The Financial Channel of Wage Rigidity

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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 ⇒ more volatile financial resources of firms ⇒ 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)

Coefficient: 2.07 (SE: 0.122)
CapEx SD: 0.09, HWI SD: 0.24
Correlation: 0.77

In period \( t \),
- the firm chooses hires \( h_{t+1} \)
- ... who start producing and earning wages in period \( t + 1 \).

\( \delta \): 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, ...)
\( \beta \): discount factor (from the households)

Firm's period-\( t \) problem:

\[
\max_{h_{t+1}} \mathbb{E}_t \sum_{s \geq t} \beta^{s-t} (p_s n_s - \Phi_s - c(h_{s+1}))
\]

s.t.
\[
\begin{align*}
n_{s+1} &= h_{s+1} + (1 - \delta) n_s & \forall s \geq t \\
\Phi_{s+1} &= w_c(s+1) h_{s+1} + (1 - \delta) \Phi_s & \forall s \geq t
\end{align*}
\]

where
\( \Phi \): total wage bill
Standard: Hiring w/o Financial Constraints

Labor demand—hiring FOC:

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

\[ \iff c'(h^*_{t+1}) + \mathbb{E}_t \sum_{s>t} \beta^{s-t} (1 - \delta)^{s-(t+1)} w_{c=t+1} = \mathbb{E}_t \sum_{s>t} \beta^{s-t} (1 - \delta)^{s-(t+1)} p_s \quad (5) \]

Fluctuations take derivative of FOC (4):

\[ \frac{d}{d \ln p} \frac{d \ln h^*_{t+1}}{d \ln p} = \frac{1}{hc''} \cdot \frac{p}{p - w_{c=t+1}} \cdot (1 - \frac{dw_{c=t+1}}{dp}) \quad (6) \]

Key insights:

- Standard amplification of hiring depends on the sensitivity of new hires’ wages, \( \frac{dw_{c=t+1}}{dp} \).
- Incumbent workers’ wages \( w_c = \bar{w}_{c \leq t} \forall c \leq t \) 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)
  \[ \Rightarrow \text{Firms must finance investment out of current cash flow} \] — adding a constraint:

\[
c(h_{t+1}) \leq p_t n_t - \Phi_t.
\]  \hspace{1cm} (7)

New FOC reflecting constraint in the form of Lagrange multiplier $\tau$ on constraint (7):
\[
(1 + \tau_t) \cdot c'(h^*_{t+1}) = \mathbb{E}_t \sum_{s > t} \beta^{s-t}(1 + \tau_s)(1 - \delta)^{s-(t+1)}(p_s - w_{c=t+1}).
\]  \hspace{1cm} (8)

For fluctuations, get clearer intuitions from direct comparative static on constraint (7):
\[
c(h^*_{t+1}) = p_t n_t - \Phi_t
\]
\[
= (p_t - \bar{w}_{c \leq t}) \cdot n_t
\]  \hspace{1cm} (9)
\hspace{1cm} (10)
\[
\Rightarrow \frac{d \ln h^*_{t+1}}{d \ln p} = \frac{1}{hc'} \cdot \frac{p}{p - \bar{w}_{c \leq t}} \cdot \left(1 - \frac{d \bar{w}_{c \leq t}}{dp}\right). \hspace{1cm} (11)
\]
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Aggregate Cash Flow Statement (2019) for the United States

Gross value added 10,458
Payroll 6,301
Taxes (prod.) 915
Cash flow 3,243
Equity raised -454
Debt raised 474
Dividends paid -637
Interest paid 223
External finance -839
Capital expenditure 2,148

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
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Coeff.: 2.07 (SE: 0.122)  
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Counterfactual: Cash-Flow-Stabilizing Additional Wage Fluctuations

Empirical ($\tilde{x}$) 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 $n$):

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

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

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

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

$$\Rightarrow \left. \left( \Delta \frac{dw}{w} \right) \right|_{\frac{dCF}{CF}=0} = \left( \frac{dCF}{CF} \right) \cdot \left( \frac{CF}{\Phi} \right) \tag{14}$$

