The Financial Channel of Wage Rigidity

Benjamin Schoefer

UC Berkeley,
NBER, CEPR, CESifo, IZA, IWH Halle

Bundesbank Research Seminar
May 31, 2023

Motivation and background:

- Useful modeling tool for amplification: rigidity of marginal—i.e., new hires'—wages.

  Erceg, Henderson and Levin (2000); Shimer (2004); Hall (2005); Blanchard and Galí (2007); Elsby (2009); Gertler and Trigari (2009); Michaillat (2012); Christiano, Eichenbaum and Trabandt (2016); Schmitt-Grohé and Uribe (2016)

- Ongoing empirical debate about new hires' wage rigidity.

  Solon, Barsky and Parker (1994); Pissarides (2009); Hagedorn and Manovskii (2013); Galuscak, Keeney, Nicolitsas, Smets, Strzelecki and Vodopivec (2012); Gertler, Huckfeldt and Trigari (2020); Hazell and Taska (2020).

- Average/incumbent workers' wages are clearly rigid.

- Theoretical paradigm: incumbents' wages' wages are, ex post, irrelevant for hiring.

  Shimer (2004); Pissarides (2009) and many others; other recent work breaking the paradigm through effort channel (Bils, Chang and Kim, forthcoming) and wage posting (Fukui, 2020)

This paper proposes and explores a financial channel of wage rigidity:

- Rigid average/incumbents' wages $\Rightarrow$ more volatile financial resources of firms $\Rightarrow$ more volatile hiring.

- Wage rigidity may be crucial to financial amplification.

Outline

1. Mechanism: simple model

2. Empirical evidence

   - Aggregate: wage rigidity $\Rightarrow$ cash flow fluctuations

   - Industry level: labor share amplifies fluctuations

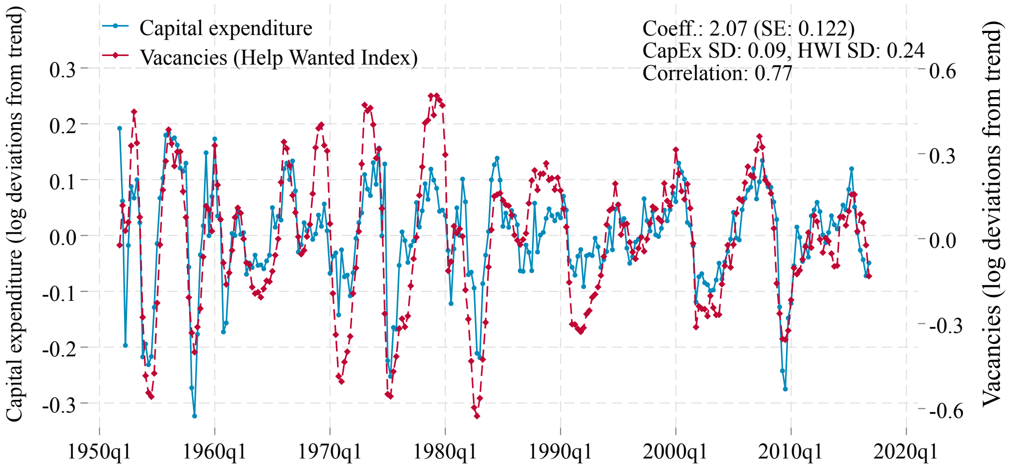
3. Search and matching (DMP) model w/ financial constraints & incumbents' wage rigidity.

   - Calibration: their interaction can provide substantial amplification.

4. Policy application: stabilization from wage subsidies/payroll taxes

   - Marginal subsidies for new hires' vs. eligibility for incumbents too

Capital Expenditure and Vacancies (Help-Wanted Index)



Source: quarterly FRB Flow of Funds data, US nonfinancial corporate sector & Barnichon (2010) Synthetic HWI

Previewing Mechanism in Simple (DMP-style) Model

In period t,

- the firm chooses hires h_{t+1}
- ... who start producing and earning wages in period $t+1$.

δ: per-period separation probability (after production/wages)

w_c: cohort-specific wages

- differentiated between hiring cohorts denoted by their first period of production c
- constant while the cohort members remain on that job (relaxed later).

$c(h_{t+1})$: upfront hiring costs (training or (DMP) recruitment costs, or complementary capital,...)

β: discount factor (from the households)

Firm's period-t problem:

$$\max_{h_{t+1}} \mathbb{E}_t \sum_{s \geq t} \beta^{s-t} \left(p_s n_s - \Phi_s - c(h_{s+1}) \right) \tag{1}$$

$$\text{s.t.} \quad n_{s+1} = h_{s+1} + (1-\delta)\, n_s \quad \forall s \geq t \tag{2}$$

$$\Phi_{s+1} = w_{c=s+1} h_{s+1} + (1-\delta)\, \Phi_s \quad \forall s \geq t \tag{3}$$

where

Φ: total wage bill

Standard: Hiring w/o Financial Constraints

Labor demand—hiring FOC:

$$c'(h^*_{t+1}) = \mathbb{E}_t \sum_{s>t} \beta^{s-t}(1-\delta)^{s-(t+1)}(p_s - w_{c=t+1}) \tag{4}$$

$$\Leftrightarrow c'(h^*_{t+1}) + \mathbb{E}_t \sum_{s>t} \beta^{s-t}(1-\delta)^{s-(t+1)} w_{c=t+1} = \mathbb{E}_t \sum_{s>t} \beta^{s-t}(1-\delta)^{s-(t+1)} p_s \tag{5}$$

Fluctuations take derivative of FOC (4):

$$\frac{d \ln h^*_{t+1}}{d \ln p} = \frac{1}{\frac{hc''}{c'}} \cdot \frac{p}{p - w_{c=t+1}} \cdot \left(1 - \frac{dw_{c=t+1}}{dp}\right) \tag{6}$$

Key insights:

- Standard amplification of hiring depends on the sensitivity of *new hires'* wages, $\frac{dw_{c=t+1}}{dp}$.
- Incumbent workers' wages $w_c = \overline{w}_{c \leq t} \forall c \leq t$ do not show up — inframarginal fixed cost!

... Macro-labor paradigm **(Shimer, 2004; Hall, 2005; Mortensen and Nagypal, 2007; Hall and Milgrom, 2008; Elsby, 2009; Pissarides, 2009; Michaillat, 2012; Haefke et al., 2013; Kudlyak, 2014; Christiano et al., 2016; Hazell and Taska, 2020; Grigsby et al., 2021)**

Twist: Hiring with Financial Constraints

- Implicit assumption in standard hiring: firms have sufficient internal funds or can raise enough external financing (e.g., debt at interest rate $r = 1/\beta - 1$) to cover the hiring costs.
- Opposite extreme case (relaxed later): no external finance (nor internal savings)

  $\Rightarrow$ Firms must finance investment out of current cash flow — adding a constraint:

$$c(h_{t+1}) \leq \underbrace{p_t n_t - \Phi_t}_{\text{Cash Flow}} . \tag{7}$$

New FOC reflecting constraint in the form of Lagrange multiplier τ on constraint (7):

$$(1 + \tau_t) \cdot c'(h^*_{t+1}) = \mathbb{E}_t \sum_{s>t} \beta^{s-t} (1 + \tau_s)(1 - \delta)^{s-(t+1)} (p_s - w_{c=t+1}). \tag{8}$$

For fluctuations, get clearer intuitions from direct comparative static on constraint (7):

$$c(h^*_{t+1}) = p_t n_t - \Phi_t \tag{9}$$

$$= (p_t - \overline{w}_{c\leq t}) \cdot n_t \tag{10}$$

$$\Rightarrow \frac{d \ln h^*_{t+1}}{d \ln p} = \frac{1}{\frac{hc'}{c}} \cdot \frac{p}{p - \overline{w}_{c\leq t}} \cdot \left(1 - \boxed{\frac{d\overline{w}_{c\leq t}}{dp}}\right). \tag{11}$$

Outline

1. Mechanism: simple model

2. Empirical evidence

   - Aggregate: Wage rigidity ⇒ cash flow fluctuations
   - Industry level: labor share amplifies fluctuations

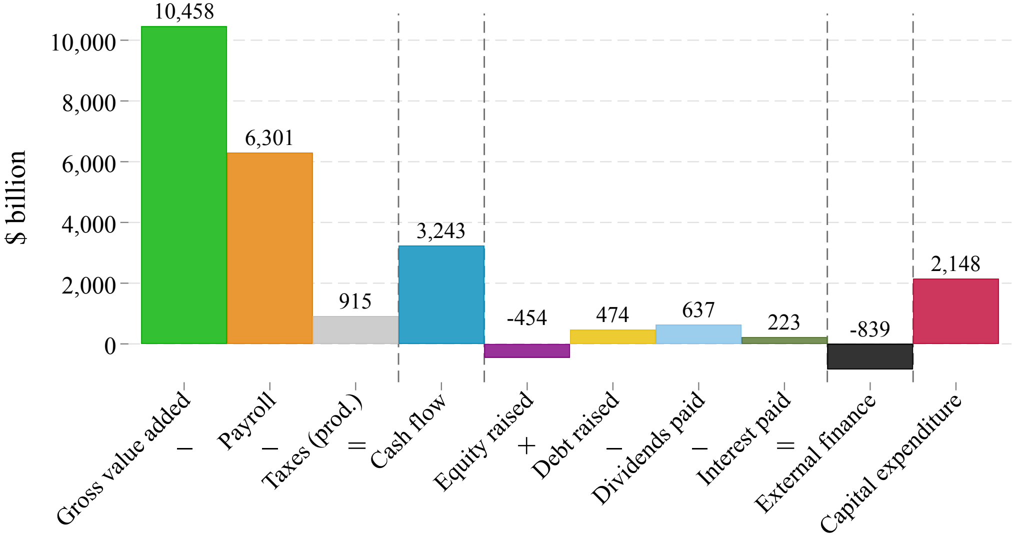
3. Search and matching (DMP) model w/ financial constraints & incumbents' wage rigidity.

   - Calibration: their interaction can provide substantial amplification.

