Aging, Social Security Reform and Factor Price in a Transition Economy

Tomoaki Yamada

Rissho University

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Introduction: Motivation

- Rapid aging of the population combined with the diminishing number of children
  - Tax burden and intergenerational inequality
  - Source of finance
- Macroeconomic perspective:
  - GDP growth rate
  - Aggregate capital and labor
  - Factor prices (not obvious)
- Microeconomic perspective:
  - Intragenerational and intergenerational heterogeneity
  - Redistribution, insurance and distortion of social security
  - Idiosyncratic income risk
Objectives

- A transition path in Japan from 2000 to 2200
  - Dynamic stochastic general equilibrium
  - Stationary equilibrium and transition
  - Quantitative analysis [positive and normative]
- Heterogeneity
  - Intergenerational
  - Intra-cohort
- Four social security reforms $\implies$ Equilibrium path and welfare
  - Reduction of the replacement rate by half
  - Full privatization
  - Finance by capital income tax
  - Finance by consumption tax
Main Results (1)

- There is more capital deepening [Benchmark]
  - The equilibrium wage increases by 6%
  - The interest rate decreases by 1.5%
  - Output per capita decreases by 20% because of the decrease in the aggregate capital and labor supply
  - Welfare measured by expected value declines for 50 years

- Reduction of the replacement rate by half moderates intergenerational inequality
Main Results (2)

- Introduction of consumption tax may not improve welfare
  - No distortion, but...
  - (i) Redistribution and insurance effect of social security decline (payroll tax)
  - (ii) Opportunity: labor supply, borrowing constraint and substitution effect

- Introducing capital income tax improves welfare of young and future generations
  - Redistribution and insurance effect
A stochastic overlapping generations model with
- Idiosyncratic income uncertainty
- Intergenerational and intragenerational heterogeneity
- Endogenous labor supply
- Pay-as-you-go social security system and payroll tax
- Redistribution effect of social security
- Compute transition path
A continuum of households exist. Each household enters labor market at 20, exits at 65, faces mortality risks, can live at most 100:

\[
U_t = E_{20,t} \left\{ \sum_{j=20}^{J} \beta^{j-1} \left( \prod_{i=20}^{j-1} \phi_{i,t} \right) u(c_{j,t+j-20}, \bar{l} - l_{j,t+j-20}) \right\}
\]

- \( c_{j,t+j-20} \): consumption, \( l_{j,t+j-20} \): labor
- \( \beta \): discount factor, \( \phi_{i,t} \): survival probability
Budget Constraint

Employee:

\[(1 + \tau_t^c) c_{j,t} + a_{j+1,t+1} \leq y_{j,t} + (1 + (1 - \tau_t^a) r_t / \phi_{j,t-1}) a_{j,t}, \]
\[y_{j,t} = (1 - \tau_t^{ss}) w_t \eta_j e_{j,t}.\]

- \(a_{j,t}\): asset holding, \(y_{j,t}\): labor income, \(\tau_t\): each tax
- \(\eta_j\): average productivity
- \(r_t\): interest rate, \(w_t\): economy-wide wage
- omit uncertainty about long-living [private annuity market]

Retiree:

\[(1 + \tau_t^c) c_{j,t} + a_{j+1,t+1} \leq w_t b(\tau_t^{ss}, W_{g,t}) + (1 + (1 - \tau_t^a) r_t / \phi_{j,t-1}) a_{j,t},\]

- \(b(\tau_t^{ss}, W_{g,t})\): replacement rate, \(W_{g,t}\): trust fund
Earnings Risk

- Three components of income shocks
  - Fixed effect
  - Persistent shock
  - Transitory shock

- Match the variance profile of log-earnings
  - Figure 1
Figure 1: Variance Profiles

Variance of Logarithm of Income Profile

Variance of Logarithm of Consumption Profile
Behavior of Firms

- Production function

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

- Aggregation

\[ K_t = \sum_{j=20}^J \mu_{j,t} \int a_{j,t} d\Phi_t (a_j, e_j) + W_{g,t}, \]

\[ L_t = \sum_{j=20}^{j_r} \mu_{j,t} \int \eta_j e_j \ell_{j,t} d\Phi_t (a_j, e_j). \]

- \( \Phi_t (a_j, e_j) \): distribution function
- \( \mu_t \): the population distribution in period \( t \)

- Factor prices

\[ r_t = \theta A_t (K_t / L_t)^{\theta-1} - \delta, \]
\[ w_t = (1 - \theta) A_t (K_t / L_t)^\theta, \]
PAYG Social Security System

- The government’s budget constraint

\[ W_{g,t+1} = (1 + r_t) W_{g,t} + (T_{t}^{SS} + T_{t}^{C} + T_{t}^{A}) - B_{t}, \]