US 1951-2019: 0.463
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

\[
\left( \Delta \frac{dw}{w} \right) \bigg|_{\left( \frac{dCF}{CF} \right) = 0} = \left( \frac{dCF}{CF} \right) \cdot \left( \frac{CF}{\Phi} \right)
\]  

(15)

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

\[
\Rightarrow \left( \Delta \frac{dw}{w} \right) \bigg|_{\left( \frac{dCF}{CF} \right) = 0} = \left( \frac{dCF}{du} \right) \cdot \left( \frac{CF}{\Phi} \right)
\]

\[
= -3.28 \cdot 0.463 = -1.52
\]

(16)

Just a moderate procyclical 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

Unemployment rate (deviations from trend)
Cash flow (log deviations from trend)
Cash-flow-stabilizing wage fluctuations

Coeff.: -3.28 (SE: 0.317)
Coeff.: -1.49 (SE: 0.146)
Robustness Checks in Paper

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

-0.4 -0.2 0.0 0.2 0.4
1950q1 1960q1 1970q1 1980q1 1990q1 2000q1 2010q1 2020q1
Pre-tax profits (log deviations from trend)
Cash-flow-stabilizing wage fluctuations

Unemployment rate (deviations from trend)
Coeff.: -6.87 (SE: 0.804)
Cash-flow-stabilizing wage fluctuations
Coeff.: -1.40 (SE: 0.168)

Pre-tax profits to payroll trend ratio
Average trend ratio: 0.206

Density
mean: 0.0006, sd: 0.022
p10: -0.028, p25: -0.011, p75: 0.016, p90: 0.025
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Industry-Level Test: Cross Section

Idea, example of shift in labor productivity $p$:

$$ CF = \frac{y}{pn} - \Phi $$

(17)

$$ \frac{d \ln CF}{d \ln p} = \frac{1 - \frac{dw}{dp}}{1 - \frac{\Phi}{\gamma}} $$

(18)

= labor share!

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

Density

mean: 0.4023, sd: 0.100
p10: 0.254, p25: 0.343, p75: 0.474, p90: 0.516
Industry-Level Evidence: Okun’s Laws of Cash Flow and Inputs

Semi-elasticity w.r.t. unemployment rate

Cash flow
Coeff.: -10.34 (SE: 1.667)

Employment
Coeff.: -9.30 (SE: 0.831)

Capital expenditure
Coeff.: -21.73 (SE: 2.213)

Density

mean: -0.1105, sd: 0.049
p10: -0.170, p25: -0.140, p75: -0.078, p90: -0.055
Industry-Level Evidence: Long-Run Changes

- Change in semi-elasticities
- Change in labor share

Cash flow: Coeff. = -16.19 (SE: 5.689)
Employment: Coeff. = -8.54 (SE: 2.929)
Capital expenditure: Coeff. = -9.94 (SE: 8.007)
Alternative Labor Share Measure: Labor Costs Over Revenue

Semi-elasticity w.r.t. unemployment rate

- Cash flow: \( \text{Coeff.: } -7.29 \text{ (SE: 2.397)} \)
- Employment: \( \text{Coeff.: } -8.32 \text{ (SE: 1.205)} \)
- Capital expenditure: \( \text{Coeff.: } -25.34 \text{ (SE: 3.028)} \)
Industry-Level Test: Cross Section

Idea, example of shift in labor productivity $p$:

$$CF = \frac{y}{pn} - \Phi$$

$$\frac{d \ln CF}{d \ln p} = \frac{1 - \frac{\Phi}{y}}{1 - \frac{\Phi}{y}}$$

= labor share!

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

Elasticities w.r.t. labor productivity

- Cash flow: Coeff. 2.33 (SE: 0.158)
- Employment: Coeff. 0.53 (SE: 0.136)
- Capital expenditure: Coeff. 2.19 (SE: 0.312)
Industry-Level Elasticities to Industry “Shocks:” TFP

Elasticities w.r.t. TFP

- Cash flow: Coeff.: 4.42 (SE: 0.393)
- Employment: Coeff.: 1.81 (SE: 0.198)
- Capital expenditure: Coeff.: 3.83 (SE: 0.448)
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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)
  - 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 $\delta$

○ Matching function $M(u, v)$, gives aggregate hiring (worker flows from unemployment into employment), using inputs vacancies $v$ and unemployed job seekers $u$

