Downward Nominal Wage Rigidity in the United States

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Motivation

- The sluggish adjustment of nominal variables matters for allocation of resources
- Recent theories of downward nominal wage rigidity show allocative consequences for employment during the Great Recession
- Other theories of nominal wage rigidity have various consequences on employment along the business cycles
- Depending on the theories of nominal wage rigidity, the effectiveness of monetary policy differs
- **Question:** Which **theory of nominal wage rigidity** has the most consistent implications with the **cyclical patterns of microdata** in the United States?

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Mapping microdata to theory

Question: Which **theory of nominal wage rigidity** has the most consistent implications with the **cyclical patterns of microdata** in the United States?

1. Document the cyclical properties of nominal wage change distributions of individual workers

   When employment decreases:

   - **Fact 1.**The share of workers with no wage change increases
   - **Fact 2.**The share of workers with wage cuts also increases
   - **Fact 3.**The increase in the share of workers with no wage change is much larger than the increase in the share of workers with wage cuts

   , for both time series and US state-level panel analyses in the US

2. Build the heterogeneous agents model with 5 alternative wage setting schemes

   The model with downward nominal wage rigidity has the most consistent implications with empirical findings.

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Related literature in the US

Empirics

- **Existence of downward nominal wage rigidity**
  - Kahn (1994), McLaughlin (1994), Gottschalk (2005), Barattieri, Basu, and Gottschalk (2014)
  - Are silent on cyclicality; shorter time span

- **Mixed results on the cyclicality of nominal wage change distributions**
  - Card and Hyslop (1997), Daly and Hobijn (2014): the share at zero is cyclical
  - Elsby, Shin and Solon (2016): the share at zero is acyclical
  - Beraja, Hurst, and Ospina (2019), Kurmann and McEntarfer (2019), Grigsby, Hurst, and Yildirmaz (2020): more flexible wages
  - Conditioning on sample period; focusing only at the share at zero; controversial

Related literature

Theory

- **Theoretical works on downward nominal wage rigidity**
  - Schmitt-Grohé and Uribe (2016), Schmitt-Grohé and Uribe (2017)
  - Representative agent model

- **Heterogeneous agent model and downward nominal wage rigidity**
  - Fagan and Messina (2009), Daly and Hobijn (2014)
  - Mineyama (2018)
  - Introduce an aggregate shock to match the empirical pattern of cyclicality of nominal wage change distributions

Part 1

Document cyclical properties of nominal wage change distributions of individual workers

Data

Panel data: the CPS and the SIPP

- Aggregated wages such as average hourly earnings suffer from the composition bias
  - more weights on higher-paid workers in a recession can lead to aggregate wages not to fall, spuriously suggesting wage rigidity

- The **CPS** (Current Population Survey): Monthly U.S. household survey of about 60,000 households
  - Sample period: 1979 - 2018 (Except 1995)
  - Longitudinal aspect (IPUMS-CPS) up to 16 months

- The **SIPP** (Survey of Income and Program Participation): Quarterly U.S. household survey approx from 14,000 to 52,000 households
  - Sample Period: 1984 - 2013 (Except 1990, 1996, 2001, 2004, and 2008)
  - Panel for 1.5 - 4 years
  - Employer Identifiers: define job stayers and job switchers

Year-over-year changes in nominal hourly wages

for individual hourly workers

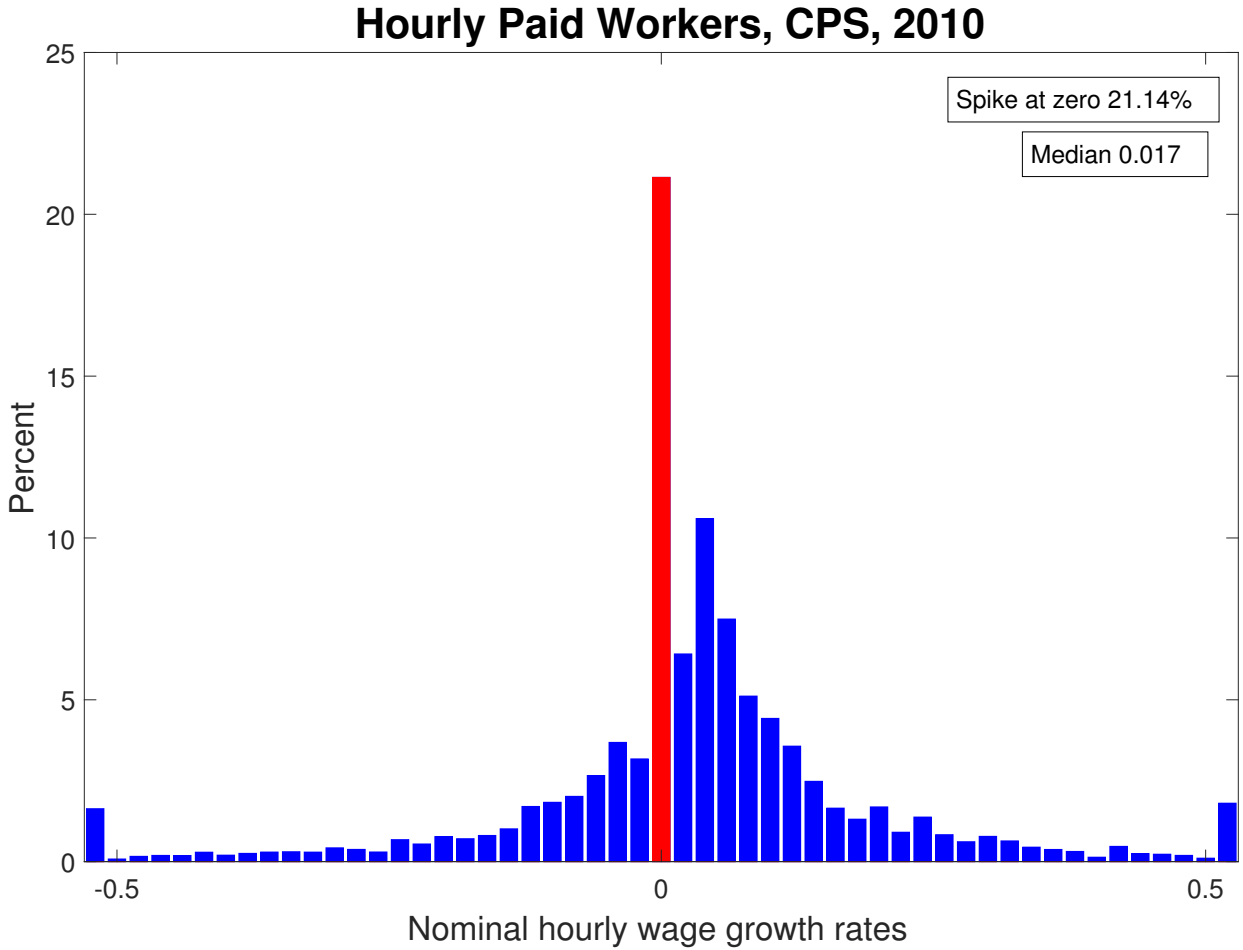
- Focus on hourly workers who report their hourly rate directly to the survey
- For the salaried worker, the hourly rate can be imputed by earnings/hours but any reporting error in hours worked can lead to excessive volatility of hourly rate
- Universe
  - Age above 16
  - Not self-employed
  - Employed both in the previous and the current year
  - Hourly worker for both in the previous and the current year
  - Not imputed and not top-coded wages
- Among those workers employed both in the previous and the current year
  - In the CPS, on average 49% of workers are hourly workers (15,418 per year)
  - In the SIPP, on average 55% of workers are hourly workers (13,937 per year)
- Main results are robust to salaried workers

Bonus

The cyclicality of the nominal wage change distributions

Asymmetric nominal wage change distribution: CPS

The distribution of individual workers' year-over-year changes in nominal hourly wages in 2010



Data source: Author's calculation from the CPS. Bin size is 0.02. Red colored bin shows the fraction of workers whose log hourly wage changes are exact zero in 2010

- A significant spike at zero. On average 21.1% of hourly workers had no wage change.
- 24.6% of hourly workers had wage cuts and 54.2% had wage increases.

The cyclicality of nominal wage change distributions

Time series analysis

- Construct the spike at zero, the fraction of wage cuts and raises and the employment to population ratio for each year
- Sample period: 1979 - 2018 (except 1995)
- Regression

$$\begin{aligned} [\text{Spike at zero}]_t &= \beta_1 + \delta_1(1 - e_t) + \epsilon_{1t} \\ [\text{Fraction of wage cuts}]_t &= \beta_2 + \delta_2(1 - e_t) + \epsilon_{2t} \\ [\text{Fraction of wage increases}]_t &= \beta_3 + \delta_3(1 - e_t) + \epsilon_{3t} \end{aligned}$$

  - e_t is the employment to population ratio in year t

- If we add all three rows

$$1 = \beta_1 + \beta_2 + \beta_3 + (\delta_1 + \delta_2 + \delta_3)(1 - e_t) + \tilde{\epsilon}_t$$

- We know that $\delta_1 + \delta_2 + \delta_3 = 0$. Report δ_1/δ_3.
- Measurement errors do not have a cyclical component; no bias on the cyclicality

The cyclicality of nominal wage change distributions

Time series analysis

Controlling for inflation, when employment decreases

- **Fact 1.** The spike at zero increases
- **Fact 2.** The share of workers with wage cuts also increases
- **Fact 3.** The increase in the spike at zero is higher than the increase in the share of workers with wage cuts

	(1) Spike at zero $\Delta W = 0$	(2) Share of cuts $\Delta W < 0$	(3) Share of raises $\Delta W > 0$	(4) Spike at zero $\Delta W = 0$	(5) Share of cuts $\Delta W < 0$	(6) Share of raises $\Delta W > 0$
1-Epop ratio $(1 - e_t)$	0.437	0.201	-0.638	0.617***	0.303*	-0.919***
	(0.296)	(0.218)	(0.493)	(0.159)	(0.154)	(0.278)
Inflation rate (π_t)				-1.181***	-0.673***	1.853***
				(0.121)	(0.142)	(0.216)
Observations	38	38	38	38	38	38
Adjusted R^2	0.0442	-0.00342	0.0332	0.731	0.340	0.705

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Data source : CPS and author's calculation. Sample Period : 1979-2017 (except 1995). Inflation rate is calculated from CPI-U.

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The cyclicality of nominal wage change distributions

Time series analysis

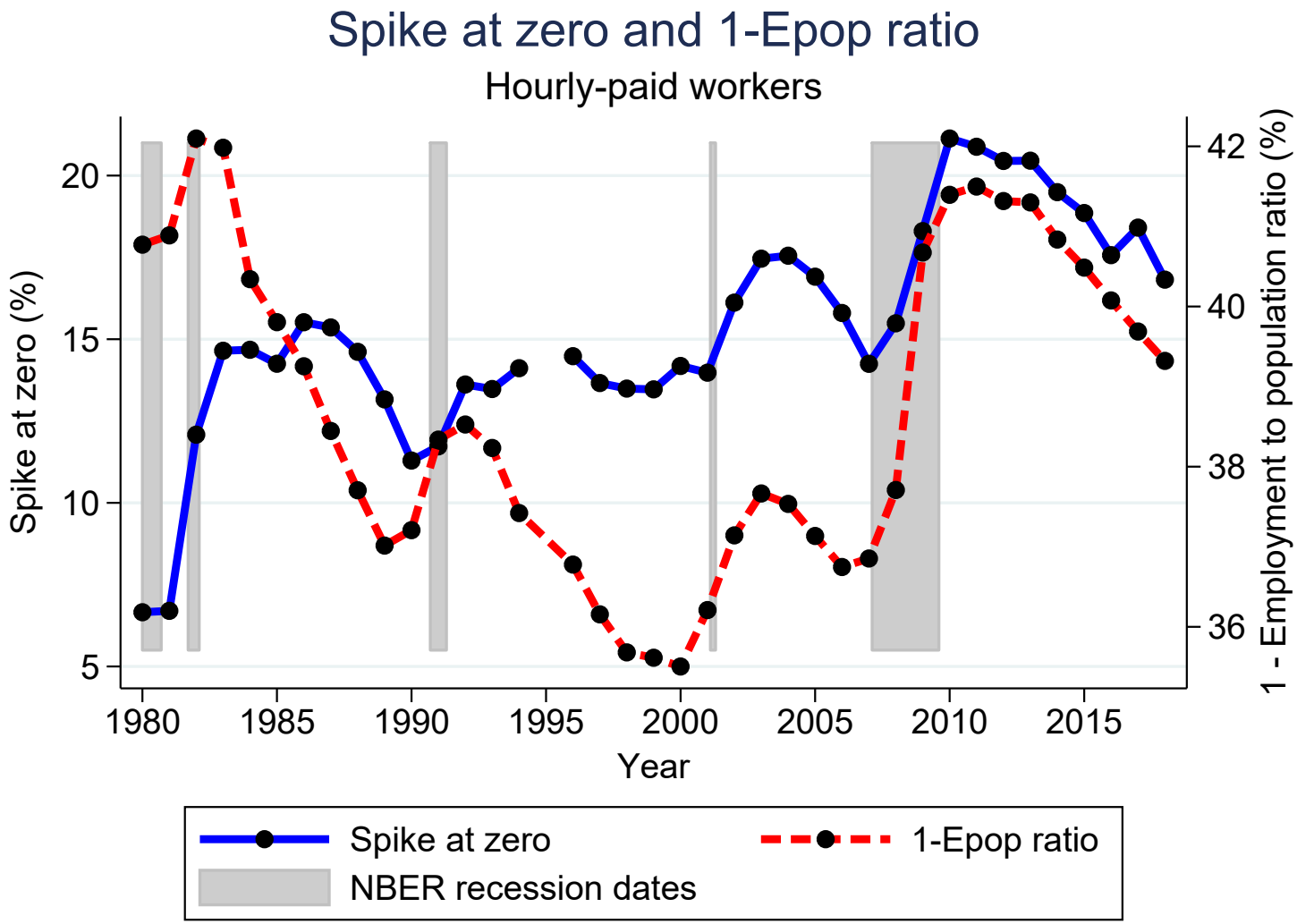
- Greater fluctuations of the spike at zero

	All			Prim-Age Men		Prime-Age Women	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Spike at zero minus share of wage cuts						
1-Epop ratio $(1 - e_t)$	0.237	0.314**	0.424**	0.472***	0.497***	0.617***	0.662***
	(0.166)	(0.143)	(0.188)	(0.0776)	(0.0725)	(0.147)	(0.137)
Inflation rate (π_t)		-0.508***	-0.471***	0.213	0.321***	-0.476***	-0.424***
		(0.152)	(0.142)	(0.138)	(0.117)	(0.0845)	(0.105)
ΔTFP			0.551		0.729**		0.679**
			(0.455)		(0.287)		(0.261)
Observations	38	38	38	38	38	38	38
Adjusted R^2	0.000989	0.153	0.190	0.590	0.658	0.428	0.517

Data: CPS and author's calculation. Inflation rate is calculated from CPI-U. Sample Period: 1979-2018 (except 1995). * p<0.10, ** p<0.05, ***p<0.01. Standard errors in parentheses.

