# Response of Inequality to a Growth Rate Slowdown in Japanese Economy during the Lost Decades

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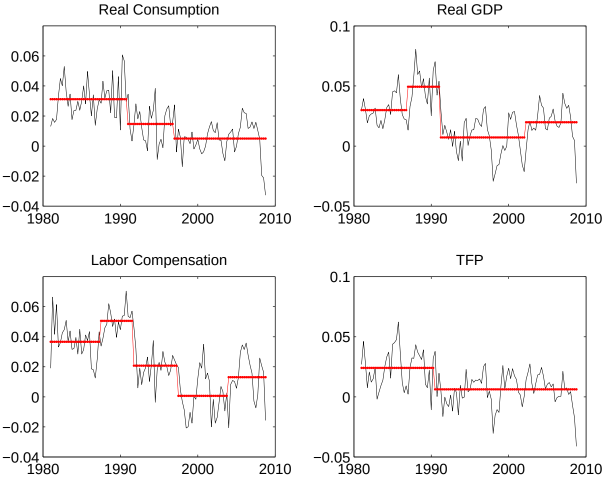
# Motivation

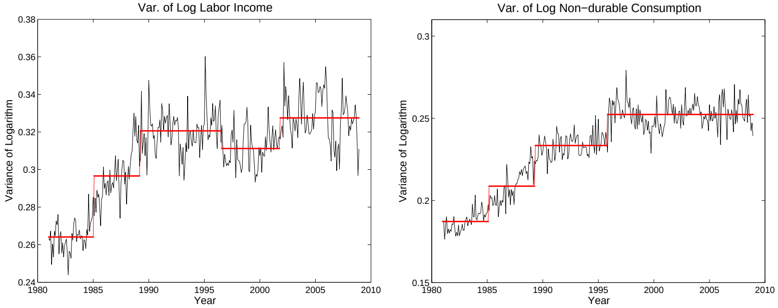
- Slowdown in aggregate growth after bubble burst in Japan (the Lost decades)
  - Hayashi and Prescott (2002)
- Changes in income and consumption distribution across households during the same period
  - Lise, Sudo, Suzuki, Yamada, and Yamada (2014, *RED*)

# Time Path of Macroeconomic Variables



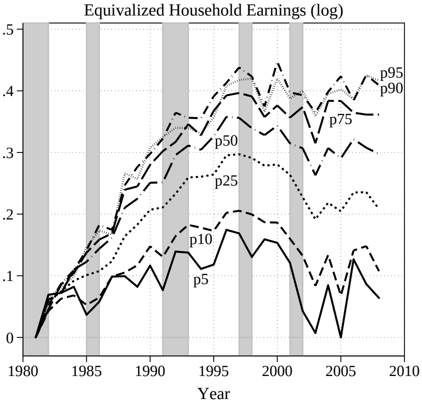

- Red line: the estimated mean of each variables with structural breaks

# Variance of Log. Income and Consumption




- Full-time employed workers: 25–59
- The lost decades are accompanied by the slowdown of inequality growth

# Percentiles of the Earnings Distribution




- Top income quantiles grow faster than bottom during 1980s
- Income growth rates decline in mid-1990s

▸ APPENDIX FIGURE

# Questions

1. What are the driving forces of these changes in income and consumption distribution?
    - (i) lower aggregate TFP growth, (ii) skill premium increases, or both?
2. Are these forces responsible for aggregate growth rate slowdown?
3. How do they affect the income and consumption distribution?

# What We Do

1. Construct *monthly* time series of variance of log income, consumption, and correlation between the two variables
   - Family Income and Expenditure Survey
2. Structural break tests on time series of cross-section moments
3. Examine link between aggregate slowdown and inequality in a dynamic general equilibrium model with heterogeneous households

# Empirical Findings

- *Macroeconomic changes during the lost decade?*

1. Aggregate output growth rate *slowdown*
2. Income inequality growth rate *slowdown*
3. Consumption inequality growth rate *slowdown*
4. *Falls in* covariance/correlation between income and consumption

# Theoretical Findings

*Slowdown of TFP and demand for skilled labor are both needed to account for the empirical findings*

| | TFP | demand for skilled labor |
|---|---|---|
| *Slower* aggregate output growth | *Yes* | *Yes* |
| *Slower* income inequality growth | *No* | *Yes* |
| *Slower* consumption inequality *growth* | *Yes* | *Yes* |
| *Lower* Cov./Corr. between $y$ & $c$ | *Yes* | *Yes / No* |