○ $M(u, v)$ is constant returns (Cobb Douglas), random search

○ ...and so labor market tightness $\theta = v/u$ determines the vacancy filling rate

\[ q(\theta) = M(u, v)/v = M(1/\theta, 1) \]

and job finding rate

\[ f(\theta) = M(u, v)/u = M(1, \theta) = \theta q(\theta). \]

○ Unemployment LoM:

\[ u_{t+1} = u_t + \delta(1 - u_t) - f(\theta_t)u_t \]  

(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 $c < t$:

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

(22)

...with commentary:

$$W_{t,c} = W_{c,c} \cdot W_{t,t}^{\rho} \cdot W_{t,t}^{1-\rho}.$$  

(23)

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

- weight on the cohort’s entry wage $w_{c,c}$
- controls the relative wage cyclical comovement (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 $\Phi$ recursive:

$$\Phi_t = \sum_{c \leq t} w_{t,c} n_{t,c} \tag{24}$$

$$= \sum_{c \leq t} w_{t,t}^{1-\rho} w_{c,c}^\rho \cdot (1 - \delta)^{t-c} h_c \tag{25}$$

$$= w_{t,t} h_t + (1 - \delta) \left( \frac{w_{t,t}}{w_{t-1,t-1}} \right)^{1-\rho} \Phi_{t-1}. \tag{26}$$

(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 $d$:

$$V (n^-, \Phi^-, h, B^-; s) = \max_{v, d, B} \left\{ d - \frac{\kappa_d}{2} (d - d^{ss})^2 - \frac{\kappa_B}{2} (B - B^{ss})^2 + E \beta V (n, \Phi, h^+, B; s^+) \right\}$$  \hspace{1cm} (27)

s.t.:

$$\Phi = w h + (1 - \delta) \left( \frac{w}{w^-} \right)^{1-\rho} \Phi^-$$ \hspace{1cm} (28)

$$n = (1 - \delta) \ n^- + h$$ \hspace{1cm} (29)

$$h^+ = v q (\theta)$$ \hspace{1cm} (30)

$$k v = p n - \Phi - d + (\Delta B - r (1 - t^B) B^- - r t^B \bar{B}^-)$$ \hspace{1cm} (31)

$$B \leq \bar{B},$$ \hspace{1cm} (32)

$v$: vacancies, of which share $q$ give hires, giving employment $n$, separating with prob $\delta$

$d$: dividends, can adjust with adjustment cost cost guided by $\kappa_d$

$B$: one-period debt, interest rate $r$

$v$: vacancies, at cost $k$ per period

$\Phi$: total payroll, with follows wage rule $w_{t,c} = w_{c,c}^\rho \cdot w_{t,t}^{1-\rho}$

$\bar{B}$: debt limit

$t^B$: tax subsidy of interest expenditure (refunded as lump sum)
Firm’s Financing

Recall firm’s budget constraint:

\[ kv = pn - \Phi - d + \left( \Delta B - r \left( 1 - t^B \right) B^\sim - rt^B \widetilde{B}^\sim \right) \]  

(33)

Rewrite to highlight demand for external finance:

\[
\begin{align*}
\text{Financing gap} &= \left( \frac{kv}{\text{Investment (Rec. Exp.)}} \right) - \left( \frac{pn - \Phi}{\text{Cash flow}} \right) = -d + \left( \Delta B - r \left( 1 - t \right) B^\sim - rt \widetilde{B}^\sim \right) \\
\text{External finance} 
\end{align*}
\]

(34)

Suppose the borrowing constraint binds and \( B^\sim = B = \bar{B} \):

\[ kv + d = pn - \Phi \]  

(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

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

(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 \( t + 1 \):

\[
\frac{k}{q(\theta_t)} = \mathbb{E}_t \sum_{s > t} \left( \beta (1 - r (1 - tB)) \right)^{s-t} (1 - \delta)^{s-(t+1)} (p_s - w_{s, t+1})
\]

(37)

