Income Risk, Consumption Inequality, and Macroeconomy in Japan

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Motivation

- Recently, economic inequality is receiving increasing attention in Japan
  - Many people *believe* that the inequality rises
  - True? Inequality of what? How large?

- Income/Earning inequality:
  - Many data sets are available
  - does not necessarily reflect economic inequality over life cycle

- Consumption inequality
  - Life Cycle Permanent Income Hypothesis (LC-PIH)
  - Useful measure for welfare evaluation and policy implication
  - Limited data set in Japan
1. Introduction

1.1 Motivation

Questions

- Explaining economic inequality in Japan based on a dynamic stochastic general equilibrium model
- What kinds of factors affect the evolution of economic inequality in Japan?
What We Do

- A transitional dynamics of economic inequality in Japan between 1980 and 2000
  - there are comparable data on income/earning and consumption inequality only for this period

- Two viewpoints of economic inequality:
  - Life cycle dimension: Age
  - Time series dimension: Time

- Three factors that affect economic inequality:
  1. Idiosyncratic income risk factor: permanent and transitory shocks
  2. A demographic factor: aging
  3. Macroeconomic factors: TFP, capital share, etc.
1.3 Literature and Facts

Literature Review

1. Empirical research on income/consumption inequality:

   Lifecycle Dimension:

   Time Series Dimension:
   - Japan: Kohara and Ohtake (2006), Abe and Inakura (2008)

2. Explaining Japanese economy based on DGE models

   - GDP in the “Lost Decade": Hayashi and Prescott (2002)
   - Saving rate: Chen et al. (2006,2007), Braun et al. (2007)
   - Extend the first moments (e.g. GDP) to the second moments (variance)
Summary of Results

1. Income/consumption inequality of life cycle dimension is well replicated in the model.
2. Rising earning inequality between mid 1980s and late 1990s is explained by the OLG model.
3. It is difficult to explain consumption inequality in 1980s using the model.
4. Counterfactual simulation:
   - TFP growth rate and reduction in work hours have large impact not only on the mean (e.g. GDP and saving rate) but also on the economic inequality.
   - Low TFP growth rate generate low economic inequality, especially in the 1990s.
5. Even without the demographic factor, the earning/income inequality has positive trend due to the macroeconomic factors.
2. Overlapping Generations Model

2.1 A Model

Sketch of Our Model

- A overlapping generations model:
  - A continuum of households exits
  - Households face idiosyncratic income risk
  - Incomplete market and self-insurance
  - Endogenous labor supply
  - Intergenerational and intragenerational heterogeneity
  - Pay-as-you-go social security system
  - Exogenously given macroeconomic variables; TFP, capital share, etc
  - Compute transition path between steady states (1980-2200)
Objective Function

- A continuum of households exist
- Each household enters labor market at 20
  - exits at 65:

\[
U_t = E_{20,t} \left\{ \sum_{j=20}^{100} \beta^{j-20} \left( \prod_{i=20}^{j-1} \phi_{i,t} \right) \frac{c_{j,t}^\sigma (\bar{h}_t - h_{j,t})^{1-\sigma}}{1-\gamma} \right\}
\]

- \( \beta > 0 \): Discount factor
- \( \gamma \): Parameter for intertemporal elasticity of substitution
- \( \sigma \): Parameter for the share of consumption and leisure
- \( \bar{h}_t \): Time endowment
- \( h_{j,t} \in [0, \bar{h}_t] \): A labor supply at age \( j \)

- Robustness check later!
2. Overlapping Generations Model
2.2 Household Behavior

Budget Constraint: Worker

- Worker:

\[ c_{j,t} + a_{j+1,t+1} = (1 + (1 - \tau_t^{\text{cap}})r_t)(a_{j,t} + b_t) + (1 - \tau_t^{\text{ss}})y_{j,t} \]

\[ y_{j,t} = w_t\kappa_j e_j h_{j,t} \]

- \( a_{j,t} \): Asset holding, \( b_t \): Accidental bequest
- \( y_{j,t} \): Labor income
- \( \kappa_j \): Average productivity for each age
- \( e_j \): Idiosyncratic income risk
- \( \tau_t^{\text{cap}} \): Capital income tax, \( \tau_t^{\text{ss}} \): Payroll tax for Social Security
- \( r_t \): Interest rate, \( w_t \): Wage
2. Overlapping Generations Model

2.2 Household Behavior

Budget Constraint: Retiree

- Retiree:

\[ c_{j,t} + a_{j+1,t+1} = (1 + (1 - \tau_t^{\text{cap}}) r_t)(a_{j,t} + b_t) + \varphi_t w_t H_t \]