4. Policy application: stabilization from wage subsidies/payroll taxes

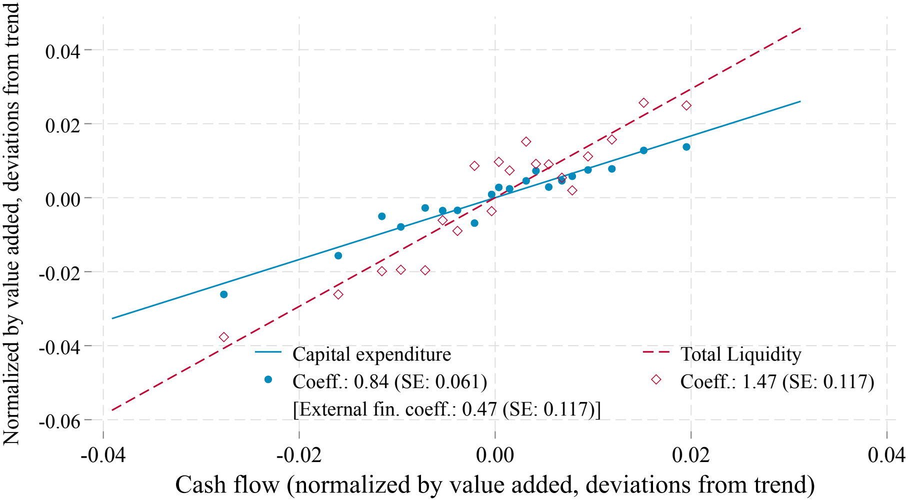
   - Marginal subsidies for new hires' vs. eligibility for incumbents too

Aggregate Cash Flow Statement (2019) for the United States



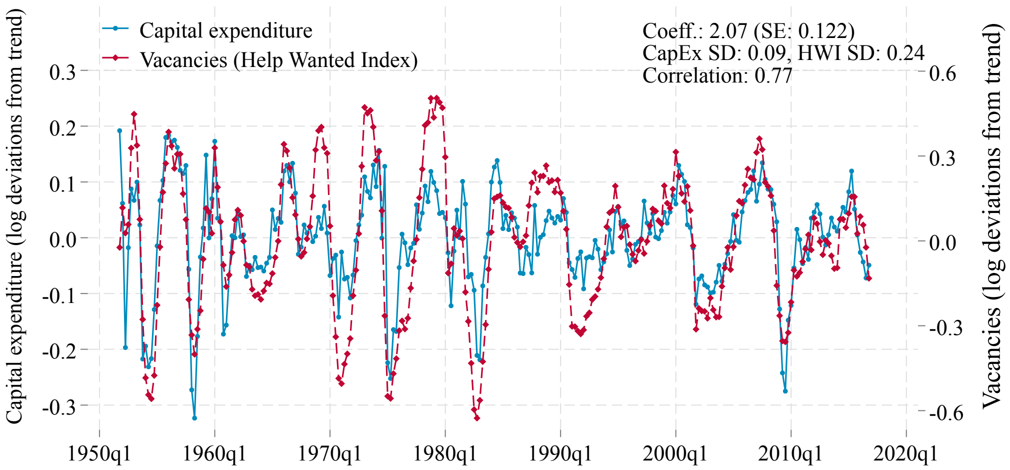
Source: quarterly FRB Flow of Funds data, US nonfinancial corporate sector (incl subseq slides)

Capital Expenditure and Liquidity Against Cash Flow



Source: quarterly FRB Flow of Funds data, US nonfinancial corporate sector

Capital Expenditure and Vacancies (Help-Wanted Index)



Source: quarterly FRB Flow of Funds data, US nonfinancial corporate sector & Barnichon (2010) Synthetic HWI

Counterfactual: Cash-Flow-Stabilizing Additional Wage Fluctuations

Empirical ($\widehat{x}$) dev'ns from trend: total derivative of cash flow CF and its components value added y and payroll $\Phi = wn$ (product of average wage w and employment n):

$$\widehat{\left(\frac{dCF}{CF}\right)} = \widehat{\left(\frac{dy}{y}\right)} \cdot \widehat{\left(\frac{y}{CF}\right)} - \widehat{\left(\frac{d\Phi}{\Phi}\right)} \cdot \widehat{\left(\frac{\Phi}{CF}\right)}. \tag{12}$$

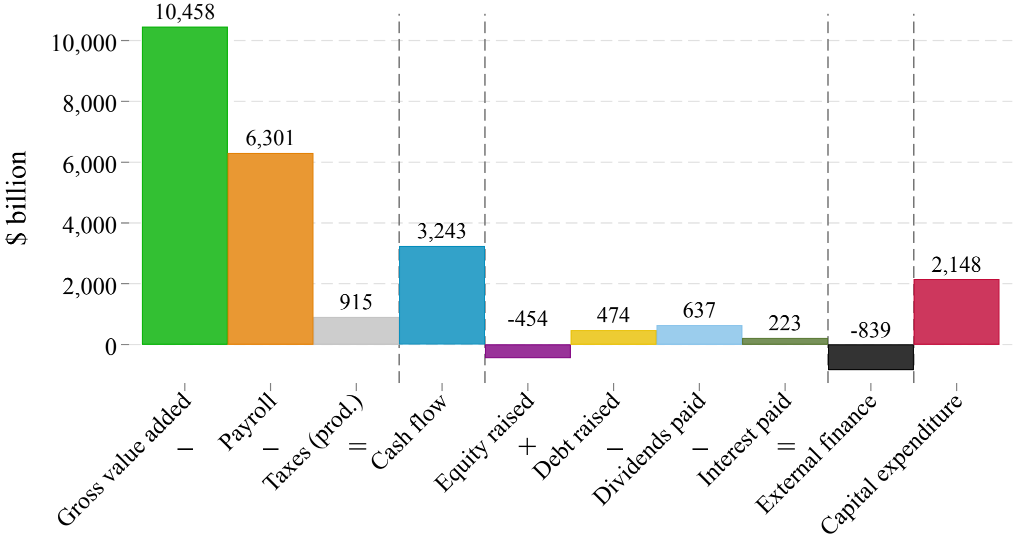
Counterfactual cash flow movement ($\widetilde{x}$) is empirical movement plus counterfactual, incremental wage change $\widetilde{\Delta w}$:

$$\widetilde{\left(\frac{dCF}{CF}\right)} = \widehat{\left(\frac{dCF}{CF}\right)} - \widetilde{\left(\Delta\frac{dw}{w}\right)} \cdot \widehat{\left(\frac{\Phi}{CF}\right)} \tag{13}$$

And hence, the add. wage change required to stabilize a given cash flow fluctuation is:

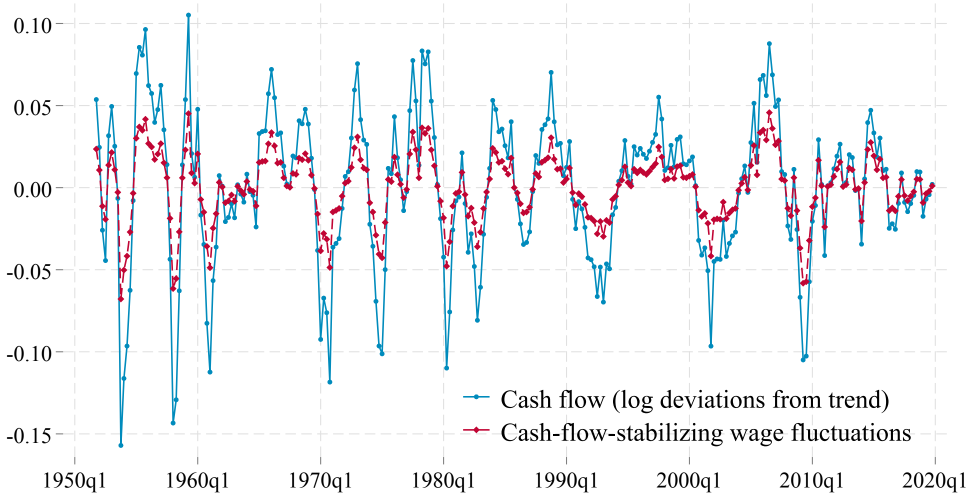
$$\Rightarrow \widetilde{\left(\Delta\frac{dw}{w}\right)}\Bigg|_{\widetilde{\left(\frac{dCF}{CF}\right)}=0} = \widehat{\left(\frac{dCF}{CF}\right)} \cdot \underbrace{\widehat{\left(\frac{CF}{\Phi}\right)}}_{\substack{\text{US 1951-2019:}\\ 0.463}} \tag{14}$$

Aggregate Cash Flow Statement (2019) for the United States

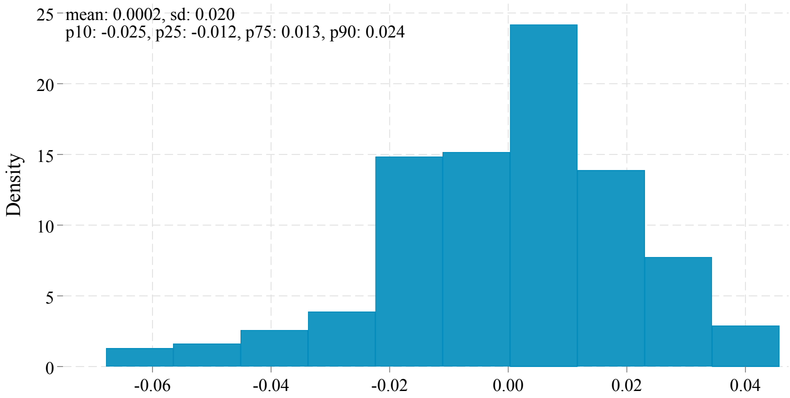


Source: quarterly FRB Flow of Funds data, US nonfinancial corporate sector

Cash Flow and Cash-Flow-Stabilizing Additional Wage Fluctuations: Time Series



Distribution of Cash-Flow-Stabilizing Incremental Wage Movements



Just a moderate volatility boost!

- Compare to idiosyncratic wage and earnings changes found in the micro data at similar frequencies (Guvenen, Karahan, Ozkan and Song, 2020)

In Math: Zeroing Out the Okun's Law of Cash Flow

$$\left(\widetilde{\Delta\frac{dw}{w}}\right)\Bigg|_{\left(\widetilde{\frac{dCF}{CF}}\right)=0} = \left(\widetilde{\frac{dCF}{CF}}\right)\cdot\left(\widetilde{\frac{CF}{\Phi}}\right) \tag{15}$$

Construct semi-elasticity w/ unemployment rate ("Okun's laws"):

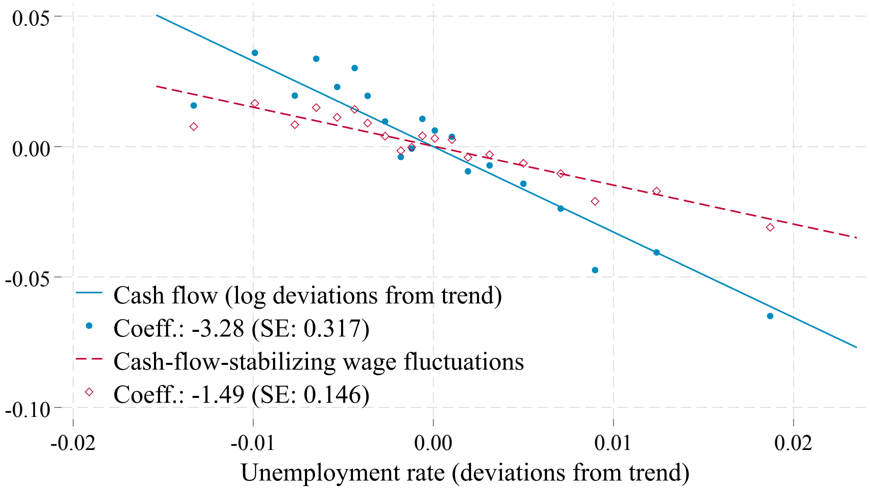
$$\Rightarrow \left(\widetilde{\frac{\Delta\frac{dw}{w}}{du}}\right)\Bigg|_{\left(\widetilde{\frac{\frac{dCF}{CF}}{du}}\right)=0} = \underbrace{\left(\widetilde{\frac{\frac{dCF}{CF}}{du}}\right)}_{-3.28}\underbrace{\left(\widetilde{\frac{CF}{\Phi}}\right)}_{0.463} \tag{16}$$

$$= -1.52$$

Just a moderate procyclicality boost!

