# Labour Market Flows, Unemployment & the Phillips Curve

Enisse Kharroubi* [1] Marius Koechlin [2]

[1]Bank for International Settlements (BIS)

[2]University of Lausanne

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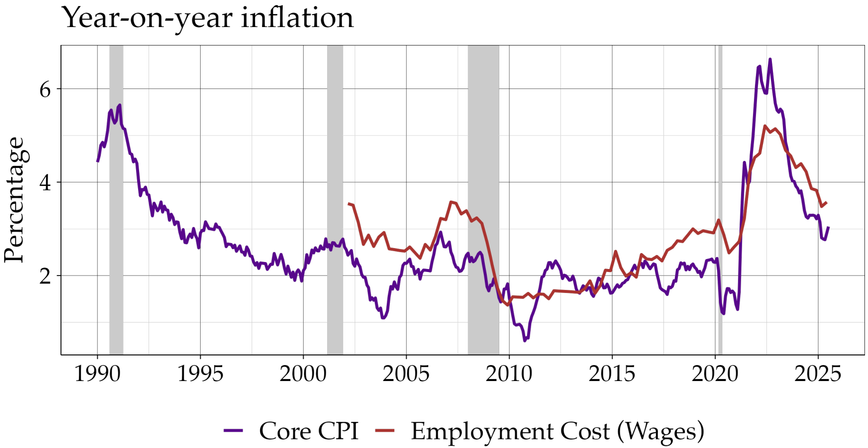
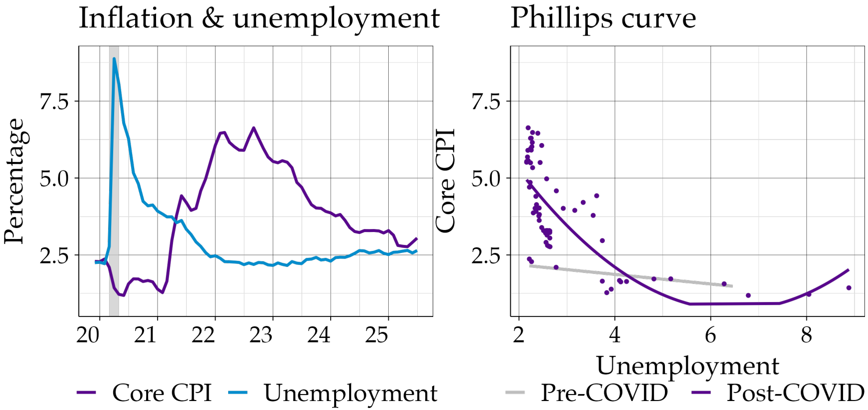
*The views expressed are those of the authors and do not necessarily reflect those of the BIS.

# Historically high inflation




- Peak price and wage inflation in 2022

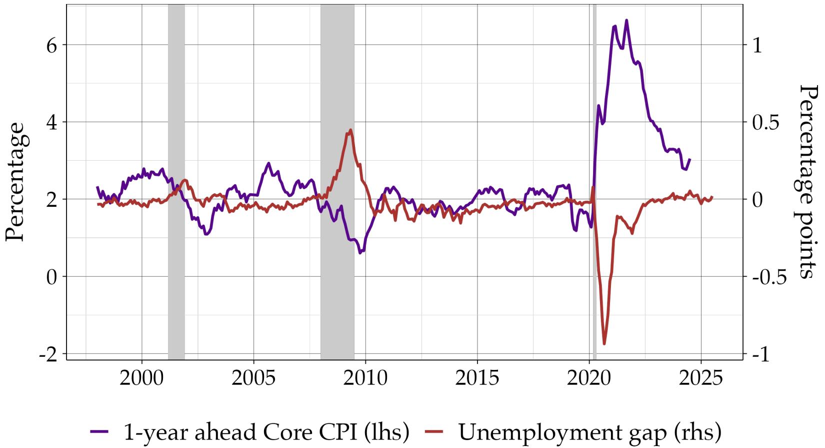
# Relationship of inflation & the labour market?




- Why did inflation increase so much?
- Could the post-COVID inflation surge have been anticipated?

# This paper: Novel measure of economic slack

**Unemployment gap** based on labour market flows




- Use unemployment gap in empirical analysis; theoretic S&M model

# Preview of results

**We find...**

- ... labour market flows contain a lot of information about labour market dynamics: *unemployment converges within **3 months** to its conditional flow steady-state*
- ... a widening of the U-gap that corresponds to a 1 percentage point increase in the unemployment rate over the next 12 months, *leads to a **1.1 percentage point** decline in 12-month-ahead core CPI inflation*
- ... the novel unemployment gap measure outperforms other economic slack measures to predict inflation: *out-of-sample fit for the post-COVID period is improved by **15%** (RMSE); explained variance increases by **10%** ($R^2$)*
- ... in the *search & matching model* with flow-, and stock-based unempl.
    - Positive U-gap (flow-based U $\downarrow$) leads to lower wages and increase in stock-based U increases them

# Related literature

- **Inflation / Phillips curve:** Benigno and Eggertsson (2023); Beaudry et al. (2024); Hazell et al. (2022); Bernanke and Blanchard (2023); Forbes et al. (2021); Jørgensen and Lansing (2019); Ball et al. (2022); Michaillat and Saez (2024); Bernanke and Blanchard (2023); Michaillat and Saez (2024); Hall and Kudlyak (2023); Bok et al. (2023); Crump et al. (2019); L'Huillier and Phelan (2023); Jørgensen and Lansing (2021); Haschka (2024) ...