- \( \varphi_t \): Replacement rate
- \( w_t H_t \): Average labor income of workers
2. Overlapping Generations Model
2.3 Production and Government

Firm’s Behavior

- Production function:

\[ Y_t = A_t K_t^{\theta_t} H_t^{1-\theta_t} \]

- \( A_t \): TFP (Deterministic), \( \theta_t \): Capital share

- Factor prices:

\[ r_t = \theta_t A_t \left( \frac{K_t}{H_t} \right)^{\theta_t-1} - \delta_t, \quad w_t = (1 - \theta_t) A_t \left( \frac{K_t}{H_t} \right)^{\theta_t} \]
The government has three roles:

1. Managing the social security system:
   - Pay-as-you-go

2. Collects capital income tax and using it for government expenditure:
   - The government expenditure yields no utility!

3. Distributes accidental bequests:
Definition: Recursive Competitive Equilibrium

- Given the paths of TFP \( \{A_t\} \), the capital share \( \{\theta_t\} \), the depreciation rate \( \{\delta_t\} \), the capital income tax rate \( \{\tau_{t \text{ cap}}\} \), the time endowment \( \{\bar{h}_t\} \) and the replacement rate \( \{\phi_t\} \),
- Recursive Competitive Equilibrium consists of
  - A household’s optimality
  - A firm’s optimality
  - Market clearing conditions
  - The government’s budget
  - Accidental bequest
  - Transition law of motion
3. Calibration

3.1 Fundamental Parameters

Fundamental Parameters

- Instantaneous utility function:

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

- \( \beta = 0.9871, \gamma = 2, \sigma = 0.55 \)

- Time endowment:
  - Reduction in work hours length was legally introduced in the late 1980s (Labor Standards Law)
  - 1980-1988: 16 hours \( \times \) 5.5 days \( \times \) 4 weeks \( \times \) 12 months
  - 1993-2000: 16 hours \( \times \) 5.0 days \( \times \) 4 weeks \( \times \) 12 months

- Replacement rate: \( \phi_t \)
  - 40% of average labor income (Oshio and Yashiro, 1997)
We consider three types of income shocks, $e_j$.

Each shock have different implications on consumption inequality:

- Fixed effect: *Uninsurable*, high consumption inequality
- Transitory shock: *Insurable* through insurance markets or saving (risk-free bond), low consumption inequality
- Persistent shock: Depend on the persistence parameter
Demographic Structure

- We consider the demographic change from 1980 to 2200.
- Population projection:
  - Survival probability
  - Population growth rate
- Three variants of projection
  - Use medium variant
- Initial population distribution: population distribution in 1980
3. Calibration
3.4 Macroeconomic Variables

Exogenous Paths

From Hayashi and Prescott (2002):

<table>
<thead>
<tr>
<th></th>
<th>70s</th>
<th>80s</th>
<th>90s</th>
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<tbody>
<tr>
<td>TFP Factor Growth Rate (%)</td>
<td>1.40</td>
<td>2.68</td>
<td>0.57</td>
</tr>
<tr>
<td>Adjusted TFP Factor Growth Rate (%)</td>
<td>1.77</td>
<td>2.21</td>
<td>0.67</td>
</tr>
<tr>
<td>Depreciation Rate (%)</td>
<td>10.19</td>
<td>8.97</td>
<td>8.40</td>
</tr>
<tr>
<td>Capital Share</td>
<td>0.3512</td>
<td>0.3536</td>
<td>0.3627</td>
</tr>
<tr>
<td>Capital Income Tax Rate (%)</td>
<td>41.55</td>
<td>47.68</td>
<td>44.92</td>
</tr>
</tbody>
</table>
Before discussing the economic inequality after 1980, we confirm whether the average paths replicates data of Japanese economy

- After tax interest rate: very good!
- Capital-output ratio: capital deepening in the lost decade
- Work hours: reduction in work hours between the late 80s and early 90s
- Saving rate: good, but there is a discrepancy period

Using an OLG model with idiosyncratic income risk and exogenously given macroeconomic factors, the model can explain the data (first moment) very clearly.
4. Quantitative Results
4.1 Macroeconomic Variables

Macroeconomic Variables: Interest Rate

(a) After Tax Interest Rate
4. Quantitative Results

4.1 Macroeconomic Variables

Macroeconomic Variables: Work Hours

(c) Work Hours

![Graph showing work hours over years]

Year

Work Hours
0.75 0.8 0.85 0.9 0.95 1 1.05

Model
Data
Life Cycle Dimension of Economic Inequality

- The variance of logarithm of income and consumption over age
- Our model replicates the "income inequality" very well without old households
- Consumption inequality
  1. Consumption inequality around 25–40 closely matches the data
  2. Consumption inequalities of old are small
Life Cycle Dimension: Income Inequality