The cyclicality of nominal wage change distributions

Time series analysis



Data source: CPS and author's calculation. Sample period: 1979 - 2018. This figure shows the spike at zero for each year (left axis) and the 1- employment to population ratio (right axis).

The cyclicality of state-level nominal wage change distributions

The cyclicality of nominal wage change distributions

US state-level variations during the Great Recession

- Beraja, Hurst, and Ospina (2019)
  - Wages were fairly flexible during the Great Recession using the US state-level variation of wages and employment
- Kurmann and McEntarfer (2019)
  - The increased incidence of wage cuts during the downturn suggests that DNWR may not be a binding constraint in times of large negative shocks.
- Grigsby, Hurst, and Yildirmaz (2020)
  - Nominal wage cuts are substantially higher during recessions. Wages are able to downwardly adjust in the face of large unanticipated shocks.

The cyclicality of nominal wage change distributions

US state-level variations

- Construct the state-level spike at zero, the fraction of wage cuts, and raises and the employment to population ratio for each state and year
- 50 states across 35 years
- Regression

$$
\begin{aligned}
[\text{Spike at zero}]_{it} &= \alpha_{i,s} + \gamma_{t,s} + \beta_s(1 - e_{it}) + \epsilon_{it,s} \\
[\text{Fraction of wage cuts}]_{it} &= \alpha_{i,n} + \gamma_{t,n} + \beta_n(1 - e_{it}) + \epsilon_{it,n} \\
[\text{Fraction of raises}]_{it} &= \alpha_{i,p} + \gamma_{t,p} + \beta_p(1 - e_{it}) + \epsilon_{it,p}
\end{aligned}
$$

  - e_{it} is employment-to-population ratio in state i in year t
  - State fixed effects (α_i) control for state-specific differential time trends
  - Time fixed effects (γ_t) control for aggregate shocks and policy for each year

- Again, $\beta_s + \beta_n + \beta_p = 0$.

The cyclicality of nominal wage change distributions

US state-level variations

Controlling for state and time fixed effects, when employment decreases,

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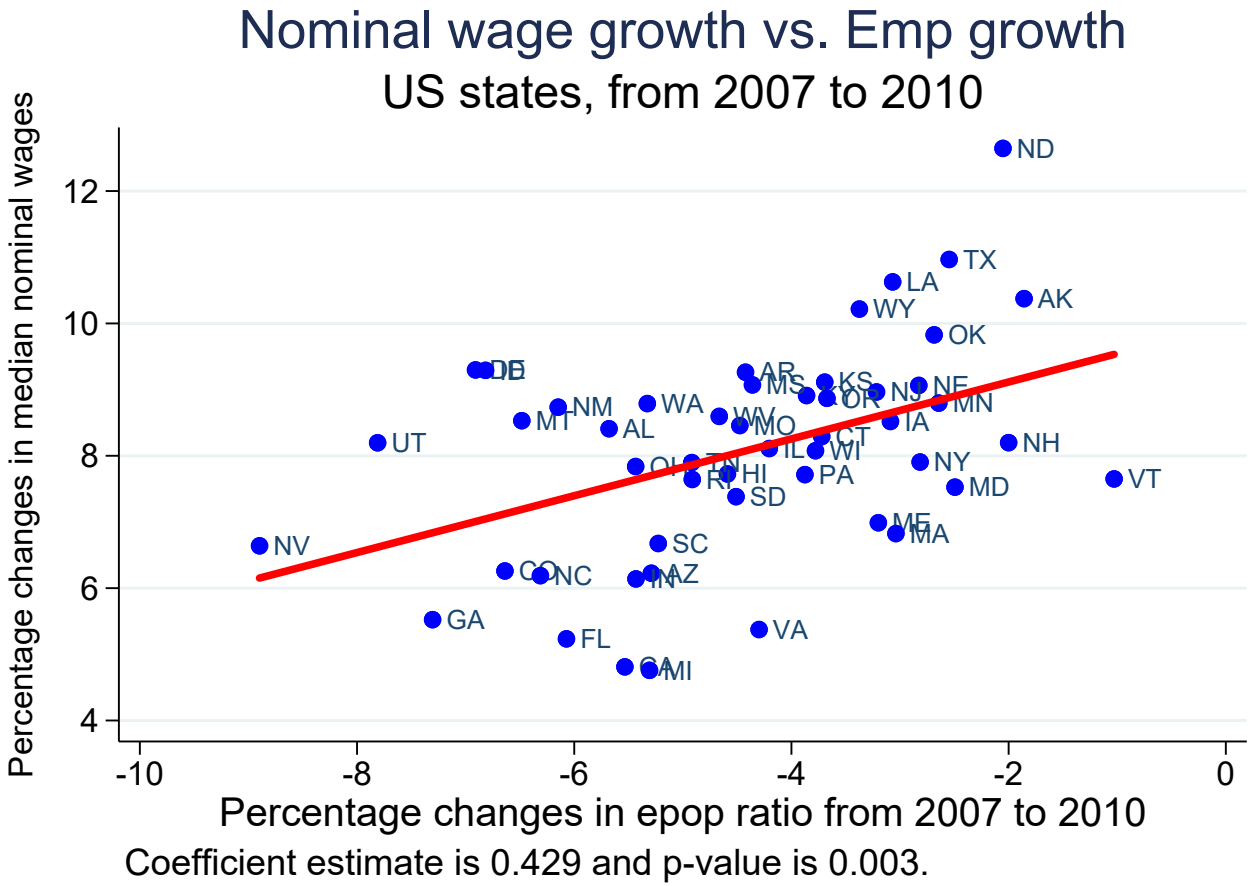
	(1) Spike at zero $\Delta W = 0$	(2) Share of cuts $\Delta W < 0$	(3) Share of raises $\Delta W > 0$	(4) Spike at zero minus Share of cuts
1-Epop ratio $(1 - e_{it})$	0.396*** (0.0798)	0.287*** (0.0628)	-0.683*** (0.0860)	0.110 (0.115)
State Fixed Effect, α_i	Yes	Yes	Yes	Yes
Time Fixed Effect, γ_t	Yes	Yes	Yes	Yes
Observations	1750	1750	1750	1750
Adjusted R^2	0.598	0.530	0.707	0.300

Data source: CPS and author's calculation. Sample Period: 1979-2018 (except 1985, 1986, 1995, and 1996 due to small sample sizes). The sample consists of 50 states over 35 years.

Were wages fairly flexible during the Great Recession?

US state-level variation during the Great Recession: 2007 - 2010

- Beraja, Hurst, and Ospina (2019): Wages were fairly flexible since US states with larger decreases in employment are also the states with lower wage increases.

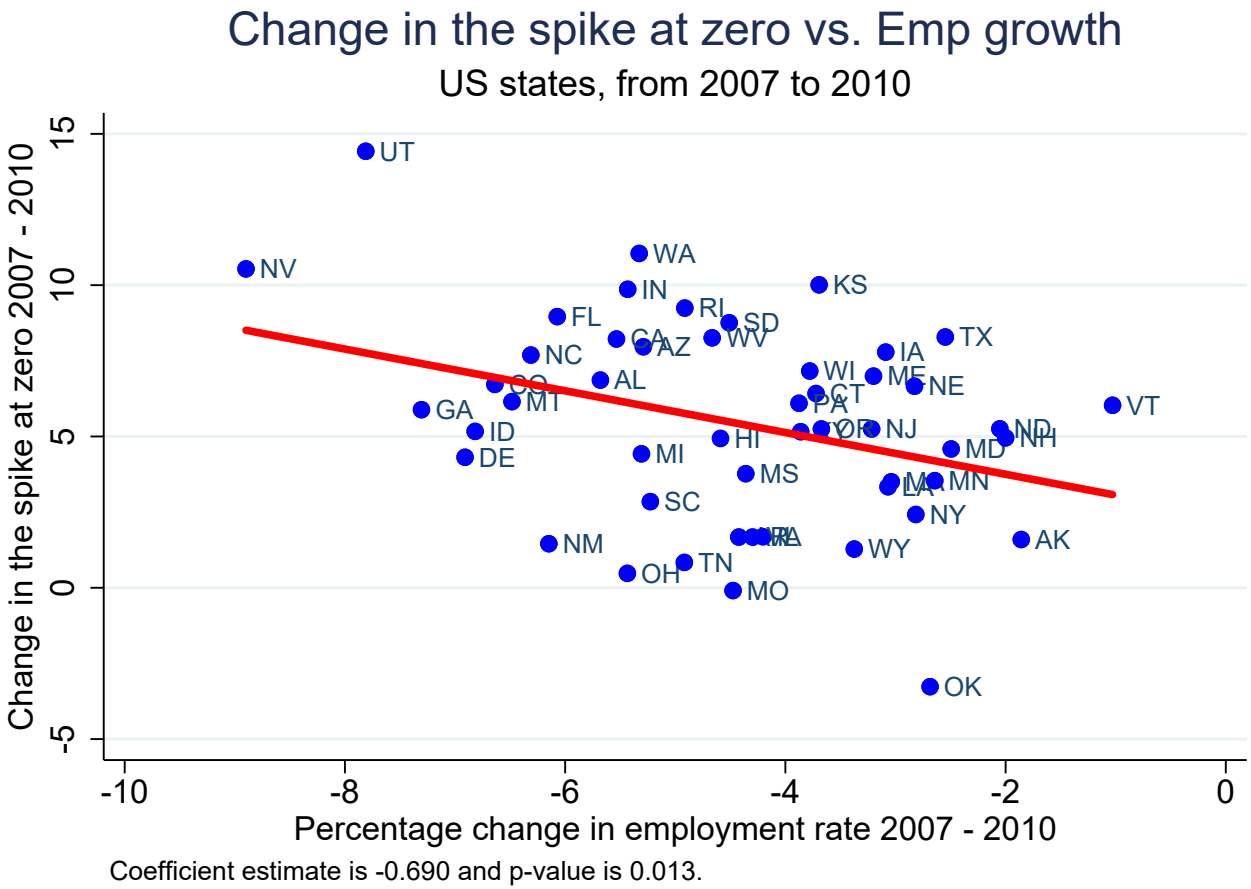


Data sources: CPS and author's calcuation.

Were wages fairly flexible during the Great Recession?

US state-level variation during the Great Recession: 2007 - 2010

- The states with larger decreases in employment are also states with greater increases in the spike at zero



Data source: CPS and author's calcuation.

Were wages fairly flexible during the Great Recession?

US state-level variation during the Great Recession: 2007 - 2010

- A state with 1 percent drop in employment is likely to have a 0.9 pp drop in the share of workers with raises.
- Out of 0.9 pp, 0.7 pp of them had no wage change.

Change in nominal wage distribution from 2007 to 2010 across states

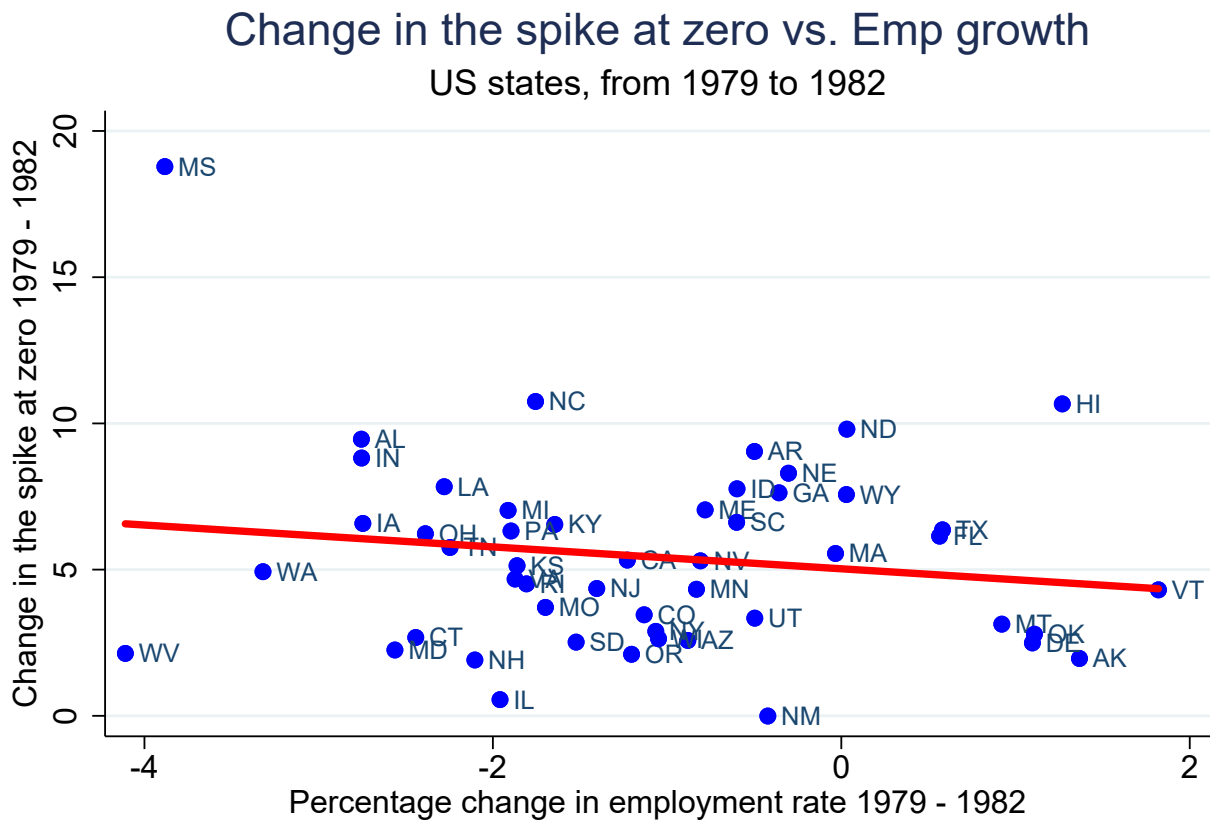
	(1) Changes in Spike at zero $\Delta W = 0$	(2) Changes in Share of cuts $\Delta W < 0$	(3) Changes in Share of raises $\Delta W > 0$	(4) Changes in Spike at zero minus Share of cuts	(5) $\ln \frac{W_{s2010}}{W_{s2008}}$
Percent change in employment rate	-0.694**	-0.213	0.907**	-0.480	0.428***
	(0.267)	(0.320)	(0.397)	(0.436)	(0.136)
Observations	50	50	50	50	50
Adjusted R^2	0.104	-0.0104	0.0699	0.0103	0.183

Data source : CPS and author's calculation. Sample Period : 2007 - 2010.