- -1.52 corresponds to the empirical wage cyclicality differential of about -1.75. estimated b/w new hires and incumbent workers estimated as semi-elasticities of wages to UR (Pissarides, 2009)
    - -1.25 for average/incumbents' wages
    - -3.00 for new hires

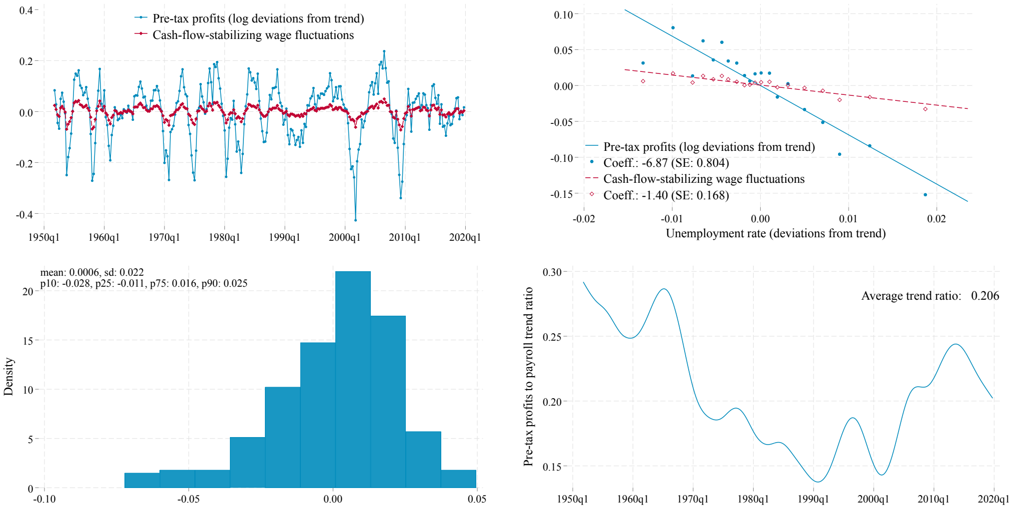
Cash Flow and Cash-Flow-Stabilizing Additional Wage Fluctuations: Okun's Laws



Robustness Checks in Paper

- Profits rather than cash flow
- Smoothing parameter
- Annual data
- Alternative sources: dividends, interest expenditures

Robustness Check: Profits



Outline

1. Mechanism: simple model

2. Empirical evidence

- Aggregate: Wage rigidity $\Rightarrow$ cash flow fluctuations
- Industry level: labor share amplifies fluctuations

3. Search and matching (DMP) model w/ financial constraints & incumbents' wage rigidity.

- Calibration: their interaction can provide substantial amplification.

4. Policy application: stabilization from wage subsidies/payroll taxes

- Marginal subsidies for new hires' vs. eligibility for incumbents too

Industry-Level Test: Cross Section

Idea, example of shift in labor productivity p:

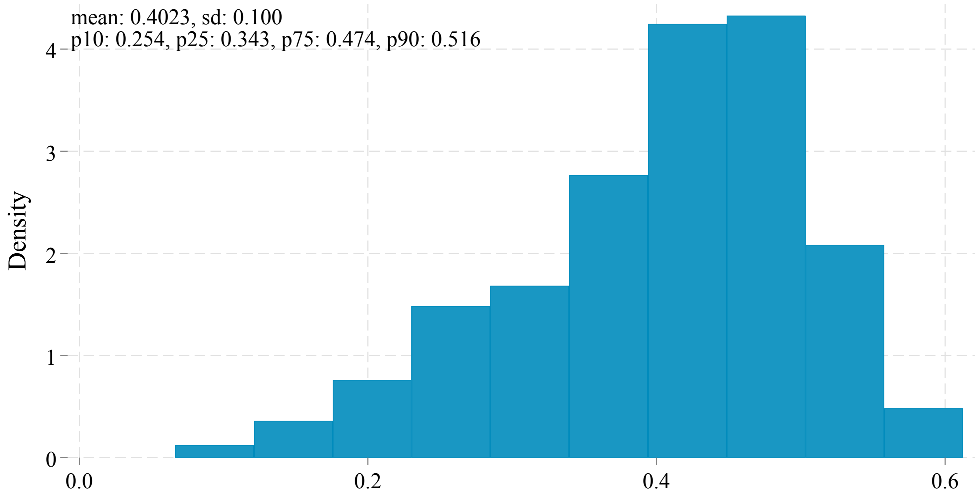
$$CF = \overbrace{pn}^{=y} - \overbrace{\Phi}^{=wn} \tag{17}$$

$$\frac{d \ln CF}{d \ln p} = \frac{1 - \frac{dw}{dp}}{1 - \underbrace{\frac{\Phi}{y}}_{=\text{ labor share!}}} \tag{18}$$

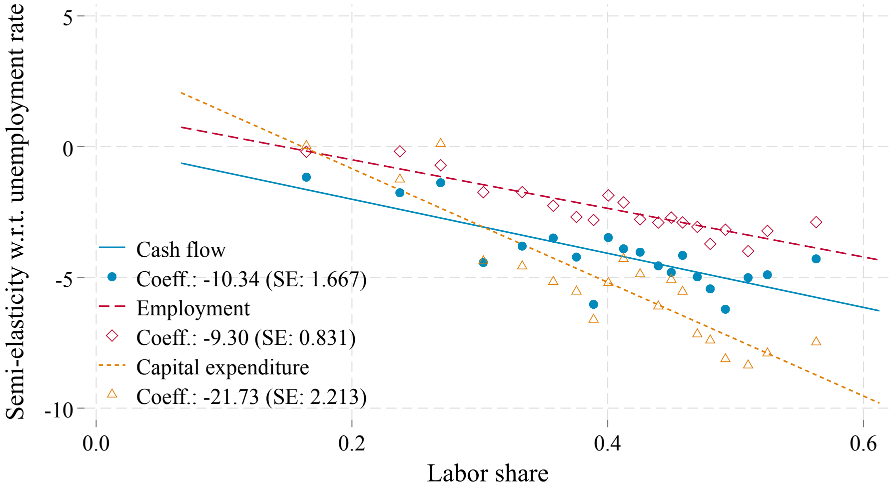
Data: US NBER-CES Manufacturing Productivity Database (1958 to 2016 for 457 industries), annual

Additional outcome variables: employment, investment.

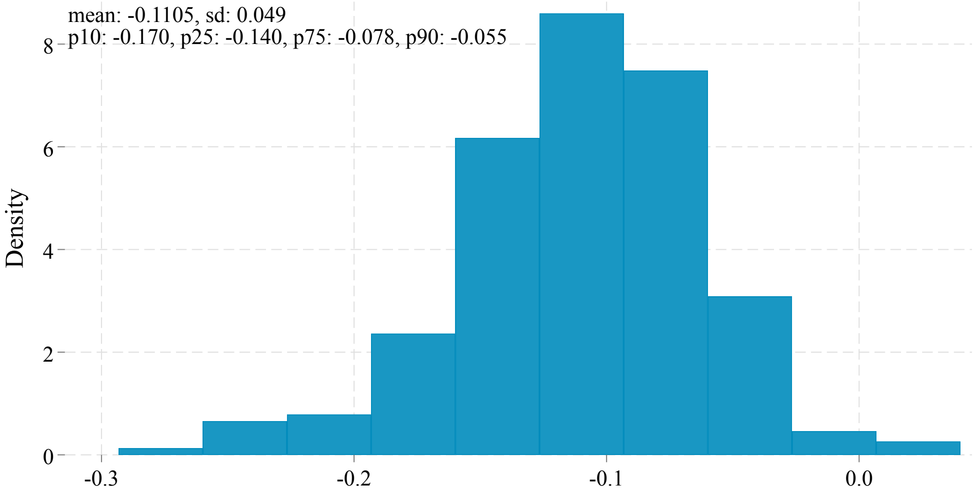
Industry Labor Shares, 1958-2016 Averages



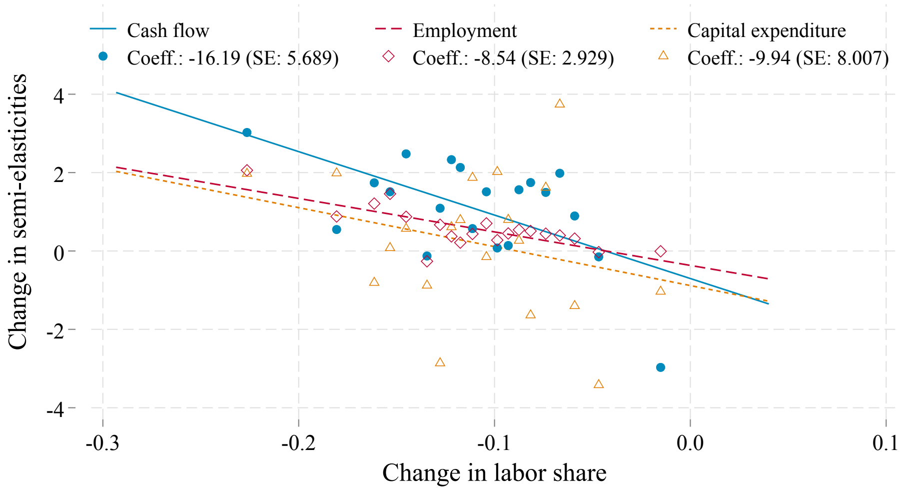
Industry-Level Evidence: Okun's Laws of Cash Flow and Inputs



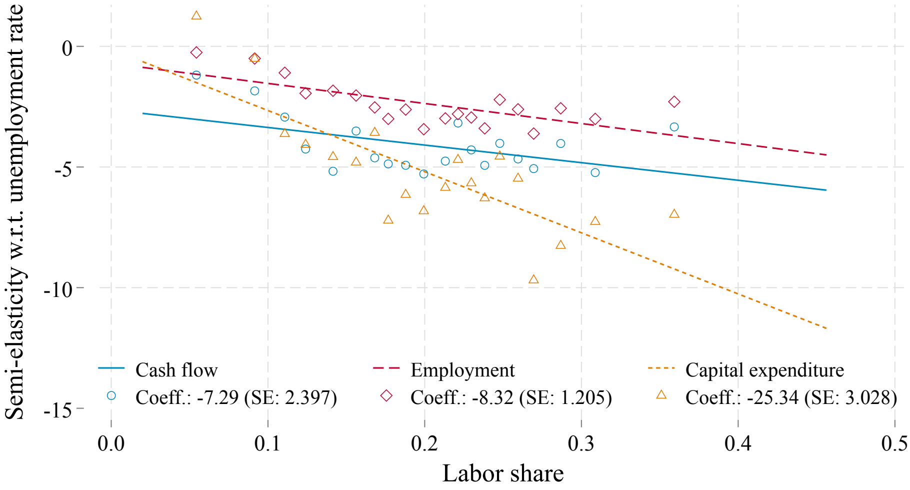
Changes in Industry Labor Share, 1983-2016 Avg Minus 1958-82 Avg



Industry-Level Evidence: Long-Run Changes



Alternative Labor Share Measure: Labor Costs Over Revenue



Industry-Level Test: Cross Section

Idea, example of shift in labor productivity p:

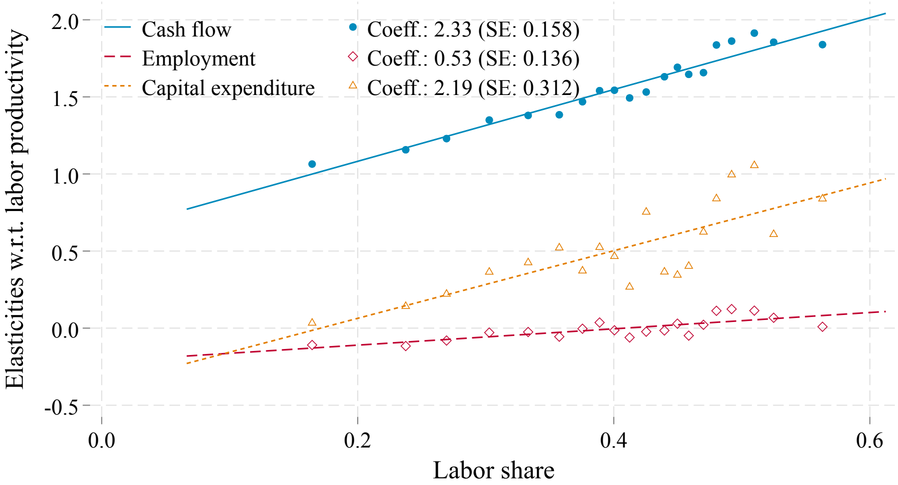
$$CF = \overbrace{pn}^{=y} - \overbrace{\Phi}^{=wn} \tag{19}$$

$$\frac{d\ln CF}{d\ln p} = \frac{1 - \frac{dw}{dp}}{1 - \underbrace{\frac{\Phi}{y}}_{=\text{ labor share!}}} \tag{20}$$

