The Young, the Old, and the Restless: Demographics and Business Cycle Volatility

Nir Jaimovich and Henry Siu

What is the role of demographic change in explaining changes in business cycle volatility?

Since the mid-1980s the U.S. and other industrialized countries have undergone a substantial decline in business cycle volatility. (The great moderation). There was also a run-up in volatility in the mid-1960s.

- Document important differences in the responsiveness of labor market activity to the business cycle for individuals of different ages.
- Use data for G7 countries to identify the effect of workforce age composition on business cycle volatility.
- Write a variant of the standard RBC model that emphasizes the role of age as determining an individual's labor market experience. Variation in age composition leads to variation in macroeconomic volatility.

A first look at US data

	15 - 19	20 - 24	25 - 29	30 - 39	40 - 49	50 - 59	60 - 64	65+
raw volatility	4.845	2.384	1.691	1.202	0.898	0.909	1.406	3.083
R^2	0.79	0.81	0.84	0.89	0.90	0.72	0.33	0.25
cyclical volatility	4.346	2.139	1.518	1.138	0.829	0.780	0.800	1.570
% of hours	3.24	10.33	12.86	25.38	23.29	17.20	4.82	2.88
% of hours volatility	11.14	17.49	15.44	22.86	15.84	10.61	3.04	3.58

Table 2.1: Volatility of Hours Worked by Age Group, US. HP filtered data.

$$h_t^i = \beta_0 + \beta_1 y_t^{HPcycle} + \beta_2 h_t^{Agg} + \beta_3 h_{t-1}^{Agg} + \varepsilon_t^i$$

Cyclical volatility is defined as $var\left(\hat{h}_t^i\right)$

A first look at Japanese data

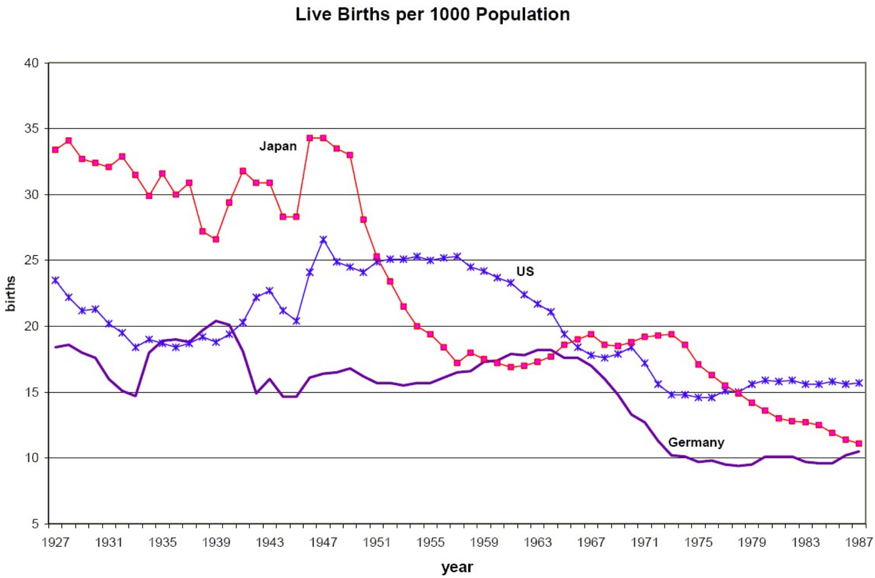
	15 - 19	20 - 24	25 - 29	30 - 39	40 - 49	50 - 59	60 - 64	65+
raw volatility	2.868	0.965	0.835	0.759	0.626	0.640	1.021	1.203
R^2	0.65	0.64	0.85	0.86	0.87	0.91	0.42	0.53
cyclical volatility	2.338	0.769	0.775	0.710	0.593	0.619	0.662	0.846
% of hours	2.21	10.18	11.77	23.34	24.19	18.67	4.92	4.73
% of hours volatility	7.17	10.88	12.67	23.02	19.93	16.06	4.52	5.75

Table 2.2: Volatility of Hours Worked by Age Group, Japan. HP filtered data.

