa Munkácsi (SPR)

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A heavier lift
By 2050, Japan’s old-age dependency ratio will rise to near 75 percent, among the highest in the world.
(ratio of population over age 65 to population aged 15-64)


Source: blogs.imf.org
Policy relevance of aging

- William C. Dudley, the President of the FED of New York in 2012:
  - "...the weaker than expected recovery [since the recent crisis] likely lies in the interplay between secular and cyclical factors”, and
  - "demographic factors have played a role in [that]."

- Aging is a challenge: it changes the relative and absolute size of cohorts, and cohorts behave differently

- Policy relevance:
  - there is an obvious impact on the public budget (more pensioners, higher pension spending, smaller labor force, lower tax revenues, etc.)
  - the relation between aging and monetary policy is less obvious

- We examine, based on a DSGE-OLG model - parametrized for a standard advanced economy - how aging affects:
  - inflation and inflation volatility in the longer term,
  - the short-term cyclical behavior of the economy,
  - the transmission channels of monetary policy,
  - and optimal policies of central banks
Empirical literature

Contradictory empirical findings:

- Aging reduces inflation: see e.g. Anderson et al. (2014) and Yoon et al. (2014)
- Aging increases inflation (i.e. age-structure-inflation puzzle): see Juselius and Takats (2015, and 2016)

Our contribution:

- We provide empirical evidence that aging reduces inflation.
- We also provide empirical evidence for higher inflation volatility in graying societies. According to our knowledge, our paper is the first to do so.
Theoretical literature

Our contribution:

- Our model, in line with our empirical findings, suggests that aging reduces inflation and increases inflation volatility in the longer term. To the best of our knowledge, our paper is the first to look into such issues using a general equilibrium framework.

- We also believe that our work is the first to discuss, using a DSGE-OLG model, how aging affects the short-term cyclical behavior of the economy and the transmission channels of monetary policy.

- The closest to our framework is Wong (2018) which is a partial equilibrium model.

- To the best of our knowledge, we are the first who examine the interplay between aging and optimal monetary policies, too.
References

♦ OGRE = Overlapping Generations and Retirement

♦ Original papers:

♦ Follow-up works:
Structure of OGRE

- A small open-economy DGE model with demography, overlapping generations (Gertler-type), unemployment and labor market rigidities, informality, and a detailed fiscal & pension block (both PAYG & fully funded)
  - short- and long-term macroeconomic impact of demographics, fiscal and pension reforms, and pension regime switches
  - single policies, reform packages, sequencing
- Small open-economy (with reexports)
- Two cohorts: young (workers, unemployed) and old (pensioners)
- Fiscal sector: several public revenue and spending items, incl. pensions; the government can issue bonds
- Rotemberg price adjustment costs and Taylor rule for monetary policy
- Informal labor and product markets; informality = tax evasion and avoiding regulations in labor and goods markets
Main channels of OGRE

- New workers
- Workers
- Just-retired
- Retired

Lump-sum taxes to Government (financing the PAYG pension system and other expenditures)

PAYG: pensions based on replacement rate and previous labor income
Main modifications

- Closed-economy framework
- Simple fiscal block with lump-sum taxes
- No unemployment
- No informal sector
- Additional rigidities:
  - consumption habit
  - Calvo wage rigidity
  - Calvo price rigidity (instead of Rotemberg price rigidity)
Main channels

1. Wealth effect and cohort-specific consumption-savings decisions

2. Age-dependent elasticities of intertemporal substitution (CRRA utility function with $\gamma = 2$ and $\sigma = 0.6$ following Wong (2015)):

$$\epsilon^Y = \frac{1}{1 + \sigma(\gamma - 1)} = 0.625$$

$$\epsilon^O = \frac{1}{\gamma} = 0.5$$

3. Frisch-elasticity (consistent with micro estimates - less than 1 -, and sensitive to aging (declines to 0.2 as OADR increases to 60 percent)):

$$\eta^Y = \frac{s^Y - L}{L} \frac{1 + \sigma(\gamma - 1)}{\gamma} = 0.44$$
Role of monetary policy
The model’s behavior in the steady state and empirics

- The demographic transition from a younger to an older society implies lower inflation in the longer term IRFs.
- Using data on developed economies we find that periods of disinflation correspond with periods of increases in the old-age dependency ratio Figure.
The model’s behavior around the steady state

- Interest rate (p.p.)
- Monetary policy shock
- Inflation (ar, %, QoQ)
- Output gap (%)

- Interest rate (p.p.)
- Government consumption shock
- Inflation (ar, %, QoQ)
- Output gap (%)

- Monetary policy shock - details
- Government consumption shock - details
Panel estimation: CPI volatility and the dependency ratio

FGLS estimator (Rother, 2004):

\[
\sigma(cpi_{-}core)_{it} = \alpha_i + \delta_t + \beta OADR_{it} + \gamma X_{it} + u_{it}
\]

Core CPI means CPI without food and energy. \(X\) contains lag and output gap volatility. Sample covers OECD countries between 1993 and 2017.