  $\Rightarrow$ *Novel measure of economic slack, using flow instead of stock data*

- **Labour market flows:** Barnichon and Nekarda (2012), Crump et al. (2024); Donovan et al. (2023); Fontaine et al. (2020); Dixon et al. (2015); Fallick and Fleischman (2004); Blanchard and Diamond (1992); Faccini and Melosi (2023); Fujita et al. (2024); Moscarini and Postel-Vinay (2023); Pilossoph and Ryngaert (2024) ...

  $\Rightarrow$ *Combine labour market flows with price dynamics*

- **Search & matching model:** Gertler and Trigari (2009); Shimer (2005); Hall (2005); Mortensen and Pissarides (1994); Krause and Lubik (2007); Krause et al. (2008); Thomas (2008); Blanchard and Galí (2010); Crump et al. (2019); Shimer (2005, 2012); Elsby et al. (2010); Hall (2005); Elsby et al. (2009) ...

  $\Rightarrow$ *Allow firms to freely negotiate wages for new hires*

# Overview of the presentation

- Labour market flows data
- Novel measure for the unemployment gap
- Labour market empirics
- Inflation empirics
- Model layout
- Conclusion

# DATA &
# UNEMPLOYMENT GAP

# Data - Labour market flows

## Data

- *Labor Force Statistics* from the *Current Population Survey*; 1990-2025 (m)
- Three states: ***employed***, ***unemployed*** and ***inactive*** (mutually exclusive)

## Individual flows

- State-persistence very high (i.e. employment stable at 96%)
- Job-separation probability & unemployment persistence most volatile flows

## Unemployment measures

- **Stock-based**: main driver is job-finding rate (explains 3/4 Shimer (2012))
- **Flow-based**: inflows into unemployment most important

Transitions into unemployment | Flow dynamics mechanism | Convergence | Probability dist
Probability time series | Probability sumstat

# Flow-based unemployment: $\tilde{u}$

Exploit dynamics in labour market flows:

- **Flow-based unemployment** is non-linear combination of all probabilities

$$\underbrace{\begin{bmatrix} \tilde{e}_t \\ \tilde{u}_t \\ \tilde{i}_t \end{bmatrix}}_{\widetilde{m}_{t+1}} = \underbrace{\begin{bmatrix} \Pr_t[e|e] & \Pr_t[e|u] & \Pr_t[e|i] \\ \Pr_t[u|e] & \Pr_t[u|u] & \Pr_t[u|i] \\ \Pr_t[i|e] & \Pr_t[i|u] & \Pr_t[i|i] \end{bmatrix}}_{M_t} \cdot \underbrace{\begin{bmatrix} \tilde{e}_t \\ \tilde{u}_t \\ \tilde{i}_t \end{bmatrix}}_{\widetilde{m}_t}$$

$\tilde{u}$ derivation

- Stock-based (observed) unemployment catches up with flow-based unemployment within approx. 3 months Convergence

Note: Implicit assumption that current probabilities are the steady state distribution

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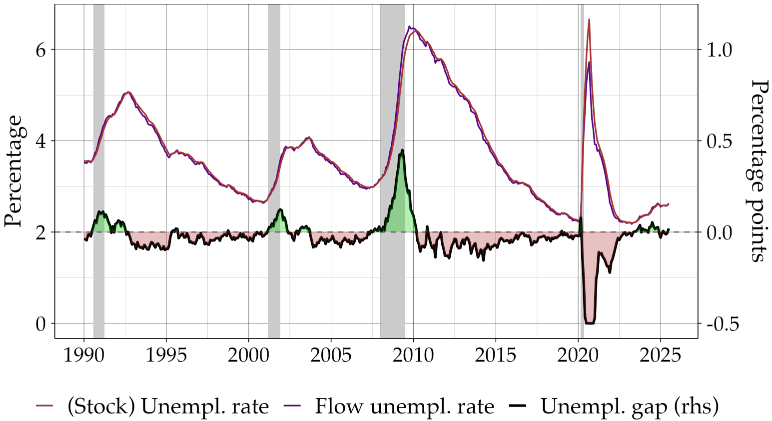
# Unemployment gap

## Unemployment gap

U gap = flow-based unemployment - stock-based unemployment

Note: *stock-based unemployment* refers to observed unemployment as a share of the total working age population.

# Unemployment gap



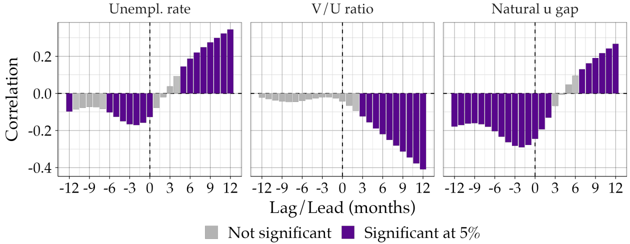

- Stock-based unemployment closely tracks flow-based unemployment
- Positive when there is slack, negative when markets are tight

Note: 6-month moving averages used.