C. Interim case: ... w/ financial constraints and w/o wage rigidity – cash valuation \( \tau_t \):

\[
\tau_t \frac{k}{q(\theta_t)} = \mathbb{E}_t \sum_{s > t} \left( \beta (1 - r (1 - tB)) \right)^{s-t} (1 - \delta)^{s-(t+1)} \tau_s (p_s - w_s)
\]

(38)

\[
\leftrightarrow \frac{k}{q(\theta_t)} = \mathbb{E}_t \sum_{s > t} \left( \beta (1 - r (1 - tB)) \right)^{s-t} (1 - \delta)^{s-(t+1)} \frac{\tau_s}{\tau_t} (p_s - w_s)
\]

(39)

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

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

(40)
Intuitions for Financial Channel of Wage Rigidity

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

$$kv = pn - [\Phi] - d - r \overline{B}$$  \hspace{1cm} (41)

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

⇒ FCs break the neutrality of incumbent workers’ wages/wage rigidity!
⇒ (Incumbents’) wage rigidity mediates financial amplification.
Details: First-order/Envelope Conditions

\[ V_d = 0 : \quad \tau = 1 - \kappa^d (d^* - d^{ss}) \quad (42) \]

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

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

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

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

\[ V_v = 0 : \quad \eta = \tau \frac{k}{q (\theta)}. \quad (47) \]

⇒ Hiring, or “zero profit condition:”

\[ \frac{k}{q (\theta)} = \mathbb{E} \left[ \beta \tau^{-1} (\mu^+ + \lambda^+ w^+) \right] \]

\[ = \mathbb{E} \left[ \beta \frac{\tau^+}{\tau} \left( p^+ - w^+ \right) + (1 - \delta) \frac{k}{q (\theta^+)} + \beta (1 - \delta) \frac{\lambda^{++}}{\tau^+} (w^+ \rho w^{++1-\rho} - w^{++}) \right] \quad (49) \]
Details: Household’s Problem: Analogous

\[ V^H(n^-, \Phi^-, h, B^-; s) = \max_{B} \{ \Phi + d - zn + rB^- - \Delta B + \mathbb{E} \beta V^H(n, \Phi, h^+, B; s^+) \} \]  
\hspace{1cm} (50)

\text{s.t.:} \quad \Phi = wh + (1 - \delta) \left( \frac{w}{w^-} \right)^{1-\rho} \Phi^-  
\hspace{1cm} (51)

\[ n = (1 - \delta)n^- + h  
\hspace{1cm} (52)\]

\[ h^+ = f(\theta)(1 - n)  
\hspace{1cm} (53)\]

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

FOCs/Env Con’s:

\[ V^H_B = 0 : \quad 1 = \mathbb{E} [\beta (1 + r)] \]  
\hspace{1cm} (54)

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

\[ V^H_n = 0 : \quad \mu^H = -z - f(\theta)\eta^H + \mathbb{E} [\beta (1 - \delta) \mu^{H^+}]  
\hspace{1cm} (56)\]

\[ V^H_{h^+} = 0 : \quad \eta^H = \mathbb{E} \left[ \beta (\lambda^{H^+} w^+ + \mu^{H^+}) \right] \]  
\hspace{1cm} (57)
Details: Nash Bargaining Over New Hires’ Entry Wage $w$

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

$$V_n^F(\tilde{w}) = \lambda^F \tilde{w} + \mu^F$$  \hspace{1cm} (58)

$$V_n^H(\tilde{w}) = \lambda^H \tilde{w} + \mu^H$$  \hspace{1cm} (59)

Nash bargained wage w/ worker bargaining power $\phi$:

$$w = \arg\max_{\tilde{w}} \{ V_n^F(\tilde{w})^\phi V_n^H(\tilde{w})^{1-\phi} \}$$  \hspace{1cm} (60)

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

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

where $\psi = V_n^H(\tilde{w})/V_n^F(\tilde{w}) = \lambda^H/\lambda^F$
Maximize comparability with standard DMP wage:

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

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

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

\[
w_{DMP} = w_{\rho=0} = \phi(p + \theta k) + (1 - \phi)z
\]

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

- Follow Shimer (2005) for standard DMP parameters
- Set $\rho$ to match incumbent/new hires’ wage cyclicality targeting values proposed by meta analysis in Pissarides (2009)
- Explore various calibrations of $\kappa^d$ (see next)
### Parameter Values – Tiny Print, Clarify As We Go Along!