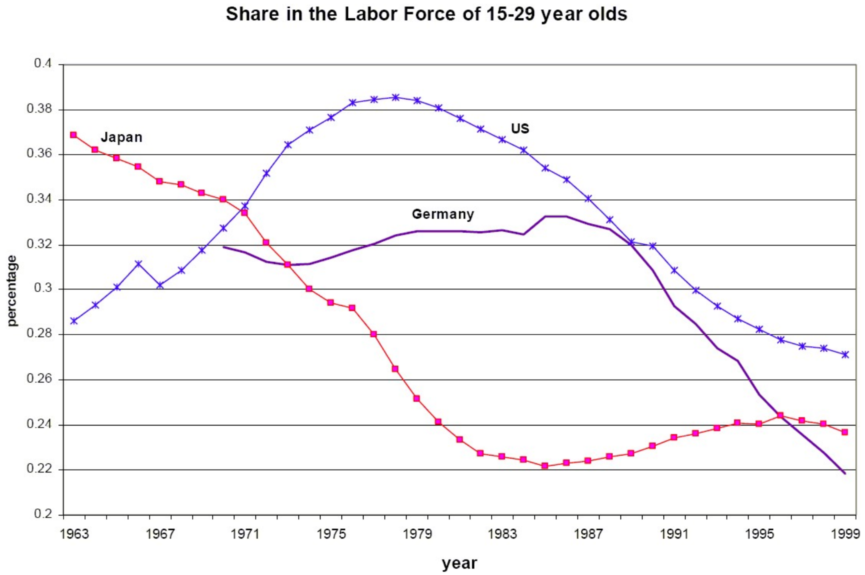
What about all G7 countries?

		15 - 19	20 - 24	25 - 29	30 - 39	40 - 49	50 - 59	60 - 64
US	cyclical volatility	4.691	2.577	1.766	1.424	1.000	1.077	0.927
	% of empl.	6.72	12.30	12.89	24.82	22.27	16.38	4.62
	% of empl. volatility	19.04	19.15	13.76	21.35	13.46	10.66	2.59
Japan[A]	cyclical volatility	6.821	1.642	1.321	1.095	1.000	1.400	2.957
	% of empl.	2.91	10.77	11.45	22.75	23.22	17.96	10.93
	% of empl. volatility	12.54	11.18	9.56	15.73	14.67	15.89	20.42
Canada	cyclical volatility	4.198	2.327	1.693	1.311	1.000	0.907	1.174
	% of empl.	7.46	12.37	13.53	26.61	22.41	14.34	3.29
	% of empl. volatility	19.92	18.31	14.57	22.21	14.26	8.28	2.45
France	cyclical volatility	9.195	6.626	2.985	1.676	1.000	1.812	4.320
	% of empl.	2.75	10.36	13.70	27.27	25.21	17.49	3.21
	% of empl. volatility	10.06	27.32	16.27	18.18	10.03	12.61	5.52
Germany	cyclical volatility	3.222	3.426	2.550	1.643	1.000	1.264	7.073
	% of empl.	7.82	12.66	11.96	24.57	23.48	16.27	3.25
	% of empl. volatility	12.20	21.01	14.77	19.56	11.37	9.96	11.13
Italy	cyclical volatility	6.452	4.101	2.125	1.169	1.000	2.466	3.176
	% of empl.	7.70	8.41	12.45	28.05	24.43	15.94	3.02
	% of cyclical employment	22.93	15.91	12.20	15.13	11.27	18.13	4.43
UK[B]	cyclical volatility	5.464	3.351	2.072	1.654	1.000	1.502	2.350
	% of empl.	6.54	10.90	12.37	25.28	23.51	17.37	4.03
	% of empl. volatility	17.97	18.38	12.89	21.04	11.83	13.13	4.77