The recession of 1979-1982 with high inflation

US state-level variation:1979 - 1982

- The aggregate price level grew by 29 percent between 1979 and 1982.
- When inflation is high, there is no distinctive relationship between the nominal wage change distributions and employment.



Data sources: CPS and author's calcuation.

Median wage Regression

The recession of 1979-1982 with high inflation

US state-level variation:1979 - 1982

- No statistically significatn relationship between nominal wage change distributions and employment

Change in nominal wage distribution from 1979-1982 across states

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Percent change in employment rate	-0.374 (0.487)	0.163 (0.333)	0.211 (0.678)	-0.537 (0.486)	0.607** (0.281)
Observations	50	50	50	50	50
Adjusted R^2	0.00407	-0.0148	-0.0166	0.00958	0.0715

Data source : CPS and author's calculation. Sample Period : 1979-1982.

Robustness

Robustness

- Job stayers vs. Job switchers
- Excluding minimum wage workers
- Salaried workers
- Low-paid young workers
- Working-age population
- Age
- Gender
- Education
- Race
- Quartiles of hourly wages
- Elsby, Shin, and Solon (2016)
- Unemployment rate

Summary of empirical findings

Controlling for inflation, when employment decreases:

- **Fact 1.** The spike at zero increases
- **Fact 2.** The share of workers with wage cuts also increases
- **Fact 3.** The increase in the spike at zero is higher than the increase in the share of workers with wage cuts

, for both time series and state-level panel analyses in the US from 1979 - 2018.

Question: Which models of nominal wage rigidity in the existing literature explain the shape and the cyclicality of nominal wage change distributions?

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Part 2

Build the heterogeneous agents model with 5 alternative wage setting schemes

Model

Model overview

- Heterogeneous agent - idiosyncratic labor productivity
- Firm
  - uses the aggregate labor to produce output
  - no product price rigidity
- Households
  - consume
  - set the wage and supply the idiosyncratic labor
- Idiosyncratic labor productivity shocks
- Aggregate shock

Firms

- Firm's production function is

$$Y_t = L_t,$$

and the firm's profit is

$$\Pi_t = P_t Y_t - W_t L_t,$$

where P_t is the price of goods and W_t is the aggregate nominal wage.

- Firm minimizes the total cost of labor

$$\min_{l_t(i)} \int W_t(i) l_t(i) di \quad \text{(s.t.)} \quad L_t = \int_0^1 (q_t(i) l_t(i))^{\frac{\theta-1}{\theta}} di$$

, where $q_t(i)$ is idiosyncratic labor productivity.

- Labor demand is

$$l_t^d(i) = q_t(i)^{\theta-1} (\frac{W_t(i)}{W_t})^{-\theta} L_t$$

Households

- There is a continuum of households $i \in [0,1]$ in the economy. Each household maximizes

$$\max_{\{C_t(i),W_t(i),l_t(i),B_{t+1}(i)\}} \mathbb{E}_0 \Sigma_{t=0}^{\infty} \beta^t \left[\frac{C_t(i)^{1-\gamma}}{1-\gamma} - \frac{1}{1+\psi} l_t(i)^{1+\psi} \right] \tag{1}$$

subject to

$$P_t C_t(i) + \mathbb{E}_t Q_{t+1} B_{t+1}(i) \leq B_t(i) + W_t(i) l_t(i) + \Pi_t$$

$$l_t^d(i) = q_t(i)^{\theta-1} \left(\frac{W_t(i)}{W_t}\right)^{-\theta} L_t$$

Wage setting constraint

- Let W^*(i) is the optimal wage maximizing (1) without the wage setting constraint in period t.

Calvo LTC Menu DNWR (menu) DNWR (Calvo)

5 alternative wage setting constraints

1. Perfectly flexible - no wage setting constraint
2. Symmetric wage rigidity - Calvo
3. Symmetric wage rigidity - Long term contract
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Close the model

- Product market clears

$$Y_t = C_t$$

- Since $\Pi_t = 0$,

$$P_t Y_t = W_t L_t \equiv M_t$$

- Aggregate shock process - Nominal GDP growth rate targeting

$$\ln(M_{t+1}) = \mu + \ln(M_t) + \eta_{t+1} \quad \eta_{t+1} \sim \mathbb{N}(0, \sigma_\eta^2)$$

- Idiosyncratic labor productivity shock process

$$\ln(q_{t+1}(i)) = \rho_q \ln(q_t(i)) + \epsilon_{t+1}(i), \quad \epsilon_{t+1}(i) \sim \mathbb{N}(0, \sigma_\epsilon^2)$$

Preview of findings

- Using numerical method (Krusell and Smith (1998)), characterize stationary wage change distribution and cyclical properties of them Calibration
- How does each model of nominal wage rigidity predict

The cyclicality of nominal wage change distributions	Heterogeneous agent model					
		Symmetric rigidity			Asymmetric rigidity	
	Perfectly flexible	Calvo	LTC	Menu	DNWR Menu	DNWR Calvo
When employment decreases						
1. The spike at zero increases	No	No	No	Yes	Yes	Yes
2. The share of workers with wage cuts also increases	Yes	Yes	Yes	Yes	Yes	Yes
3. The increase in the spike at zero is larger than increase in the share of workers with wage cuts	No	No	No	No	Yes	Yes

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Symmetric menu cost model

Symmetric menu cost model

- Given $(q_t(i), L_t, \frac{W_{t-1}(i)}{W_t})$, solve household utility maximization problem without the wage setting constraint in period t.
- Let W^*(i) is the optimal wage without the wage setting constraint in period t.
- Symmetric wage rigidity - menu cost

$$W_t(i) = \begin{cases} \begin{cases} W_t^*(i) & \text{if } W_t^*(i) \neq W_{t-1}(i), \text{ pays cost } K \\ W_{t-1}(i) & \text{No cost} \end{cases} & \text{,with the prob } \mu^{\text{Menu}} \\ W_t^*(i) & \text{,with the prob } (1\text{-}\mu^{\text{Menu}}) \end{cases}$$

Households

Stationary wage change distribution: Symmetric menu cost

- Generates the spike at zero. Both μ^{Menu} and K determine the spike at zero.
- The higher portion of the spike at zero comes from right to the zero rather than the left to the zero
- Inconsistent with empirical nominal wage change distribution.

Model generated stationary distribution of log wage differences

Cyclicality of wage change distribution: Menu cost model

- When the employment declines, the [Fraction of $\Delta W > 0$] declines.
  - Spike at zero increases - consistent with empirical patterns
  - $|\Delta$[Fraction of $\Delta W < 0]| > |\Delta$[Spike at zero]$|$ - inconsistent with empirical patterns

Data vs. simulated data

	Spike at zero $\Delta W = 0$	Fraction of $\Delta W < 0$	Fraction of $\Delta W > 0$
		Data	
Employment	-0.616	-0.305	0.921
Inflation	-1.181	-0.674	1.855
		Menu cost model	
Employment	-0.187	-0.329	0.516
Inflation	-1.623	-3.452	5.074

Data source : CPS and author's calculation. Sample Period : 1979-2017 (except 1995). Inflation rate is calculated from CPI-U. Model simulation is done for 5000 periods for 5000 households. Regression results come from the burning initial 1000 periods.

Robustness Back

Cyclicality of wage change distribution: Menu cost model

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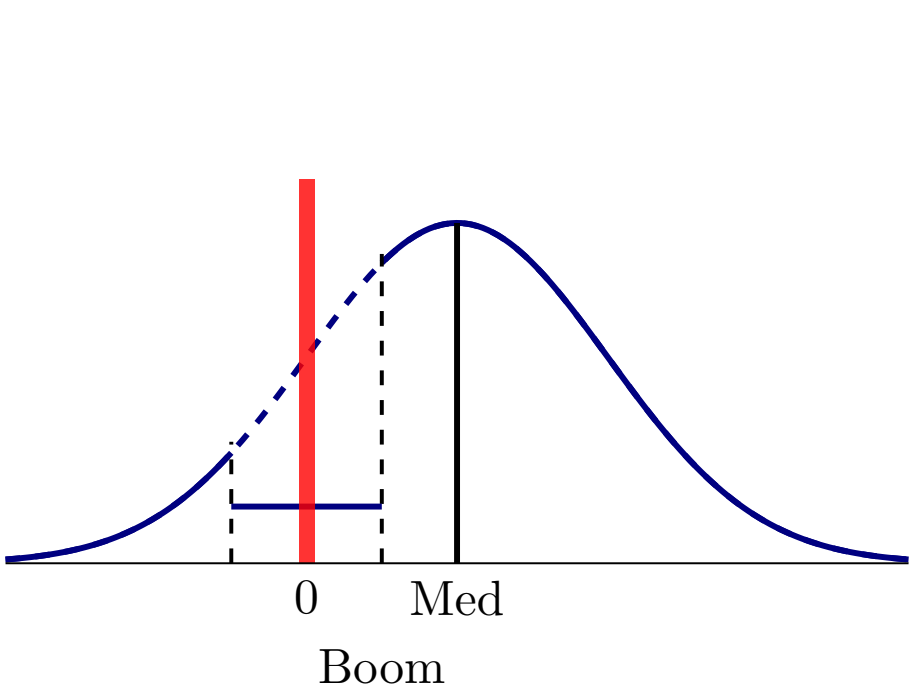
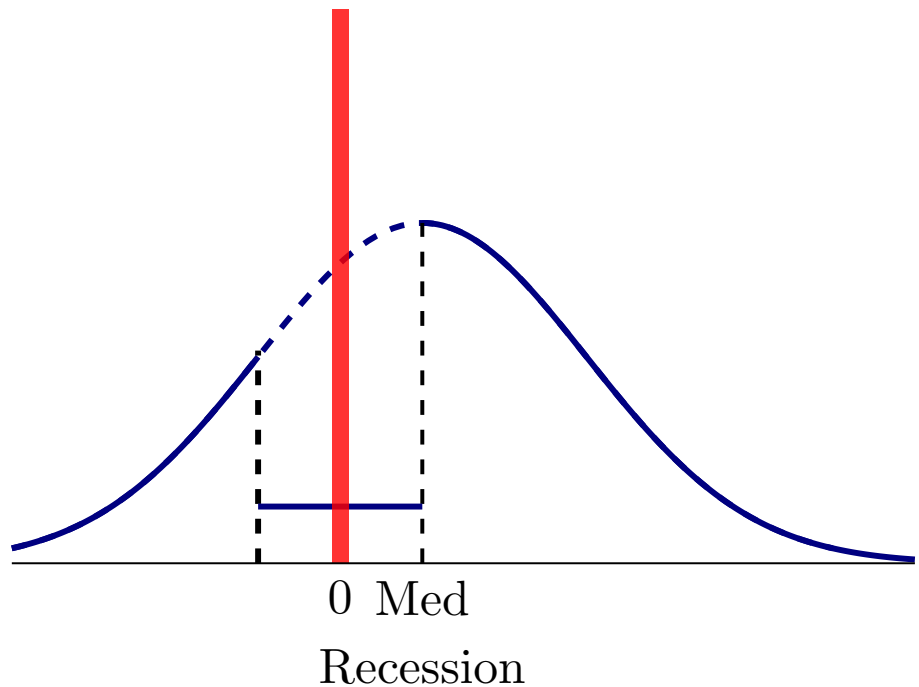




Robustness Back

Downward nominal wage rigidity

Asymmetric menu cost model

Downward nominal wage rigidity model

Asymmetric menu cost model

- Given $(q_t(i), L_t, \frac{W_{t-1}(i)}{W_t})$, solve household utility maximization problem without the wage setting constraint in period t. Households
- Let W^*(i) is the optimal wage without the wage setting constraint in period t.

