The Great Increase in Relative Volatility of Real Wages in the United States

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- Document that volatility of U.S. real hourly wage *relative* to volatility of output increased 2.5-3.5 times during the Great Moderation
- Use CPS microdata to show that increase in relative wage volatility is not due to compositional changes but occured across entire U.S. workforce
- Build New Keynesian DSGE model to illustrate that
  - changes in exogenous shock processes have sizable effect on *absolute* volatility and cyclicality of wages, but not on *relative* volatility of wages
  - greater wage flexibility due to deunionization and shift towards performance pay accounts for substantial part of increased relative wage volatility
  - greater wage flexibility also decreases magnitude of business cycles, thus providing new source for Great Moderation

Aggregate hourly wages: data

- Hourly wage rate: Nonfarm business total compensation / total hours
  - Source: BLS' Labor Productivity and Cost program (LPC)
  - Total compensation is based on QCEW (covering 98% of private-sector jobs) and includes
    - ★ direct payments (wages and payments; incl. exec comp)
    - ★ comissions, tips, bonuses
    - ★ supplements (vacation pay, employer contributions to pension and health plans)
  - Total hours from CES, supplemented with CPS data
- Price level: PCE deflator
  - Source: BEA
  - Robustness checks with CPI and GDP deflator

The Great Increase in Relative Volatility of Real Wages

Non-farm GDP and real wage volatilities

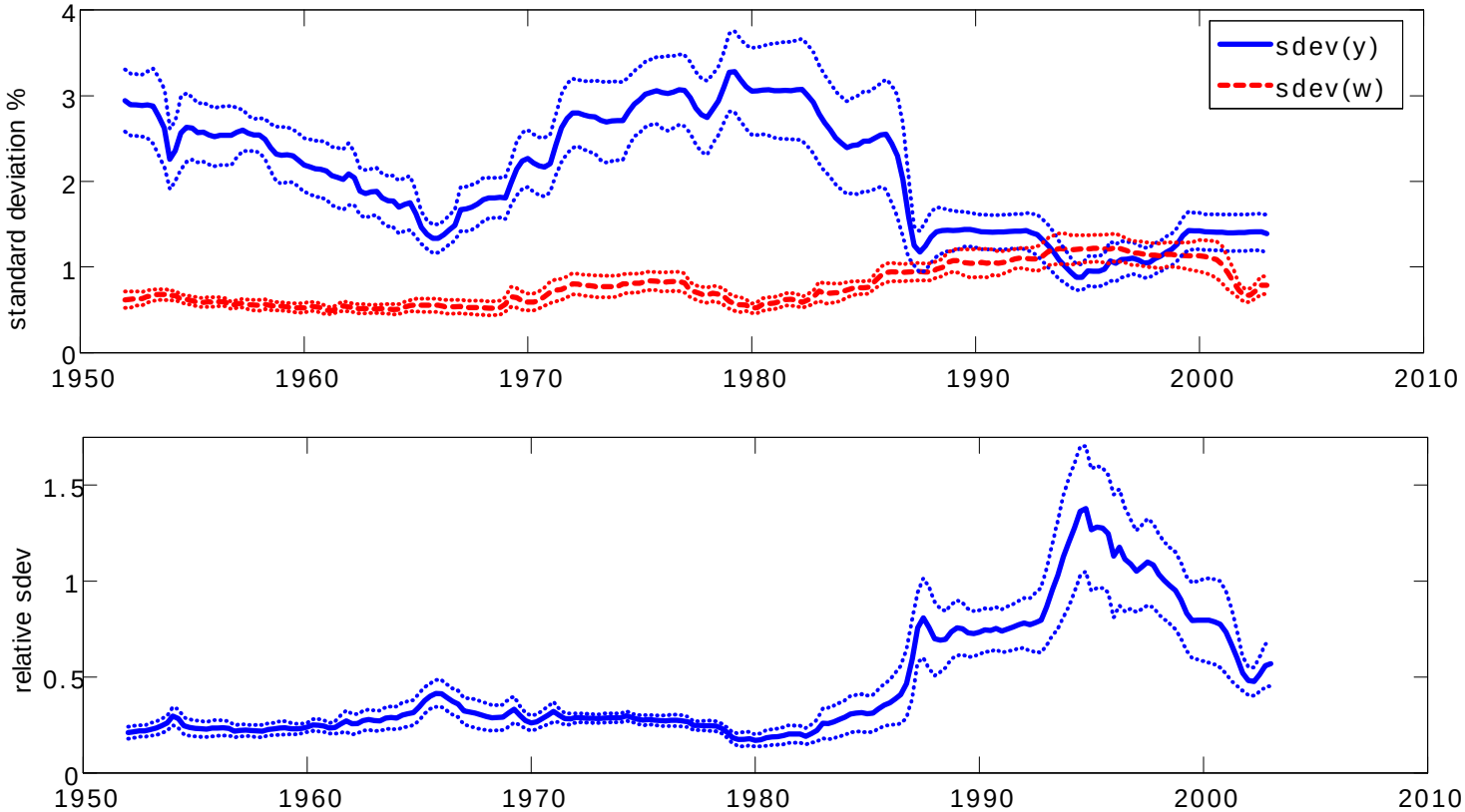

Figure 1: Rolling windows of standard deviations (upper panel) and relative standard deviations (lower panel). Dotted lines represent +/- one standard deviation bands.

The Great Increase in Relative Volatility of Real Wages

TABLE 1
Changes in Volatility

	Standard Deviation				Relative Standard Deviation		
	Pre-84	*Post-84*	*Post/Pre-84*	*p-value*	*Pre-84*	*Post-84*	*Post/Pre-84*
First-Difference							
Output	1.52	0.68	0.45	0.00	1.00	1.00	1.00
	(0.10)	(0.07)					
Wage	0.50	0.68	1.37	0.01	0.33	1.00	**3.04**
	(0.03)	(0.07)			(0.02)	(0.12)	
HP-Filter							