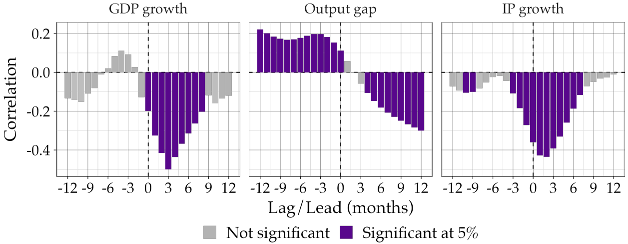
Summary stats u gap

# Unemployment gap correlations - leading indicator

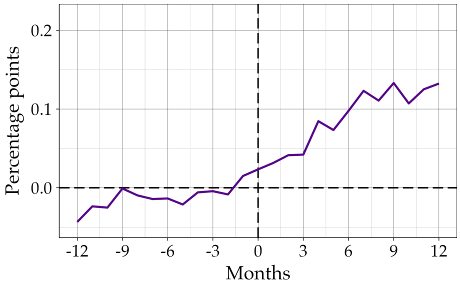
## Labour market:



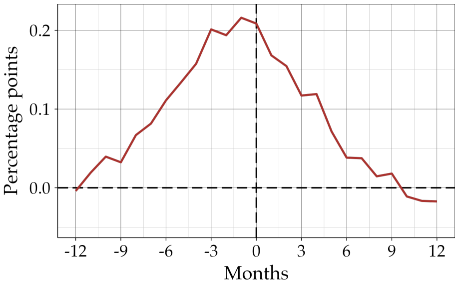

## Business cycle:



# Dynamics around recessions: unemployment gap




**(a)** Recession start

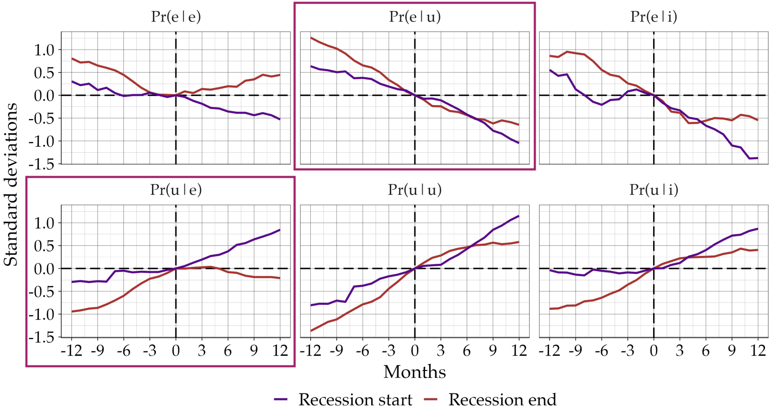



**(b)** Recession end

- Recession start: Unemployment gap stable (slightly negative), then starts increasing in a consistent manner
- Recession end: unemployment gap follows inverted V-shaped trajectory

Note: Average around NBER defined recession periods.

# Dynamics around recessions: transition probabilities




- Job-finding rate decreases before & after recession, reverses with lag
- Unemployment persistence is an early indicator for recessions
- Flows into unemployment most important for unemployment gap

# EMPIRICAL ANALYSIS

# Empirical approach

Effect of unemployment gap on ...

... **labour market**

$$\Delta \text{Unempl. rate}_{t+h} = \alpha_h + \beta_h \text{U gap}_t + \gamma_h \text{Controls}_t + \delta_h \text{U rate}_{t-1} + \varepsilon_{t+h}$$

... **inflation**

- Price dynamics: Core CPI inflation (monthly) [headline, PCE, ..]
- Wage dynamics: Employment cost index (quarterly) [ULC]

$$\Delta \text{Price}_{t+h} = \alpha_h + \beta_h \text{U gap}_t + \gamma_h \text{Controls}_t + \delta_h \text{Price}_{t-1} + \varepsilon_{t+h}$$

Controls: Inflation expectation, productivity, oil price infl., labour market participation rate

Note: Variables are either 6-months growth rates or 6-months moving averages.

# Change in unemployment rate

| | 12-month ahead change in unemployment rate | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Stock-unempl. rate ($u$) | $-0.344^{***}$ | | $-0.407^{***}$ | $-0.302^{***}$ | $-0.213^{*}$ | $-0.283^{***}$ | $-0.305^{***}$ |
| | (0.108) | | (0.073) | (0.086) | (0.112) | (0.083) | (0.086) |
| Flow-unempl. rate ($\tilde{u}$) | | $-0.304^{***}$ | $0.370^{***}$ | | | | |
| | | (0.107) | (0.071) | | | | |
| Stock-empl. rate ($e$) | | | | | 0.049 | | |
| | | | | | (0.050) | | |
| Unemployment gap | | | | $0.382^{***}$ | $0.427^{***}$ | $0.438^{***}$ | $0.366^{***}$ |
| | | | | (0.073) | (0.094) | (0.088) | (0.090) |
| Employment gap | | | | | $0.209^{**}$ | | |
| | | | | | (0.106) | | |
| Change in unempl. | | | | | | $-0.254^{**}$ | |
| | | | | | | (0.122) | |
| Productivity | | | | | | | $-0.065$ |
| | | | | | | | (0.093) |
| Oil price inflation | | | | | | | 0.083 |
| | | | | | | | (0.081) |
| Labour part. rate | | | | | | | 0.040 |
| | | | | | | | (0.054) |
| Adj. $R^2$ | 0.146 | 0.111 | 0.296 | 0.296 | 0.335 | 0.331 | 0.309 |
| Num. obs. | 415 | 415 | 415 | 415 | 415 | 415 | 409 |
| RMSE | 0.883 | 0.901 | 0.802 | 0.802 | 0.779 | 0.782 | 0.795 |

*Notes:* Asteriks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$; **$p < 0.05$; *$p < 0.1$). Standard errors are NW corrected. The constant term is omitted from the table.