<table>
<thead>
<tr>
<th>Models</th>
<th>FGLS(1)</th>
<th>FGLS(2)</th>
<th>FGLS(3)</th>
<th>FGLS(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\sigma(cpi_{-}core)_{i,t-1})</td>
<td>0.106***</td>
<td>0.101***</td>
<td>0.106***</td>
<td>0.09***</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.015)</td>
<td>(0.015)</td>
<td>(0.015)</td>
</tr>
<tr>
<td>(OADR_{it})</td>
<td>0.017***</td>
<td>0.018***</td>
<td>0.016***</td>
<td>0.015***</td>
</tr>
<tr>
<td></td>
<td>(0.0003)</td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>(\sigma(Y)_{it})</td>
<td>0.001***</td>
<td>0.001***</td>
<td>0.001***</td>
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<tr>
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<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
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<tr>
<td>Country FE</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Year FE</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>N.obs</td>
<td>793</td>
<td>793</td>
<td>759</td>
<td>759</td>
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<tr>
<td>(R^2)</td>
<td>0.24</td>
<td>0.23</td>
<td>0.31</td>
<td>0.33</td>
</tr>
</tbody>
</table>

*** is \(p < 0.1\%\), ** is \(p < 1\%\), * is \(p < 5\%\)
Welfare consequences

Welfare loss function

We assume the following welfare loss function (following Levin and Williams (2003), and Adolfson and Linde (2011)):

\[ L = \text{Var}(\pi) + 0.5 \text{Var}(\text{output gap}) + 0.2 \text{Var}(\Delta i) \]

where \( \text{Var} \) denotes unconditional variance.

<table>
<thead>
<tr>
<th>Old-age dependency ratios</th>
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<tbody>
<tr>
<td>( s = 0.30 )</td>
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<tr>
<td>Initial losses</td>
</tr>
<tr>
<td>Inflation:</td>
</tr>
<tr>
<td>Output gap:</td>
</tr>
<tr>
<td>Interest rate:</td>
</tr>
</tbody>
</table>

Note: Initial losses are normalized by the initial loss value of the case \( s = 0.3 \).
Monetary policy rules

\[ i_t = \rho i_{t-1} + (1 - \rho) \left\{ \begin{array}{l}
\phi_{\pi_t} \pi_t \\
\phi_{E_t} E_{t+1} \pi_{t+1} \\
\phi_{\pi_t} \pi_t + \phi_{\hat{Y}_t} \hat{Y}_t \\
\phi_{E_t} E_{t+1} \pi_{t+1} + \phi_{\hat{Y}_t} \hat{Y}_t \\
\phi_{\hat{P}_t} \hat{P}_t \\
\phi_{P_t} Y_t P_t Y_t \\
\end{array} \right\} \]

- Pure IT
- Pure IT & Fwd
- Flex IT
- Flex IT & Fwd
- Price level targeting
- Nominal GDP targeting
## Optimal reaction parameters