# Literature Review

- **TFP decline in Japan:**
  - Hayashi and Prescott (2002)
- **Skill premium:**
  - Acemoglu (2002), Kawaguchi and Mori (2014), and so on
- **Permanent/transitory shocks:**
  - Storesletten, et al. (2004), Blundell, et al. (2008), Guvenen, et al. (2013), and so on
- **Consumption inequality:**
  - Meyer and Sullivan (2013)
- **Overlapping-generations models:**
  - Heckman, et al. (1998), Kaplan and Violante (2009), Heathcote, et al. (2010), and so on

# Data

**Family Income and Expenditure Survey (FIES)**

- Monthly survey on household income and expenditures
  - January 1981 – December 2008
  - The number of observations: 8,000
  - Panel data: 6 months
- Focus on full-time employed workers: 25–59
  - Two-or-more household members
- Construct *monthly series* of variables on economic inequality

# Data (cont.)

## Definition of Variables

- Labor income $y$:
  - Sum of monthly labor income of household members
  - Household head + his/her spouse + other household members
  - Equivalized by OECD equivalent scale
- Consumption $c$:
  - Nondurable expenditures: housing, purchasing cars and durables such as furniture are excluded

DETAILS

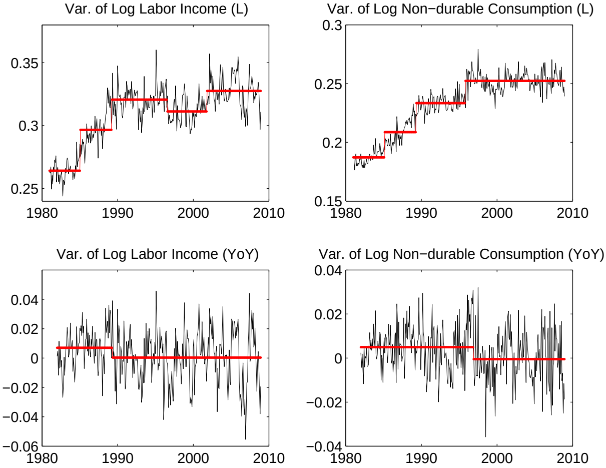
# Time-series Analysis

**Structural Break Test:** Bai and Perron (1998)

$$
\begin{aligned}
\xi_t &= x_t\beta + u_t, && \text{for} \quad t = 1, \ldots, T_1, \\
\xi_t &= x_t\beta + z_1\delta_1 + u_t, && \text{for} \quad t = T_1 + 1, \ldots, T_2, \\
&\vdots \\
\xi_t &= x_t\beta + \textstyle\sum_{j=1}^{l} z_j\delta_j + u_t, && \text{for} \quad t = T_l + 1, \ldots, T_{l+1} \\
&\vdots \\
\xi_t &= x_t\beta + \textstyle\sum_{j=1}^{m} z_j\delta_j + u_t, && \text{for} \quad t = T_m + 1, \ldots, T.
\end{aligned}
$$

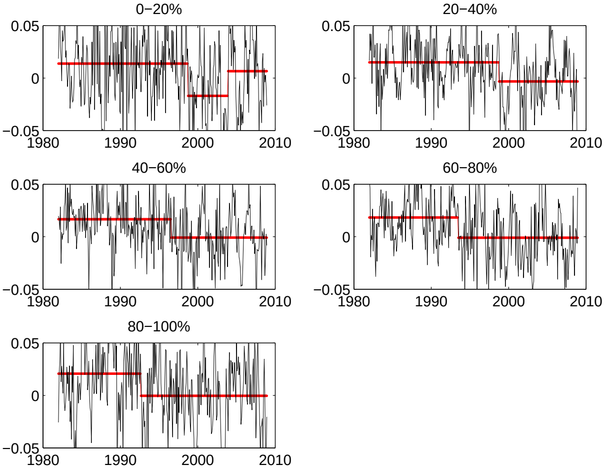
- $\xi_t$: each of the monthly time series
- $T_1, \ldots, T_m$: break dates, $m$: the number of breaks
- $\delta_j$: break size