Pre-COVID Alternative measures

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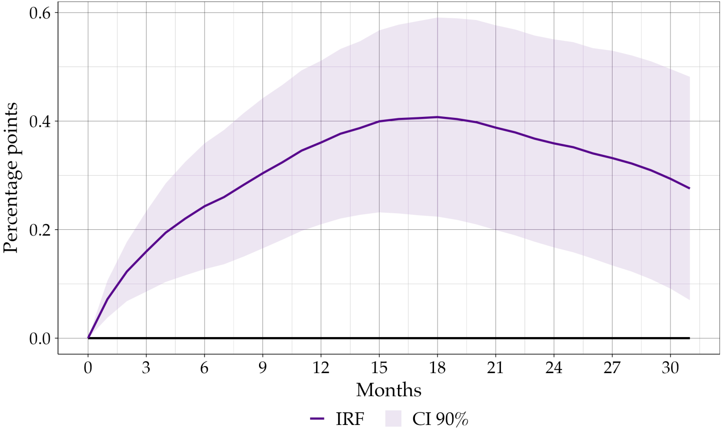
Pre-COVID   Alternative measures

# Local projection: 1 SD change in the unemployment gap

Unemployment dynamics:




- Persistent effect on (observed) stock-unemployment

# Inflation - Core CPI

| | Core CPI inflation - 12-months ahead | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Stock-unempl. rate ($u$) | 0.082 | | | 0.445*** | | | |
| | (0.095) | | | (0.062) | | | |
| Flow-unempl. rate ($\tilde{u}$) | | 0.031 | | −0.440*** | | | |
| | | (0.085) | | (0.062) | | | |
| Unemployment gap | | | | | −0.459*** | −0.494*** | −0.412*** |
| | | | | | (0.069) | (0.054) | (0.057) |
| Change in unempl. | | | 0.004 | | | 0.175** | |
| | | | (0.225) | | | (0.076) | |
| Infl. expectation (2y) | −0.097 | −0.103 | −0.106 | 0.059 | 0.057 | 0.045 | 0.223 |
| | (0.194) | (0.201) | (0.204) | (0.125) | (0.128) | (0.124) | (0.186) |
| Productivity | | | | | | | 0.079 |
| | | | | | | | (0.053) |
| Oil price inflation | | | | | | | 0.036 |
| | | | | | | | (0.071) |
| Labour part. rate | | | | | | | −0.096 |
| | | | | | | | (0.066) |
| Lagged inflation | 1.386*** | 1.362*** | 1.347*** | 1.282*** | 1.262*** | 1.313*** | 1.098*** |
| | (0.211) | (0.211) | (0.182) | (0.159) | (0.158) | (0.146) | (0.207) |
| Adj. $R^2$ | 0.538 | 0.533 | 0.532 | 0.703 | 0.703 | 0.715 | 0.698 |
| Num. obs. | 415 | 415 | 415 | 415 | 415 | 415 | 409 |
| RMSE | 0.721 | 0.725 | 0.726 | 0.578 | 0.578 | 0.566 | 0.560 |

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# Inflation - Core CPI

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| Flow-unempl. rate ($\tilde{u}$) | | 0.031 | | −0.440*** | | | |
| | | (0.085) | | (0.062) | | | |
| Unemployment gap | | | | | −0.459*** | −0.494*** | −0.412*** |
| | | | | | (0.069) | (0.054) | (0.057) |
| Change in unempl. | | | 0.004 | | | 0.175** | |
| | | | (0.225) | | | (0.076) | |
| Infl. expectation (2y) | −0.097 | −0.103 | −0.106 | 0.059 | 0.057 | 0.045 | 0.223 |
| | (0.194) | (0.201) | (0.204) | (0.125) | (0.128) | (0.124) | (0.186) |
| Productivity | | | | | | | 0.079 |
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| Num. obs. | 415 | 415 | 415 | 415 | 415 | 415 | 409 |
| RMSE | 0.721 | 0.725 | 0.726 | 0.578 | 0.578 | 0.566 | 0.560 |

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Summary stats y | Summary stats x | Subperiods | Alternative slack measure | Further infl. measures

# Inflation - Employment cost index

| | Employment cost (wage) inflation - 12-months ahead | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Stock-unempl. rate ($u$) | −0.010 | | | 0.281*** | | | |
| | (0.141) | | | (0.066) | | | |
| Flow-unempl. rate ($\tilde{u}$) | | −0.081 | | −0.292*** | | | |
| | | (0.120) | | (0.067) | | | |
| Unemployment gap | | | | | −0.290*** | −0.284*** | −0.244*** |
| | | | | | (0.060) | (0.067) | (0.072) |
| Change in unempl. | | | −0.134 | | | −0.082 | |
| | | | (0.105) | | | (0.067) | |
| Infl. expectation (2y) | −0.442 | −0.457 | −0.444 | −0.117 | −0.098 | −0.109 | 0.129 |
| | (0.351) | (0.378) | (0.393) | (0.260) | (0.266) | (0.269) | (0.297) |
| Productivity | | | | | | | 0.002 |
| | | | | | | | (0.065) |
| Oil price inflation | | | | | | | 0.128** |
| | | | | | | | (0.052) |
| Labour part. rate | | | | | | | −0.084** |
| | | | | | | | (0.034) |
| Lagged inflation | 1.744*** | 1.626*** | 1.743*** | 1.422*** | 1.564*** | 1.558*** | 1.371*** |
| | (0.451) | (0.445) | (0.259) | (0.308) | (0.211) | (0.199) | (0.224) |
| Adj. $R^2$ | 0.657 | 0.662 | 0.668 | 0.787 | 0.784 | 0.785 | 0.801 |
| Num. obs. | 92 | 92 | 92 | 92 | 92 | 92 | 92 |
| RMSE | 0.547 | 0.543 | 0.538 | 0.431 | 0.434 | 0.432 | 0.417 |