Output	2.57	1.28	0.50	0.00	1.00	1.00	1.00
	(0.24)	(0.14)					
Wage	0.63	1.02	1.62	0.00	0.24	0.80	**3.33**
	(0.06)	(0.10)			(0.02)	(0.12)	
BP-Filter							
Output	2.50	1.16	0.46	0.00	1.00	1.00	1.00
	(0.26)	(0.11)					
Wage	0.62	0.94	1.52	0.00	0.25	0.81	**3.24**
	(0.07)	(0.10)			(0.02)	(0.13)	

Notes: Total sample extends from 1953:2 to 2006:4 with split in 1984:1. Quarterly data. P-values are reported for a test of equality of variances across the two subsamples. Standard errors appear in parentheses below estimates.

more

Evidence from disaggregate data

- Current Population Survey (CPS)
  - monthly survey of about 60,000 households
  - compensation is top-coded and measures only regular bonuses and commissions
- Annual series for 1973 – 2006 from CPS May Supplements and CPS ORG (as in Lemieux, 2006)
  - Hourly wage measured directly for hourly paid workers (about 60%)
  - Hourly wage constructed from weighted weekly earnings/weekly hours for salaried workers

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- Results for aggregate CPS wage series: 1973-1983 / 1984-2006
  - absolute wage volatility increases less and not significantly
  - relative wage volatility increases by a factor of 2.9

Evidence from disaggregate data

- Use CPS to construct hourly wages for different worker decompositions
- Skill decomposition important in all cases
  - **skilled workers** = college or more;
  - **unskilled workers** = some college or less (Krusell et al., 2000)
- Create worker-groups according to *skill* and
  - gender
  - age
  - employment status (hourly paid or salaried)
  - industry
  - occupation

Evidence from disaggregate data

Results for skill/gender decomposition

	Standard Deviation				Relative Standard Deviation		
	Pre-84	*Post-84*	*Post/Pre-84*	*p-value*	*Pre-84*	*Post-84*	*Post/Pre-84*
SKILL / GENDER							
Male unskilled	0.71	0.83	1.16	0.55	0.25	0.72	2.92
	(0.08)	(0.16)			(0.03)	(0.17)	
Male skilled	0.41	1.11	2.71	0.10	0.14	0.96	6.80
	(0.04)	(0.23)			(0.01)	(0.26)	
Female unskilled	0.78	0.73	0.94	0.90	0.27	0.63	2.35
	(0.12)	(0.13)			(0.05)	(0.15)	
Female skilled	1.47	0.84	0.57	0.11	0.51	0.73	1.43
	(0.31)	(0.10)			(0.13)	(0.14)	