# Variance of Log. Income and Consumption

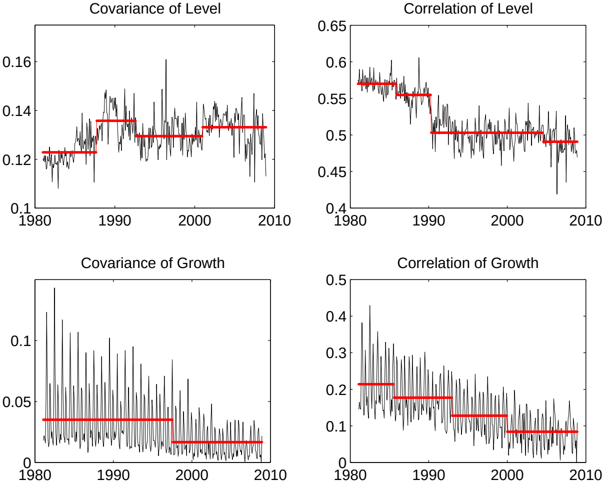



- The lost decades are accompanied by the slowdown of inequality growth

# Income Growth Rate with Different Income Quintiles



# Covariance and Correlation




- Transmission from income growth to consumption growth

# Model

**An incomplete-market overlapping-generations model:**

- transition between two steady states
- individuals face idiosyncratic income risks
- two types of individuals
  - skilled and unskilled: $e \in \{s, u\}$
- age: $j \in \{1, ..., j^{ret}, ..., J\}$
- population distribution:

$$\mu_{j+1} = s_{j+1}\mu_j$$

# Labor Income

**Idiosyncratic Labor Income Risk:**

- Labor income of individuals of age $j$ at period $t$

$$y^e_{j,t} = w^e_t \kappa^e_j \eta_j \varepsilon_j, \quad e \in \{s, u\}$$

- Persistent component of labor income

$$\ln \eta_{j+1} = \lambda \ln \eta_j + \omega_j, \quad \omega \sim \mathcal{N}(0, \sigma^2_\omega)$$

- Transitory shock

$$\ln \varepsilon \sim \mathcal{N}(-\sigma^2_\varepsilon/2, \sigma^2_\varepsilon), \quad \mathbb{E}_t \varepsilon_{t+1} = 1$$

# Household Problem

**Bellman Equation:**

$$V^e_{j,t}(a_{j,t},\eta,\varepsilon) = \max \frac{c_{j,t}^{1-\gamma}}{1-\gamma} + s_{j+1}\beta\mathbb{E}\left[V^e_{j+1,t+1}(a_{j+1,t+1},\eta',\varepsilon')\right]$$

subject to

$$c_{j,t} + a_{j+1,t+1} = \tilde{y}_{j,t} + (1+(1-\tau^k)r_t)(a_{j,t}+b_t)$$

$$\tilde{y}_{j,t} = \begin{cases} (1-\tau^y-\tau^{ss})y_{j,t} & \text{if} \quad j \leq j^{ret} \\ ss_t & \text{if} \quad j > j^{ret} \end{cases}$$

$$a_{j+1,t+1} \geq 0$$

# Aggregation

- Labor supply by skill type:

$$L_t^e = \sum_{j=1}^{j^{ret}} \mu_j \int \kappa_j^e \eta \varepsilon d\Psi_{j,t}^e(a, \eta, \varepsilon), \quad e \in \{s, u\}$$

- Aggregate labor:

$$L_t = \left[(A_t^s L_t^s)^\rho + (A_t^u L_t^u)^\rho\right]^{\frac{1}{\rho}}, \quad \rho \leq 1$$

  - $\frac{1}{1-\rho}$: elasticity of substitution between skilled and unskilled

- Aggregate capital:

$$K_t = \sum_{s,u} \sum_{j=1}^{J} \mu_j \int a d\Psi_{j,t}^e(a, \eta, \varepsilon)$$

# Production

- A representative firm's production function:

$$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha}$$

- Factor prices:

$$\begin{aligned} r_t &= \alpha Y_t / K_t - \delta, \\ w_t^e &= (1-\alpha) A_t \left( \frac{K_t}{L_t} \right)^{\alpha} L_t^{1-\rho} (A_t^e)^{\rho} (L_t^e)^{\rho-1}, e \in \{s, u\} \end{aligned}$$

- TFP factor growth rate:

$$\frac{A_{t+1}^{1/(1-\alpha)}}{A_t^{1/(1-\alpha)}} = 1 + g_{t+1}$$

# Government Budget

- Government budget:

$$G_t = \tau^y \sum_{s,u} \sum_{j=1}^{j^{ret}} \mu_j \int w_t^e \kappa_j^e \eta \varepsilon d\Psi_{j,t}^e(a,\eta,\varepsilon)$$

$$+\tau^k \sum_{s,u} \sum_{j=1}^{J} \mu_j \int r_t a d\Psi_{j,t}^e(a,\eta,\varepsilon).$$

- Social security system:

$$\sum_{s,u} \sum_{j=1}^{j^{ret}} \mu_j \int \tau^{ss} w_t^e \kappa_j^e \eta \varepsilon d\Psi_{j,t}^e(a,\eta,\varepsilon) =$$

$$\sum_{s,u} \sum_{j=j^{ret}+1}^{J} \mu_j \int \phi w_t^e \bar{L}_t^e d\Psi_{j,t}^e(a,\eta,\varepsilon)$$