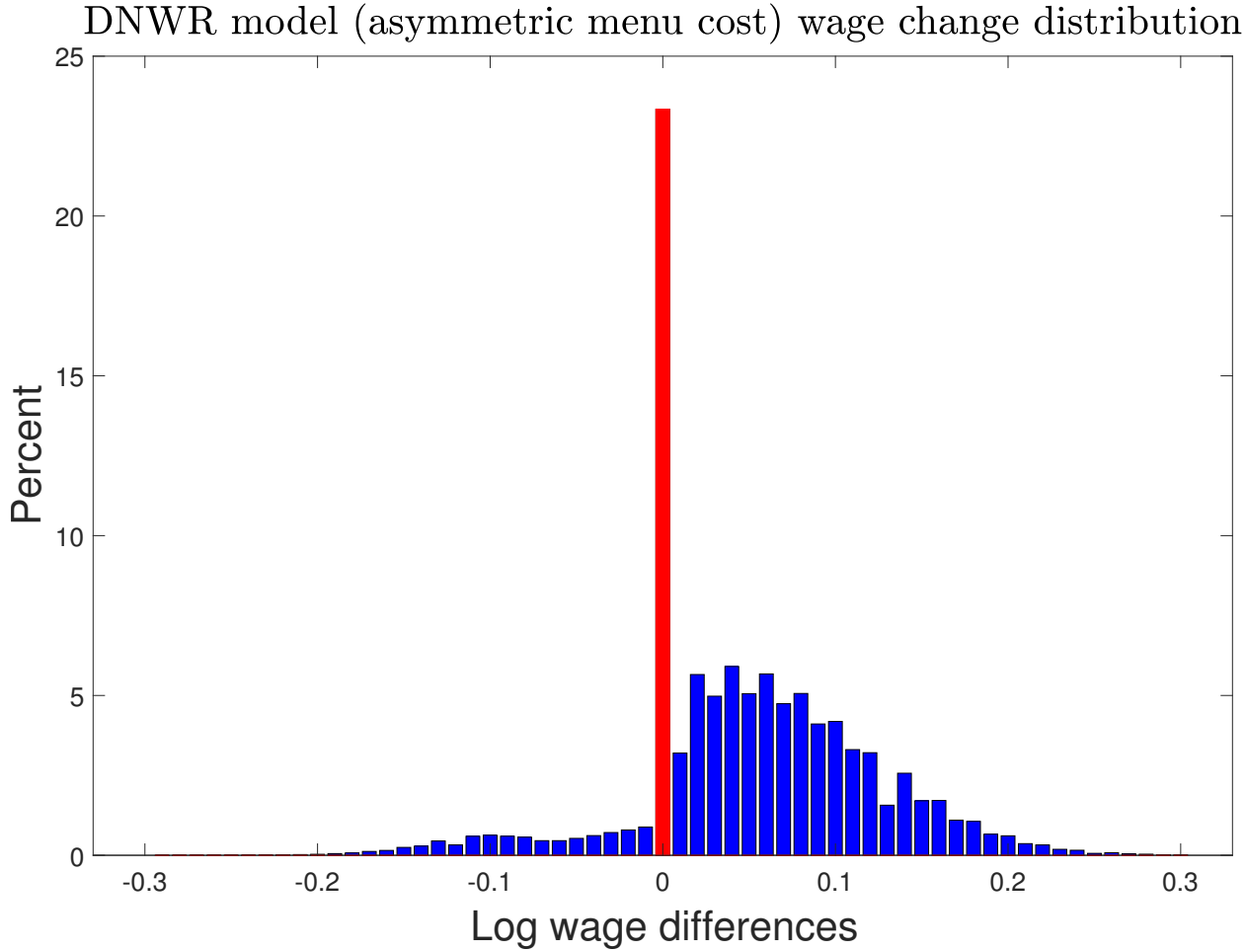
- One sided wage rigidity - DNWR (Asymmetric menu costs)

$$W_t(i) = \begin{cases} \begin{cases} W_t^*(i) & \text{if } W_t^*(i) \geq W_{t-1}(i), \text{no cost} \\ W_t^*(i) & \text{if } W_t^*(i) < W_{t-1}(i), \text{pays cost } K^d \\ W_{t-1}(i) & \text{if } W_t^*(i) < W_{t-1}(i), \text{no cost} \end{cases} & \text{,with the prob } \mu^{\text{Menu}} \\ W_t^*(i) & \text{,with the prob } (1\text{-}\mu^{\text{Menu}}) \end{cases}$$

Stationary wage change distribution: DNWR

Asymmetric menu cost model

- Generates the spike at zero. Both μ^{Menu} and K^d determine the spike at zero.
- The lack of wage cuts compared to wage increases
- Consistent with empirical nominal wage change distribution.



Model generated stationary distribution of log wage differences

Cyclicality of wage change distribution: DNWR

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- When the employment declines, the [Fraction of $\Delta W > 0$] declines.
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Data			
Employment	-0.616	-0.305	0.921
Inflation	-1.181	-0.674	1.855
DNWR (Asymmetric menu costs) model			
Employment	-0.539	-0.213	0.752
Inflation	-3.185	-2.078	5.263

Data source : CPS and author's calculation. Sample Period : 1979-2017 (except 1995). Inflation rate is calculated from CPI-U. Model simulation is done for 5000 periods for 5000 households. Regression results come from the burning initial 1000 periods.

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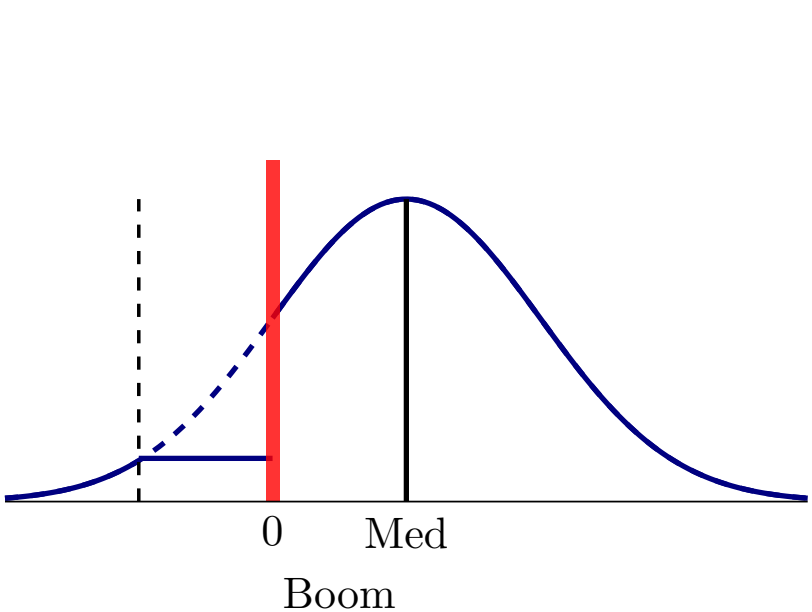

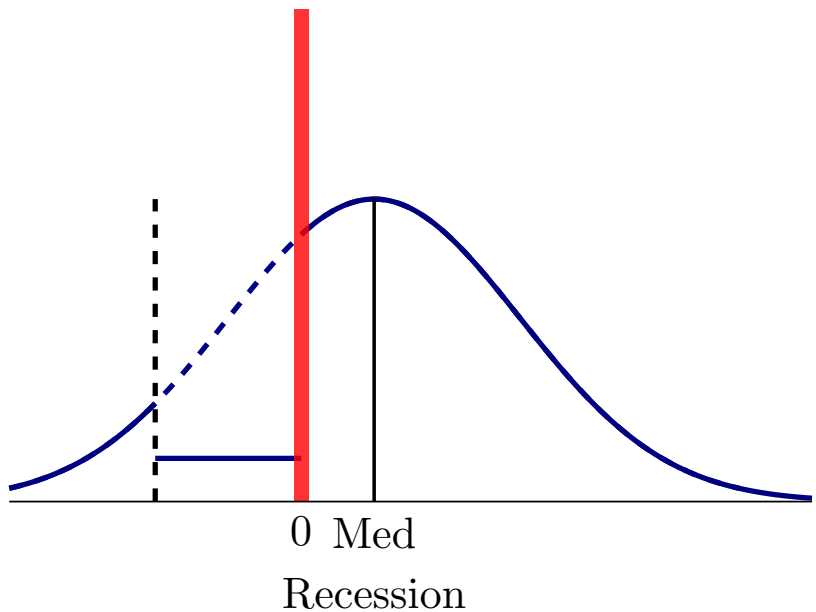

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Data moments

Which models explain the skewness of employment growth rate?

	Wage growth rates	Employment growth rates	Spike at zero $\Delta W = 0$	Fraction of $\Delta W < 0$	Fraction of $\Delta W > 0$
			Data		
Mean	4.102	0.020	15.484	21.318	63.198
SD	1.539	0.792	3.059	2.436	4.686
Skewness	1.032	-1.492			
			Calvo model		
Mean	4.378	0.000	23.171	17.626	59.203
SD	1.529	1.051	1.703	6.663	6.905
Skewness	0.006	0.032	-	-	-
			Long term contract		
Mean	4.363	0.001	22.994	15.944	61.062
SD	1.403	0.476	0.603	6.128	6.151
Skewness	0.051	-0.003	-	-	-
			Menu cost model		
Mean	4.374	0.000	23.085	17.332	59.583
SD	2.069	0.503	3.625	7.351	10.616
Skewness	0.073	-0.019	-	-	-
			DNWR model		
Mean	4.382	0.000	23.025	10.530	66.445
SD	1.645	0.812	6.820	3.219	9.901
Skewness	0.320	-0.061	-	-	-

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Conclusion

Conclusion

- DNWR has the most consistent implications with the empirical findings regarding the shape and the cyclicality of the nominal wage change distributions
- Suggestive evidence of the allocative consequences of DNWR Hours
- Asymmetric wage adjustment has asymmetric consequences for employment Moments

How big are bonuses?

- The BLS report "Employer costs for employee compensation"
  - In September 2018, nonproduction bonuses are 2.4% of the total compensation
  - In December 2010, nonproduction bonuses are 1.3% of the total compensation

- Grigsby, Hurst, and Yildirmaz (2018): over 2008 - 2016 period
  - 22.2% of hourly workers received bonus payment. The mean share of bonuses for hourly workers is 0.7 %
  - 33.5% of salaried workers received bonus payment. The mean share of bonuses for salaried worker is 2.0%

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The cyclicality of nominal wage change distributions

Time series analysis: salaried workers

- Results are robust to salaried workers.

The spike at zero, the share of wage cuts, and raises for salaried workers

	(1) Spike at zero $\Delta W = 0$	(2) Share of cuts $\Delta W < 0$	(3) Share of raises $\Delta W > 0$	(4) Spike at zero minus Share of cuts	(5) Spike at zero $\Delta W = 0$	(6) Share of cuts $\Delta W < 0$	(7) Share of raises $\Delta W > 0$	(8) Spike at zero minus Share of cuts
1-Epop ratio $(1 - e_t)$	0.432***	-0.0627	-0.369	0.495***	0.474***	0.0521	-0.526**	0.421***
	(0.0812)	(0.238)	(0.306)	(0.181)	(0.0553)	(0.163)	(0.195)	(0.145)
Inflation rate (π_t)					-0.282***	-0.779***	1.061***	0.496***
					(0.0337)	(0.120)	(0.132)	(0.117)
Observations	37	37	37	37	37	37	37	37
Adjusted R^2	0.413	-0.0263	0.0246	0.117	0.656	0.434	0.600	0.292

Data source: CPS and author's calculation. Sample Period: 1979-2018 (except 1994, 1995). Inflation rate is calculated from CPI-U. Hourly rate is calculated from usual weekly earning/usual hours worked per week. Controlling for inflation, the spike at zero exhibits countercylical fluctuations in employment while the share of workers with wage cuts does not respond to employment. *p $<$ 0.10, **p $<$ 0.05, ***p $<$ 0.01. Standard errors in parentheses

- Hourly wage = usual weekly earning / usual weekly hours worked.

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The cyclicality of nominal wage change distributions

Time series analysis: excluded minimum wage workers

- Results are robust to excluding minimum wage workers. On average 9 % of hourly paid workers are minimum wage paid workers. Among hourly paid workers with no wage changes, 10% of workers are minimum wage workers.

Excluding minimum wage workers, the spike at zero, the fraction of wage cuts, and raises

	(1) Spike at zero $\Delta W = 0$	(2) Share of cuts $\Delta W < 0$	(3) Share of raises $\Delta W > 0$	(4) Spike at zero minus Share of cuts	(5) Spike at zero $\Delta W = 0$	(6) Share of cuts $\Delta W < 0$	(7) Share of raises $\Delta W > 0$	(8) Spike at zero minus Share of cuts
1-Epop ratio $(1 - e_t)$	0.369	0.197	-0.566	0.172	0.557***	0.300*	-0.856***	0.257
	(0.333)	(0.220)	(0.527)	(0.201)	(0.199)	(0.155)	(0.313)	(0.170)
Inflation rate (π_t)					-1.239***	-0.675***	1.915***	-0.564***
					(0.132)	(0.139)	(0.194)	(0.189)
Observations	38	38	38	38	38	38	38	38
Adjusted R^2	0.0172	-0.00489	0.0170	-0.0149	0.679	0.332	0.686	0.144

Data source: CPS and author's calculation. Sample Period: 1980-2018 (except 1995). Inflation rate is calculated from CPI-U. *p $<$ 0.10, **p $<$ 0.05, ***p $<$ 0.01. Standard errors in parentheses.

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The cyclicality of nominal wage change distributions

Time series analysis: working-age population, 25-54

- **Fact 1-3** hold for working age population.

The spike at zero, the fraction of wage cuts, and raises among prime-aged hourly workers along the business cycles

	(1) Spike at zero $\Delta W = 0$	(2) Share of cuts $\Delta W < 0$	(3) Share of raises $\Delta W > 0$	(4) Spike at zero minus Share of cuts	(5) Spike at zero $\Delta W = 0$	(6) Share of cuts $\Delta W < 0$	(7) Share of raises $\Delta W > 0$	(8) Spike at zero minus Share of cuts
1-Epop ratio $(1 - e_t)$	0.608***	0.0336	-0.642***	0.575***	0.401***	-0.150	-0.251	0.551***
	(0.0794)	(0.122)	(0.180)	(0.101)	(0.0759)	(0.130)	(0.179)	(0.113)
Inflation rate (π_t)					-0.841***	-0.744***	1.585***	-0.0966
					(0.103)	(0.129)	(0.218)	(0.0823)
Observations	38	38	38	38	38	38	38	38
Adjusted R^2	0.501	-0.0254	0.204	0.537	0.799	0.299	0.616	0.528

Data source: CPS and author's calculation. Sample Period: 1979-2018 (except 1995). Inflation rate is calculated from CPI-U. The spike at zero, the share of wage cuts and raises are constructed among prime-aged hourly paid workers. *p < 0.10, **p < 0.05, ***p < 0.01. Standard errors in parentheses.