- Change in *absolute* wage volatility varies across decompositions, but **relative wage volatility increases for all worker groups**
- Wage volatility increases most for skilled and salaried workers

Volatility accounting

- Express w_t as weighted sum of hourly wages w_{it} of worker groups i

$$w_t = \sum_i w_{i,t} \frac{H_{i,t}}{H_t} = \sum_i w_{i,t} h_{i,t} = \sum_i x_{i,t}$$

  - $h_{i,t}$ = hours share of group i in t

- Growth rates

$$\frac{\Delta w_t}{w_{t-1}} = \sum_i \frac{x_{i,t-1}}{w_{t-1}} \frac{\Delta x_{i,t}}{x_{i,t-1}} => \Delta \log w_t = \sum_i s_{i,t-1} (\Delta \log w_{i,t} + \Delta \log h_{i,t})$$

  - $s_{i,t-1} = w_{i,t-1} H_{i,t-1} / w_{t-1} H_{t-1}$ = 'wage share' of group i in $t-1$

Volatility accounting

- Approximate relative variance of aggregate hourly wage

$$\begin{aligned}
\frac{var(\Delta \log w_t)}{var(\Delta \log y_t)} &\equiv \frac{\sigma_w^2}{\sigma_y^2} \\
&\approx \sum_i \bar{s}_i^2 \left[\frac{\sigma_{w_i}^2}{\sigma_y^2} + \frac{\sigma_{h_i}^2}{\sigma_y^2} + \frac{\sigma_{w_i,h_i}}{\sigma_y^2} \right] \\
&\quad + \sum_{i \neq j} \bar{s}_i \bar{s}_j \left[\frac{\sigma_{w_i,w_j}}{\sigma_y^2} + \frac{\sigma_{w_i,h_j}}{\sigma_y^2} + \frac{\sigma_{h_i,w_j}}{\sigma_y^2} + \frac{\sigma_{h_i,h_j}}{\sigma_y^2} \right]
\end{aligned}$$

- Decompose change in relative variance of aggregate hourly wage across two subsamples; i.e. $\frac{\sigma_w^2(b)}{\sigma_y^2(b)} - \frac{\sigma_w^2(a)}{\sigma_y^2(a)}$ into
  - changes in average wage shares (compositional effect)
  - changes in relative volatility of hourly wages
  - changes in relative volatility of hours shares
  - changes in correlations

Volatility accounting

Results for different decompositions

Relative Volatility Accounting Across Different Decompositions

Decomposition	Gender/ Skill	Age/ Skill	Emp Status/ Skill	Industry(22)/ Skill
CPS wage	100.00%	100.00%	100.00%	100.00%
Changing s_i	6.08%	6.49%	12.28%	6.73%
Changing σ*(hourly wages)*^{2}	77.94%	71.05%	70.28%	69.06%
Changing σ*(hours shares)*^{2}	-6.30%	-6.40%	-2.64%	-4.88%
Changing correlations	22.28%	28.86%	20.09%	29.09%

Notes: Total sample extends from 1973 to 2006 with split in 1984 (Except for Industry(22)/Education, which stops in 2002). HP-filtered data. Nonfarm business sector. Employment status stands for hourly paid or salaried workers. Hourly paid workers' wages have been adjusted for the 1994 CPS redesign (see appendix for details).