# Parameters

- TFP factor growth rates: Muto, et al. (2013)
  - 1.84%: initial steady state
  - 0.16%: final steady state
- Preference parameters:
  - $\beta = 0.98$, $\gamma = 2$
- Production parameters: İmrohoroğlu and Sudo (2011)
  - $\alpha = 0.377$, $\delta = 0.08$
- Persistent shock parameters: Lise, et al. (2014)
  - $\lambda = 0.97$, $\sigma_\omega^2 = 0.01$
- Transitory shock parameter: Lise, et al. (2014)
  - $\sigma_\varepsilon^2 = 0.03$

# Calibration

- $j^{ret} = 45$ and $J = 81$
  - Individuals enter at age 20, retire at 65, and live at most 100
- $\{s_j\}_{j=1}^{J}$: Survival probabilities
  - National Institute of Population and Social Security Research
- Tax rates:
  - $\tau^y$=10%, $\tau^k$=39.8%, $\tau^{ss}$: 13.58%

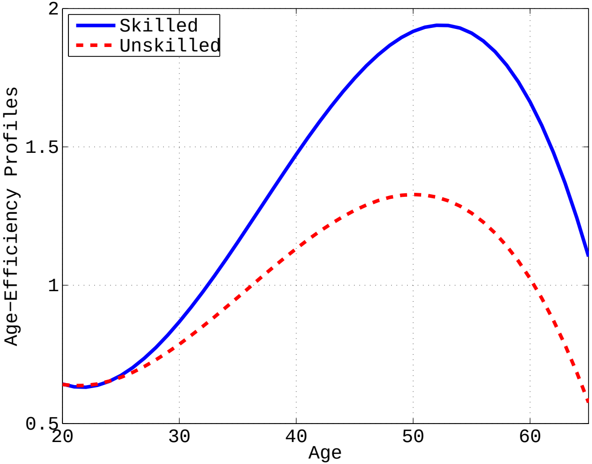
# Calibration

- Factor-augmenting skill terms (Acemoglu, 2002):

$$\frac{A^s}{A^u} = \frac{S_H^{\zeta/(\zeta-1)}}{L^s/L^u}, \quad S_H = \frac{w^s L^s}{w^u L^u}$$

  - use Basic Survey on Wage Structure
  - $s$: college graduates, $u$: high school graduates
  - $\zeta \equiv \frac{1}{1-\rho} = 1.4$: Heathcote, et al. (2010,JPE)
  - $w^s/w^u = 1.26$ in 1980s
  - $w^s/w^u = 1.35$ in 2000s
- $\{\kappa_j^e\}_{j=1}^{j^{ret}}$: age-efficiency profile

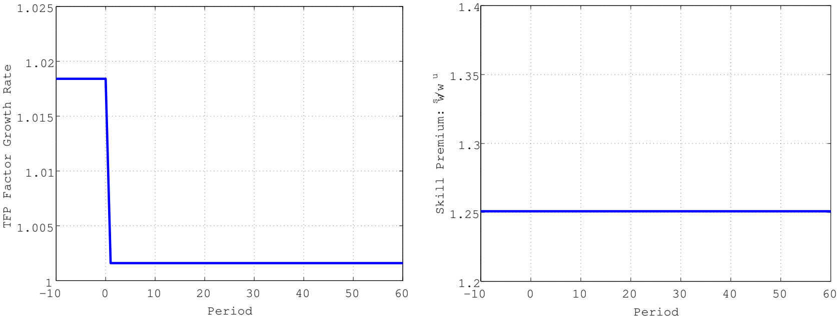
# Age-Efficiency Profile



# TFP Factor Growth Rate Shock

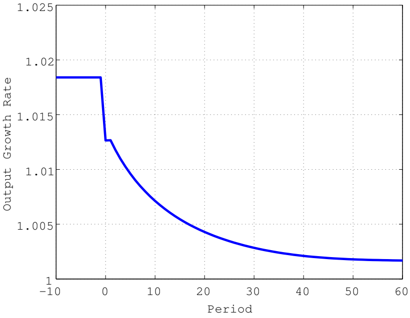
**TFP factor growth rate declines at period 1**