(a) Income Inequality

Variance of Log Age

NSFIE (1984)
NSFIE (1999)
Model

Age
Life Cycle Dimension: Consumption Inequality

(b) Consumption Inequality

Variances of Log Age

NSFIE (1984)
NSFIE (1999)
Model
4. Quantitative Results

4.3 Time Series Dimension of Earning, Income and Consumption Inequality

Time Series Dimension: Earning Inequality

(a) Earning Inequality (Variance of Log)
Time Series Dimension: Consumption Inequality

(c) Consumption Inequality (Variance of Log)

Year

Deviation from Mean


Ohtake
Kohara
Model
Saito
Ohtake

-0.15 -0.1 -0.05 0 0.05 0.1 0.15
Counterfactual Simulation

- Question: What was occurred if the macroeconomic factors are constant at...

1. TFP factor growth rates: constant at 2%
2. Time endowment: $\bar{h} = 3840$
3. Capital share: $\theta = 0.362$
4. Capital income tax: $\tau^{\text{cap}} = 0.45$
   - Small effect on the economic inequality
5. Depreciation rate: $\delta = 0.083$
   - Small effect on the economic inequality
4. Quantitative Results

4.4 Counterfactual Simulation

Counterfactual Simulation: TFP and Time Endowment

(a) Earning Inequality (Variance of Log)
Conunterfactual Simulation: TFP and Time Endowment

(c) Consumption Inequality (Variance of Log)

- Benchmark
- TFP
- Time Endowment

Year

<table>
<thead>
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<th></th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Deviation from Mean</td>
<td>-0.08</td>
<td>-0.06</td>
<td>-0.04</td>
<td>-0.02</td>
<td>0</td>
</tr>
<tr>
<td>Time Endowment</td>
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<td>-0.06</td>
<td>-0.04</td>
<td>-0.02</td>
<td>0</td>
</tr>
<tr>
<td>TFP</td>
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<td>-0.06</td>
<td>-0.04</td>
<td>-0.02</td>
<td>0</td>
</tr>
<tr>
<td>Benchmark</td>
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<td>-0.06</td>
<td>-0.04</td>
<td>-0.02</td>
<td>0</td>
</tr>
</tbody>
</table>
Demographic Factor vs Macroeconomic Factors

- **Demographic factor:**
  - Constant population distribution
  - No population aging: income inequality path is flattens over the period (consistent with empirical research!)
  - There remains positive trend of the earning inequality

- **Macroeconomic factors:**
  - Without changing the macroeconomic factors, the time paths are smooth and single peaked
4. Quantitative Results

4.5 Demographic Factor vs Macroeconomic Factors

Demographic Factor vs Macroeconomic Factors

(c) Consumption Inequality (Variance of Log)

![Graph showing consumption inequality variance over years](image-url)

- Benchmark
- Population
- Macro
Intuition: Period $t$

- Income
- Age

Intra-generational Inequality
Intuition: Period $t$
5. Sensitivity Analysis

5.1 Separability and the Intertemporal Elasticity of Substitution

Separability and the Intertemporal Elasticity of Substitution

- To eliminate the effect of time reduction from the marginal utility function
- Separable utility function when $\gamma = 1$:
  \[ u(c_{j,t}, \bar{h}_t - h_{j,t}) = \sigma \log c_{j,t} + (1 - \sigma) \log(\bar{h}_t - h_{j,t}) \]
- High IES: $\gamma = 4$
5. Sensitivity Analysis

5.1 Separability and the Intertemporal Elasticity of Substitution

Separability and the IES

(a) Earning Inequality (Variance of Log)

Year
Deviation from Mean
-0.2 -0.15 -0.1 -0.05 0 0.05 0.1 0.15 0.2

Benchmark
- Log-Log
Gamma=4

Graph showing deviation from mean earning inequality over years 1980 to 2000.
5. Sensitivity Analysis
5.1 Separability and the Intertemporal Elasticity of Substitution

Separability and the IES

(c) Consumption Inequality (Variance of Log)

Year
Deviation from Mean
0 0.05 0.1

Benchmark
Log-Log
Gamma=4
Concluding Remarks and Future Research

- We consider quantitative impacts of the three factors on the economic inequality between 1980 and 2000 in Japan
  1. Macroeconomic factors
  2. A demographic factor
  3. Idiosyncratic income risk

- The economic inequality in Japan is, at least partially, explained by an OLG model with idiosyncratic income risk
  - In this respect, our result is considered to be an extension of the result obtained by Hayashi and Prescott (2002)

Future research
- Liquidity constraint (zero wealth holding)
- Female labor supply
- Skill biased technology progress/Human capital accumulation