On the consequences of demographic change for rates of return to capital, and the distribution of wealth and welfare

Dirk Krueger and Alexander Ludwig

(Journal of Monetary Economics, 2006)
Presented by Ismael Gálvez

January 26, 2016
Population is aging in all major industrialized countries.

Generalized process in all countries, but extent and timing differ.  ▶ Graphs

Research question: What are the welfare and distributional consequences of this demographic change?

Objective: Quantify consequences for international capital flows, returns to capital, wages and welfare.
Main Contribution and Results

- **OLG model & exogenous demographic projections**
- Main ingredients:
  - **Multi-country** (capital flows across regions)
  - Idiosyncratic *income shock* (redistribution issues + precautionary savings)
  - **Endogenous** labor supply.
  - PAYGO public *pension system*.
- Main results:
  1. Aging population $\rightarrow$ Labor is scare $\rightarrow$ ↑ *Wages* and ↓ *Capital returns*.
  2. Greater impact when U.S. is an *open* economy.
  3. Welfare consequences:
     - Who *gain*? $\rightarrow$ *Young* people with little assets.
     - Who *loose*? $\rightarrow$ *Older* asset-rich individuals.
Demographics and Technology

- Exogenous demographic evolution (data and projections)
- Household starts life at age 20 \((j = 0)\), retire at age 65 \((jr = 45)\) and die at \(J = 75\).
- Probability to survive from \(j\) to \(j + 1\) given by \(s_{t,j,i}\)
- \(N_{t,j,i}\): Population of age \(j\) at time \(t\) in country \(i\).

- Single consumption good produces in each country.
- Standard neoclassical production function:

\[
Y_{t,i} = Z_i K_{t,i}^\alpha (A_t L_{t,i})^{1-\alpha}
\]
Utility function:

\[
E \left\{ \sum_{j=0}^{J} \beta^j u(c_j, 1 - l_j) \right\}
\]

Household heterogeneity given by:
- \( \theta_k \): agent’s type, \( k \in \{1, \ldots, K\} \)
- \( \varepsilon_j \): average age-specific productivity of cohort \( j \)
- \( \eta \): idiosyncratic shock, \( \eta \in \{1, \ldots, E\} \) follows a time-invariant Markov chain \( \pi(\eta' | \eta) \) transition probabilities.

Labor productivity = \( \theta_k \varepsilon_j \eta \)
Government policies

- Gives accidental bequest $h_{t,i}$ (lump-sum)
- PAYGO public pension system:
  - Revenues: flat tax $\tau_{t,i}$ on labor earnings.
  - Expenditures: pensions $b_{t,k,i}$:
    \[ b_{t,k,i} = \rho_{t,i} \theta_k (1 - \tau_{t,i}) w_{t,i} \] (1)
    -$\rho_{t,i}$: replacement rate
- Assume balanced pension system budget:
  \[ \tau_{t,i} w_{t,i} L_{t,i} = \sum_k b_{t,k,i} \sum_{j \geq jr} N_{t,j,k,i} \] (2)
- 3 different scenarios for the evolution of the system:
  - $\tau_{t,i}$ constants and $\rho_{t,i}$ adjust.
  - $\rho_{t,i}$ constants and $\tau_{t,i}$ adjust.
  - Increase in the retirement age.
Household’s problem

\[ W(t, j, k, i, \eta, a) = \max_{c, a', 1-l} \left\{ u(c, 1-l) + \beta s_{t,j,i} \sum_{\eta'} \pi(\eta'|\eta) W(t+1, j+1, k, i, \eta', a') \right\} \]

s.t.

\[ c + a' = \begin{cases} (1 - \tau_{t,i}) w_{t,i} \theta_{k \epsilon j} \eta l + (1 + r_t)(a + h_{t,i}) & \text{for } j < jr \\ b_{t,k,i} + (1 + r_t)(a + h_{t,i}) & \text{for } j \geq jr \end{cases} \]

\[ a', c \geq 0 \text{ and } l \in [0, 1] \]
**Definition of equilibrium**

Given initial capital stocks and measures \( \{K_0, i, \Phi_0, i\}_{i \in I} \), a competitive equilibrium are sequences of individual functions for the household \( \{W(t, \cdot), c(t, \cdot), l(t, \cdot), a'(t, \cdot)\}_{t=0}^{\infty} \), sequences of production plants for firms \( \{L_{t, i}, K_{t, i}\}_{t=0}^{\infty}, i \in I \) policies \( \{\tau_{t, i}, \rho_{t, i}, b_{t, i}\}_{t=0}^{\infty}, i \in I \), prices \( \{w_{t, i}, r_{t}\}_{t=0}^{\infty}, i \in I \), transfers \( \{t_{t, i}\}_{t=0}^{\infty}, i \in I \) and measures \( \{\Phi_{t, i}\}_{t=0}^{\infty}, i \in I \) such that:

1. Given prices, transfers and initial conditions \( W(t, \cdot) \) solves the HP and \( c(t, \cdot), l(t, \cdot), a'(t, \cdot) \) are the associated policy functions.