Back

The cyclicality of nominal wage change distributions

Time series analysis by education

- **Fact 1-3** hold for both less-educated and more-educated hourly workers.

The spike at zero, the fraction of wage cuts and raises by education

	High School or less				College or more			
	(1) Spike at zero $\Delta W = 0$	(2) Share of cuts $\Delta W < 0$	(3) Share of raises $\Delta W > 0$	(4) Spike at zero minus Share of cuts	(5) Spike at zero $\Delta W = 0$	(6) Share of cuts $\Delta W < 0$	(7) Share of raises $\Delta W > 0$	(8) Spike at zero minus Share of cuts
1-Epop	0.551***	0.296*	-0.847***	0.255	0.666***	0.324**	-0.989***	0.342**
	(0.167)	(0.167)	(0.295)	(0.156)	(0.178)	(0.147)	(0.288)	(0.152)
Inflation	-1.188***	-0.717***	1.906***	-0.471***	-1.235***	-0.628***	1.863***	-0.606***
	(0.123)	(0.145)	(0.226)	(0.145)	(0.139)	(0.126)	(0.201)	(0.174)
Observations	38	38	38	38	38	38	38	38
Adjusted R^2	0.699	0.353	0.688	0.112	0.713	0.315	0.696	0.197

Data source: CPS and author's calculation. Sample Period: 1979-2018 (except 1995). Inflation rate is calculated from CPI-U. The spike at zero, the share of wage cuts and raises are constructed by the level of education: high school or less and college or more. *p $<$ 0.10, **p $<$ 0.05, ***p $<$ 0.01. Standard errors in parentheses.

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The cyclicality of nominal wage change distributions

Time series analysis by age

- **Fact 1-3** hold for both young and old hourly workers.

The spike at zero, the fraction of wage cuts and raises by age

	16 <= age < 40				40 <= age < 64			
	(1) Spike at zero $\Delta W = 0$	(2) Share of cuts $\Delta W < 0$	(3) Share of raises $\Delta W > 0$	(4) Spike at zero minus Share of cuts	(5) Spike at zero $\Delta W = 0$	(6) Share of cuts $\Delta W < 0$	(7) Share of raises $\Delta W > 0$	(8) Spike at zero minus Share of cuts
1-Epop	0.578***	0.245	-0.823***	0.333***	0.616***	0.356*	-0.971***	0.260
	(0.150)	(0.150)	(0.275)	(0.118)	(0.160)	(0.176)	(0.283)	(0.180)
Inflation	-1.091***	-0.697***	1.788***	-0.393***	-1.181***	-0.609***	1.790***	-0.571***
	(0.109)	(0.124)	(0.200)	(0.119)	(0.127)	(0.173)	(0.237)	(0.190)
Observations	38	38	38	38	38	38	38	38
Adjusted R^2	0.738	0.391	0.675	0.185	0.716	0.214	0.680	0.0981

Data source: CPS and author's calculation. Sample Period: 1979-2018 (except 1995). Inflation rate is calculated from CPI-U. The spike at zero, the share of wage cuts and raises are constructed by age: age less than 40 and age greater than 40. *p $<$ 0.10, **p $<$ 0.05, ***p $<$ 0.01. Standard errors in parentheses.

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The cyclicality of nominal wage change distributions

Time series analysis by gender

- **Fact 1-3** hold for both male and female.

The spike at zero, the fraction of wage cuts and raises by gender

	Male				Female			
	(1) Spike at zero $\Delta W = 0$	(2) Share of cuts $\Delta W < 0$	(3) Share of raises $\Delta W > 0$	(4) Spike at zero minus Share of cuts	(5) Spike at zero $\Delta W = 0$	(6) Share of cuts $\Delta W < 0$	(7) Share of raises $\Delta W > 0$	(8) Spike at zero minus Share of cuts
1-Epop	0.515***	0.340**	-0.855***	0.175	0.716***	0.252	-0.968***	0.463***
	(0.176)	(0.161)	(0.285)	(0.181)	(0.149)	(0.168)	(0.291)	(0.127)
Inflation	-1.102***	-0.506***	1.608***	-0.596***	-1.264***	-0.878***	2.142***	-0.387***
	(0.116)	(0.169)	(0.213)	(0.197)	(0.133)	(0.130)	(0.239)	(0.110)
Observations	38	38	38	38	38	38	38	38
Adjusted R^2	0.674	0.190	0.622	0.138	0.758	0.463	0.735	0.162

Data source: CPS and author's calculation. Sample Period: 1979-2018 (except 1995). Inflation rate is calculated from CPI-U. The spike at zero, the share of wage cuts and raises are constructed by gender. *p $<$ 0.10, **p $<$ 0.05, ***p $<$ 0.01. Standard errors in parentheses.

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The cyclicality of nominal wage change distributions

Time series analysis by race

- **Fact 1-3** hold for both white and non-white.

The spike at zero, the fraction of wage cuts and raises by race

	White				Non-white			
	(1) Spike at zero $\Delta W = 0$	(2) Share of cuts $\Delta W < 0$	(3) Share of raises $\Delta W > 0$	(4) Spike at zero minus Share of cuts	(5) Spike at zero $\Delta W = 0$	(6) Share of cuts $\Delta W < 0$	(7) Share of raises $\Delta W > 0$	(8) Spike at zero minus Share of cuts
1-Epop	0.632***	0.333**	-0.964***	0.299**	0.554***	0.0753	-0.629**	0.479*
	(0.164)	(0.147)	(0.281)	(0.135)	(0.153)	(0.205)	(0.272)	(0.238)
Inflation	-1.200***	-0.677***	1.877***	-0.523***	-1.077***	-0.589***	1.666***	-0.489*
	(0.119)	(0.135)	(0.213)	(0.139)	(0.145)	(0.197)	(0.244)	(0.245)
Observations	38	38	38	38	38	38	38	38
Adjusted R^2	0.739	0.368	0.710	0.182	0.615	0.149	0.623	0.0672

Data source: CPS and author's calculation. Sample Period: 1979-2018 (except 1995). Inflation rate is calculated from CPI-U. The spike at zero, the share of wage cuts and raises are constructed by race. *p $<$ 0.10, **p $<$ 0.05, ***p $<$ 0.01. Standard errors in parentheses.

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The cyclicality of nominal wage change distributions

Time series analysis by hourly wage quartiles

The spike at zero, the share of wage cuts and raises by hourly wage quartiles

	25th below				From 25th to Median			
	(1) Spike at zero $\Delta W = 0$	(2) Share of cuts $\Delta W < 0$	(3) Share of raises $\Delta W > 0$	(4) Spike at zero minus Share of cuts	(5) Spike at zero $\Delta W = 0$	(6) Share of cuts $\Delta W < 0$	(7) Share of raises $\Delta W > 0$	(8) Spike at zero minus Share of cuts
1-Epop	0.972***	0.221	-1.193**	0.751***	0.622**	0.128	-0.750*	0.494**
	(0.271)	(0.246)	(0.453)	(0.251)	(0.231)	(0.213)	(0.390)	(0.216)
Inflation	-1.246***	-0.935***	2.181***	-0.310	-1.216***	-0.685***	1.900***	-0.531**
	(0.317)	(0.273)	(0.560)	(0.189)	(0.111)	(0.157)	(0.189)	(0.195)
Observations	38	38	38	38	38	38	38	38
Adjusted R^2	0.494	0.291	0.485	0.127	0.586	0.195	0.540	0.111

	Median to 75th				Above 75th			
	(1) Spike at zero $\Delta W = 0$	(2) Share of cuts $\Delta W < 0$	(3) Share of raises $\Delta W > 0$	(4) Spike at zero minus Share of cuts	(5) Spike at zero $\Delta W = 0$	(6) Share of cuts $\Delta W < 0$	(7) Share of raises $\Delta W > 0$	(8) Spike at zero minus Share of cuts
1-Epop	0.426*	0.381***	-0.807**	0.0453	0.552***	0.439***	-0.992***	0.113
	(0.225)	(0.139)	(0.321)	(0.193)	(0.191)	(0.152)	(0.298)	(0.175)
Inflation	-1.114***	-0.403***	1.517***	-0.711***	-1.150***	-0.703***	1.852***	-0.447**
	(0.179)	(0.123)	(0.249)	(0.180)	(0.130)	(0.133)	(0.186)	(0.186)
Observations	38	38	38	38	38	38	38	38
Adjusted R^2	0.537	0.193	0.533	0.205	0.661	0.428	0.718	0.0829

Data source: CPS and author's calculation. Sample Period: 1979-2018 (except 1995). Inflation rate is calculated from CPI-U. *p $<$ 0.10, **p $<$ 0.05, ***p $<$ 0.01. Standard errors in parentheses.

Back

The cyclicality of nominal wage change distributions

Time series analysis: low-paid young workers

- **Fact 1-3** hold for low-paid young workers.

The spike at zero, the fraction of wage cuts, and raises for low-paid young workers

	(1) Spike at zero $\Delta W = 0$	(2) Share of cuts $\Delta W < 0$	(3) Share of raises $\Delta W > 0$	(4) Spike at zero minus Share of cuts	(5) Spike at zero $\Delta W = 0$	(6) Share of cuts $\Delta W < 0$	(7) Share of raises $\Delta W > 0$	(8) Spike at zero minus Share of cuts
1-Epop ratio $(1 - e_t)$	0.702**	0.806**	-1.508***	-0.104	0.899***	0.884**	-1.783***	0.0146
	(0.332)	(0.358)	(0.540)	(0.431)	(0.205)	(0.346)	(0.415)	(0.389)
Inflation rate (π_t)					-1.298***	-0.513	1.811***	-0.784*
					(0.117)	(0.449)	(0.477)	(0.449)
Observations	38	38	38	38	38	38	38	38
Adjusted R^2	0.105	0.0986	0.161	-0.0259	0.696	0.142	0.509	0.0918

Data source: CPS and author's calculation. Sample Period: 1979-2018 (except 1995). Inflation rate is calculated from CPI-U. The spike at zero, the share of workers with raises and cuts come from the annual nominal hourly wage growth distribution of low-paid young workers. *p $<$ 0.10, **p $<$ 0.05, ***p $<$ 0.01. Standard errors in parentheses.

- Low-paid young workers: age $\leq$30 and hourly wage $\leq$25th percentile
- 6% of overall sample

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The cyclicality of nominal wage change distributions

US state-level variations: unemployment rate

- **Fact 1-3** hold
- Time fixed effects control for the decline in labor force participation

The spike at zero, the share of wage cuts and raises across states with unemployment rate

	(1) Spike at zero $\Delta W = 0$	(2) Share of cuts $\Delta W < 0$	(3) Share of raises $\Delta W > 0$	(4) Spike at zero minus Share of cuts
Unemployment rate (u_{it})	0.695***	0.520***	-1.215***	0.175
	(0.106)	(0.0928)	(0.153)	(0.128)
State Fixed Effect, α_i	Yes	Yes	Yes	Yes
Time Fixed Effect, γ_t	Yes	Yes	Yes	Yes
Observations	1750	1750	1750	1750
Adjusted R^2	0.606	0.536	0.718	0.301

Data source: CPS and author's calculation. Sample Period: 1980-2018 (except 1985, 1986, 1995, and 1996 due to small sample sizes). The sample consists of 50 states over 35 years. *p $<$ 0.10, **p $<$ 0.05, ***p $<$ 0.01. Standard errors in parentheses.

The cyclicality of nominal wage change distributions

Time series analysis: unemployment rate

The spike at zero, the share of wage cuts, and raises with unemployment rate

	(1) Spike at zero $\Delta W = 0$	(2) Share of cuts $\Delta W < 0$	(3) Share of raises $\Delta W > 0$	(4) Spike at zero minus Share of cuts	(5) Spike at zero $\Delta W = 0$	(6) Share of cuts $\Delta W < 0$	(7) Share of raises $\Delta W > 0$	(8) Spike at zero minus Share of cuts
Unemployment rate (u_t)	0.180	0.447*	-0.627	-0.268	0.441*	0.607***	-1.048***	-0.166
	(0.350)	(0.238)	(0.561)	(0.209)	(0.239)	(0.181)	(0.381)	(0.188)
Inflation rate (π_t)					-1.162***	-0.708***	1.871***	-0.454**
					(0.141)	(0.136)	(0.217)	(0.172)
Observations	38	38	38	38	38	38	38	38
Adjusted R^2	-0.0194	0.0559	0.0129	-0.00234	0.637	0.438	0.691	0.112

Data source : CPS and author's calculation. Sample Period : 1979-2018 (except 1995). Inflation rate is calculated from CPI-U. *p $<$ 0.10, **p $<$ 0.05, ***p $<$ 0.01. Standard errors in parentheses.