- Results direct search for possible explanations towards
  - structural changes that have similar effects on wage setting in different labor markets...
  - ...but affect some worker groups more than others

New Keynesian DSGE model

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  - changes in shock processes (i.e. 'good luck hypothesis')
  - greater wage flexibility due to *deunionization* and *shift towards performance-pay*

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  - private-sector union density dropped over past 35 years (Farber and Western, 2001) while proportion of workers with performance-pay contracts increased substantially (Lemieux et al. 2009a)

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    - ★ union contracts are set in advance and renegotiated on average only every 3 years (Rich and Tracy, 2004)
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    - ★ performance-pay contracts define wage as a function of observed outcomes / non-performance contracts are set in advance (Lemieux et al., 2009a,b)
  - Our CPS evidence: wage volatility increases most for skilled, salaried workers and least in sectors that remain highly unionized

New Keynesian DSGE Model

- Workers invest and set wages / supply labor to maximize

$$E_0 \sum_{t=0}^{\infty} \beta^t Z_{t-1} \left[\log C_t - \frac{N(i)_t^{1+\phi}}{1+\phi} \right]; \quad Z_{t-1} = \text{preference shock}$$

- Monopolistic firms set prices, hire labor and capital to maximize

$$E_0 \sum_{t=0}^{\infty} \left(\beta^t \frac{C_0}{C_t} \right) \left[mc_t K_t^{\alpha} (A_t N_t)^{1-\alpha} - w_t N_t - r^k K_t \right]; \quad A_t = \text{ TFP shock}$$

  - staggered Calvo price setting implies linearized NKPC

$$\pi_t = \beta E_t \pi_{t+1} + \kappa mc_t$$

- Monetary authority: $R_t^n = (R_{t-1}^n)^{\rho} (\Pi_t)^{(1-\rho)\theta_{\pi}} (Y_t / Y_{t-1})^{(1-\rho)\theta_y}$

Labor market

- 4 types of imperfectly substitutable workers

	no performance pay	**performance pay**
union	high market power infrequent wage setting	high market power continuous wage setting
non-union	low market power infrequent wage setting	low market power continuous wage setting

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- Firms hire labor composite $N_t = \left[s^u \left(N_t^u \right)^{\frac{\mu-1}{\mu}} + (1-s^u) \left(N_t^{nu} \right)^{\frac{\mu-1}{\mu}} \right]^{\frac{\mu}{\mu-1}}$
  - union workers: $N_t^u = \left[\int_0^1 N_t^u(i)^{\frac{\mu^u-1}{\mu^u}} di \right]^{\frac{\mu^u}{\mu^u-1}}$; fraction p^u has p-pay
  - non-union workers: $N_t^{nu} = \left[\int_0^1 N_t^{nu}(i)^{\frac{\mu^{nu}-1}{\mu^{nu}}} di \right]^{\frac{\mu^{nu}}{\mu^{nu}-1}}$; fraction p^{nu} has p-pay

Wage setting

- Non-performance pay workers
  - union workers reoptimize nominal wage with prob $\left(1-\xi^{u}\right)$
  - non-union workers reoptimize nominal wage with prob $\left(1-\xi^{nu}\right)$
  - reoptimization is based on $t-1$ information
  - non-reoptimized wages are indexed to consumption growth γ and partially to past inflation

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  - non-reoptimized wages are indexed to consumption growth γ and partially to past inflation
- Performance pay workers
  - renegotiate wages every period based on t information
  - unionized p-pay workers: $W_t^{u,p}/P_t = \frac{\mu^u}{\mu^u-1} \times mrs_t$
  - non-unionized p-pay workers: $W_t^{nu,p}/P_t = \frac{\mu^{nu}}{\mu^{nu}-1} \times mrs_t$

Wage setting

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- Given aggregate real wage w_t, firms hire labor such that $w_t = mc_t + y_t - n_t$
  - firms have right-to-manage $=>$ wages are allocative
  - workers are not on their labor supply but $w_t > mrs_t$

Calibration (quarterly)

- Standard parameters

α	β	γ	δ	$1/\phi$	g/y	κ	ρ	θ_π	θ_y
0.33	0.99	0.005	0.025	1	0.15	0.05	0.8	2.0	0.3

- Labor market parameters

	$\frac{W^u N^u}{WN}$	p^u	p^{nu}	μ^u	μ^{nu}	μ	$\frac{1}{1-\xi^u}$	$\frac{1}{1-\xi^{nu}}$	ω
pre-1984	**0.30**	**0.17**	**0.34**	3.1	6	10	12	6	0.5
post-1984	**0.13**	**0.32**	**0.64**	3.1	6	10	12	6	0.5