*Notes:* Asteriks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$; **$p < 0.05$; *$p < 0.1$). Standard errors are NW corrected. The constant term is omitted from the table.

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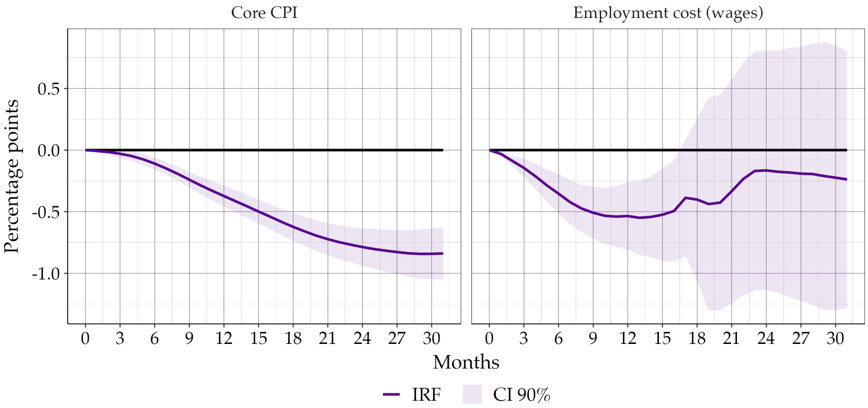
Subperiods | Alternative slack measure | Further infl. measures | Out-of-sample

# Local projection: 1 SD change in the unemployment gap

Inflation dynamics:




- Persistent effect over time; stronger for prices

# MODEL

# Key points & model idea

Set-up:

- Building on classic search & matching model (Mortensen and Pissarides, 1994) with sticky wages (Shimer, 2005)
- *New* sticky-wage determination: only pre-existing workers face sticky wages, new hires can freely bargain theirs (unlike Gertler and Trigari (2009))
- Assumption: 2-state economy $(e, u)$; firing rate $f$ exogenous
- Aggregate shock $s_t$: increases productivity and hiring rate $h$
- Incorporate flow-based and stock-based unemployment

# Unemployment gap

Unemployment gap $z$ defined as:

$$z_t = \tilde{u}_t - u_t = \underbrace{\frac{f}{f + h_{t-1}}}_{steady-state} - \underbrace{[u_{t-1}(1 - h_{t-1}) + (1 - u_{t-1})f]}_{actual} \quad (1)$$

Effect of hiring rate on unemployment gap:

- $h_{t-1} \uparrow$ cuts both $\tilde{u}_t$ and $u_t$
- But $\tilde{u}_{t+n}$ flat while and $u_{t+n}$ persistently lower
- For $z_{t+n}$ to decrease, hiring rate autocorrelation $\rho$ must satisfy

$$\left.\frac{\partial z_{t+n}}{\partial h_{t-1}}\right|_{z_t=0} \leq 0 \Leftrightarrow \rho^n + [1 - f - h]^n \geq 1 \quad (2)$$

$\rightarrow$ Need persistence in hiring rate Persistence

# Environment, preferences & technology

**Environment**

- Time: discrete, infinite periods
- Agents: infinitely lived workers and firms (identical)
    - Worker: employed/unemployed (two-state) (Crump et al., 2019; Shimer, 2005, 2012; Elsby et al., 2010; Hall, 2005; Elsby et al., 2009)
- Commodities: one consumption good

**Preferences**

- Workers & firms: maximize expected discounted lifetime consumption

$$u = \mathbb{E}_0 \Sigma_{t \geq 0} \beta^t c_t$$

**Production technology**

- Cobb-Douglas production function, TFP affected by shock $s_t$

$$y_t = A(s_t) k_t^{\alpha} n_t^{1-\alpha}$$

**Wages**

- Wages possibly sticky (à la Calvo): **wages for new hires always flexible**

# Value function: Worker

## Employed worker

$$V_w\left(w_t, s_t\right) = w_t + \beta f \underbrace{\int U(s_{t+1}) dF(s_{t+1})}_{\text{Becoming unemployed}}$$

$$+ \beta(1-f)\left[(1-\theta)\underbrace{\int V_w\left(w_{t+1}^{(0)}, s_{t+1}\right) dF(s_{t+1})}_{\text{New flexible wage}} + \theta \underbrace{\int V_w\left(w_t, s_{t+1}\right) dF(s_{t+1})}_{\text{Old wage due to rigidity}}\right]$$

## Unemployed worker

$$U(s_t) = b + \beta(1-h_t)\underbrace{\int U(s_{t+1}) dF(s_{t+1})}_{\text{Remaining unemployed}} + \beta h_t \underbrace{\int \left[(1-\theta)V_w\left(w_{t+1}^{(0)}, s_{t+1}\right) + \theta V_w\left(w_{t+1}^{(1)}, s_{t+1}\right)\right] dF(s_{t+1})}_{\text{Finding a job}}$$