# TFP Factor Growth Rate and Skill Premium



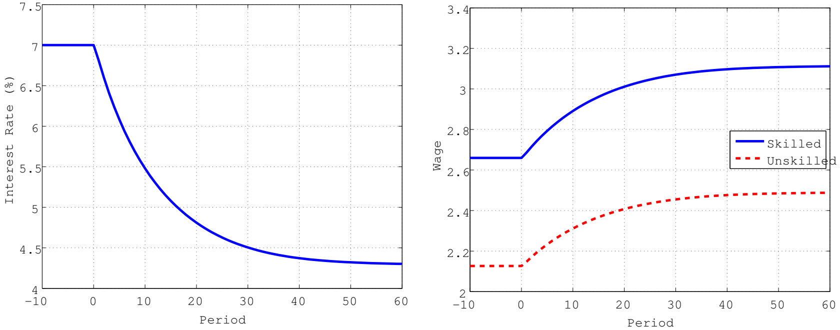

- Left: TFP factor growth rate, Right: skill premium

# Output Growth Rate and Var. Log. $y$



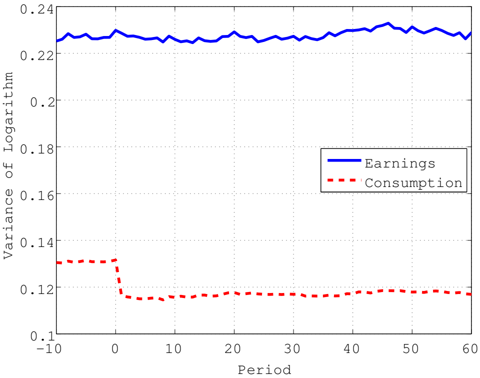

- Left: output growth rate, Right: variance of logarithm of earnings

# Interest Rate and Wage



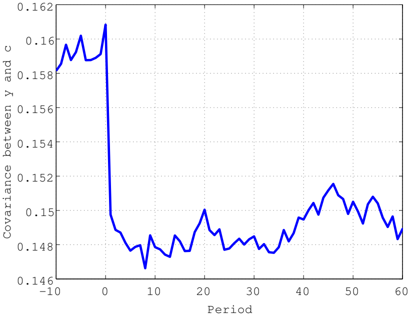

- Left: after-tax rate of return, Right: wages of skilled and unskilled workers

# Variance of Log. $y$ and $c$



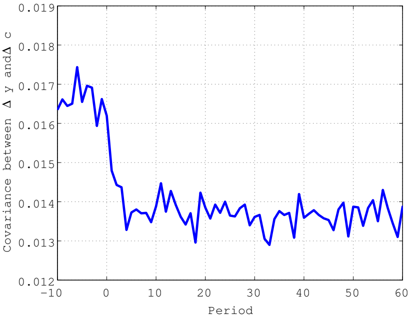

- # simulated households=60,000, aged 25–59

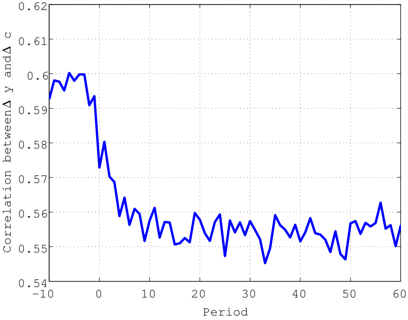
# Covariance and Correlation: $y$ and $c$




- Left: covariance, Right: correlation

# Covariance and Correlation: $\Delta y$ and $\Delta c$



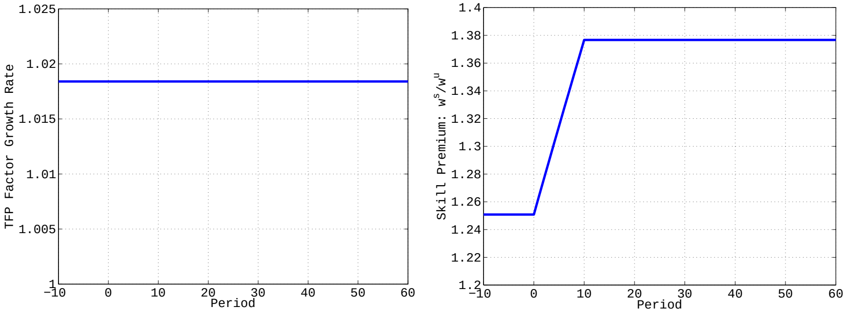




- Left: covariance of the first differences, Right: correlation of the first differences