  - union wage share: CPS data calculations from Hirsch and Macpherson (2010)
  - proportion of performance pay contracts: extrapolations from Lemieux et al. (2009a)
  - ratio of steady state markups: CPS data calculations from Hirsch and Macpherson (2010)
  - wage setting parameters: Rich and Tracy (2004); Barattieri et al. (2010) and Hofmann et al. (2010)

Calibration (quarterly)

- Shock processes
  - $a_t = \rho_a a_{t-1} + \varepsilon_{at}$ with ε_{at} *iid* $(0, \sigma^2_{\varepsilon_a})$; use Basu et al. (2006)'s TFP measures of a_t
  - $\Delta z_t = \rho_{\Delta z} \Delta z_{t-1} + \varepsilon_{\Delta zt}$ with $\varepsilon_{\Delta zt}$ *iid* $(0, \sigma^2_{\varepsilon_{\Delta z}})$; use household's Euler equation in riskless bonds (linearized) $c_t = E_t c_{t+1} - (r^n_t - E_t \pi_{t+1}) - \Delta z_t$ to estimate Δz_t

	ρ_a	σ_{ε_a}	$\rho_{\Delta z}$	$\sigma_{\varepsilon_{\Delta z}}$	σ_a	$\sigma_{\Delta z}$
pre-1984	0.9788	0.0094	0.7956	0.0033	**0.0549**	**0.0054**
post-1984	0.9738	0.0057	0.8951	0.0020	**0.0172**	**0.0046**

- Preference shock becomes about 3 times more volatile relative to technology shock

Simulations

	US Data			Simulation 1
	Pre-84	*Post-84*	*Relative*	*Pre-84 calibration, Pre-84 shock*
$\sigma(y)$	2.56	1.28	0.50	2.55
$\sigma(n)/\sigma(y)$	0.78	1.15	1.47	0.86
$\sigma(w)/\sigma(y)$	0.24	0.80	3.33	0.26
$\sigma(y/n)/\sigma(y)$	0.49	0.59	1.20	0.32
$\sigma(nomW)/\sigma(y)$	0.37	0.82	2.22	0.29
$\rho(y,w)$	0.36	-0.14	-0.50	0.64
$\rho(y,y/n)$	0.65	0.01	-0.64	0.55
$\rho(n,y/n)$	0.21	-0.50	-0.71	0.27
$\rho(nomW,P)$	0.81	0.28	-0.53	0.63

Simulations

	US Data			Simulation 1	Simulation 2	
	Pre-84	*Post-84*	*Relative*	*Pre-84 calibration, Pre-84 shock*	*Pre-84 calibration, Post-84 shock*	*Relative*
$\sigma(y)$	2.56	1.28	0.50	2.55	1.65	0.65
$\sigma(n)/\sigma(y)$	0.78	1.15	1.47	0.86	0.93	1.08
$\sigma(w)/\sigma(y)$	0.24	0.80	3.33	0.26	0.25	0.97
$\sigma(y/n)/\sigma(y)$	0.49	0.59	1.20	0.32	0.33	1.02
$\sigma(nomW)/\sigma(y)$	0.37	0.82	2.22	0.29	0.28	0.97
$\rho(y,w)$	0.36	-0.14	-0.50	0.64	0.65	0.02
$\rho(y,y/n)$	0.65	0.01	-0.64	0.55	0.36	-0.19
$\rho(n,y/n)$	0.21	-0.50	-0.71	0.27	0.03	-0.23
$\rho(nomW,P)$	0.81	0.28	-0.53	0.63	0.50	-0.13