# Value function: Firm

## Firm

$$\Pi\left(w_t^{(0)}; n_t; s_t\right) = \max_{k_t} \left\{ \underbrace{A(s_t)\, k_t^{\alpha} n_t^{1-\alpha} - r_t k_t - w_t^{(0)} n_t}_{\text{Profit today}} + \beta(1-\theta) \underbrace{\int \Pi\left(w_{t+1}^{(0)}; n_{t+1}; s_{t+1}\right) dF(s_{t+1})}_{\text{Continuation value flex. wage}} \right.$$
$$\left. + \beta\theta \underbrace{\int \Pi\left(w_{t+1}^{(1)}; n_{t+1}; s_{t+1}\right) dF(s_{t+1})}_{\text{Continuation value rigid wage}} \right\}$$

- where $w^{(0)}$ is the flexible wage, and $w^{(1)}$ is the sticky wage

## Law of motion of workers

$$n_{t+1} = (1-f) \cdot n_t + h_t \cdot (1-n_t)$$

# Value function: Firm - per worker & net of capital

## Flexible-wage firm

$$V_f\left(w_t^{(0)}, s_t\right) = y(s_t) - w_t^{(0)} + \beta \underbrace{\frac{n_{t+1}}{n_t}}_{\text{g empl.}} \left[ (1-\theta) \underbrace{\int V_f\left(w_{t+1}^{(0)}, s_{t+1}\right) dF(s_{t+1})}_{\text{Flexible wages}} + \theta \underbrace{\int V_f\left(w_{t+1}^{(1)}, s_{t+1}\right) dF(s_{t+1})}_{\text{Rigid wages}} \right]$$

**Rigid-wage firm**: $\lambda_t = (1 - n_{t-1})h_{t-1}/n_t$ denotes the fraction of new hires

$$V_f(w_t^{(1)}, s_t) = y(s_t) - \underbrace{\lambda_t w_t^{(1)} - (1-\lambda_t)w_{t-1}^{(0)}}_{\text{Wage composition}}$$

$$+ \beta \frac{n_{t+1}}{n_t} \left[ (1-\theta) \underbrace{\int V_f(w_{t+1}^{(0)}, s_{t+1}) dF(s_{t+1})}_{\text{Flexible wages}} + \theta \underbrace{\int V_f(w_{t+1}^{(2)}, s_{t+1}) dF(s_{t+1})}_{\text{2nd period of rigid wages}} \right]$$

**Note**: going forward assume max. 1 period of rigid wages

With CRS, can express everything in per-worker terms, as each worker contributes equally, regardless of workforce size.

# Wage setting

**Nash bargaining** with firm (worker) bargaining power $\eta$ (1-$\eta$), with two possible cases: *flexible-wage* and *rigid-wage firms*

- **Wages for new hires are always flexible**

**Flexible-wage firms:**

- Set wage $w^{(0)}$ for entire labour force
- Optimal surplus sharing rule "as-if" no wage rigidity risk: $\eta(V_w - U) = (1-\eta)V_f$

**Rigid-wage firms:**

- Set wage $w^{(1)}$ only for new hires (share $\lambda$)
- Optimal surplus sharing rule "as-if" firms' wage bargaining power was $\eta\lambda$ not $\eta$: $\eta\lambda(V_w - U) = (1-\eta)V_f$ (bargaining power shifts to worker)
- But optimal surplus sharing rule also depends on legacy wage bill $(1-\lambda)w^{(0)}$

# Comparative statics: *Change in stock U; change in flow U*

- **Negative U-gap** (hiring rate $h \uparrow$) raises wage $w^{(0)}$ through 3 channels:
  - higher value of unemployment state
  - higher value of *current* matches bc of higher employment growth
  - higher value of *future* matches: higher fraction $\lambda$, lower wage for future new hires, higher future surplus.
- **Low flow-based U** raises *subsequent* wages $w^{(0)}_{t+i}$ if job-finding probability $h$ is sufficiently persistent:

$$\rho \geq (1-\phi) \sum_{k=0}^{i} \left[ \frac{\phi}{\rho} \right]^k \Longrightarrow \frac{dw^{(0)}_{t+i}}{dh_t} \geq 0$$

- High **stock-based U** raises subsequent wages $w^{(0)}_{t+i}$ bc unemployment is mean-reverting

# Key takeaways from model

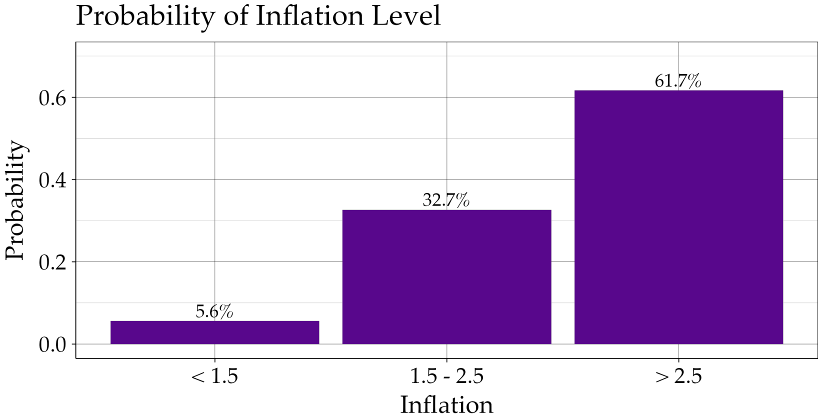
- Flow- and stock-based unemployment have different effects on wages and prices. Wages and prices decrease with flow-based U, but increase with stock-based U.