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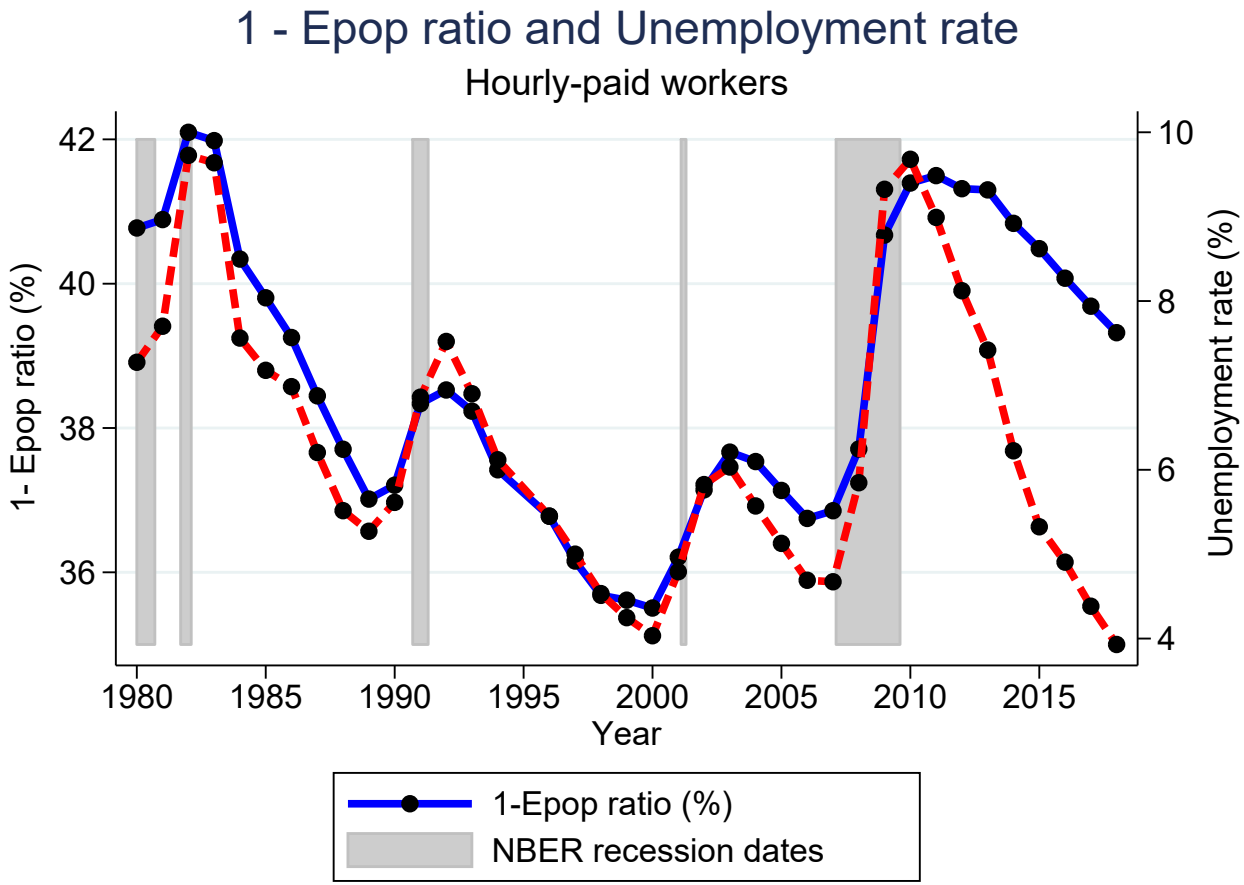
The cyclicality of nominal wage change distributions

1 - Epop vs. Unemployment rate

- Rapid drop in unemployment after the Great Recession due to the decline in labor force participation



Data source: CPS and author's calculation. Sample period: 1979 - 2018. This figure shows the 1 - Epop ratio (left axis) and the unemployment rate (right axis).

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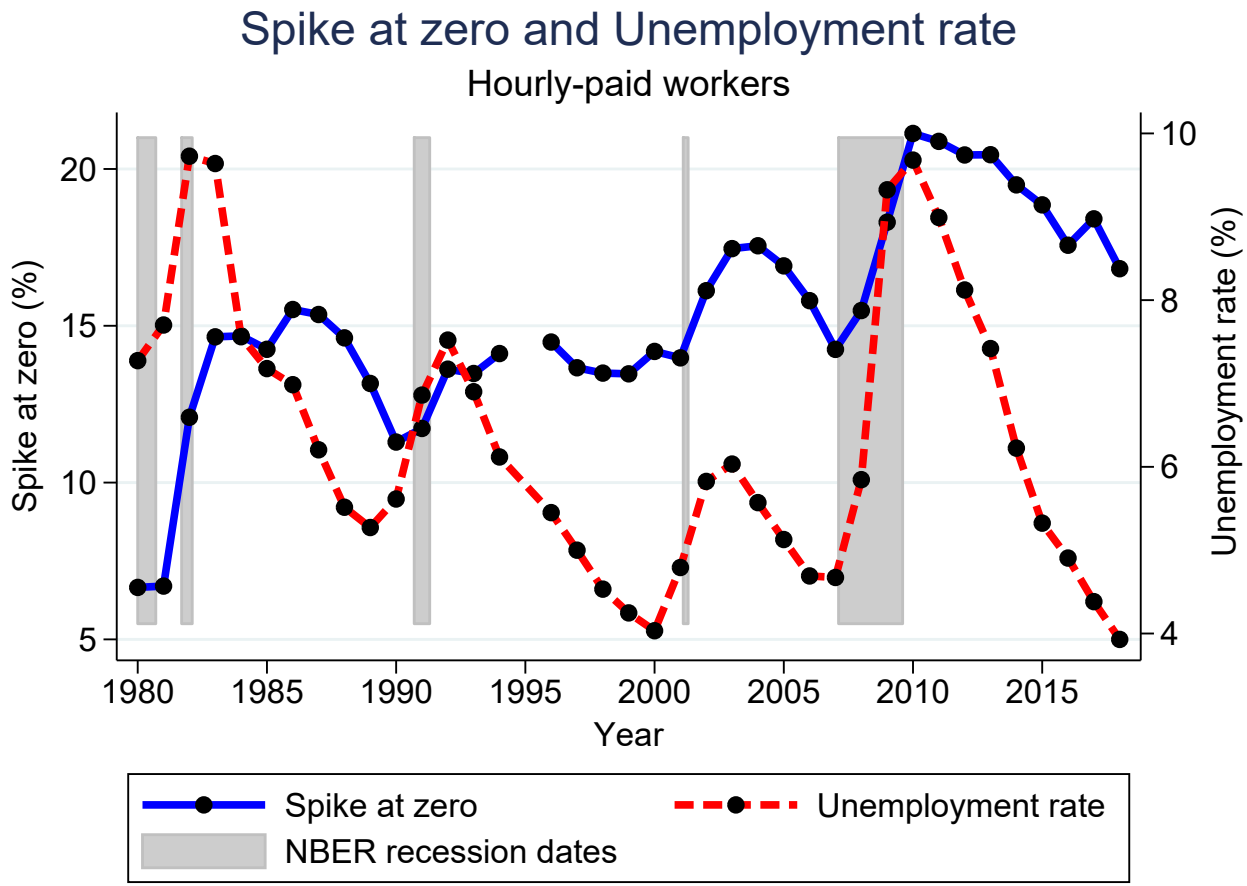
The cyclicality of nominal wage change distributions

Time series analysis: unemployment rate



Data source: CPS and author's calculation. Sample period: 1979 - 2018. This figure shows the spike at zero for each year (left axis) and the unemployment rate (right axis).

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Hours worked for job stayers: CPS

Jo, Schmitt-Grohé, and Uribe (2018)

Median hours worked per week, CPS

Year	Spike at zero $\Delta W = 0$	Fraction of $\Delta W < 0$	Fraction of $\Delta W > 0$
1997	40	40	40
1998	40	40	40
1999	40	40	40
2000	40	40	40
2001	40	40	40
2002	40	40	40
2003	40	40	40
2004	40	40	40
2005	40	40	40
2006	40	40	40
2007	40	40	40
2008	40	40	40
2009	37	40	40
2010	38	40	40
2011	38	40	40
2012	40	40	40
2013	38	40	40
2014	40	40	40
2015	40	40	40
2016	40	40	40

Data source : CPS and author's calculation. Sample Period : 1996-2016 (except 1995). This table shows the median hours worked among hourly paid job stayers for those who had no wage change, wage cuts, and increases.

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State-level cyclicality of wage change distributions

Job stayers vs. Job switchers using the SIPP

- State-level panel regressions for both job stayers and job switchers
- **Fact 1-3.** hold for both job stayers and job switchers.

	All hourly paid workers			Job stayers			Job switchers		
	(1) Spike at zero	(2) Share of cuts	(3) Share of raises	(4) Spike at zero	(5) Share of cuts	(6) Share of raises	(7) Spike at zero	(8) Share of cuts	(9) Share of raises
1-Epop ratio $(1 - e_{it})$	0.407*** (0.101)	0.0989 (0.0767)	-0.506*** (0.111)	0.489*** (0.123)	0.121 (0.0789)	-0.610*** (0.121)	0.348*** (0.101)	0.124 (0.176)	-0.471** (0.182)
State Fixed Effect, α_i	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect, γ_t	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	855	855	855	855	855	855	855	855	855
Adjusted R^2	0.842	0.341	0.783	0.871	0.499	0.814	0.171	0.0608	0.148

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Descriptive statistics: SIPP

- Why have [...] stopped working for the previous employer?
- Note that more than half of them are missing.

The spike at zero, the fraction of wage cuts, and increases(%) for job-switchers by reasons of switching, SIPP

	%	Spike at zero $\Delta W = 0$	Fraction of $\Delta W < 0$	Fraction of $\Delta W > 0$
On layoff	11.53	14.06	37.05	48.89
Fired/Discharged	2.35	9.96	43.98	46.07
Quit to take another job	8.27	9.33	22.89	67.78
Contingent worker/temporary employed	4.22	14.38	29.97	55.65
Illness/Injury	1.26	14.26	38.69	47.05
Others	19.54	12.17	32.79	55.04
Missing	52.82	12.23	27.79	59.98

Data source : SIPP and author's calculation. Sample Period : 1986-2013 (except 1990, 1996, 2001, 2004, 2008). This table shows the average of spike at zero and the fraction of workers with wage decreases and increases over time by demographic group.

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Descriptive statistics: SIPP

Size of wage change

Median size of wage change, SIPP

	Median size of ΔW given $\Delta W < 0$	Median size of ΔW given $\Delta W > 0$
Job-stayer	-7.07	6.76
Job-switcher	-16.29	16.20

Source : SIPP and author's calculation. Sample Period : 1984-2013 (except 1990, 1996, 2001, 2004, 2008).

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Appendix: Theory

Solution Algorithm

1. Followed by Krusell and Smith (1998), predict the law of motion for aggregate wage inflation based on the first and second moments of aggregate variable

$$\ln\left(\frac{W_{t+1}}{W_t}^{P}\right) = H\left(\ln\left(\frac{M_{t+1}}{W_t}\right)\right) = \gamma_0 + \gamma_1 \ln\frac{M_{t+1}}{W_t} + \gamma_2\left(\ln\frac{M_{t+1}}{W_t}\right)^2$$

2. Given the predicted law of motion, solve the wage setter's optimization problem.
3. Simulate the economy with the policy function from the step 2. Iterate until the predicted aggregate wage inflation becomes close enough to the simulated aggregate wage inflation.

- To check the accuracy of predicted law of motion,
  - Krusell and Smith (1998) : $R^{2,\text{DNWR}} = 0.98$, $R^{2,\text{Calvo}} = 0.98$, $R^{2,\text{Menu}} = 0.99$, $R^{2,\text{Flex}} = 0.99$
  - Den Haan (2007) : the maximum forecast error, $\left|\ln\left(\frac{W^S_{t+1}}{W_t}\right) - \ln\left(\frac{W^P_{t+1}}{W_t}\right)\right| \leq 0.1\%$

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Calvo model

Calvo model

- Given $(q_t(i), L_t, \frac{W_{t-1}(i)}{W_t})$, solve household utility maximization problem without the wage setting constraint in period t.
- Let W^*(i) is the optimal wage without the wage setting constraint in period t.
- Two sided wage rigidity - Calvo

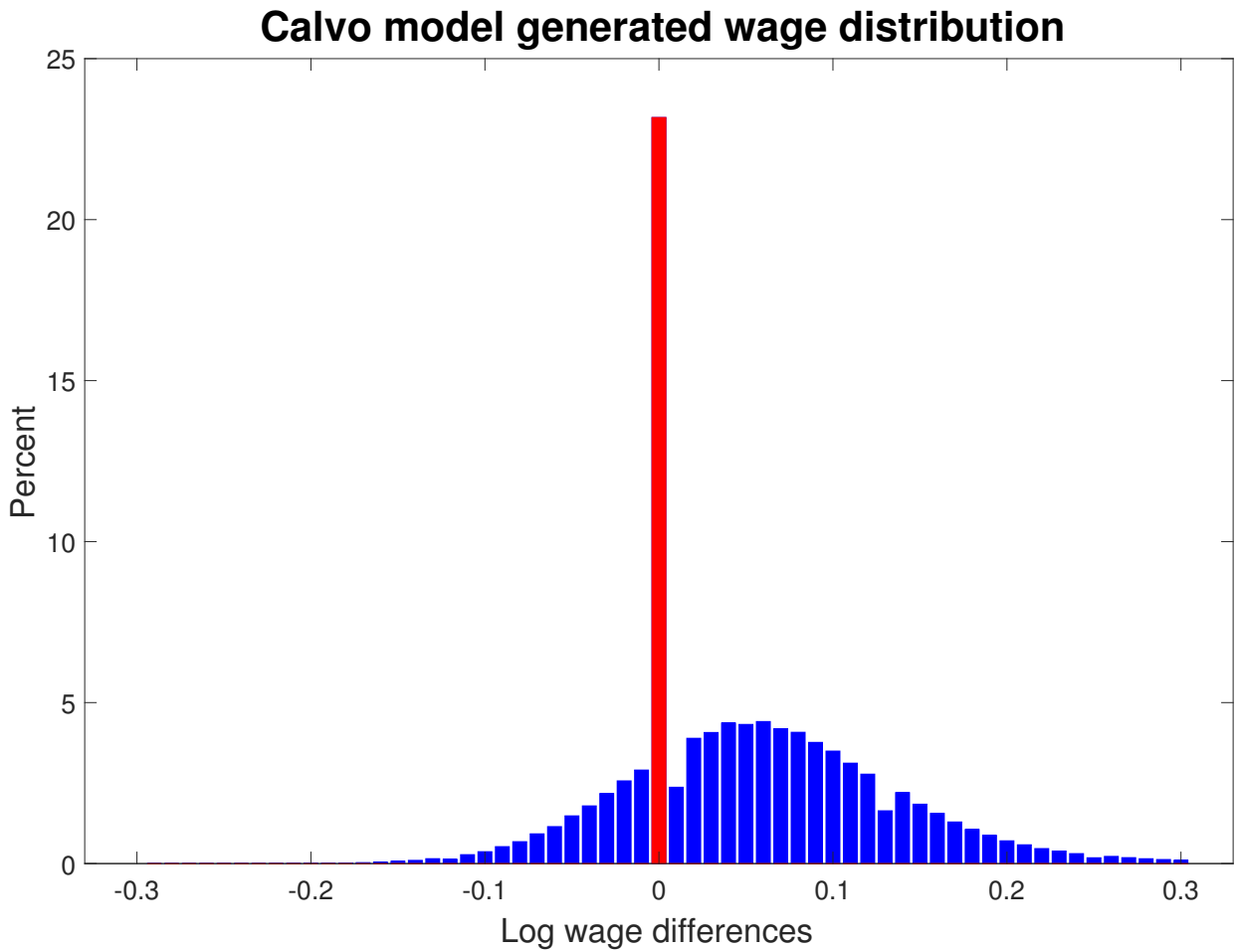
$$W_t(i) = \begin{cases} W_{t-1}(i) & \text{, with the prob } \mu^{\text{Calvo}} \\ W_t^*(i) & \text{, with the prob } (1-\mu^{\text{Calvo}}) \end{cases}$$

, where W^*(i) is the optimal wage without the wage setting constraint in peiod t.