# Skill Premium Shock

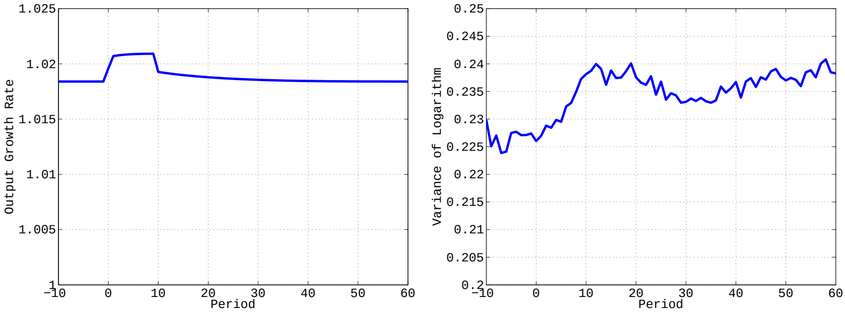
**Skill premium increases gradually for 10 years**

# TFP Factor Growth Rate and Skill Premium



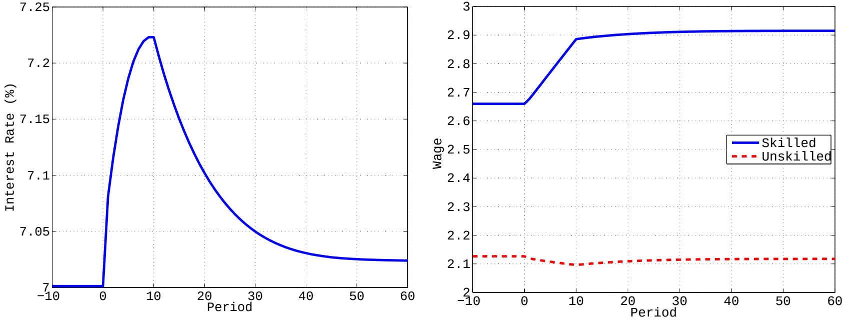

- Left: TFP factor growth rate, Right: skill premium

# Output Growth Rate and Var. Log. $y$



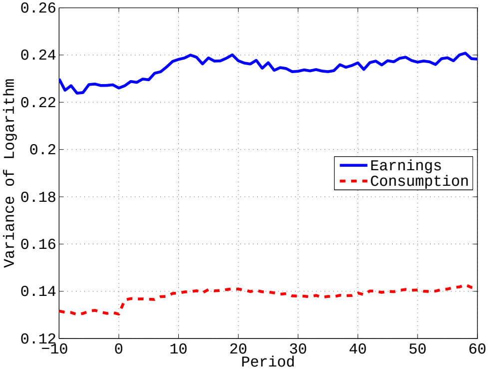

- Left: output growth rate, Right: variance of logarithm of earnings

# Interest Rate and Wage



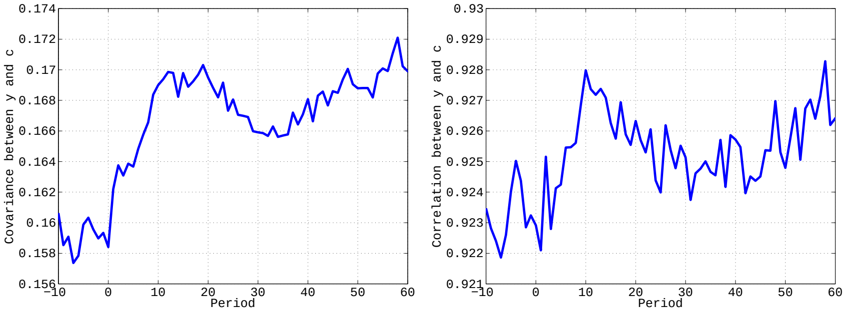

- Left: after-tax rate of return, Right: wages of skilled and unskilled workers

# Variance of Log. $y$ and $c$



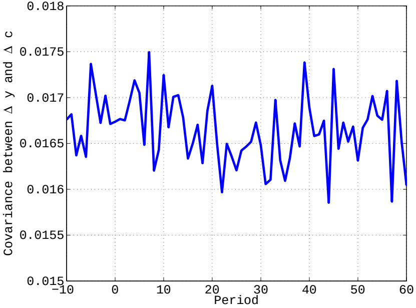

- \# simulated households=60,000, aged 25–59

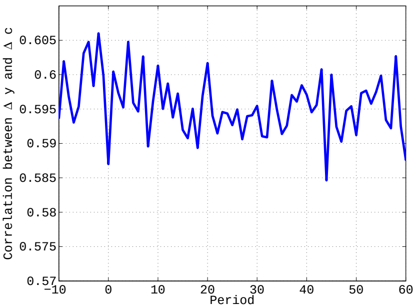
# Covariance and Correlation




- Left: covariance, Right: correlation

# Covariance and Correlation: $\Delta y$ and $\Delta c$



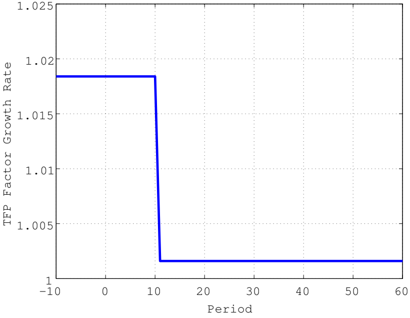



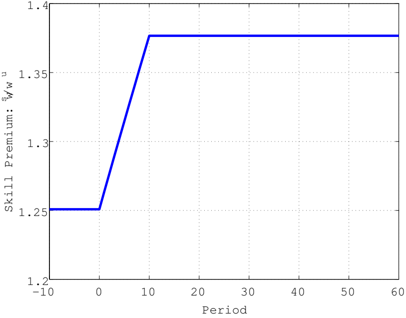

- Left: covariance of the first differences, Right: correlation of the first differences