Timing of Demographic Change varies across countries I



Timing of Demographic Change varies across countries 2



Demographics and Business Cycle volatility I

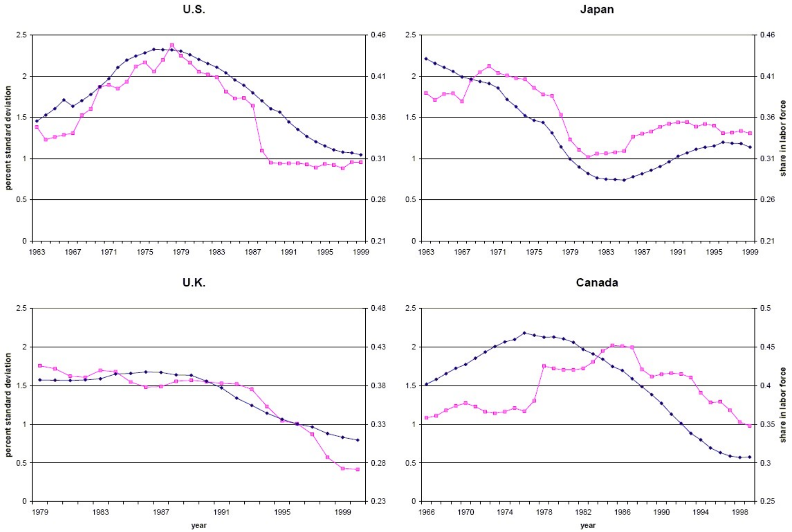


Figure 6. Demographics and Business Cycle Volatility, G7 Economies, Part 1. Light, square-hatched line: business cycle output volatility; dark, diamond-hatched line: 'volatile aged' labor force share.

Demographics and Business Cycle volatility II

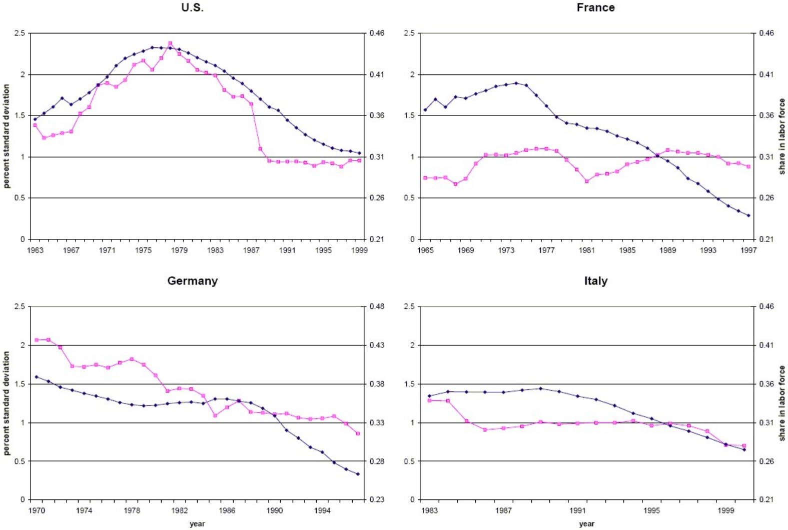


Figure 7. Demographics and Business Cycle Volatility, G7 Economies, Part 2. Light, square-hatched line: business cycle output volatility; dark, diamond-hatched line: 'volatile aged' labor force share.

Estimating the effect of age composition on Business cycle volatility I

$$\sigma_{it} = \alpha_i + \beta_t + \gamma share_{it} + \epsilon_{it}$$

	1	2	3	4	5	6	7
	$\text{HP}^{A,\bigstar}$	$\text{HP}^{A,\blacktriangle}$	$\text{HP}^{B,\blacktriangle}$	$\text{FD}^{A,\blacktriangle}$	$\text{FD}^{B,\blacktriangle}$	$\text{BP(hi)}^{A,\blacktriangle}$	$\text{BP(lo)}^{A,\blacktriangle}$
$\hat{\gamma}$	4.022***	4.022***	4.955***	2.090***	2.250**	2.345***	2.507***
	(0.792)	(1.134)	(1.500)	(0.693)	(0.996)	(0.704)	(0.936)
Nobs	207	207	213	207	213	180	180

A and B: 41 qtr and 21 qtr window used to construct dependent variable, respectively.
★ and ▲: OLS and Newey-West robust standard error, respectively.
** and ***: significant at 5% and 1% level, respectively.