- Revenue and Benefits

  \[ T_{t}^{SS} : \text{payroll tax} \]
  \[ T_{t}^{C} : \text{consumption tax} \]
  \[ T_{t}^{A} : \text{capital income tax} \]
  \[ B_{t} : \text{social security benefit} \]
Definition of Recursive Competitive Equilibrium

- Recursive Competitive Equilibrium consists of
  - Household’s optimality
  - Firm’s optimality
  - Market clearing
  - Government’s budget
  - Transition law of motion

- *Detrend* by population growth rate and TFP growth rate
Four Policy Experiments

- A Benchmark:
  - use *medium variant* of the population projection by the National Institute of Population and Social Security Research
  - The replacement rate is targeted at 50%

1. Social security reform I: reduction of the replacement rate by half for 50 years
2. Social security reform II: (almost) full privatization for 50 years
3. The other source of finance I: capital income tax set at 30% (2001)
4. The other source of finance II: consumption tax set at 5% (2001)
Calibration: Fundamental Parameters

- Set initial stationary state in 2000
- Survival probability from Life Table (NIPSSR)
- Instantaneous utility function

\[ u(c_{j,t}, \bar{\ell} - \ell_{j,t}) = \frac{c_{j,t}^\sigma (\bar{\ell} - \ell_{j,t})^{1-\sigma}}{1 - \gamma} \]

- \( \beta = 0.985, \gamma = 2, \sigma = 0.38 \)
- Replacement rate:
  - 50% of average earnings
- Production parameters
  - \( \theta = 0.312, \delta = 0.089, A_t^{\frac{1}{1-\theta}} / A_t^{\frac{1}{1-\theta}} = 1.01 (\forall t) \)
We consider the transition path from 2000 to 2200.

Use the NIPSSR(2002)’s projection

- from 2001 to 2050

Three variants of projection

- Medium variant [Benchmark]
- High variant
- Low variant

Converge to zero population growth (new stationary state)

- population distribution converges to stationary state in 2160
Figure 2: Population Dynamics in Japan

(a) Population Distribution in 2000

(b) Population Dynamics: Low Variant

(c) Population Dynamics: Medium Variant

(d) Population Dynamics: High Variant
Main Results: Stationary State

- Macroeconomic variables in 2000 as targets
  - $K/Y = 2.42, \ r \div 4.0\%$
  - SS in 2000 $\Rightarrow$ SS in 2200
    - $K/Y$ increases by 3.11%
    - the interest rate decreases by 39 basis points

- Benchmark $\Rightarrow$ Capital Income Tax by 30%
  - remaining payroll tax rate$\div 5\%$
  - labor supply increases
  - $ch(L) \neq ch(H)$

- Benchmark $\Rightarrow$ Consumption Tax by 5%
  - remaining payroll tax rate$\div 5\%$
  - labor supply decreases
### Stationary Equilibrium (Table 3&4)

<table>
<thead>
<tr>
<th>Medium Variant</th>
<th>Rep. Rate 25%</th>
<th>Rep. Rate 0.1%</th>
<th>Tax Reform cons.</th>
<th>Tax Reform cap.</th>
<th>Year 2200</th>
</tr>
</thead>
<tbody>
<tr>
<td>$K/Y$</td>
<td>2.42</td>
<td>2.63</td>
<td>3.03</td>
<td>2.45</td>
<td>2.24</td>
</tr>
<tr>
<td>$\text{ch}(K/Y)$: %</td>
<td>—</td>
<td>8.72</td>
<td>25.53</td>
<td>1.54</td>
<td>-7.49</td>
</tr>
<tr>
<td>$r$ (%)</td>
<td>4.01</td>
<td>2.97</td>
<td>1.38</td>
<td>3.81</td>
<td>5.05</td>
</tr>
<tr>
<td>$w$</td>
<td>1.03</td>
<td>1.07</td>
<td>1.14</td>
<td>1.03</td>
<td>0.99</td>
</tr>
<tr>
<td>$\tau^{ss}$ (%)</td>
<td>10.17</td>
<td>5.09</td>
<td>0.02</td>
<td>4.99</td>
<td>5.25</td>
</tr>
<tr>
<td>$K/N$</td>
<td>3.50</td>
<td>4.10</td>
<td>5.36</td>
<td>3.58</td>
<td>3.14</td>
</tr>
<tr>
<td>$L/N$</td>
<td>0.97</td>
<td>1.01</td>
<td>1.07</td>
<td>0.97</td>
<td>0.97</td>
</tr>
<tr>
<td>$\text{ch}(L/N)$: %</td>
<td>—</td>
<td>3.78</td>
<td>9.97</td>
<td>0.09</td>
<td>0.52</td>
</tr>
<tr>
<td>$\text{ch}(\text{hours})$: %</td>
<td>—</td>
<td>4.35</td>
<td>11.52</td>
<td>-0.04</td>
<td>0.74</td>
</tr>
<tr>
<td>$Y/N$</td>
<td>1.45</td>
<td>1.56</td>
<td>1.76</td>
<td>1.46</td>
<td>1.40</td>
</tr>
</tbody>
</table>
### Stationary Equilibrium (Table 3)