Simulations

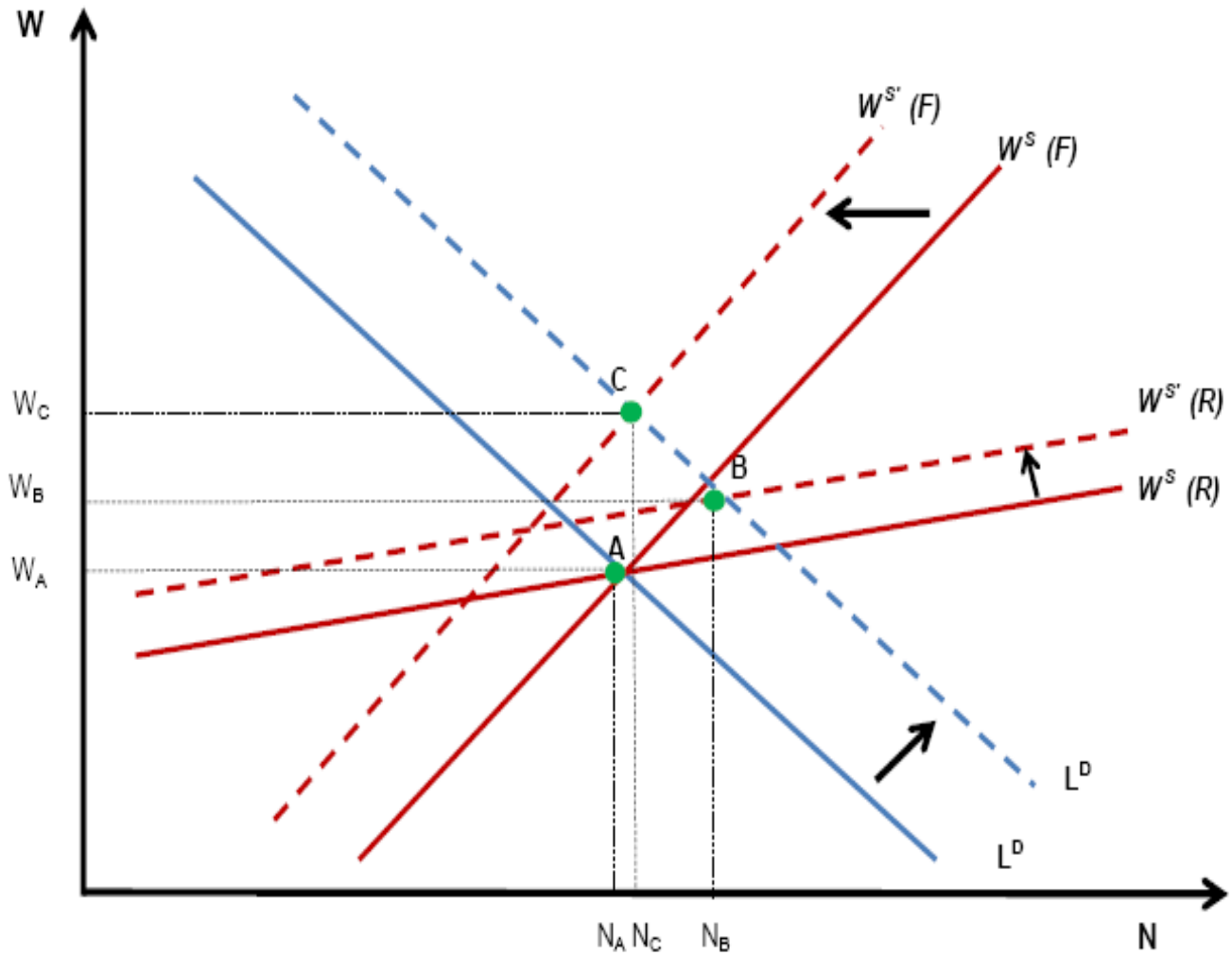
	US Data			Simulation 1	Simulation 3	
	Pre-84	*Post-84*	*Relative*	*Pre-84 calibration, Pre-84 shock*	*Post-84 calibration, Pre-84 shock*	*Relative*
$\sigma(y)$	2.56	1.28	0.50	2.55	2.12	0.83
$\sigma(n)/\sigma(y)$	0.78	1.15	1.47	0.86	0.73	0.84
$\sigma(w)/\sigma(y)$	0.24	0.80	3.33	0.26	0.40	1.56
$\sigma(y/n)/\sigma(y)$	0.49	0.59	1.20	0.32	0.44	1.36
$\sigma(nomW)/\sigma(y)$	0.37	0.82	2.22	0.29	0.42	1.45
$\rho(y,w)$	0.36	-0.14	-0.50	0.64	0.78	0.14
$\rho(y,y/n)$	0.65	0.01	-0.64	0.55	0.76	0.20
$\rho(n,y/n)$	0.21	-0.50	-0.71	0.27	0.44	0.17
$\rho(nomW,P)$	0.81	0.28	-0.53	0.63	0.41	-0.22