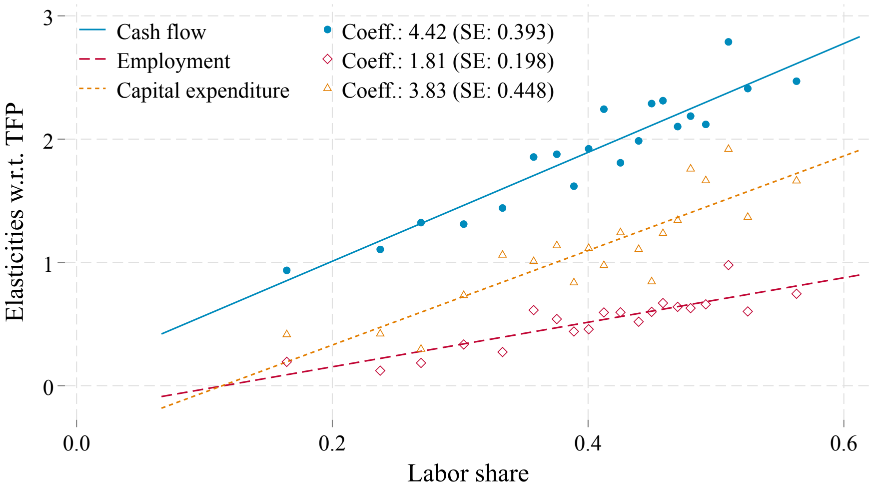
Data: US NBER-CES Manufacturing Productivity Database (1958 to 2016 for 457 industries), annual

Additional outcome variables: employment, investment.

Industry-Level Elasticities to Industry "Shocks:" Labor Productivity



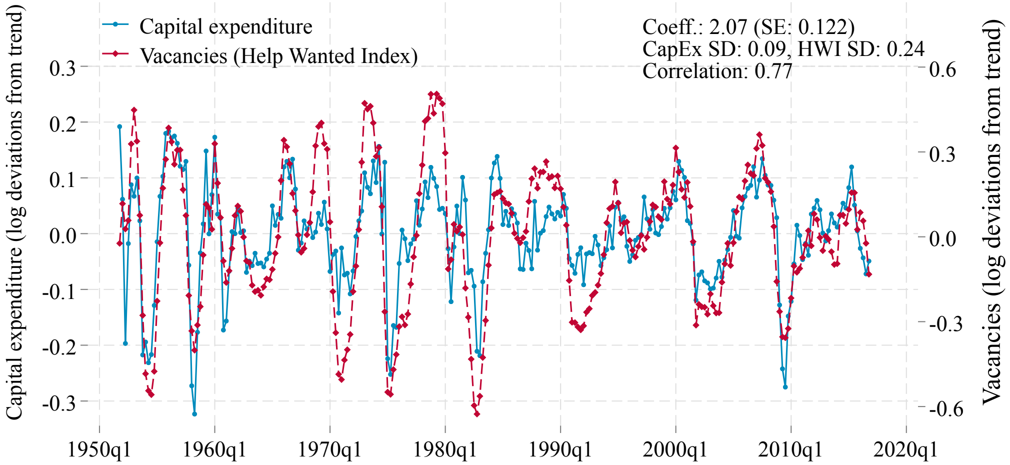
Industry-Level Elasticities to Industry "Shocks:" TFP



Outline

1. Mechanism: simple model
2. Empirical evidence
   - Aggregate: Wage rigidity $\Rightarrow$ cash flow fluctuations
   - Industry level: labor share amplifies fluctuations
3. Search and matching (DMP) model w/ financial constraints & incumbents' wage rigidity.
   - Calibration: their interaction can provide substantial amplification.
4. Policy application: stabilization from wage subsidies/payroll taxes
   - Marginal subsidies for new hires' vs. eligibility for incumbents too

Capital Expenditure and Vacancies (Help-Wanted Index)



Equilibrium Model

- DMP search and matching model
- Calibrate DMP block following Shimer (2005)
- Ex-post wage rigidity for incumbent workers — ax ante, new hires' wages flexibly set at match formation
  - Calibrate incumbents' wage rigidity following empirical meta analysis of Pissarides (2009)
- Firm faces financial constraints a la Jermann and Quadrini (2012)
- Without financial constraints: nest Shimer (2005) — insufficient volatility in model
  - Neutrality of incumbents' wage rigidity due to flexible bargaining of new hires' entry wages to leave the present value of wages unaffected! (Shimer, 2004; Pissarides, 2009)
- With financial constraints: interaction w/ incumbents' wage rigidity is crucial!

DMP Aspects

- Similar setup as simple model, but endogenous wages, (potentially frictional) access to external finance, and intermediate degrees of wage rigidity for incumbent workers
- Long-term jobs – separate with probability δ
- Matching function $\mathcal{M}(u, v)$, gives aggregate hiring (worker flows from unemployment into employment), using inputs vacancies v and unemployed job seekers u
- $\mathcal{M}(u, v)$ is constant returns (Cobb Douglas), random search
- ...and so labor market tightness $\theta = v/u$ determines the vacancy filling rate $q(\theta) = \mathcal{M}(u, v)/v = \mathcal{M}(1/\theta, 1)$ and job finding rate $f(\theta) = \mathcal{M}(u, v)/u = \mathcal{M}(1, \theta) = \theta q(\theta)$.
- Unemployment LoM:

$$u_{t+1} = u_t + \delta(1 - u_t) - f(\theta_t)u_t \tag{21}$$

- Constant labor force of size one, so employment is $n = 1 - u$.
- Vacancy posting cost k per period — investment expenditure is in recruitment, vk
- (No capital)

Incumbent-Only Wage Rigidity

The period-t wage of an incumbent worker that started employment in period $c < t$:

$$w_{t,c} = w_{c,c}^{\rho} \cdot w_{t,t}^{1-\rho}, \tag{22}$$

...with commentary:

$$\overbrace{w_{t,c}}^{\substack{\text{Cohort } c\text{'s wage} \\ \text{in period } t > c}} = \underbrace{\overbrace{w_{c,c}}^{\substack{\text{Cohort } c\text{'s original, ex-ante} \\ \text{flexible entry wage set in period } c}}{}^{\overbrace{\rho}^{\substack{\text{Rigidity} \\ \text{parameter}}}}}_{\substack{\text{Ex-post rigid} \\ \text{cohort effect}}} \cdot \underbrace{\overbrace{w_{t,t}}^{\substack{\text{Entry wage of} \\ \text{current new hires}}}{}^{1-\rho}}_{\substack{\text{Cyclical wage} \\ \text{component}}}. \tag{23}$$

Incumbents' wage rigidity parameter $\rho \in [0,1]$:

- weight on the cohort's entry wage $w_{c,c}$
- controls the relative wage cyclicality (comovement) of incumbents vis-à-vis new hires (as $\frac{d \ln w_{t,c}}{d \ln w_{t,t}} = 1 - \rho \ \forall \ c < t$)

Recursive Formulation

Wage rule $w_{t,c} = w_{c,c}^{\rho} \cdot w_{t,t}^{1-\rho}$ renders the LoM for payroll Φ recursive:

$$
\begin{aligned}
\Phi_t &= \sum_{c \leq t} w_{t,c} n_{t,c} && (24)\\
&= \sum_{c \leq t} w_{t,t}^{1-\rho} w_{c,c}^{\rho} \cdot (1-\delta)^{t-c} h_c && (25)\\
&= w_{t,t} h_t + (1-\delta) \left(\frac{w_{t,t}}{w_{t-1,t-1}} \right)^{1-\rho} \Phi_{t-1}. && (26)
\end{aligned}
$$

(where $n_{t,c} = (1-\delta)^{t-c} h_c$: workers of the initial $h_c = n_{c,c}$ hires of cohort c still employed in t)

Recursive Notation:

- x^-, x, x^+ and x^{++} for x_{t-1}, x_t, x_{t+1} and x_{t+2}, respectively.
- New hires' entry wages: $w = w_{t,t}$
- ... flexibly bargained over at match formation (discussed soon)

Firm's Problem

Max EPV of dividends d:

$$V\left(n^{-},\Phi^{-},h,B^{-};\mathbf{s}\right)=\max_{v,d,B}\left\{d-\frac{\kappa^{d}}{2}\left(d-d^{ss}\right)^{2}-\frac{\kappa^{B}}{2}\left(B-B^{ss}\right)^{2}+\mathbb{E}\,\beta V\left(n,\Phi,h^{+},B;\mathbf{s}^{+}\right)\right\} \quad (27)$$

$$\text{s.t.:}\quad \Phi=wh+(1-\delta)\left(\frac{w}{w^{-}}\right)^{1-\rho}\Phi^{-} \quad (28)$$

$$n=(1-\delta)\,n^{-}+h \quad (29)$$

$$h^{+}=vq\left(\theta\right) \quad (30)$$

$$kv=pn-\Phi-d+\left(\Delta B-r(1-t^{B})B^{-}-rt^{B}\widetilde{B}^{-}\right) \quad (31)$$

$$B\leq\overline{B}, \quad (32)$$

v: vacancies, of which share q give hires, giving employment n, separating with prob δ
d: dividends, can adjust with adjustment cost cost guided by κ^{d}
B: one-period debt, interest rate r
v: vacancies, at cost k per period
Φ: total payroll, with follows wage rule $w_{t,c}=w_{c,c}^{\rho}\cdot w_{t,t}^{1-\rho}$
$\overline{B}$: debt limit
t^{B}: tax subsidy of interest expenditure (refunded as lump sum)

Firm's Financing

Recall firm's budget constraint:

$$kv = pn - \Phi - d + \left(\Delta B - r(1 - t^B)B^- - rt^B\widetilde{B}^-\right) \tag{33}$$

Rewrite to highlight demand for external finance:

$$\Leftrightarrow \overbrace{\underbrace{kv}_{\substack{\text{Investment}\\\text{(Rec. Exp.)}}} - \underbrace{(pn - \Phi)}_{\text{Cash flow}}}^{\text{Financing gap}} = \underbrace{-d + \left(\Delta B - r(1 - t)B^- - rt\widetilde{B}^-\right)}_{\text{External finance}} \tag{34}$$

Suppose the borrowing constraint binds and $B^- = B = \overline{B}$:

$$kv + d = pn - \Phi \tag{35}$$

Either adjust dividends d or recruitment expenditures kv!