- In the data, higher job-finding probability cuts current and future U-gaps when auto-correlation is sufficiently large
- In the model, job-finding probability raises current and subsequent wages and prices, when auto-correlation is sufficiently strong

- **Main mechanism**: endogenous bargaining power whereby expectations of higher job-finding probability raise surpluses from future matches, leading to higher wages.

# CONCLUSION

# Outlook




- Likelihood of 1-year ahead core CPI inflation, conditional on u gap today

# Conclusion

**Empirics:**

- Novel economic slack indicator with strong forecasting ability

**Model:**

- Incorporate role of labour market flows into traditional S&M model

**Next steps:**

- Develop model further
- Incorporate your feedback / comments?

Thank you for your attention!

Enisse Kharroubi: enisse.kharroubi@bis.org
Marius Koechlin: marius.koechlin@unil.ch

Data available here: sites.google.com/view/mariuskoechlin/flow-based-u-gap

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# APPENDIX

# Summary statistics of transition probabilities

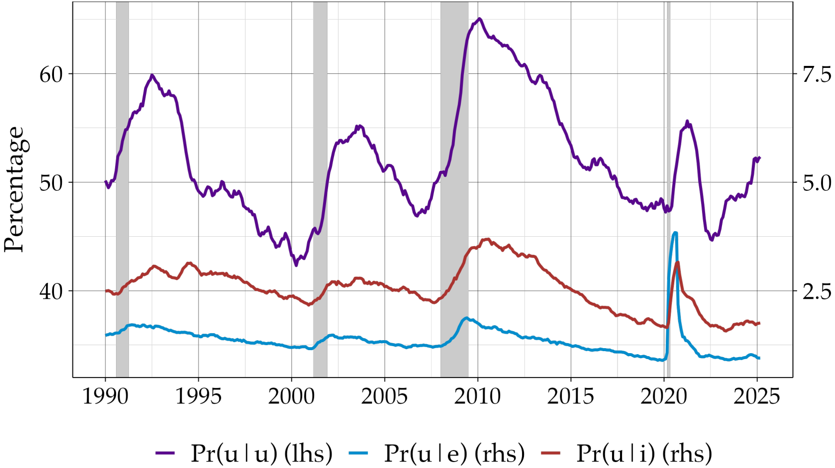
| Transition | Mean | S.D. | Skew. | Kurt. | $10^{th}$ perc. | $25^{th}$ perc. | $50^{th}$ perc. | $75^{th}$ perc. | $90^{th}$ |
|---|---|---|---|---|---|---|---|---|---|
| $\Pr_t[e\|e]$ | 95.85 | 0.7 | −16.31 | 306.48 | 95.63 | 95.76 | 95.91 | 96.03 | 96.15 |
| $\Pr_t[u\|e]$ | 1.35 | 0.56 | 13.48 | 237.26 | 0.98 | 1.17 | 1.32 | 1.5 | 1.66 |
| $\Pr_t[i\|e]$ | 2.79 | 0.25 | 5.83 | 75.93 | 2.54 | 2.64 | 2.77 | 2.91 | 3.02 |
| $\Pr_t[e\|u]$ | 25.56 | 4.21 | −0.48 | 2.83 | 18.33 | 23.4 | 26.21 | 28.28 | 30.47 |
| $\Pr_t[u\|u]$ | 52.1 | 5.55 | 0.51 | 2.52 | 45.75 | 48.17 | 51.14 | 55.75 | 60.52 |
| $\Pr_t[i\|u]$ | 22.34 | 2.36 | −0.02 | 5.18 | 19.12 | 20.83 | 22.63 | 24 | 25 |
| $\Pr_t[e\|i]$ | 4.7 | 0.39 | −0.02 | 2.62 | 4.15 | 4.42 | 4.72 | 4.95 | 5.2 |
| $\Pr_t[u\|i]$ | 2.55 | 0.53 | 0.14 | 2.6 | 1.77 | 2.22 | 2.56 | 2.88 | 3.26 |
| $\Pr_t[i\|i]$ | 92.76 | 0.53 | 0.48 | 3.22 | 92.18 | 92.4 | 92.64 | 93.15 | 93.53 |

Summary statistics of monthly transition probabilities

- High state-persistence, i.e. $\Pr_t[e|e]$, $\Pr_t[u|u]$, $\Pr_t[i|i]$
- $\Pr_t[u|e]$ is most volatile, followed by $\Pr_t[u|i]$ and then $\Pr_t[u|u]$

Back

# Labour flows into unemployment move a lot




- Business cycle fluctuations

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# Derivation of flow-based unemployment

Transition probabilities matrix:

$$M_t = \begin{bmatrix} \Pr_t[e|e] & \Pr_t[e|u] & \Pr_t[e|i] \\ \Pr_t[u|e] & \Pr_t[u|u] & \Pr_t[u|i] \\ \Pr_t[i|e] & \Pr_t[i|u] & \Pr_t[i|i] \end{bmatrix}$$