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Source/Strategy</th>
<th>Target</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta$ Discount factor</td>
<td>0.996</td>
<td>Annual interest rate</td>
<td>0.04</td>
<td>0.04</td>
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<td>$\zeta$ Matching elasticity</td>
<td>0.72</td>
<td>Shimer (2005)</td>
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<td>$m$ Matching efficiency</td>
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<td>Job finding probability (s.s.)</td>
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<td>$\delta$ Separation rate</td>
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<td>Unemployment rate (s.s.)</td>
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<td>$\phi$ Bargaining power</td>
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<td>Hosios condition</td>
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<td>$z$ Unemployment flow payoff</td>
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<td>Avg. replacement rate</td>
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<td>$k$ Vacancy posting cost</td>
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<td>Normalization $\theta^{55} = 1$</td>
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<tr>
<td>$\bar{z}$ Productivity, mean</td>
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<tr>
<td>$\sigma^P_\epsilon$ Productivity innovation, SD</td>
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<td>SD of ALP (quarterly)</td>
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<td>$\rho^P$ Productivity, autocorrelation</td>
<td>0.98</td>
<td>Persistence of ALP (quarterly)</td>
<td>0.892</td>
<td>0.901</td>
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<td>$\rho$ (One minus) indexation of incumbents' wages to new hires' entry wages</td>
<td>No Wage Rigidity 0</td>
<td>Wage Rigidity for Incumbent Workers 0.8</td>
<td>Relative cyclicality of new to average wages (see figure) 2.5</td>
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<td>$t^B$ Tax benefit of debt</td>
<td>0.3</td>
<td>Fraction of periods constraint binding (see figure)</td>
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<tr>
<td>$B$ Borrowing limit</td>
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<tr>
<td>$\kappa^B$ Debt adjustment cost</td>
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<tr>
<td>$\kappa^d$ Dividend adjustment cost</td>
<td>No Constraints 0</td>
<td>Financial Constraints 20</td>
<td>Judge by hiring-cash flow sensitivity (see figure)</td>
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Note: Parameter values and targets are the same across all model variants, except for $\kappa^d$ and $\rho$. 
<table>
<thead>
<tr>
<th>Panel</th>
<th>( \log u )</th>
<th>( \log \nu )</th>
<th>( \log \theta )</th>
<th>( \log f )</th>
<th>( \log p )</th>
<th>( \log w )</th>
<th>( \log \bar{w} )</th>
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<tr>
<td><strong>Panel A: Data</strong></td>
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<td>0.400</td>
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<td><strong>Panel B: Neither Financial Constraints Nor Incumbents’ Wage Rigidity</strong></td>
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<tr>
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<td>-0.958</td>
<td>-0.958</td>
<td>-0.958</td>
<td>-0.958</td>
<td>-0.958</td>
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<td><strong>Panel C: No Financial Constraints but Incumbents’ Wage Rigidity</strong></td>
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<td><strong>Panel D: Both Financial Constraints and Incumbents’ Wage Rigidity</strong></td>
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<td>Standard deviation</td>
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<td>0.159</td>
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<tr>
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</table>
Calibrating Incumbent Workers’ Wage Rigidity $\rho$ to $\rho$ on Relative Semi-Elasticity of New Hires’ vs. Average Wages
Sensitivity: Effect of $\rho$ on the SD of Labor Market Tightness

Wage rigidity parameter; 

Calibration

Cost of dividend adjustment $\kappa^d = 0$

$\kappa^d = 20$ (benchmark calibration)

$\kappa^d = 100$

Standard deviation of labor market tightness $\theta$
Sensitivity: Dividend Adjustment Cost Parameter $\kappa^d$

- SD of labor market tightness $\theta$
- Hiring-cash flow sensitivity $k \cdot \frac{dv}{dCF}$
- Propensity to retain cash flow shocks $1 - \frac{dd}{dCF}$
- SD of labor market tightness $\theta$ when $\rho = 0$