If "dividends" cannot adjust easily, real effects of cash flow shocks on hiring investment (consistent w/ corp fin (CapEx) evidence, akin to rep firm and RBC in Jermann and Quadrini (2012)

Main Implication: Hiring

A. Standard "zero profit condition:" w/o financial constraints and w/o wage rigidity

$$\frac{k}{q(\theta_t)} = \mathbb{E}_t \sum_{s>t} \left(\beta(1-r(1-t^B))\right)^{s-t} (1-\delta)^{s-(t+1)} (p_s - w_s) \qquad (36)$$

B. Interim case: ... w/o financial constraints and w/ wage rigidity – wages depend on hiring cohort (here: cohort hired today, productive tomorrow, indexed by $t+1$):

$$\frac{k}{q(\theta_t)} = \mathbb{E}_t \sum_{s>t} \left(\beta(1-r(1-t^B))\right)^{s-t} (1-\delta)^{s-(t+1)} (p_s - w_{s,\boxed{t+1}}) \qquad (37)$$

C. Interim case: ... w/ financial constraints and w/o wage rigidity – cash valuation τ_t:

$$\boxed{\tau_t}\frac{k}{q(\theta_t)} = \mathbb{E}_t \sum_{s>t} \left(\beta(1-r(1-t^B))\right)^{s-t} (1-\delta)^{s-(t+1)} \boxed{\tau_s}(p_s - w_s) \qquad (38)$$

$$\Leftrightarrow \frac{k}{q(\theta_t)} = \mathbb{E}_t \sum_{s>t} \left(\beta(1-r(1-t^B))\right)^{s-t} (1-\delta)^{s-(t+1)} \boxed{\frac{\tau_s}{\tau_t}}(p_s - w_s) \qquad (39)$$

D. Financial channel of wage rigidity: ... w/ financial constraints and w/ wage rigidity:

$$\frac{k}{q(\theta)} = \mathbb{E}_t \sum_{s>t} \beta^{s-t} (1-\delta)^{s-(t+1)} \boxed{\frac{\tau_s}{\tau_t}}(p_s - w_{s,\boxed{t+1}}) \qquad (40)$$

Intuitions for Financial Channel of Wage Rigidity

- Same as in simple model in essence!
- Productivity shocks affect firms' inframarginal cash flow—depending on ρ!
- Effect on liquidity and hiring is guided by κ^d: external finance (dividend) adjustment cost.
- If no FC ($\kappa^d = 0$), standard DMP equilibrium irrespective of ρ.
  - Recover present-value neutrality of incumbent' wages—canonical macro-labor paradigm.
- When $\kappa^d > 0$ and $B = \overline{B}$, firms' hiring is financially constrained:

$$kv = pn - \boxed{\Phi} - d - r\overline{B} \tag{41}$$

- Manifests itself through τ, the firm's internal value of cash, or equivalently through distortions in the stochastic discount factor $\beta\frac{\tau^+}{\tau}$.

⇒ FCs break the neutrality of incumbent workers' wages/wage rigidity!

⇒ (Incumbents') wage rigidity mediates financial amplification.

Details: First-order/Envelope Conditions

$$V_d = 0: \qquad \tau = 1 - \kappa^d (d^* - d^{ss}) \tag{42}$$

$$V_B = 0: \qquad \tau = (1 + r(1 - t^B))\, \mathbb{E}[\beta \tau^+] + \kappa^B (B^* - B^{ss}) + \nu \tag{43}$$

$$V_\Phi = 0: \qquad \lambda = -\tau + \mathbb{E}\left[\beta(1-\delta)\left(\frac{w^+}{w}\right)^{1-\rho} \lambda^+\right] \tag{44}$$

$$V_n = 0: \qquad \mu = p\tau + \mathbb{E}[\beta(1-\delta)\mu^+] \tag{45}$$

$$V_{h^+} = 0: \qquad \eta = \mathbb{E}[\beta(\mu^+ + \lambda^+ w^+)] \tag{46}$$

$$V_v = 0: \qquad \eta = \tau \frac{k}{q(\theta)}. \tag{47}$$

⇒ **Hiring, or "zero profit condition:"**

$$\frac{k}{q(\theta)} = \overbrace{\mathbb{E}\left[\beta\tau^{-1}(\mu^+ + \lambda^+ w^+)\right]}^{=\mathbb{E}_t \sum_{s>t} \beta^{s-t} \frac{\tau_s}{\tau_t} (1-\delta)^{s-(t+\mathbf{1})} (p_s - w_{s,t+\mathbf{1}})} \tag{48}$$

$$= \mathbb{E}\left[\beta \frac{\tau^+}{\tau}\left((p^+ - w^+) + (1-\delta)\frac{k}{q(\theta^+)} + \beta(1-\delta)\frac{\lambda^{++}}{\tau^+}\left(w^{+\rho} w^{++1-\rho} - w^{++}\right)\right)\right] \tag{49}$$

Details: Household's Problem: Analogous

$$V^H(n^-, \Phi^-, h, B^-; \mathbf{s}) = \max_B \left\{ \Phi + d - zn + rB^- - \Delta B + \mathbb{E}\,\beta V^H(n, \Phi, h^+, B; \mathbf{s}^+) \right\} \tag{50}$$

$$\text{s.t.:} \quad \Phi = w\,h + (1-\delta)\left(\frac{w}{w^-}\right)^{1-\rho} \Phi^- \tag{51}$$

$$n = (1-\delta)n^- + h \tag{52}$$

$$h^+ = f(\theta)(1-n) \tag{53}$$

One new parameter: z, payoff from nonemployment (UI, leisure,...)

FOCs/Env Con's:

$$V^H_B = 0: \qquad 1 = \mathbb{E}\left[\beta\left(1+r\right)\right] \tag{54}$$

$$V^H_\Phi = 0: \qquad \lambda^H = 1 + \mathbb{E}\left[\beta(1-\delta)\left(\frac{w^+}{w}\right)^{1-\rho}\lambda^{H+}\right] \tag{55}$$

$$V^H_n = 0: \qquad \mu^H = -z - f(\theta)\eta^H + \mathbb{E}\left[\beta\left(1-\delta\right)\mu^{H+}\right]. \tag{56}$$

$$V^H_{h^+} = 0: \qquad \eta^H = \mathbb{E}\left[\beta\left(\lambda^{H+}w^+ + \mu^{H+}\right)\right] \tag{57}$$

Details: Nash Bargaining Over New Hires' Entry Wage w

Value of a new worker—hired at an arbitrary entry wage $\widetilde{w}$—for the firm and for the household:

$$V_n^F(\widetilde{w}) = \lambda^F \widetilde{w} + \mu^F \tag{58}$$

$$V_n^H(\widetilde{w}) = \lambda^H \widetilde{w} + \mu^H \tag{59}$$

Nash bargained wage w/ worker bargaining power ϕ:

$$w = \underset{\widetilde{w}}{\text{argmax}}\{V_n^H(\widetilde{w})^\phi V_n^F(\widetilde{w})^{1-\phi}\} \tag{60}$$

$$\Rightarrow \phi \frac{V_n^{H\prime}(w)}{V_n^H(w)} + (1-\phi)\frac{V_n^{F\prime}(w)}{V_n^F(w)} = 0 \tag{61}$$

$$\Leftrightarrow \lambda^H w = (1-\phi)(-\mu^H) + \phi\psi\mu^F \tag{62}$$

where $\psi = V_n^{H\prime}(\widetilde{w})/V_n^{F\prime}(\widetilde{w}) = \lambda^H/-\lambda^F$

Details: Further Characterization of the Wage Bargain

Maximize comparability with standard DMP wage:

$$w = (1-\widetilde{\phi})z + \widetilde{\phi}(p+k\theta) - \mathbb{E}\left\{\beta(1-\delta)w^{+(1-\rho)}(w^{\rho} - w^{+\rho})\left[(1-\widetilde{\phi})\lambda^{+H} + \widetilde{\phi}(-\lambda^{+F})\right]\right\} + \gamma, \quad (63)$$

where $\widetilde{\phi} = \frac{\tau\psi\phi}{\tau\psi\phi+(1-\phi)}$, $\psi = \frac{\lambda^H}{-\lambda^F}$, $\gamma = \mathbb{E}\left\{\widetilde{\phi}(1-\frac{\psi^+}{\psi})(1-\delta)\beta V_n^F(\widetilde{w})^+\right\}$.

When $\tau = 1$ and $\rho = 0$, the wage bargain gives the standard DMP wage:

$$w_{DMP} = w_{\rho=0} = \phi\,(p+\theta k) + (1-\phi)z \quad (64)$$

If $\tau = 0$ but $\rho = 1$, nest perfectly rigid incumbent wages considered in Shimer (2004).

Calibration

- Follow Shimer (2005) for standard DMP parameters
- Set ρ to match incumbent/new hires' wage cyclicality targeting values proposed by meta analysis in Pissarides (2009)
- Explore various calibrations of κ^d (see next)

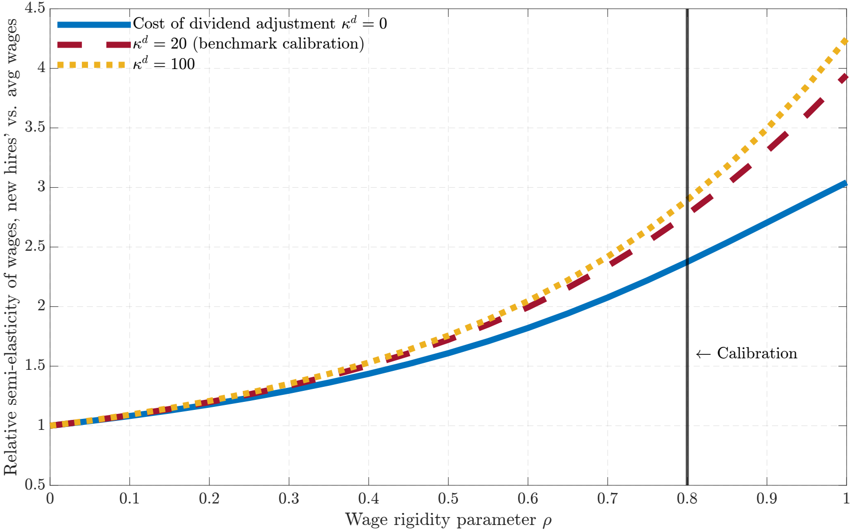
Parameter Values – Tiny Print, Clarify As We Go Along!

	Parameter	Value		Source/Strategy	Target	Model
β	Discount factor	0.996		Annual interest rate	0.04	0.04
ζ	Matching elasticity	0.72		Shimer (2005)	0.72	0.72
m	Matching efficiency	0.45		Job finding probability (s.s.)	0.45	0.45
δ	Separation rate	0.0237		Unemployment rate (s.s.)	0.05	0.05
ϕ	Bargaining power	0.72		Hosios condition	0.72	0.72
z	Unemployment flow payoff	0.4		Avg. replacement rate	0.40	0.40
k	Vacancy posting cost	0.2149		Normalization $\theta^{ss} = 1$	–	1.00
$\bar{z}$	Productivity, mean	1		Normalization	–	1.00
σ^{ε^p}	Productivity innovation, SD	0.0064		SD of ALP (quarterly)	0.020	0.020
ρ^p	Productivity, autocorrelation	0.98		Persistence of ALP (quarterly)	0.892	0.901
		No Wage Rigidity	Wage Rigidity for Incumbent Workers			
ρ	(One minus) indexation of incumbents' wages to new hires' entry wages	0	0.8	Relative cyclicality of new to average wages (see figure)	2.5	2.5
t^B	Tax benefit of debt	0.3		Fraction of periods constraint binding (see figure)		
$\overline{B}$	Borrowing limit	0.03		"		
κ^B	Debt adjustment cost	100		"		
		No Constraints	Financial Constraints			
κ^d	Dividend adjustment cost	0	20	Judge by hiring-cash flow sensitivity (see figure)		

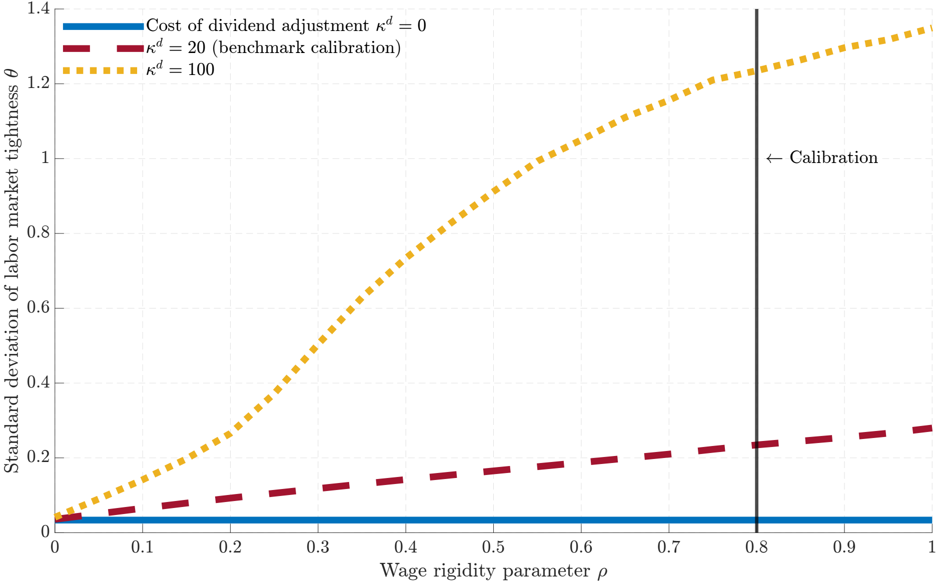
Note: Parameter values and targets are the same across all model variants, except for κ^d and ρ.