Estimating the effect of age composition on Business cycle volatility II

		endogeneity			*Blanchard - Simon*	
	1	2	3	4	5	6
	OLS	IV1	IV2	BP	OLS	IV2
A. annual						
$\hat{\gamma}$	4.022***	3.635***	3.946***	4.284***	5.430***	5.381***
	(1.134)	(1.424)	(1.138)	(1.203)	(1.095)	(1.089)
Nobs	207	207	207	207	203	203
B. 4-year						
$\hat{\gamma}$	4.306***	3.411*	4.272***	4.532***	5.728***	5.447***
	(1.427)	(1.987)	(1.422)	(1.596)	(1.390)	(1.379)
Nobs	55	55	55	55	53	53

* and ***: significant at 10% and 1% level, respectively.

Table 3.2: Effect of Volatile Group Shares on Business Cycle Volatility: Additional Robustness Checks. All regressions include country fixed effects and time dummies. Newey-West robust standard errors in parentheses.

Looking at the entire age distribution

		30 - 39	40 - 49	50 - 59	60 - 64	Nobs
1	OLS	-3.026^{*}	-4.058^{***}	-6.226^{***}	-0.716	207
		(1.672)	(1.489)	(2.086)	(4.371)	
2	IV1	-3.237^{**}	-4.177^{***}	-6.440^{***}	-0.588	207
		(1.680)	(1.485)	(2.165)	(4.448)	
3	IV2	-2.935^{*}	-4.010^{***}	-6.039^{***}	-1.018	207
		(1.676)	(1.500)	(2.077)	(4.406)	
4	BP	-2.745	-4.335^{***}	-6.769^{***}	-0.614	207
		(1.739)	(1.674)	(2.520)	(4.658)	

*, **, and *** significant at 10%, 5%, and 1% level, respectively.

Table 3.3: Effect of the Age Distribution on Business Cycle Volatility, annual observations. All regressions include country fixed effects and time dummies. Newey-West robust standard errors in parentheses.

A back of the envelope calculation

- Volatility peaks in 1978 when the 15-29 year old labor force share was 38.5%
- By 1999 the 15-29 year old labor force share had gone down to 27.1%.
- The OLS estimates predict a drop in the volatility of output of $0.114 \times 4.058 = 0.4063$.
- During the same time period cyclical volatility falls from 2.379 to 0.955. So changes in age composition account for about 1/3 of the moderation.

Modelling the Great Moderation

- Goal: to construct a RBC model that generates age-group differences in the cyclical volatility of hours worked.
- Differences accross age groups can arise from:
  - Differences in Preferences (Labor Supply)
  - Differences in factors relating to Technology (Labor Demand)
- Model with two age groups. Young workers (15-29) are "inexperienced" while all old workers (30+) are "experienced".
- Production exhibits *capital-experience complementarity* so that differences in the cyclical demand for experienced and inexperienced labor can take place.

Production Function

$$Y_t = \left[\mu\left(A_t H_{Yt}\right)^{\sigma} + (1-\mu)\left[\lambda K_t^{\rho} + (1-\lambda)\left(A_t H_{Ot}\right)^{\rho}\right]^{\frac{\sigma}{\rho}}\right]^{\frac{1}{\sigma}}$$

- Labor-Augmenting technology follows a deterministic growth path with persistent transitory shocks:

$$\begin{aligned} A_t &= \exp\left(gt + z_t\right) \\ z_t &= \phi z_{t-1} + \varepsilon_t,\ 0 < \phi < 1, var\left(\varepsilon\right) = \sigma_{\varepsilon}^2 \end{aligned}$$

- Following Krusell et. al (2000) production exhibits capital-experience complementarity when $\sigma > \rho$.
- Firms rent capital, and young and old worker's time from perfectly competitive factor markets to maximize profits. Optimality then entails equating factor prices with marginal revenue products.