Benchmark calibration

Cost of dividend adjustment $\kappa^d$
<table>
<thead>
<tr>
<th>Panel</th>
<th>Data</th>
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<td>1.000 -0.927 -0.959 -0.956 -0.956</td>
</tr>
</tbody>
</table>
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
Fiscal Policy Application: Wage Subsidies and Payroll Taxes As Stabilization Tools

Introduce payroll tax rate “x” on firm side:

\[ kv = zn - (1 + x(s))\Phi - T^x(s) - d + (\Delta B - r(1 - t^B)B^r - rt^B\tilde{B}^r), \]  \hspace{1cm} (65)

Payroll tax indexed to labor market tightness deviations from SS—procyclicality parameter \( \alpha \):

\[ x(s) = \left( \frac{\theta_t}{\theta_{ss}} \right)^\alpha - 1. \]  \hspace{1cm} (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 $\alpha$ 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.

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   - 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”:

\[
\varepsilon_{n,w}^{\text{Total}} = \varepsilon_{n,w}^{\text{Marginal}} \bigg|_{d\text{Liquidity}=0} - \frac{wdn}{dCF}
\] (67)
Sensitivity Analysis: Average and New Hires’ Wage Cyclicality (Semi-elasticity w.r.t. the Unemployment Rate) by $\rho$ 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 and Balance Sheet Components (Divided by Trend Gross Value Added)

#### Normalized Cash Flow Statement Components

<table>
<thead>
<tr>
<th>Quarter</th>
<th>Gross Value Added</th>
<th>Payroll</th>
<th>Taxes (prod.)</th>
<th>Cash Flow</th>
<th>Equity Raised</th>
<th>Debt Raised</th>
<th>Dividends Paid</th>
<th>Interest Paid</th>
<th>CapEx</th>
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<tr>
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<tr>
<td>2000q1</td>
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<td>1.00</td>
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<tr>
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#### Average of Normalized Cash Flow Statement Components

<table>
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<tr>
<th>Component</th>
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<tr>
<td>Gross Value Added</td>
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<td>Payroll</td>
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<td>Taxes (prod.)</td>
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<tr>
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<td>Interest Paid</td>
<td>0.022</td>
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<td>External Finance</td>
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#### Graphical Representation

- **Gross value added**
- **Payroll**
- **Taxes (prod.)**
- **Cash flow**
- **Equity raised**
- **Debt raised**
- **Dividends paid**
- **Interest paid**
- **Capital expenditure**

The graph shows the trends for each component over time, with a focus on the average values across different quarters.
The Cyclical Comovement of U.S. Capital Expenditure, Hiring, Job Openings, and the Help-Wanted Index
Cash Flow and Investment: Accounting for Heterogeneity/Financial Intermediation
Robustness Check: Pre-tax Profits

-0.15 -0.10 -0.05 0.00 0.05 0.10 -0.02 -0.01 0.00 0.01 0.02

Unemployment rate (deviations from trend)
Pre-tax profits (log deviations from trend)

Coeff.: -6.87 (SE: 0.804)

Cash-flow-stabilizing wage fluctuations
Coeff.: -1.40 (SE: 0.168)

Average trend ratio: 0.206

Pre-tax profits to payroll trend ratio
1950q1 1960q1 1970q1 1980q1 1990q1 2000q1 2010q1 2020q1
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

![Graph showing the relationship between DMP fundamental surplus amplification factor (proxy) and Labor share. The graph includes a linear regression line with a coefficient of 5.82 (SE: 84.093).]
Industry-Level Recession Case Studies: Cash Flow

Recessions:
- 1970 vs. 1968
- 1975 vs. 1972
- 1982 vs. 1980
- 2002 vs. 2001
- 2009 vs. 2007
Industry-Level Recession Case Studies: Investment

- 1970 vs. 1968
- 1975 vs. 1972
- 1982 vs. 1980
- 2002 vs. 2001
- 2009 vs. 2007

[Graph showing the relationship between labor share and capital expenditure change for different recession periods.]
Industry-Level Recession Case Studies: Employment

Recessions:
- 1970 vs. 1968
- 1975 vs. 1972
- 1982 vs. 1980
- 2002 vs. 2001
- 2009 vs. 2007

% Employment change vs. Labor share

Graph showing the relationship between % Employment change and Labor share for different recession periods.
References I


References II


References III


