The smarter, the cheaper
Aging, bounded rationality and the natural rate of interest

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Introduction and motivation

1. Secular stagnation hypothesis through the lens of bounded rationality (and level-$k$ thinking)

2. Effect of aging on natural rate of interest at the center of discussions
   - Standard OLG-models: lower interest rates over medium term
   - Not fully supported by the data
   - Anecdotical and empirical evidences: agents are not fully rational e.g.: insufficient level of savings

3. This paper
   - Non-rational behavior with its effects on medium term behavior and interest rate
   - Sheds light on the weakness of naive estimation strategies

4. My contribution
   - Gertler-type OLG model with bounded rationality
   - Secular stagnation hypothesis holds only for those countries where the agents’ behavior is consistent with the rational expectation
OLG-model a la Gertler

Model equations

Daniel Baksa
Bounded rationality with level-\(k\) thinking

- Cognitive limits (Fahri-Werning (2017), Gabaix (2018))
- Conventional rational expectation: all available information influences the decision

\[
x_t = \alpha x_{t+1}^e + \beta f(y_t) = \beta \sum_{n=0}^{\infty} \alpha^n f(y_{t+n}^e)
\]

- Bounded Rationality Equilibrium with level-\(k\) thinking (\(k\) is given): put limits on processed information

\[
x_t^k = \alpha^k x_{t+1}^{e,0} + \beta \sum_{n=0}^{k-1} \alpha^n f(y_{t+n}^e)
\]

- Iterative solution:

\[
x_t^k = \alpha x_{t+1}^{e,k-1} + \beta f(y_t)
\]

In the case of \(k = 0\) the expectation terms is the initial steady-state. If \(k \to \infty\), the two concepts are identical.
Population aging and short-run dynamics

Old-Age Dependency Ratio
(% of worker population)

GDP per capita
(%)

Consumption: Workers
(% of GDP)

Natural Rate of Interest
(%)

REE - k = ∞\hline
BRE - k = 30\hline
BRE - k = 60\hline
BRE - k = 90
Naive estimates (1)

\[ r_{it} = \rho \cdot r_{it-1} + \alpha_i + \delta_t + \beta \cdot OADR_{i,t} + u_{i,t} \]

where \( r_{i,t} \) 10Y nominal yields minus inflation, \( OADR \) old-age dependency ratio, \( \alpha_i \) country fixed effect, \( \delta_t \) time fixed effect

- Sample: OECD countries between 1992 and 2016, \( OADR \) is taken from UN database
- Estimation strategy: static and dynamic FE, alternative GMM (Arellano-Bond)
### Naive estimates (2)

<table>
<thead>
<tr>
<th>Dependent variable:</th>
<th>( r_{it} )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FE (1)</td>
</tr>
<tr>
<td>( r_{it-1} )</td>
<td>0.45 (0.08)**</td>
</tr>
<tr>
<td>( OADR_{it} )</td>
<td>-0.30 (0.08)**</td>
</tr>
</tbody>
</table>

| Country FE | Yes | Yes | Yes | Yes |
| Year FE    | No  | No  | Yes | Yes |
| Observations | 504 | 503 | 504 | 503 |
| \( R^2 \)  | 0.12 | 0.32 | 0.39 | 0.55 |

**Note:** *p<0.1; **p<0.05; ***p<0.01
Robust standard errors in parentheses
Proxies for rationality

- Based on models countries can be full or bounded rational (interest rate reactions are different)

- Financial literacy (Fin.Lit):
  - 2014 S&P FinLit Survey (Klapper et al, 2014)
  - Global survey, measures the participants understanding in risk diversification, inflation, interest rate and compound interest rate calculations

- Time Preference (GPS):
  - 2018 Global Preference Survey (Falk et al, 2018)
  - Global survey, measures the participants risk and time preference, positive and negative reciprocity, altruism and trust
  - Increasing value means more patient agents

- Country level correlation between long term interest rate and old-age dependency ratio
  - Correlation is stronger for countries with higher level financial literacy or time preference
Estimation with interaction terms

\[ r_{i,t} = \rho \cdot r_{i,t-1} + \alpha_i + \delta_t + (\beta + \xi \cdot D_i) \cdot OADR_{i,t} + u_{i,t} \]