# TFP Shock and Skill Premium Shock

**TFP shock and skill premium shock**

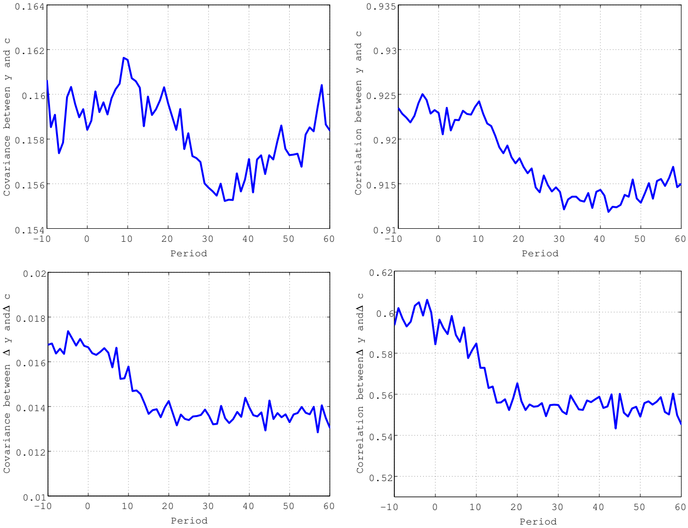
# TFP Factor Growth Rate and Skill Premium



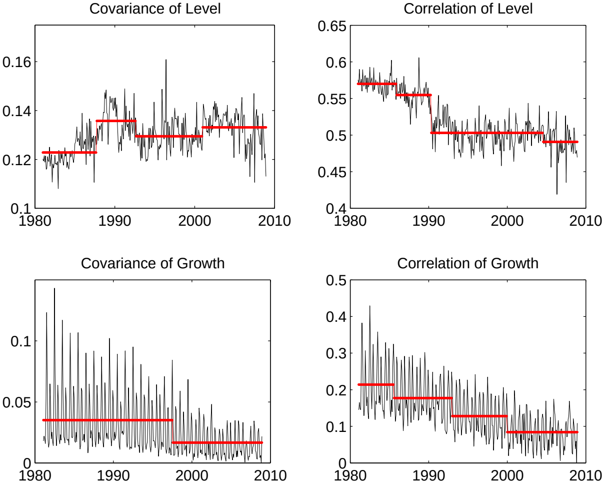




- Left: TFP factor growth rate, Right: skill premium

# Covariance and Correlation



# Data Again




- Transmission from income growth to consumption growth

# Discussion: Other Important Mechanisms?

1. Labor supply decisions
2. Borrowing limit due to the bubble burst
3. Demographic change
4. Tax reforms and transfers
5. Changes in permanent/transitory shocks
   $\Rightarrow$ Precautionary savings

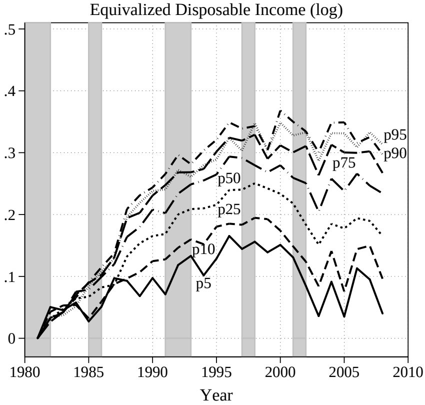
# Conclusion

1. The lost decades has come together with permanent slowdown of income and consumption inequality growth and weakening of income and consumption correlation
2. Declining the macroeconomic growth rate can be a possible explanation for the weakening of income and consumption correlation

- Future works: expected/unexpected shocks, demography, mpc, borrowing limit, tax code etc.