2. Interest rates and wages satisfy

\[
 r_{t} = \alpha Z_{i} \left( \frac{K_{t, i}}{A_{t}L_{t, i}} \right)^{\alpha - 1} - \delta \\
 w_{t, i} = (1 - \alpha) Z_{i} A_{t} \left( \frac{K_{t, i}}{A_{t}L_{t, i}} \right)^{\alpha}
\]

3. Transfers are given by

\[
 h_{t+1, i} = \frac{\int (1 - s_{t,j,i}) a'(t, j, k, i, \eta, a) \Phi_{t, i}(dj \times dk \times d\eta \times da)}{\int \Phi_{t+1, i}(dj \times dk \times d\eta)}
\]
Definition of equilibrium

4. Government policies satisfy 1 and 2 in every period.
5. Markets clear in all \( t, i \)

\[
L_{t,i} = \int \theta k \in \eta l(t, j, k, i, \eta, a) \Phi_{t,i}(dj \times dk \times d\eta \times da) \text{ for all } i,
\]

\[
\sum_{i=1}^{l} K_{t+1,i} = \sum_{i=1}^{l} \int a'(t, j, k, i, \eta, a) \Phi_{t,i}(dj \times dk \times d\eta \times da) \text{ for all } i,
\]

\[
\sum_{i=1}^{l} \int c(t, j, k, i, \eta, a) \Phi_{t,i}(dj \times dk \times d\eta \times da) + \sum_{i=1}^{l} K_{t+1,i}
\]

\[
= \sum_{i=1}^{l} A_{t,i} K_{t,i}^{\alpha} L_{t,i}^{1-\alpha} + (1 - \delta) \sum_{i=1}^{l} K_{t,i} \text{ for all } i
\]

6. The cross-sectional measures \( \Phi_{t,i} \) evolve as

\[
\Phi_{t+1,i}(S \times K \times \varepsilon \times A) = \int P_{t,i}((j, k, \eta, a), S \times K \times \varepsilon \times A) \Phi_{t,i}(dk \times dk \times d\eta \times da)
\]
Calibration

- Demographic processes from UN projections.
- Two state Markov chain for $\eta$ with 0.98 annual persistence.
- Two types $\theta_1 = 0.57$ (low ability) and $\theta_2 = 1.43$ (high ability).
- CRRA utility function with separable in $c$ and $l$.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>U.S.</th>
<th>EU</th>
<th>ROECD</th>
<th>ROW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Share $\alpha$</td>
<td></td>
<td></td>
<td></td>
<td>0.33</td>
</tr>
<tr>
<td>Growth Rate of Technology $g$</td>
<td></td>
<td></td>
<td>0.018</td>
<td></td>
</tr>
<tr>
<td>Depreciation Rate $\delta$</td>
<td></td>
<td></td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>Total Factor Productivity $Z_i$</td>
<td>1.0</td>
<td>0.88</td>
<td>0.65</td>
<td>0.11</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parameter</th>
<th>U.S.</th>
<th>EU</th>
<th>ROECD</th>
<th>ROW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient of RRA $\sigma$</td>
<td></td>
<td></td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Time Discount Factor $\beta$</td>
<td></td>
<td></td>
<td>0.9422</td>
<td></td>
</tr>
<tr>
<td>Consumption Share Parameter $\omega_i$</td>
<td>0.459</td>
<td>0.446</td>
<td>0.444</td>
<td>0.500</td>
</tr>
</tbody>
</table>
Benchmark model: No Social Security
Steady state comparison