<table>
<thead>
<tr>
<th></th>
<th>Old-age dependency ratios</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>$s = 0.30$</td>
<td>$s = 0.35$</td>
<td>$s = 0.43$</td>
<td>$s = 0.60$</td>
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<tr>
<td>Initial rule</td>
<td>$\phi_{\pi_t}$</td>
<td>1.500</td>
<td>1.500</td>
<td>1.500</td>
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<tr>
<td>Pure IT</td>
<td>$\phi_{\pi_t}$</td>
<td>4.227</td>
<td>4.473</td>
<td>4.972</td>
</tr>
<tr>
<td>Pure IT &amp; Fwd</td>
<td>$\phi_{E_t\pi_{t+1}}$</td>
<td>6.856</td>
<td>7.152</td>
<td>7.749</td>
</tr>
<tr>
<td>Flex. IT</td>
<td>$\phi_{\pi_t}$</td>
<td>6.240</td>
<td>6.532</td>
<td>7.165</td>
</tr>
<tr>
<td></td>
<td>$\phi_{\gamma_t}$</td>
<td>3.572</td>
<td>3.502</td>
<td>3.378</td>
</tr>
<tr>
<td>Flex. IT &amp; Fwd</td>
<td>$\phi_{E_t\pi_{t+1}}$</td>
<td>6.639</td>
<td>6.957</td>
<td>7.553</td>
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<tr>
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<td>$\phi_{\gamma_{t+1}}$</td>
<td>3.228</td>
<td>3.135</td>
<td>2.947</td>
</tr>
<tr>
<td>Price level targ.</td>
<td>$\phi_{\rho_t}$</td>
<td>0.588</td>
<td>0.787</td>
<td>1.155</td>
</tr>
<tr>
<td>Nominal GDP targ.</td>
<td>$\phi_{\frac{p_t}{Y_t}}$</td>
<td>6.326</td>
<td>6.477</td>
<td>6.844</td>
</tr>
</tbody>
</table>
### Initial and optimal welfare losses

<table>
<thead>
<tr>
<th></th>
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</tr>
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<tbody>
<tr>
<td></td>
<td>$s = 0.30$</td>
</tr>
<tr>
<td>Initial losses</td>
<td>1.000</td>
</tr>
<tr>
<td>Pure IT: $\phi_{\pi_t}$</td>
<td>0.881</td>
</tr>
<tr>
<td>Pure IT &amp; Fwd: $\phi_{E_t \pi_{t+1}}$</td>
<td>0.831</td>
</tr>
<tr>
<td>Flex. IT: $\phi_{\pi_t}, \phi_{\hat{Y}_t}$</td>
<td>0.476</td>
</tr>
<tr>
<td>Flex. IT &amp; Fwd: $\phi_{E_t \pi_{t+1}, \phi_{\hat{Y}_t}}$</td>
<td>0.495</td>
</tr>
<tr>
<td>Price level targ.: $\phi_{\hat{P}_t}$</td>
<td>1.097</td>
</tr>
<tr>
<td>Nominal GDP targ.: $\phi_{\hat{P}_t \hat{Y}_t}$</td>
<td>0.486</td>
</tr>
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</table>

Note: Initial losses are normalized by the initial loss value of the case $s = 0.3$, while further values are normalized by their own initial loss values.
Aging redistributes wealth among generations, generations behave differently, and there are labor market implications as well.

Based on a DSGE-OLG model with demographics and overlapping generations - calibrated for a standard advanced economy -, we examined:

1. how aging affects the inflation rate
   - model: the demographic transition from a younger to an older society implies disinflation in the longer term
   - data: empirical evidence supports this finding

2. how aging affects inflation volatility
   - model: in older societies the volatility of inflation is higher
   - data: a panel regression using data on OECD countries supports this finding
Based on a DSGE-OLG model with demographics and overlapping generations calibrated for a standard advanced economy, we examined:

3 how aging affects the short-term cyclical behavior of the economy and monetary policy transmission
   - our model suggests that aging, due to the wealth effect, makes monetary policy less efficient, and aggregate demand less elastic to changes in the interest rate

4 and how aging affects optimal monetary policies
   - central banks should more strongly react to nominal variables to compensate for higher welfare losses, and in very old societies nominal GDP targeting becomes the most efficient rule

According to the best of our knowledge, this is the first paper which explores the impact of aging on:

1 inflation volatility
2 short-term fluctuations and monetary policy transmission
3 and optimal monetary policies

in a general equilibrium modeling framework.
Thank you for your attention!

Questions?
Comments?

daniel.baksa@gmail.com
zmunkacsi@IMF.org
Aging and disinflation in the model

- GDP (%)
- Interest rate (p.p., ar)
- Inflation (%)
- Old-age dependency ratio (p.p.)
- Total Consumption ratio (% of GDP)
- Investment ratio (% of GDP)
Core inflation and dependency ratio in the data

- **United States**
- **United Kingdom**
- **Germany**
- **France**
- **Japan**
- **Portugal**

**CPI wo Food & Energy (%, YoY)**

**Old-Age Dependency Ratio*(-1) (%)**
Monetary policy shock: 1 pp increase in the policy rate
Government consumption shock: 1 % of GDP size increase