Simulations

	US Data			Simulation 1	Simulation 4	
	Pre-84	*Post-84*	*Relative*	*Pre-84 calibration, Pre-84 shock*	*Post-84 calibration, Post-84 shock*	*Relative*
$\sigma(y)$	2.56	1.28	0.50	2.55	1.39	0.55
$\sigma(n)/\sigma(y)$	0.78	1.15	1.47	0.86	0.83	0.96
$\sigma(w)/\sigma(y)$	0.24	0.80	3.33	0.26	0.43	1.67
$\sigma(y/n)/\sigma(y)$	0.49	0.59	1.20	0.32	0.43	1.33
$\sigma(nomW)/\sigma(y)$	0.37	0.82	2.22	0.29	0.45	1.53
$\rho(y,w)$	0.36	-0.14	-0.50	0.64	0.74	0.11
$\rho(y,y/n)$	0.65	0.01	-0.64	0.55	0.57	0.02
$\rho(n,y/n)$	0.21	-0.50	-0.71	0.27	0.17	-0.09
$\rho(nomW,P)$	0.81	0.28	-0.53	0.63	0.28	-0.35

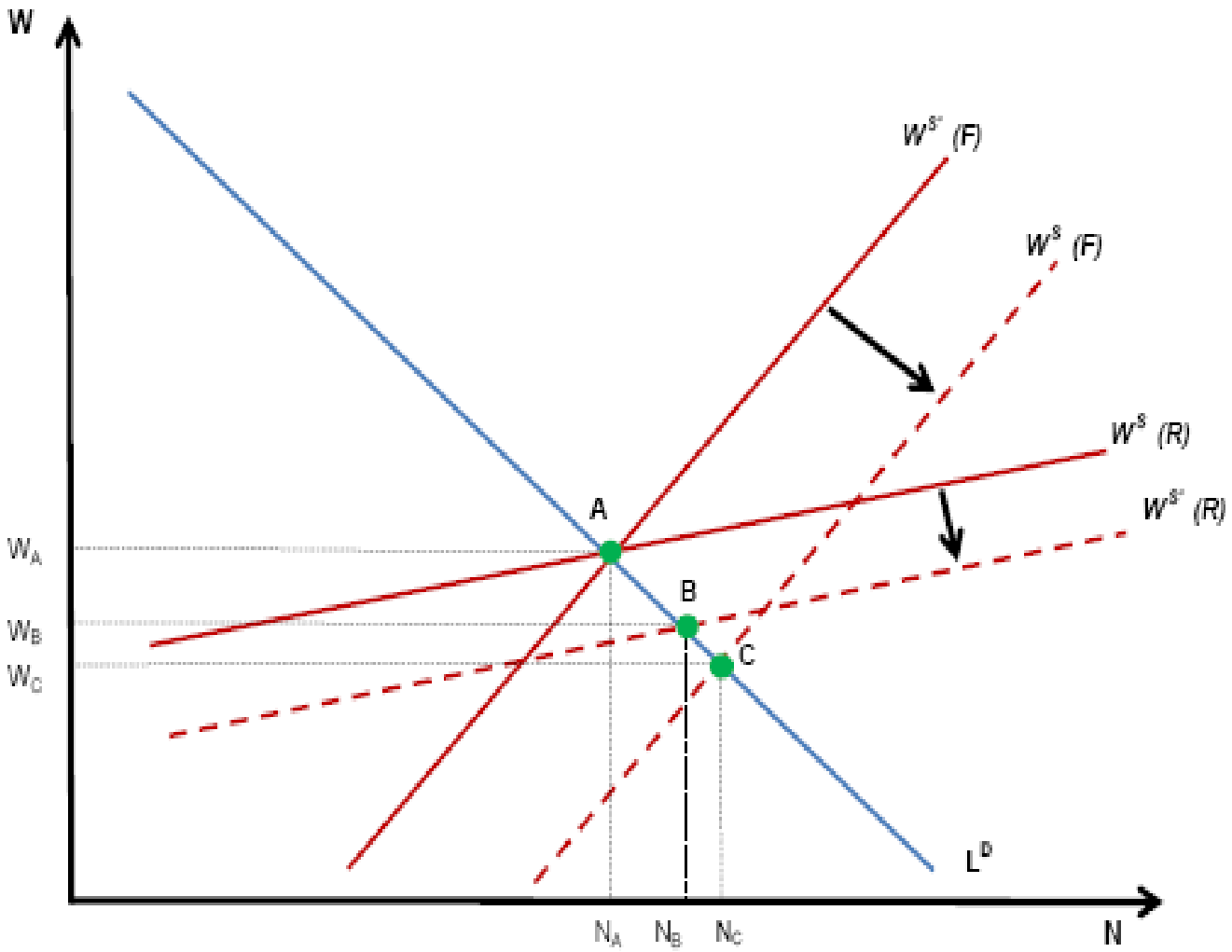
Rigid vs. Flexible Wages

Labor market adjustments after technology shock



Rigid vs. Flexible Wages

Labor market adjustments after preference shock



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- Show in a New Keynesian DSGE model that
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  - greater wage flexibility due to deunionization and shift towards performance-pay accounts for substantial part of increase in relative wage volatility
  - combination of changes in exogenous shocks and greater wage flexibility goes a long way in accounting for changes in labor market dynamics and Great Moderation

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  - combination of changes in exogenous shocks and greater wage flexibility goes a long way in accounting for changes in labor market dynamics and Great Moderation
- Model represents a first attempt to **quantify** impact of structural changes in U.S. labor market on wage and hours dynamics

Real Wages during the Great Moderation

Evidence from alternative aggregate wage series (HP filtered)

	Standard Deviation				Relative Standard Deviation		
	Pre-84	*Post-84*	*Post/Pre-84*	*p-value*	*Pre-84*	*Post-84*	*Post/Pre-84*
Annual							