	$\log u$	$\log v$	$\log \theta$	$\log f$	$\log p$	$\log w$	$\log \overline{w}$
Panel A: Data							
Standard deviation	0.203	0.206	0.400	0.139	0.020		
Autocorrelation	0.946	0.941	0.947	0.928	0.892		
Correlation with u	0.977	-0.904	0.960	-0.956	-0.239		
Panel B: Neither Financial Constraints Nor Incumbents' Wage Rigidity							
Standard deviation	0.009	0.025	0.033	0.009	0.020	0.020	0.020
Autocorrelation	0.924	0.860	0.895	0.894	0.894	0.894	0.894
Correlation with u	1.000	-0.926	-0.958	-0.958	-0.958	-0.958	-0.958
Panel C: No Financial Constraints but Incumbents' Wage Rigidity							
Standard deviation	0.009	0.025	0.033	0.009	0.020	0.013	0.006
Autocorrelation	0.924	0.860	0.895	0.894	0.894	0.894	0.967
Correlation with u	1.000	-0.926	-0.958	-0.958	-0.958	-0.958	-0.822
Panel D: Both Financial Constraints and Incumbents' Wage Rigidity							
Standard deviation	0.052	0.159	0.225	0.056	0.020	0.013	0.007
Autocorrelation	0.915	0.847	0.880	0.885	0.894	0.893	0.966
Correlation with u	0.999	-0.906	-0.925	-0.953	-0.954	-0.955	-0.718
Panel E: Financial Constraints, but no Incumbents' Wage Rigidity							
Standard deviation	0.009	0.027	0.035	0.010	0.020	0.020	0.020
Autocorrelation	0.925	0.865	0.898	0.897	0.894	0.894	0.894
Correlation with u	1.000	-0.927	-0.959	-0.959	-0.956	-0.956	-0.956

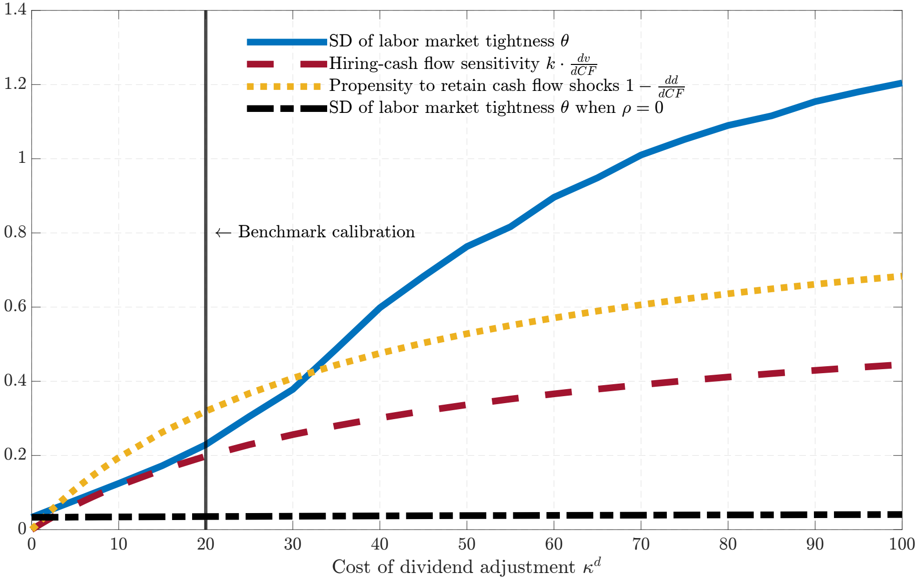
Calibrating Incumbent Workers' Wage Rigidity ρ to ρ on Relative Semi-Elasticity of New Hires' vs. Average Wages



Sensitivity: Effect of ρ on the SD of Labor Market Tightness



Sensitivity: Dividend Adjustment Cost Parameter κ^d



	$\log u$	$\log v$	$\log \theta$	$\log f$	$\log p$	$\log w$	$\log \overline{w}$
Panel A: Data							
Standard deviation	0.203	0.206	0.400	0.139	0.020		
Autocorrelation	0.946	0.941	0.947	0.928	0.892		
Correlation with u	0.977	-0.904	0.960	-0.956	-0.239		
Panel B: Neither Financial Constraints Nor Incumbents' Wage Rigidity							
Standard deviation	0.009	0.025	0.033	0.009	0.020	0.020	0.020
Autocorrelation	0.924	0.860	0.895	0.894	0.894	0.894	0.894
Correlation with u	1.000	-0.926	-0.958	-0.958	-0.958	-0.958	-0.958
Panel C: No Financial Constraints but Incumbents' Wage Rigidity							
Standard deviation	0.009	0.025	0.033	0.009	0.020	0.013	0.006
Autocorrelation	0.924	0.860	0.895	0.894	0.894	0.894	0.967
Correlation with u	1.000	-0.926	-0.958	-0.958	-0.958	-0.958	-0.822
Panel D: Both Financial Constraints and Incumbents' Wage Rigidity							
Standard deviation	0.052	0.159	0.225	0.056	0.020	0.013	0.007
Autocorrelation	0.915	0.847	0.880	0.885	0.894	0.893	0.966
Correlation with u	0.999	-0.906	-0.925	-0.953	-0.954	-0.955	-0.718
Panel E: Financial Constraints, but no Incumbents' Wage Rigidity							
Standard deviation	0.009	0.027	0.035	0.010	0.020	0.020	0.020
Autocorrelation	0.925	0.865	0.898	0.897	0.894	0.894	0.894
Correlation with u	1.000	-0.927	-0.959	-0.959	-0.956	-0.956	-0.956

Outline

1. Mechanism: simple model

2. Empirical evidence

   - Aggregate: Wage rigidity $\Rightarrow$ cash flow fluctuations
   - Industry level: labor share amplifies fluctuations

3. Search and matching (DMP) model w/ financial constraints & incumbents' wage rigidity.

   - Calibration: their <u>interaction</u> can provide substantial amplification.

4. Policy application: stabilization from wage subsidies/payroll taxes

   - Marginal subsidies for new hires' vs. eligibility for incumbents too

Fiscal Policy Application: Wage Subsidies and Payroll Taxes As Stabilization Tools

Introduce payroll tax rate "x" on firm side:

$$kv = zn - (1 + x(\mathbf{s}))\Phi - T^{x}(\mathbf{s}) - d + \left(\Delta B - r(1 - t^{B})B^{-} - rt^{B}\widetilde{B}^{-}\right), \tag{65}$$

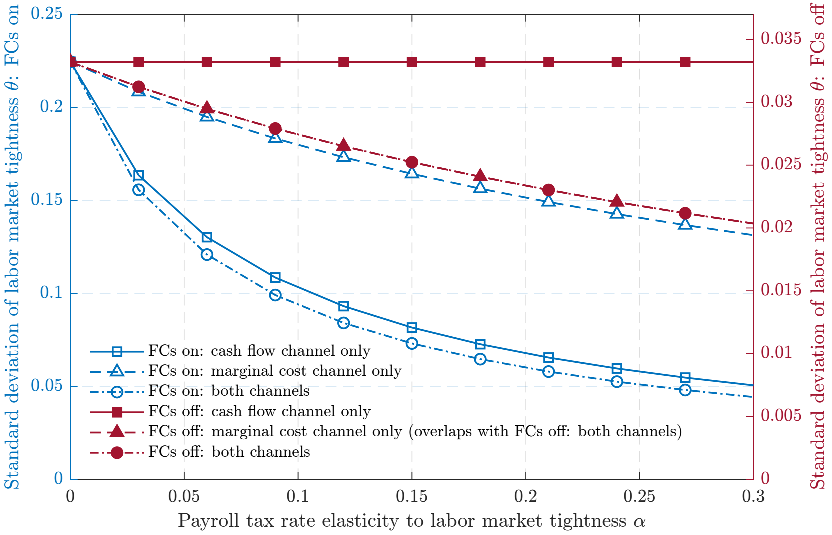
Payroll tax indexed to labor market tightness deviations from SS—procyclicality parameter α:

$$x(\mathbf{s}) = \left(\frac{\theta_t}{\theta^{ss}}\right)^{\alpha} - 1. \tag{66}$$

Three cases (see paper for details):

- **Case I: Cash Flow and Marginal Channels**: baseline.
- **Case II: Marginal Channel Only**: shut off cash flow channel (via tax rebate the firm takes as given).
- **Case III: Inframarginal, Financial Channel Only**: shut off effects on new hires' net of tax wages (lump sum taxes only).

$SD(\theta)$ by Countercyclicality of Wage Subsidy α w/ Financial Constraints (Left Axis) and w/o (Right Axis)



Outline

1. Mechanism: simple model

2. Empirical evidence

- Aggregate: Wage rigidity $\Rightarrow$ cash flow fluctuations
- Industry level: labor share amplifies fluctuations

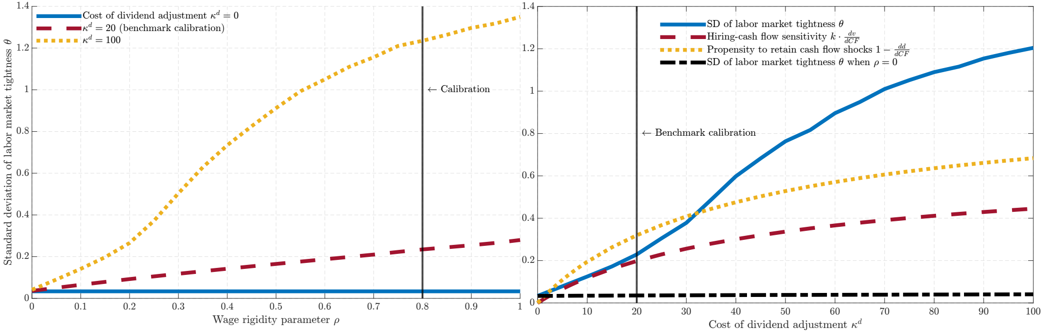
3. DMP model w/ financial constraints & incumbents' wage rigidity.

- Calibration: their interaction can provide substantial amplification.

4. Policy application: stabilization from wage subsidies/payroll taxes

- Marginal subsidies for new hires' vs. eligibility for incumbents too

Conclusion: The Interaction of Wage Rigidity & Financial Constraints



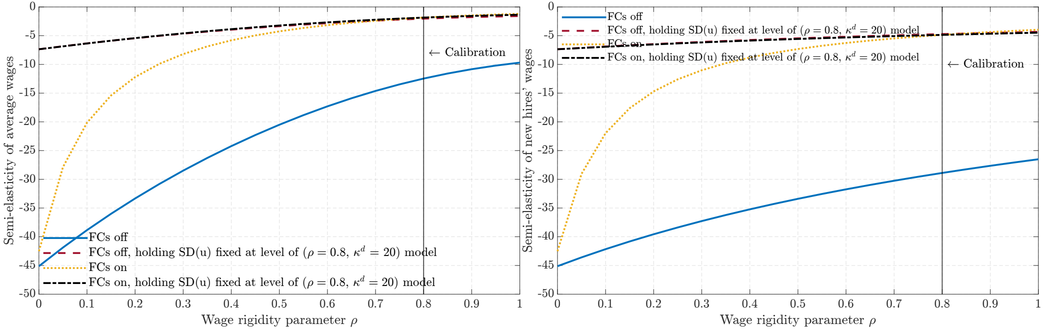
Many open questions and limitations!