Table 3
Steady state comparison

<table>
<thead>
<tr>
<th>Variable</th>
<th>United States (%)</th>
<th>European Union (%)</th>
<th>Rest OECD (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(r)</td>
<td>-3.06</td>
<td>-3.06</td>
<td>-3.06</td>
</tr>
<tr>
<td>(w)</td>
<td>14.1</td>
<td>14.1</td>
<td>14.1</td>
</tr>
<tr>
<td>(Y/N)</td>
<td>-2.23</td>
<td>-0.10</td>
<td>-5.8</td>
</tr>
<tr>
<td>(\bar{l})</td>
<td>5.4</td>
<td>6.0</td>
<td>4.1</td>
</tr>
</tbody>
</table>

- From 1950 to 2300:
- \(\downarrow r\) and \(Y/N\)
- \(\uparrow w\) and \(\bar{l}\) (average hours worked per person in working age)
Benchmark model: No Social Security
Dynamics of aggregate statistics

- Lower decline in output per capita in the U.S.
- ↓ saving rates for all regions (lower $r$ and more retired)
- Lower decrease in investment rate in the U.S. → Higher deficit.
Benchmark model: No Social Security
Inequality and welfare consequences

- Increase in income inequality.
- Newborn agents gain (higher wages).
- $\Delta^+ \text{ Low productivity} > \Delta^+ \text{ High productivity.}$
- Old agents loose.  

Table 4
Welfare consequences, U.S.

<table>
<thead>
<tr>
<th>Productivity $\eta_1$</th>
<th>Productivity $\eta_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9%</td>
<td>0.6%</td>
</tr>
</tbody>
</table>

Figure 9: Evolution of Income Inequality in 3 Regions
The role of Social Security
Agregate statistics and welfare consequences

Table 5
Evolution of aggregates in U.S., 2005–2080

<table>
<thead>
<tr>
<th>Variable</th>
<th>No social security (%)</th>
<th>$\tau$ fixed (%)</th>
<th>$\rho$ fixed (%)</th>
<th>Adjustment of $jr$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$r$</td>
<td>-0.89</td>
<td>-0.86</td>
<td>-0.18</td>
<td>-0.87</td>
</tr>
<tr>
<td>$w$</td>
<td>4.2</td>
<td>4.1</td>
<td>0.8</td>
<td>4.0</td>
</tr>
<tr>
<td>$\tau$</td>
<td>0</td>
<td>0</td>
<td>7.3</td>
<td>0</td>
</tr>
<tr>
<td>$\rho$</td>
<td>0</td>
<td>-7.9</td>
<td>0</td>
<td>-5.0</td>
</tr>
<tr>
<td>$Y/N$</td>
<td>-7.6</td>
<td>-7.2</td>
<td>-12.6</td>
<td>-5.7</td>
</tr>
</tbody>
</table>

Table 6
Welfare Consequences, Newborns in U.S.

<table>
<thead>
<tr>
<th>Type</th>
<th>No social security</th>
<th>$\tau$ fixed</th>
<th>$\rho$ fixed</th>
<th>Change in $jr$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\eta_1$ (%)</td>
<td>$\eta_2$ (%)</td>
<td>$\eta_1$ (%)</td>
<td>$\eta_2$ (%)</td>
</tr>
<tr>
<td>$k_1$</td>
<td>0.9</td>
<td>0.6</td>
<td>0.8</td>
<td>0.2</td>
</tr>
<tr>
<td>$k_2$</td>
<td>0.9</td>
<td>0.6</td>
<td>0.4</td>
<td>0.0</td>
</tr>
</tbody>
</table>

- No SS vs SS with $\tau$ fixed → Changes in factor prices are roughly the same.
- No SS vs SS with $\rho$ fixed → Changes in factor prices are less pronounced, higher ↓ in output pc and ↓ newborn welfare.
- No SS vs SS with higher $jr$ → Changes in factor prices are roughly the same, lower $\Delta^-$ in output pc and unproductive newborns are better off.
Conclusions

- **Population aging** has a large **impact** on the return to **factor prices**. (↓ $r$ and ↑ $w$)
- **Welfare consequences** of these changes are **substantial**.
- Welfare gains for newborns only if $\tau$ are held constant.
- The option of **increasing the retirement age** leads to **less welfare losses** (and even gains for some groups).
- Endogenous **human accumulation** as a possible **adjustment** channel?
Figure 1: Evolution of the Population Growth Rate in 4 Regions

Figure 2: Evolution of Working Age to Population Ratios in 4 Regions
Appendix

Figure 8: Evolution of Net Investment Rate in 3 Regions
Welfare Consequences for age 60 in year 2005

Figure 11: Welfare Consequences by Asset Levels