Households

Stationary wage change distribution: Calvo

- Generates the spike at zero. μ^{Calvo} determines the spike at zero.
- Symmetric distribution around the median except the spike at zero.
- Inconsistent with empirical nominal wage change distribution.



Model generated stationary distribution of log wage differences

Empirics

Cyclicality of wage change distribution: Calvo

- When the employment declines, the [Fraction of $\Delta W > 0$] declines.
  - $|\Delta[\text{Fraction of } \Delta W > 0]| \approx |\Delta[\text{Fraction of } \Delta W < 0]|$
  - $|\Delta[\text{Spike at zero}]| \approx 0$
- Cannot explain the countercyclical spike at zero.

Data vs. simulated data

	Spike at zero $\Delta W = 0$	Fraction of $\Delta W < 0$	Fraction of $\Delta W > 0$
	Data		
Employment	-0.616	-0.305	0.921
Inflation	-1.181	-0.674	1.855
	Calvo model		
Employment	0.089	-0.553	0.465
Inflation	-0.192	-3.919	4.111

Data source : CPS and author's calculation. Sample Period : 1979-2017 (except 1995). Inflation rate is calculated from CPI-U. Model simulation is done for 5000 periods for 5000 households. Regression results come from the burning initial 1000 periods.

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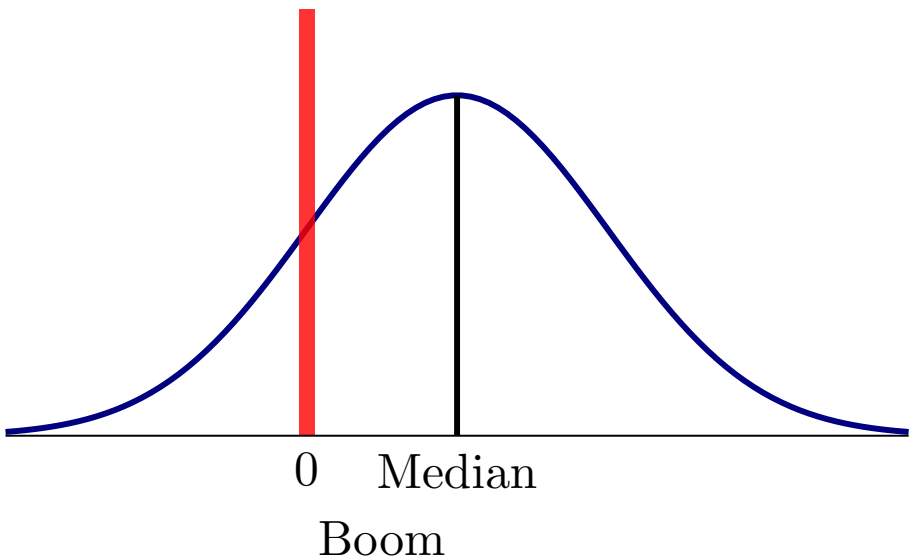
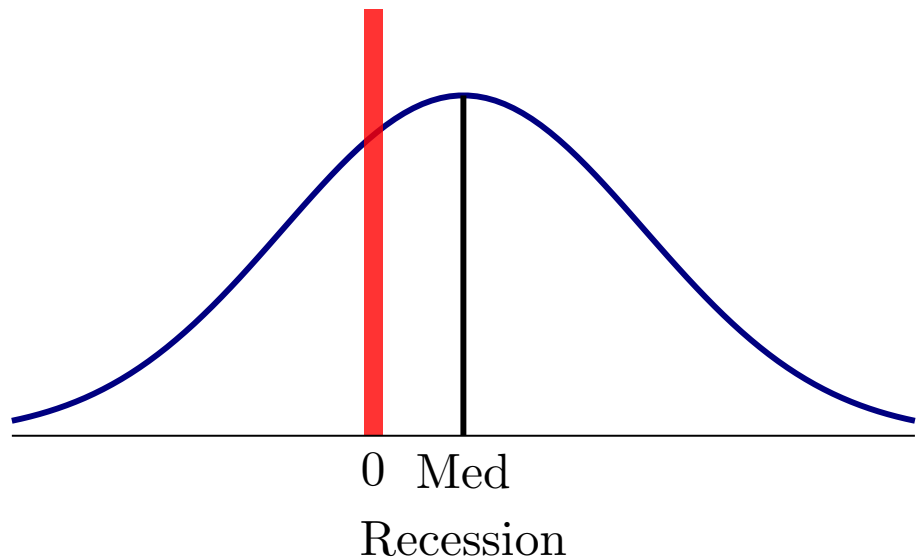
Cyclicality of wage change distribution: Calvo

- When the employment declines, the [Fraction of $\Delta W > 0$] declines.
  - $|\Delta[\text{Fraction of } \Delta W > 0]| \approx |\Delta[\text{Fraction of } \Delta W < 0]|$
  - $|\Delta[\text{Spike at zero}]| \approx 0$
- Cannot explain the countercyclical spike at zero.





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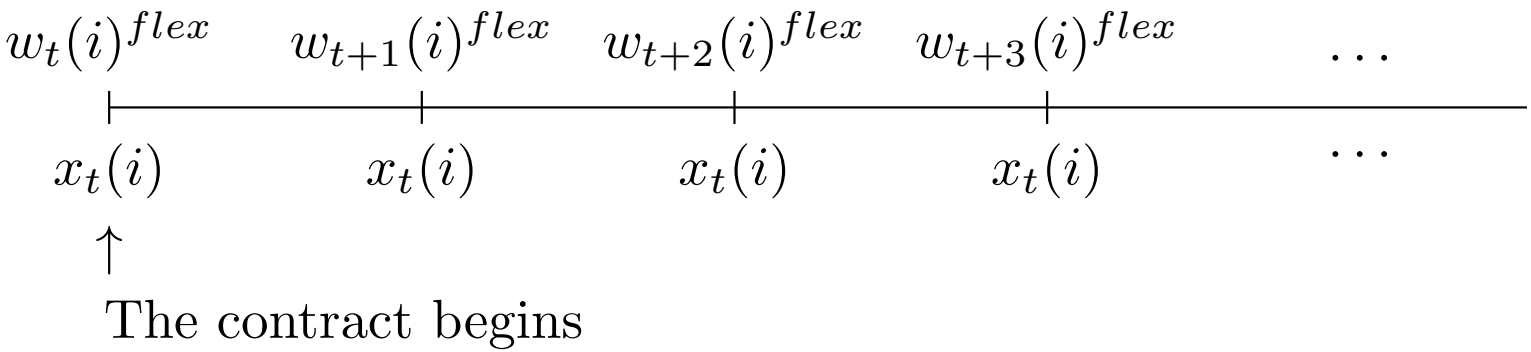
Long term contract model

Long term contract

Barro's critique (1977)

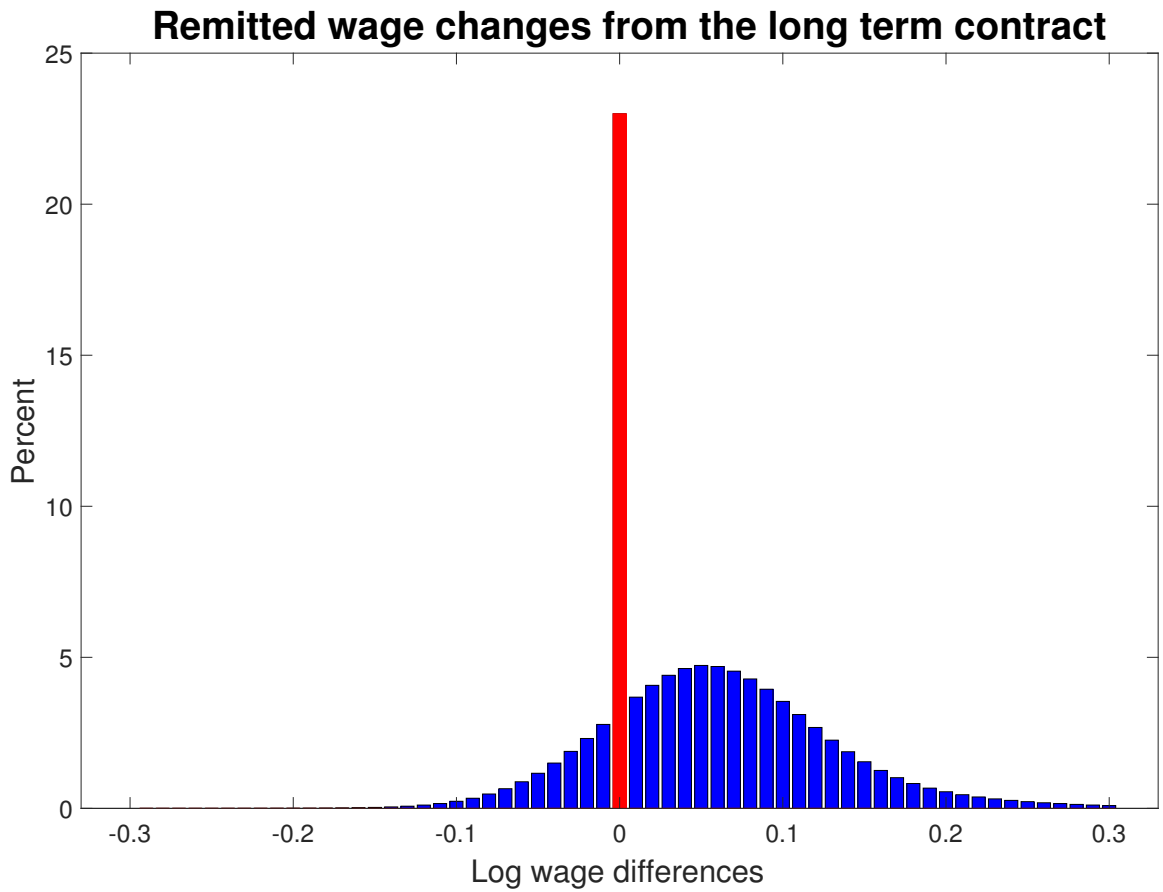
- Worker signs a long term contract at a fixed wage, $x_t(i)$. The stickiness of individual wages does not mean that nominal rigidities have allocative consequences.
- Followed by Basu and House (2016): two wages
  - Observed wages (remitted wages), $x_t(i)$
  - Allocative wages, which determine hours worked and employment, $w_t(i)$



- The present discounted value of the fixed remitted wages $x_t(i)$ over the contract is the same as the present discounted value of future allocative wages $(w_t(i))$
- With the probability of s, workers reset their wages Households

Stationary wage change distribution: Long term contract

- Generates the spike at zero. s, renegotiation prob, determines the spike at zero.
- Symmetric distribution around the median except the spike at zero.
- Inconsistent with empirical nominal wage change distribution.



Remitted wages are calculated from allcative wages from perfectly flexible model. Model generated stationary distribution of log remitted wage differences. The average duration of the contract is 1.3 years.

Empirics

Cyclicality of wage change distribution: Long term contract

- When the employment declines, the [Fraction of $\Delta W > 0$] declines.
  - $|\Delta[\text{Fraction of } \Delta W > 0]| \approx |\Delta[\text{Fraction of } \Delta W < 0]|$
  - $|\Delta[\text{Spike at zero}]| \approx 0$
- Cannot explain the countercyclical spike at zero.

Data vs. simulated data

	Spike at zero $\Delta W = 0$	Fraction of $\Delta W < 0$	Fraction of $\Delta W > 0$
	Data		
Employment	-0.616	-0.305	0.921
Inflation	-1.181	-0.674	1.855
	Long term contract		
Employment	0.005	-0.424	0.419
Inflation	-0.018	-4.207	4.225

Data source : CPS and author's calculation. Sample Period : 1979-2017 (except 1995). Inflation rate is calculated from CPI-U. Model simulation is done for 5000 periods for 5000 households. Regression results come from the burning initial 1000 periods.