- Quantitative role of financial factors in BCs and hence scope for the channel
- Heterogeneity
- Other investment margins
- Alternative driving forces than "productivity"
- Financial channel of wages in labor demand & investment – "Slutsky identity":

$$\varepsilon_{n,w}^{\text{Total}} = \varepsilon_{n,w}^{\text{Marginal}}\Big|_{d\text{Liquidity}=0} - \frac{wdn}{dCF} \tag{67}$$

APPENDIX

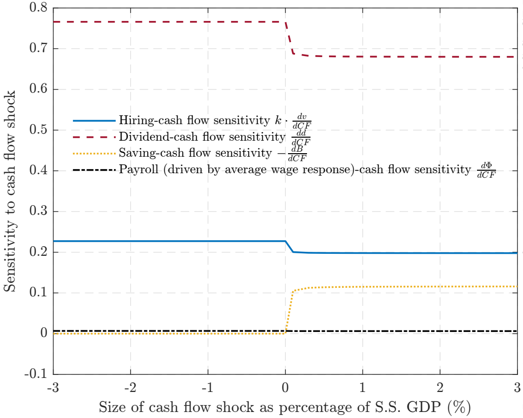
Sensitivity Analysis: Average and New Hires' Wage Cyclicality (Semi-elasticity w.r.t. the Unemployment Rate) by ρ and for Models with and without Financial Constraints



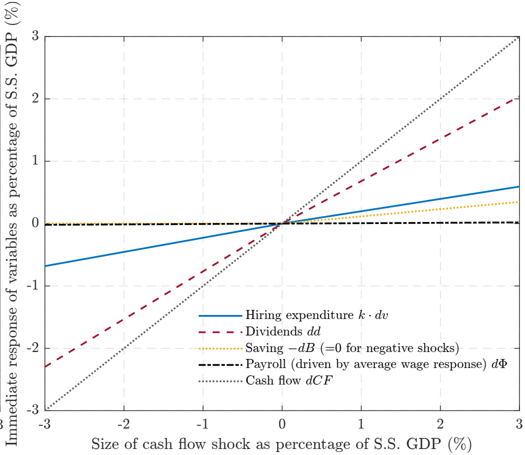
(a) Average Wages

(b) New Hires' Wages

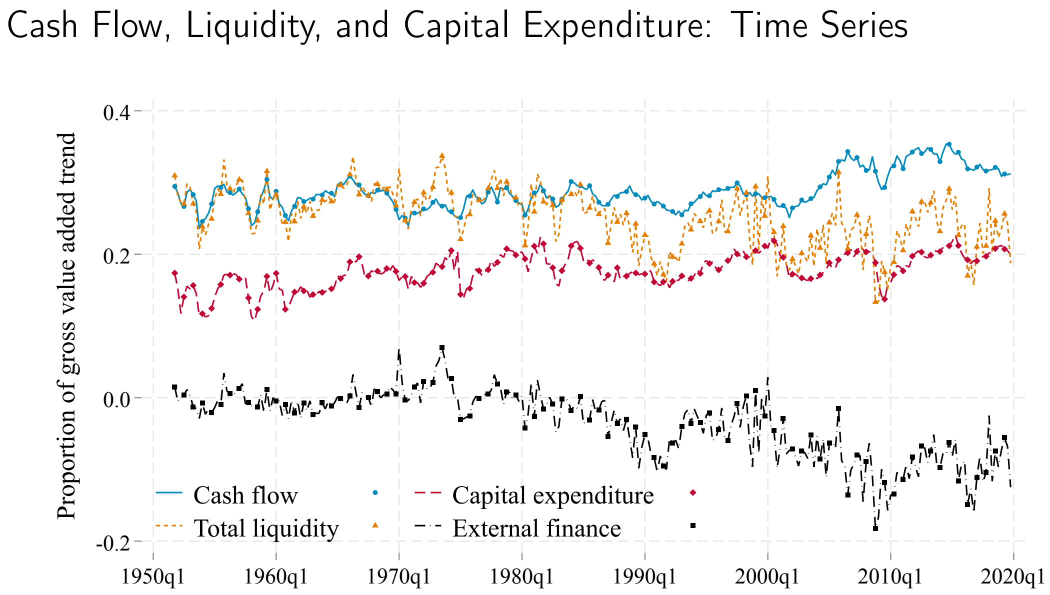
Sensitivity Analysis: On-Impact Responses to Perfectly Transitory Cash Flow Shocks)



(c) Responses as Fraction of the Shock (+1% of Steady State GDP)

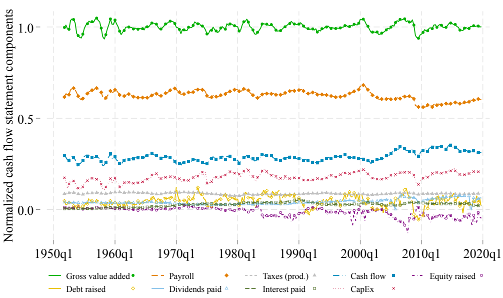


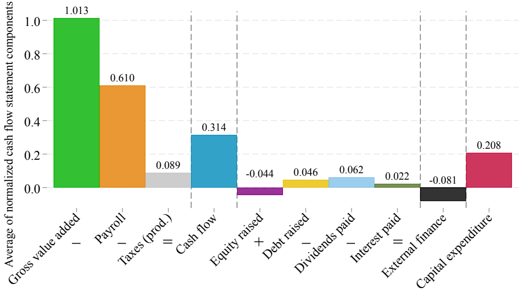
(d) Responses (Normalized by Steady State GDP) to Cash Flow Shocks of Different Sizes (as Fraction of Steady State GDP)



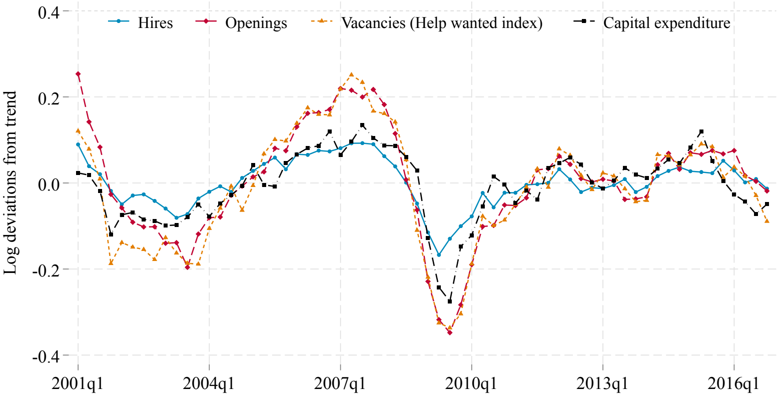
Cash Flow, Liquidity, and Capital Expenditure: Time Series
Proportion of gross value added trend
0.4
0.2
0.0
-0.2
1950q1
1960q1
1970q1
1980q1
1990q1
2000q1
2010q1
2020q1
Cash flow
Total liquidity
Capital expenditure
External finance

Cash Flow and Balance Sheet Components (Divided by Trend Gross Value Added)

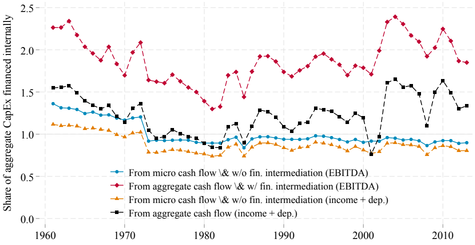


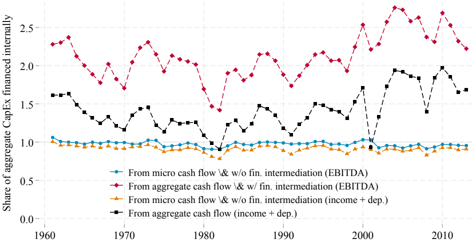


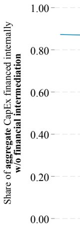
The Cyclical Comovement of U.S. Capital Expenditure, Hiring, Job Openings, and the Help-Wanted Index



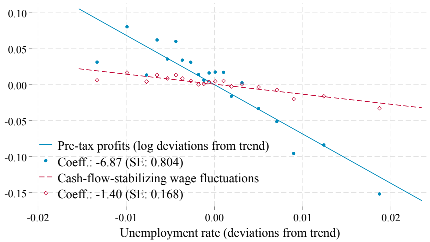
Cash Flow and Investment: Accounting for Heterogeneity/Fin Intermediation

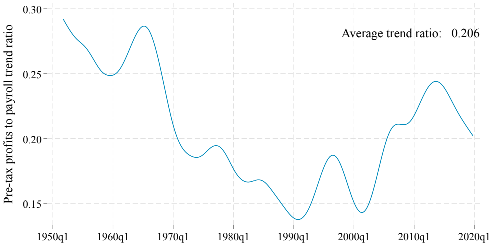




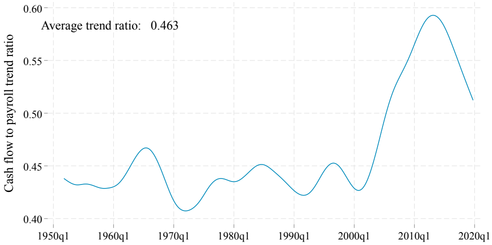


Robustness Check: Pre-tax Profits

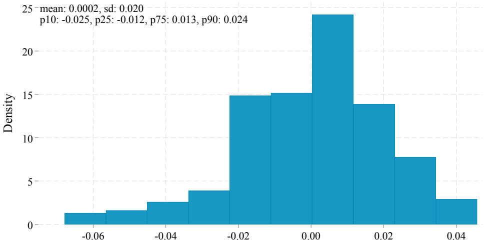




Additional Facts: Cash-Flow-Stabilizing Incremental Wage Movements

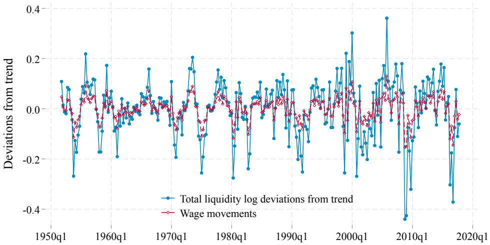


(e) Cash Flow to Payroll Trend Ratios

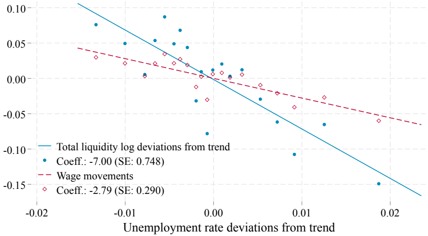


(f) [Distribution of Cash-Flow-Stabilizing Incremental Wage Movements

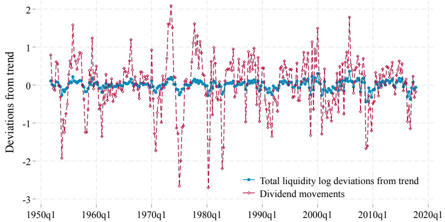
Robustness Checks: Total Liquidity rather than Cash Flow, and Other Sources of Stabilization than Cash Flow (Dividends and Interest)