<table>
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<th>Medium Variant</th>
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<th>Tax Reform cap.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gini (20-100)</td>
<td>0.596</td>
<td>0.590</td>
<td>0.583</td>
<td>0.605</td>
</tr>
<tr>
<td>Gini (30-65)</td>
<td>0.531</td>
<td>0.549</td>
<td>0.565</td>
<td>0.543</td>
</tr>
<tr>
<td>Gini (20s)</td>
<td>0.586</td>
<td>0.591</td>
<td>0.605</td>
<td>0.643</td>
</tr>
<tr>
<td>Gini (30s)</td>
<td>0.589</td>
<td>0.586</td>
<td>0.589</td>
<td>0.634</td>
</tr>
<tr>
<td>Gini (40s)</td>
<td>0.393</td>
<td>0.420</td>
<td>0.443</td>
<td>0.409</td>
</tr>
<tr>
<td>Gini (50s)</td>
<td>0.263</td>
<td>0.254</td>
<td>0.232</td>
<td>0.267</td>
</tr>
<tr>
<td>Gini (60s)</td>
<td>0.303</td>
<td>0.238</td>
<td>0.171</td>
<td>0.302</td>
</tr>
</tbody>
</table>
Closed Economy

- Welfare Criteria:
  \[
  Ev_t(a_{20}, s_{20}) = \sum \pi(s) v_t(0, s_{20}),
  \]
  \[
  EV(a_{20}, s_{20}) = \left( \frac{Ev^\text{Reform}_t(a_{20}, s_{20})}{Ev^\text{Bench}_t(a_{20}, s_{20})} \right) \frac{1}{\sigma(1-\gamma)}.
  \]

- Cohort’s value and consumption equivalent

- Benchmark
  - The cohort’s welfare decreases for the aging period of 50 years and reaches the lowest point around 2050
  - Introducing capital income tax improves welfare of current young and future generations
  - Introducing consumption tax does not improves welfare

- Figure 8
Figure 8: Welfare Comparison (Cohort at Age 20)
Figure 8: Welfare Comparison (EV)
Small Open Economy

  - Equilibrium payroll tax rate does not change so much
  - Welfare implication changes
- Introducing capital income tax improves welfare more
- Figure 9
Figure 9: Welfare Comparison (Cohort at Age 20)
Figure 9: Welfare Comparison (EV)
What causes the differences?

- Consumption tax improves welfare:
  - e.g. Tachibanaki et al. (2006)
  - Intragenerational heterogeneity
  - Borrowing constraint

- Introducing consumption tax does not necessarily improve welfare of the economy: Nishiyama and Smetters (2005, JPE)
  - with/without intragenerational heterogeneity
  - redistribution and insurance effect of social security system

- Insurance or Opportunity?: Heathcote, Storesletten, and Violante (2005, JME)
  - The social security offers insurance for life-time income
  - Concentration of labor supply at high productivity (covariance of hourly wage and work hours)
A Benchmark Case, SSR I & II

- A Benchmark Case
  - The equilibrium interest rate decrease
  - The equilibrium wage increase up to 5%
  - The payroll tax rate increases up to 18%
  - Output per capita decreases by 20%

- SSR I (Reduction by Half)
  - The wage level increases by 10%
  - The payroll tax rate does not exceed 12%
  - Output per capita is flatter than in the benchmark case

- SSR II (Full Privatization)
  - The real return on capital becomes negative
  - The equilibrium wage rises over 20%
Figure 3: Benchmark Case (Medium Variant)

Factor Prices

Social Security System

Capital and Labor: Population Adjusted (K, L)

Output Per Capita
Figure 4: Social Security Reform I (25%)
Figure 5: Social Security Reform II (0.1%)
Capital Income Tax and Consumption Tax

**Capital Income Tax**
- The maximum payroll tax rate does not exceed 16%
- Relatively small effect on the factor prices path
- Per capita output is large relative to the benchmark case

**Consumption Tax**
- Factor price pathes are similar to the benchmark case
- The maximum payroll tax does not exceed 14%
Figure 6: Capital Income Tax

Factor Prices

Social Security System

Capital and Labor: Population Adjusted (K, L)

Output Per Capita

- interest rate
- wage
- replacement rate
- payroll tax rate
- capital
- labor
- output
Figure 7: Consumption Tax

Factor Prices

Social Security System

Capital and Labor: Population Adjusted (K, L)

Output Per Capita
Conclusion

- Capital income tax weakly improves the young and future generations' welfare
- Consumption tax should not necessarily improve the welfare because of
  - Heterogeneity
  - Redistribution effect of social security
  - Labor supply incentives
- Partial privatization will improve the welfare of future cohorts
- How to incorporate aggregate risk?
  - Intergenerational risk sharing by a social security system (Krueger and Kubler, 2005 AER)
  - Demographic risk