Ouput	2.90	1.15	0.40	0.00	1.00	1.00	1.00
	(0.19)	(0.13)					
Aggr. Wage (LPC)	0.60	0.93	1.55	0.14	0.21	0.80	3.89
	(0.08)	(0.09)			(0.04)	(0.13)	
Aggr. Wage (CPS)	0.63	0.72	1.14	0.57	0.22	0.62	2.86
	(0.06)	(0.12)			(0.03)	(0.15)	
Quarterly							
Output	2.73	1.28	0.47	0.00	1.00	1.00	1.00
	(0.31)	(0.14)					
Aggr. Wage (LPC)	0.65	1.02	1.58	0.00	0.24	0.80	3.38
	(0.08)	(0.10)			(0.03)	(0.12)	
Aggr. Wage (CES)	1.11	0.45	0.41	0.00	0.41	0.36	0.87
	(0.19)	(0.05)			(0.07)	(0.07)	

Notes: Total sample extends from 1964 to 2006 for quarterly data; 1973 to 2006 for annual data; Nonfarm business sector. HP-filtered data. PCE-deflated wages. P-values are reported for a test of equality of variances across the two subsamples. Standard errors computed using GMM and the Delta method appear in parentheses below estimates.

Discrepancy between LPC and CES data

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  - monthly survey of 400,000 establishments; expanded starting in 1980s
  - only covers production workers in goods-producing sectors and non-supervisory workers in service-providing industries (about 60% of total compensation)

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- Potential sources of discrepancy
  - CES includes bonuses and commissions only if paid on regular basis
    - ★ robustness checks with CPS data show that this is not the source of discrepancy
  - wages of production and non-supervisory workers reported in CES behave very differently from wages of average worker
    - ★ Abraham, Spletzer and Stewart (1998): CPS replication of CES can account for large part of divergent wage trends
    - ★ Champagne and Kurmann (in progress): CPS replication of CES can account for 35% of drop in wage volatility
  - sample expansion in 1980s occurred mostly for smaller firms in service sector
    - ★ expansion may have lead to spurious compositional change

Back