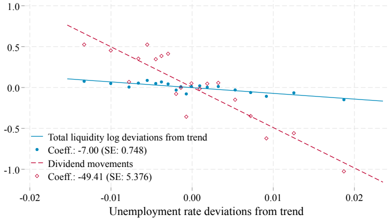
(g) Fluctuations of Total Liquidity and Total-Liquidity-Stabilizing Incremental Wage Movements



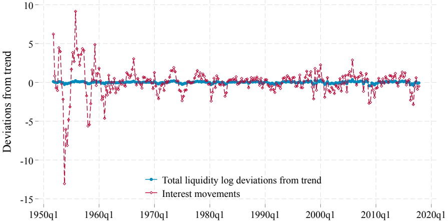
(h) Okun's Laws for Total Liquidity and Total-Liquidity-Stabilizing Incremental Wage Movements



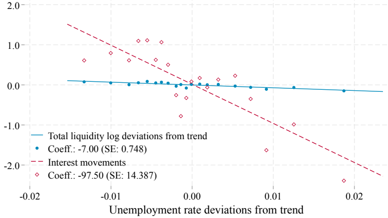
(i) Fluctuations of Total Liquidity and Total-Liquidity-Stabilizing Incremental Dividend Movements



(j) Okun's Laws for Total Liquidity and Total-Liquidity-Stabilizing Incremental Dividend Movements

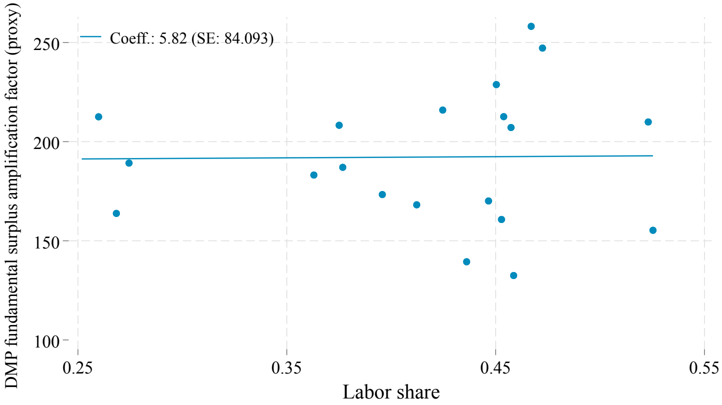


(k) Fluctuations of Total Liquidity and Total-Liquidity-Stabilizing Incremental Interest Expenditure Movements

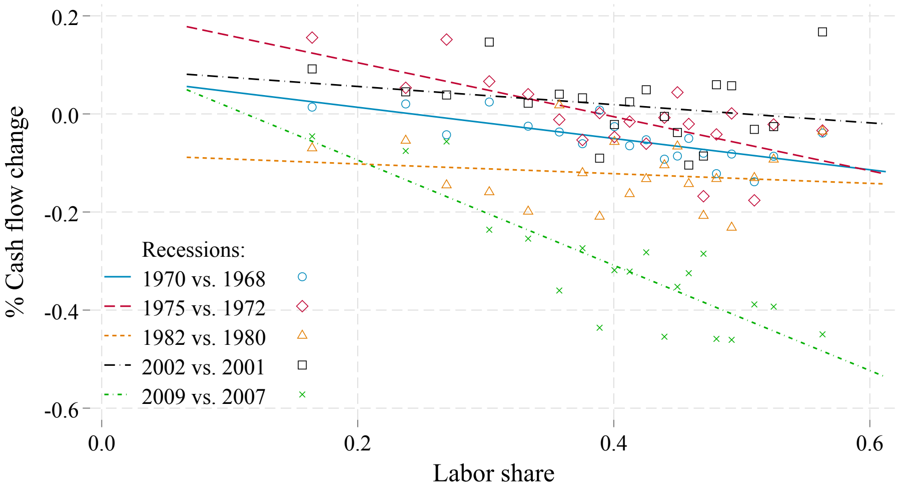


(l) Okun's Laws for Total Liquidity and Total-Liquidity-Stabilizing Incremental Interest Expenditure Movements

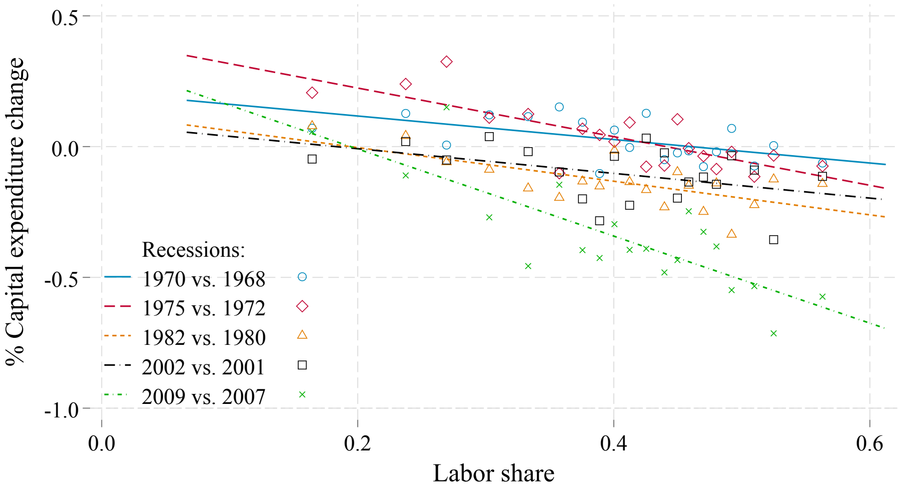
The Orthogonality of Fundamental Surplus Proxy vs. Standard Labor Income Share



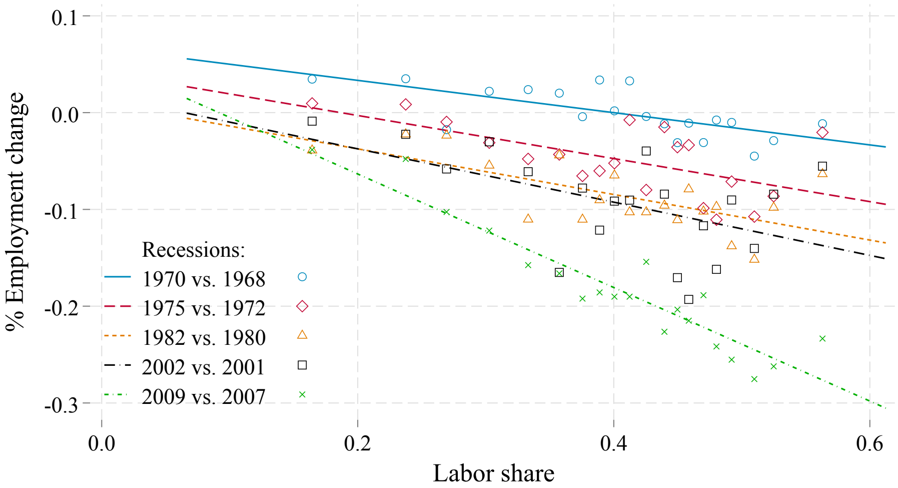
Industry-Level Recession Case Studies: Cash Flow



Industry-Level Recession Case Studies: Investment



Industry-Level Recession Case Studies: Employment



References I

Bils, Mark, Yongsung Chang, and Sun-Bin Kim, "How Sticky Wages In Existing Jobs Can Affect Hiring," *American Economic Journal: Macroeconomics*, forthcoming.

Blanchard, Olivier and Jordi Galí, "Real Wage Rigidities and the New Keynesian Model," *Journal of Money, Credit and Banking*, 2007, *39*, 35–65.

Christiano, Lawrence, Martin Eichenbaum, and Mathias Trabandt, "Unemployment and Business Cycles," *Econometrica*, 2016, *84* (4), 1523–1569.

Elsby, Michael, "Evaluating the Economic Significance of Downward Nominal Wage Rigidity," *Journal of Monetary Economics*, 2009, *56* (2), 154–169.

Erceg, Christopher, Dale Henderson, and Andrew Levin, "Optimal Monetary Policy with Staggered Wage and Price Contracts," *Journal of Monetary Economics*, 2000, *46* (2), 281–313.

Fukui, Masao, "A Theory of Wage Rigidity and Unemployment Fluctuations with On-the-Job Search," *Working Paper*, 2020.

Galuscak, Kamil, Mary Keeney, Daphne Nicolitsas, Frank Smets, Pawel Strzelecki, and Matija Vodopivec, "The Determination of Wages of Newly Hired Employees: Survey Evidence on Internal Versus External Factors," *Labour Economics*, 2012, *19* (5), 802–812.

References II

Gertler, Mark and Antonella Trigari, "Unemployment Fluctuations with Staggered Nash Wage Bargaining," *Journal of Political Economy*, 2009, *117* (1), 38–86.

__ , Christopher Huckfeldt, and Antonella Trigari, "Unemployment Fluctuations, Match Quality, and the Wage Cyclicality of New Hires," *Review of Economic Studies*, 2020, *87* (4), 1876–1914.

Grigsby, John, Erik Hurst, and Ahu Yildirmaz, "Aggregate Nominal Wage Adjustments: New Evidence from Administrative Payroll Data," *American Economic Review*, 2021, *111* (2), 428–71.

Guvenen, Fatih, Fatih Karahan, Serdar Ozkan, and Jae Song, "What Do Data on Millions of US Workers Reveal About Life-cycle Earnings Risk?," *NBER Working Paper*, 2020.

Haefke, Christian, Marcus Sonntag, and Thijs Van Rens, "Wage Rigidity and Job Creation," *Journal of Monetary Economics*, 2013, *60* (8), 887–899.

Hagedorn, Marcus and Iourii Manovskii, "Job Selection and Wages over the Business Cycle," *American Economic Review*, 2013, *103* (2), 771–803.

Hall, Robert, "Employment Fluctuations with Equilibrium Wage Stickiness," *American Economic Review*, 2005, pp. 50–65.

References III

— **and Paul Milgrom**, "The Limited Influence of Unemployment on the Wage Bargain," *American Economic Review*, 2008, pp. 1653–1674.

Hazell, Jonathon and Bledi Taska, "Downward Rigidity in the Wage for New Hires," *LSE Working Paper*, 2020.

Jermann, Urban and Vincenzo Quadrini, "Macroeconomic Effects of Financial Shocks," *American Economic Review*, 2012, *102* (1), 238–71.

Kudlyak, Marianna, "The Cyclicality of the User Cost of Labor," *Journal of Monetary Economics*, 2014.

Michaillat, Pascal, "Do Matching Frictions Explain Unemployment? Not in Bad Times," *American Economic Review*, 2012, *102* (4), 1721–1750.

Mortensen, Dale and Eva Nagypal, "More on Unemployment and Vacancy Fluctuations," *Review of Economic Dynamics*, 2007, *10* (3), 327–347.

Pissarides, Christopher, "The Unemployment Volatility Puzzle: Is Wage Stickiness the Answer?," *Econometrica*, 2009, *77* (5), 1339–1369.

References IV

Schmitt-Grohé, Stephanie and Martin Uribe, "Downward Nominal Wage Rigidity, Currency Pegs, and Involuntary Unemployment," *Journal of Political Economy*, 2016, *124* (5), 1466–1514.

Shimer, Robert, "The Consequences of Rigid Wages in Search Models," *Journal of the European Economic Association*, 2004, *2* (2-3), 469–479.

_ , "The Cyclical Behavior of Equilibrium Unemployment and Vacancies," *American Economic Review*, 2005, pp. 25–49.

Solon, Gary, Robert Barsky, and Jonathan Parker, "Measuring the Cyclicality of Real Wages: How Important is Composition Bias?," *Quarterly Journal of Economics*, 1994, *109* (1), 1–25.