Households

The representative household's date t problem is to maximize:

$$E_t \sum_{j=t}^{\infty} \beta^{j-t} \left\{ s_Y \left[\log C_{Yj} - \psi_Y \frac{N_{Yj}^{1+\theta_Y}}{1+\theta_Y} \right] + (1-s_Y) \left[\log C_{Oj} - \psi_O \frac{N_{Oj}^{1+\theta_O}}{1+\theta_O} \right] \right\}$$

subject to

$$s_Y C_{Yj} + (1-s_Y) C_{Oj} + \tilde{K}_{j+1} = (1-\delta) \tilde{K}_j + r_j \tilde{K}_j + s_Y W_{Yj} N_{Yj} + (1-s_Y) W_{Oj} N_{Oj}$$

Optimality in this setup entails:

$$C_{Yt} = C_{Ot} = C_t$$

The optimal condition for hours worked are given by:

$$\begin{aligned} W_{Yt} &= \psi_Y C_t N_{Yt}^{\theta_Y} \\ W_{Ot} &= \psi_O C_t N_{Ot}^{\theta_O} \end{aligned}$$

"Structural Estimation of σ"

First order condition with respect to the demand for H_{Yt}

$$W_{Yt} = Y_t^{1-\sigma} \mu A_t^{\sigma} H_{Yt}^{\sigma-1}$$

write this in logged first differenced form:

$$\Delta \log W_{Yt} = a_0 + (\sigma - 1) \Delta \log (H_{Yt}/Y_t) + \sigma u_t$$

Multiply both sides by H_{Yt}

$$\Delta \log LI_{Yt} = a_0 + \sigma \Delta \log (H_{Yt}) + (1 - \sigma) \Delta \log Y_t + \sigma u_t$$

Estimate this equation by restricted least squares

"Structural Estimation of ρ"

First order condition with respect to the demand for H_{Ot}

$$W_{Ot} = Y_t^{1-\sigma} (1-\mu) \left[\lambda K_t^{\rho} + (1-\lambda)(A_t H_{Ot})^{\rho}\right]^{\frac{\sigma-\rho}{\rho}} (1-\lambda) A_t^{\rho} H_{Ot}^{\rho-1}$$

write this in logged first differenced form:

$$\Delta \log \left(\frac{Q_{Ot}}{Q_{Kt}} \right) = a_2 + \rho \Delta \log (H_{Ot}/K_t) + \rho u_t$$

Estimate this equation by restricted least squares.

They use Ramey-Shapiro dates and lagged birth rates to instrument their regressors. $\hat{\rho} = 0.12\,(0.31)$ and $\hat{\sigma} = 0.62\,(0.2)$.

Calibration I

- $\beta = 0.995$
- $\delta = 0.023$
- $\theta_Y = \theta_O = 0$ household members have Rogerson-Hansen preferences.
- μ and λ are set to match the 1968-1984 income shares of $Q_K = 0.37$ and $Q_O = 0.47$.

Calibration II

Given values for $\{\sigma, \rho, \mu, \lambda\}$ and data on output and factor inputs, they back out $\{A_t\}$.

- $\phi = 0.93$, $\sigma_{\varepsilon}^{1968-1984} = 0.0087$ and $\sigma_{\varepsilon}^{1985-2004} = 0.0050$
- $S_Y = 0.35$ matches the share of young individuals in 1968-1984.
- $N_{Y_{ss}}$ and $N_{O_{ss}}$ are set to match the ratio of young to old hours worked and $H_{ss} = 0.3$
- In the postmoderation period $s_Y = 0.27$ and $N_{O_{ss}}$ is increased by 12%.

Results

	A. *US data*			B. *benchmark model*			C. *counterfactual*	
	PRE	POST	CHANGE	PRE	POST	CHANGE	POST	CHANGE
std(Y)	1.99	0.95	−0.74	1.85	1.00	−0.62	1.06	−0.55
std(H)	1.90	0.90	−0.75	1.90	0.99	−0.66	1.09	−0.55
std(H) /std(Y)	0.95	0.94	−0.01	1.03	0.99	−0.04	1.03	0
std(H_Y) /std(Y)	1.38	1.79	+0.27	1.58	1.65	+0.04	1.58	0
std(H_O) /std(Y)	0.78	0.74	−0.04	0.76	0.80	+0.04	0.76	0
std(H_Y) /std(H_O)	1.76	2.40	+0.31	2.07	2.08	+0.00	2.07	0

Table 5.1: Second Moment Statistics. A: US data, 1968-1984 and 1985-2004. B and C: model generated values from the benchmark and conterfactual calibrations.

Some observations

- Not enough heterogeneity.
- Might be important to model the participation margin.
- Labor Supply considerations are important and vary across the life cycle.