- \( D_i = 1 \) if the financial literacy or time preference is higher than average (more consistent with rational behavior)
- Static and dynamic FE estimations
### Secular stagnation: rationality by financial literacy (2)

#### Dependent variable:

<table>
<thead>
<tr>
<th></th>
<th>FE</th>
<th>FE (Fin.Lit.)</th>
<th>FE (GPS)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(4)</td>
<td>(5)</td>
<td>(6)</td>
</tr>
<tr>
<td>( r_{it} )</td>
<td>0.49</td>
<td>0.48</td>
<td>0.47</td>
</tr>
<tr>
<td></td>
<td>(0.09)**</td>
<td>(0.09)**</td>
<td>(0.09)**</td>
</tr>
<tr>
<td>( OADR_{it} )</td>
<td>0.02</td>
<td>0.03</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>(0.03)</td>
<td>(0.03)</td>
<td>(0.03)</td>
</tr>
<tr>
<td>( D_i \cdot OADR_{it} )</td>
<td>−0.09</td>
<td>−0.13</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.04)**</td>
<td>(0.04)**</td>
<td></td>
</tr>
</tbody>
</table>

- Country FE: Yes
- Year FE: Yes
- Observations: 503
- \( R^2 \): 0.55

**Note:**

* \( p < 0.1; \) ** \( p < 0.05; \) *** \( p < 0.01 \)

Robust standard errors in parentheses.
Conclusion

1. The decline in the natural rate of interest is common prediction of DSGE-OLG-models
   ▶ But empirical findings not fully consistent
2. Gertler-type OLG model with bounded rationality:
   ▶ expectations are biased, insufficient savings
   ▶ increasing interest rate at the time of aging
3. Potential existence of selection bias:
   ▶ patience or financial literacy are potential proxies for rationality

**Policy message**: natural rate of interest decreases because of demographic only in those countries where the expectation is consistent with the rational expectation
Thank you for your attention!
Secular stagnation: models vs empirics

1. OLG models have a robust prediction about the future decline in medium term interest rate
   ▶ Old-age dependency ratio increases from 15-20% to 40-50% between 1980 and 2030
   ▶ Kara and von Thadden (2016): in euro area the natural rate declines by 90 bp between 2008 and 2030
   ▶ Bielecki et al (2018): natural rate declines by 150 bp between 1980 and 2030

2. Empirical evidence is not fully consistent with the predictions of the benchmark models:
   ▶ Aksoy et al (2018): demographic trends have negative impacts on interest rate, but not robust for two-ways estimation
   ▶ Favero and Galasso (2015): the demographic trends in Europe do not support the secular stagnation hypothesis
Natural Rate of Interest: important - focal point for policy

- Real interest rate
- Tight monetary policy
- Neutral real interest rate
- Loose monetary policy
- Current real interest rate
OLG-model a la Gertler: two main equations

1. "Dynamic IS-curve" or aggregate "Euler-equation"

\[
\left( \frac{1}{MPC^Y} - \frac{1}{\sigma} \right) \tilde{C}^Y_t = \tilde{B}^Y_t \left( 1 - \frac{(1 - \omega^Y_t)^2}{1 + g^{N,Y}_t} \right) + \\
\underbrace{\text{Young wealth effect}} \quad + \frac{1}{1 + r_t} E_t \left( \omega^Y_t \nu \tilde{Y}_t \Omega^{O}_{t+1} + (1 - \omega^Y_t) \frac{1 + s_{t+1}}{1 + s_t} \right) \underbrace{\text{Expected pension}} + \frac{1}{MPC^{Y}_{t+1}} \tilde{C}^{Y}_{t+1} \underbrace{\text{Youngs' expectation}}
\]

2. Demand for young households’ bonds

\[
\tilde{B}^{Y}_t = \tilde{Debt}_t - \left( 1 - MPC^O_t \Omega^O_t \right) \tilde{R}_t \underbrace{\text{Retired net savings}} - \frac{1 + r_{t-1}}{1 + g^N_t} \left( 1 - MPC^O_t \right) \left[ \tilde{Debt}_{t-1} - (1 - \omega^Y_t) \tilde{B}^Y_{t-1} \right] \underbrace{\text{Retired initial wealth}}
\]
Financial Literacy and Correlation ($r_{it}, OADR_{it}$)
Patience and Correlation ($r_{it}, OADR_{it}$)