# Appendix Figures

# Percentiles of the Earnings Distribution

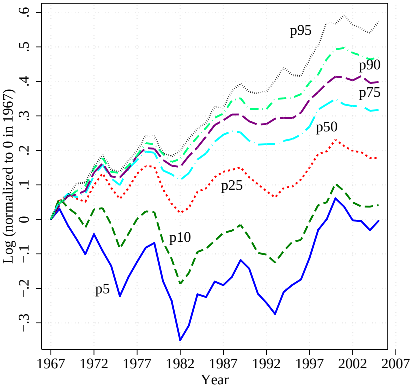



- Top income quantiles grow faster than bottom during 1980s
- Income growth rates decline in mid-1990s

RETURN

# Earnings Distribution in the U.S.

Fig.9, Heathcote, Perri, and Violante (2010)



# Data

# Data (cont.)

## Definition of Variables

- Labor income $y$:
  - sum of monthly labor income of household members, which include household head, his/her spouse and other household members
- Nondurable expenditure $c$:
  - food; repair and maintenance of houses; fuel, light and water charges; domestic utensils, non-durable goods, and services; clothing and footwear; medical care; transportation and communication, excluding purchase of vehicles and bicycles; education; culture and recreation, excluding recreational durable goods; and other consumption expenditure, excluding remittance

RETURN

# Two Period Model

# Two Period Model

**Why declines in economic growth rate affect second moments (consumption inequality)?**

$$
\begin{aligned}
\max_{c_1, c_2, a_2} \quad & u(c_1) + \beta u(c_2), \\
\text{subject to} \quad & c_1 + a_2 = y_1 + a_1, \\
& c_2 = y_2 + (1 + r) a_2, \\
& a_2 \geq 0, \\
& y_2 = \alpha y_1, \\
& a_1 \text{ given}, \ c_1, c_2 > 0.
\end{aligned}
$$

- $u(c) = \frac{c^{1-\gamma}}{1-\gamma}$
- $\alpha$: income growth rate

# Two Period Model

**Analytical solution: non-binding case**

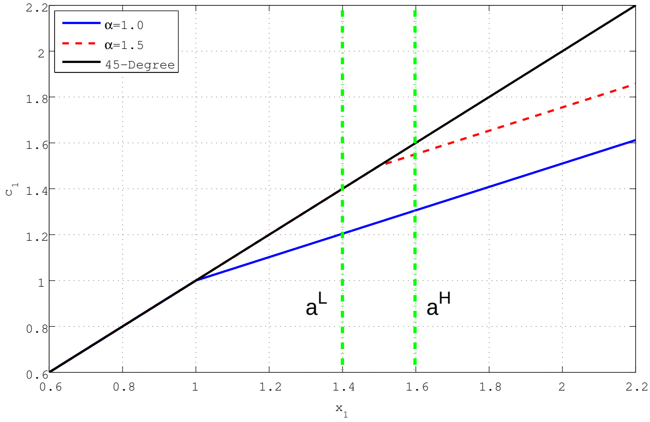
$$
\begin{aligned}
a_2 &= \frac{1}{1+r+\Gamma}(\Gamma x_1 - y_2) \\
c_1 &= \left(\frac{1+r}{1+r+\Gamma}\right)\left(x_1 + \frac{1}{1+r}y_2\right) \\
c_2 &= \Gamma\left\{\left(\frac{1+r}{1+r+\Gamma}\right)\left(x_1 + \frac{1}{1+r}y_2\right)\right\} = \Gamma c_1
\end{aligned}
$$

- $x_1 \equiv y_1 + a_1$: cash on hand
- $\Gamma \equiv [\beta(1+r)]^{\frac{1}{\gamma}}$: consumption growth rate

# Numerical Examples

- Discount factor: $\beta = 0.96$
- IES: $\gamma = 1$
- Interest rate: $r = 1/\beta - 1 \Rightarrow \Gamma = 1$
- Labor income at period 1: $y_1 \in \{0.8, 1, 1.2\}$
- Growth rate: $\alpha \in \{1, 1.5\}$

# Growth Rate Decline and Borrowing Limit




- Consumption function: $y_1 = 1, a^L = 0.4, a^H = 0.6$

# Growth Rate Decline and Borrowing Limit

| | Low Growth | High Growth |
|---|---|---|
| | $\alpha = 1$ | $\alpha = 1.5$ |
| $c_1$: $a^H$ | 1.3061 | 1.5510 |
| $c_1$: $a^L$ | 1.2041 | 1.4000 |
| $c_2$: $a^H$ | 1.3061 | 1.5510 |
| $c_2$: $a^L$ | 1.2041 | 1.5000 |
| Var. Log. $c_1$ | 0.0033 | 0.0052 |