Back

DNWR model

Downward nominal wage rigidity model

- Given $(q_t(i), L_t, \frac{W_{t-1}(i)}{W_t})$, solve household utility maximization problem without the wage setting constraint in period t.
- Let W^*(i) is the optimal wage without the wage setting constraint in period t.
- One sided wage rigidity - Downward nominal wage rigidity (Asymmetric Calvo)

$$\text{if } W_t^*(i) \geq W_{t-1}(i) \left\{ W_t(i) = W_t^*(i) \right.$$

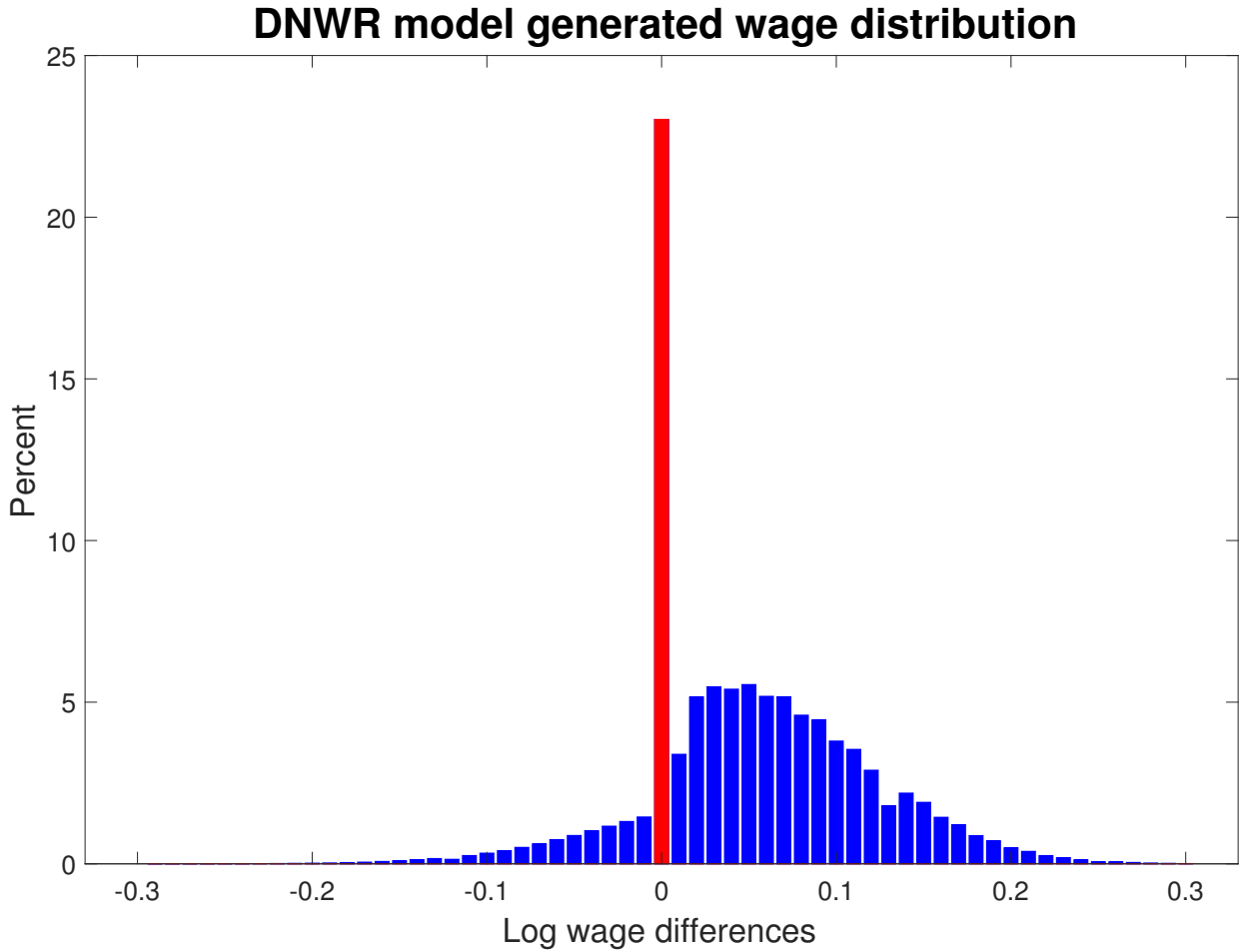
$$\text{if } W_t^*(i) < W_{t-1}(i) \begin{cases} W_t(i) = W_{t-1}(i) & \text{,with the prob } \mu^{\text{DNWR}} \\ W_t(i) = W_t^*(i) & \text{,with the prob } (1-\mu^{\text{DNWR}}) \end{cases}$$

, where W^*(i) is the optimal wage without the wage setting constraint in period t.

Households

Stationary wage change distribution: DNWR

- Generates the spike at zero. μ^{Menu} determines the spike at zero.
- The lack of wage cuts compared to wage increases
- Consistent with empirical nominal wage change distribution.



Model generated stationary distribution of log wage differences

Empirics

Sensitivity μ Sensitivity q Back

Cyclicality of wage change distribution: DNWR

- When the employment declines, the [Fraction of $\Delta W > 0$] declines.
  - Spike at zero increases - consistent with empirical patterns
  - $|\Delta$[Fraction of $\Delta W < 0]| < |\Delta$[Spike at zero]$|$ - consistent with empirical patterns

Data vs. simulated data

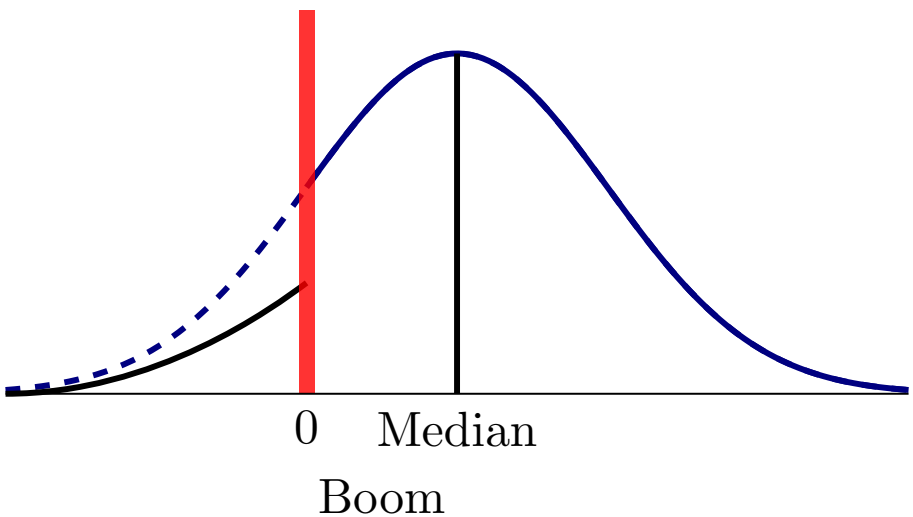
	Spike at zero $\Delta W = 0$	Fraction of $\Delta W < 0$	Fraction of $\Delta W > 0$
		Data	
Employment	-0.616	-0.305	0.921
Inflation	-1.181	-0.674	1.855
		DNWR model	
Employment	-0.712	-0.329	1.041
Inflation	-3.699	-1.772	5.470

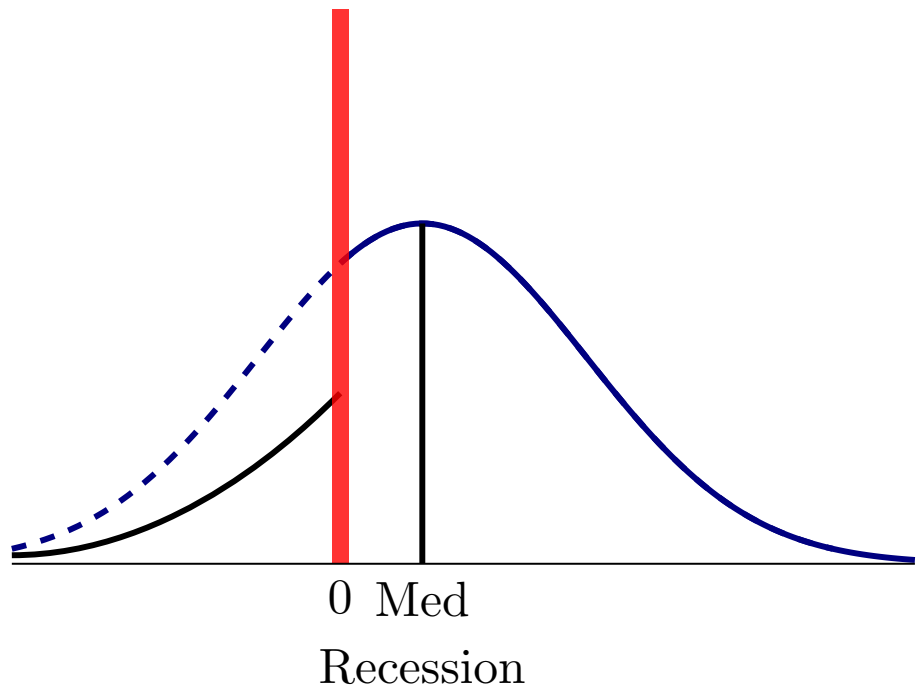
Data source : CPS and author's calculation. Sample Period : 1979-2017 (except 1995). Inflation rate is calculated from CPI-U. Model simulation is done for 5000 periods for 5000 households. Regression results come from the burning initial 1000 periods.

Sensitivity μ Sensitivity q Back

Cyclicality of wage change distribution: DNWR

- When the employment declines, the [Fraction of $\Delta W > 0$] declines.
  - Spike at zero increases - consistent with empirical patterns
  - $|\Delta[\text{Fraction of } \Delta W < 0]| < |\Delta[\text{Spike at zero}]|$ - consistent with empirical patterns

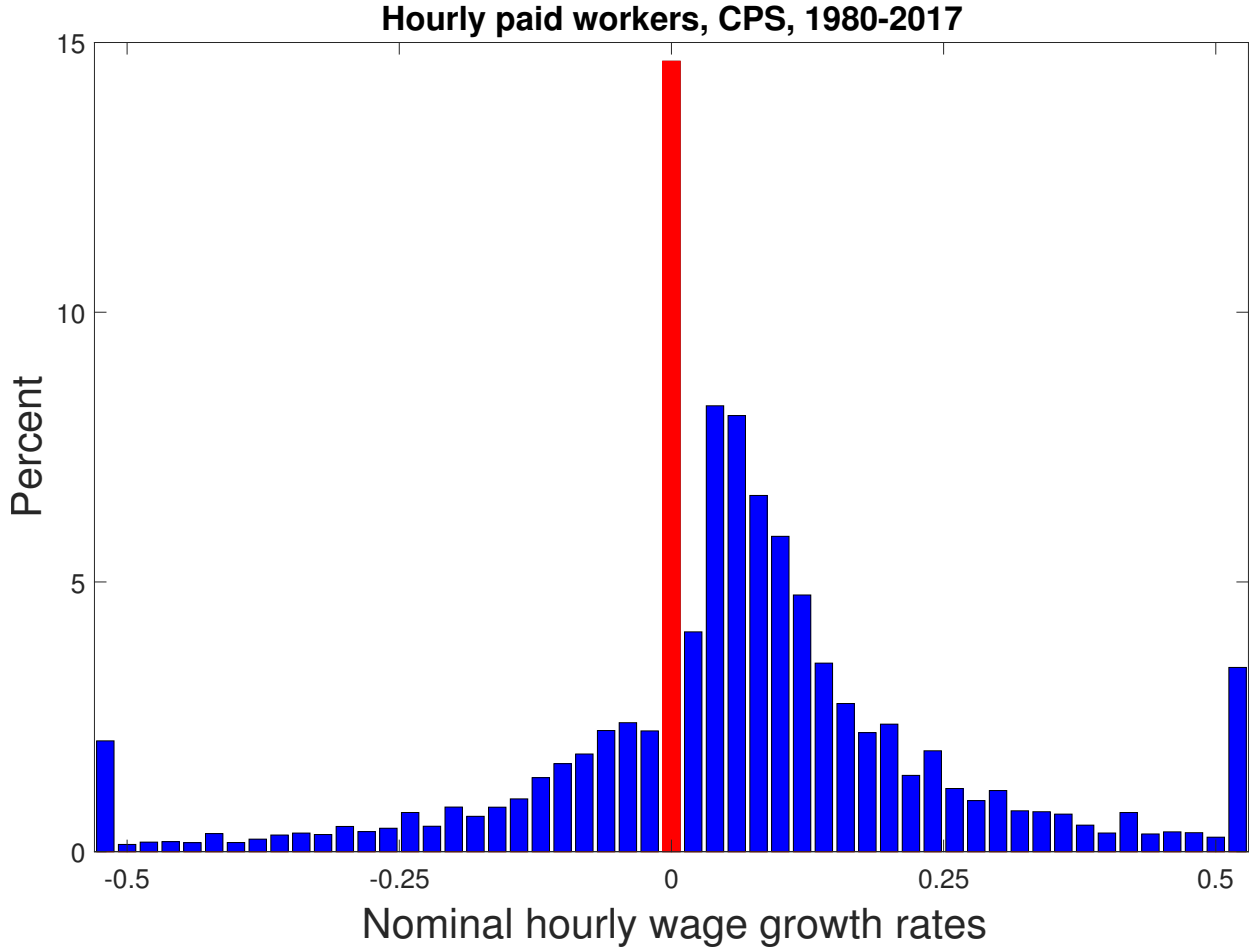




Sensitivity μ Sensitivity q Back

Asymmetric nominal wage change distribution: CPS

The distribution of individual workers' year-over-year changes in nominal hourly wages 1980 - 2017



Data source: Author's calculation from the CPS. Bin size is 0.02. Red colored bin shows the fraction of workers whose log hourly wage changes are exact zero from 1980 - 2017.

- An apparent spike at zero. On average 15% of hourly workers had no wage change.
- 21% of workers had wage cuts and 63% of workers had wage increases. Back

Numerical solution

- Use Krusell and Smith (1998) algorithm Solution algorithm

Calibrated Parameters

Parameters	Value	Description	Target/Source
γ	1	Relative Risk Aversion	
β	0.971	Discount rate	Annual interest rate, 3%
ψ	0.5	Inverse of Frisch elasticity	Chetty et al. (2011)
θ	3	Elasticity of substitution	Smets and Wouters (2007)
μ	0.044	Mean level of aggregate shock	Total wage payment
σ_m	0.021	Standard deviation of aggregate shock	
ρ_q	0.821	Persistence of idiosyncratic shock	Guvenen (2009)
σ_q	0.17	Standard deviation of idiosyncratic shock	
μ^{DNWR}	0.67	The probability of DNWR	
μ^{Calvo}	0.22	The frequency of no wage change	Matching the
μ^{Menu}	0.8	The probability of facing menu cost	average
K	0.002	Menu cost	spike at zero
K^d	0.013	Asymmetric menu cost	
s	0.23	The probability of continuing contract	

Time unit is a year.

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