- Each transition matrix $M_t$ has a steady-state
- Lets assume currently observed flows represent steady state
- Labour market dynamics are $m_{t+1} = M_{t+1} \cdot m_t$, where $m_t = (e_t, u_t, i_t)'$
- Let $\widetilde{m}$ be vector of steady-state $e$, $u$, and $i$, such that $\widetilde{m}_t = M_t \cdot \widetilde{m}_t$.
- $\tilde{u}$ in $\widetilde{m}$ is then the flow-based unemployment rate

$$\tilde{u}_t = \frac{\Pr_t[u|i]\,(1 - \Pr[e|e]) + \Pr[u|e]\Pr[e|i]}{\Pr[u|i]\,(1 - \Pr[e|e] + \Pr[e|u]) + \Pr[u|e]\,(\Pr[e|i] - \Pr[e|u]) + (1 - \Pr[u|u])\,(1 - \Pr[e|e] + \Pr[e|i])}$$

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# Convergence: stock-based unemployment to flow-based unemplo

| | Dependent var.: $u_t - u_{t-1}$ | |
|---|---|---|
| | Month-on-month | 6-month MA |
| $\tilde{u}_t - u_{t-1}$ | 0.760*** | 0.488*** |
| | (0.019) | (0.019) |
| Adj. $R^2$ | 0.797 | 0.622 |
| Num. obs. | 422 | 422 |
| RMSE | 0.149 | 0.076 |

*Notes:*

- Convergence of the unemployment rate to its conditional steady state $\tilde{u}$ is quite fast (in line with Barnichon and Nekarda (2012)).
- 90% happens within 3 months (less than 2 months for the MoM measure)

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# Unemployment gap summary statistics

| Transition | Mean | S.D. | Skew. | Kurt. | $10^{th}$ perc. | $25^{th}$ perc. | $50^{th}$ perc. | $75^{th}$ perc. | $90^{th}$ |
|---|---|---|---|---|---|---|---|---|---|
| Stock-based U | 3.71 | 1.07 | 0.79 | 2.95 | 2.41 | 2.95 | 3.54 | 4.34 | 5.24 |
| Flow-based U | 3.68 | 1.06 | 0.81 | 3.03 | 2.41 | 2.94 | 3.51 | 4.26 | 5.19 |
| U gap | $-0.03$ | 0.12 | $-2.47$ | 22.82 | $-0.09$ | $-0.06$ | $-0.03$ | 0 | 0.05 |

**Notes:** Summary statistics are expressed in percent. S.D. stands for standard deviation, Med. stands for median. Flow-based unemployment computed using monthly transition probabilities.

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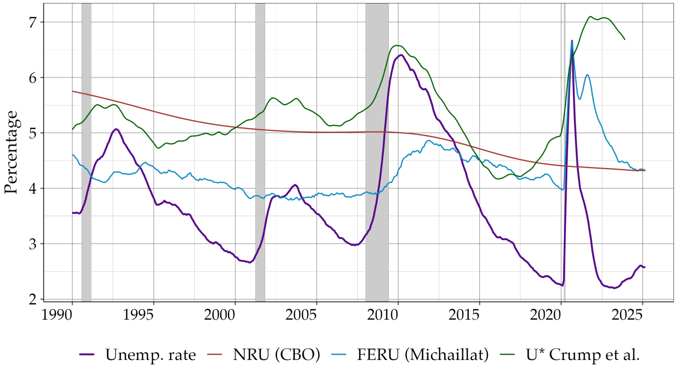
# Alternative unemployment gap measures I/II




- *NRU* stands for "Noncyclical Rate of Unemployment" (calculated by the Congressional Budget Office), and is used to calculate the *natural u gap*. *FERU* stands for "full-employment rate of unemployment" (Michaillat and Saez, 2024). Finally, *U* Crump et al.* is developed in Crump et al. (2019).

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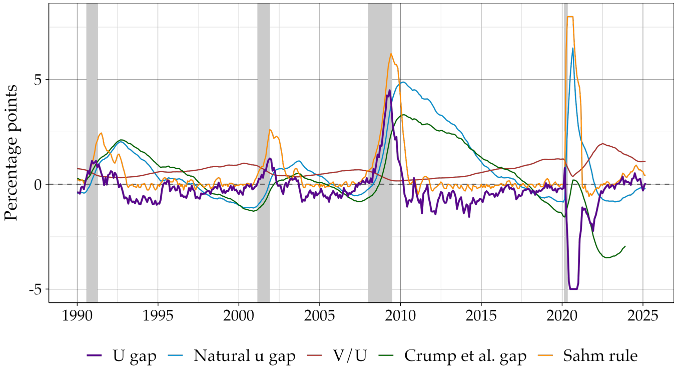
# Alternative unemployment gap measures II/II




- The *Natural u gap* is the natural unemployment gap defined as the difference between the observed unemployment rate as a share of the labour force and the Congressional Budget Office's *Noncyclical Rate of Unemployment*. *V/U* is the vacancy-to-unemployment ratio. *Crump et al. gap* is the gap based on Crump et al. (2019). *Sahm rule* shows the measure defined in Sahm (2019). The *U gap* and the *Sahm rule* are truncated at the bottom and top, respectively.

Back

# Unemployment rate dynamics 12-months ahead - pre-COVID

| | 12-month ahead change in unempl. rate: pre-COVID | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| Stock-unempl. rate ($u$) | | $-0.512^{***}$ | | $-0.369^{***}$ | $-0.371^{***}$ |
| | | (0.119) | | (0.114) | (0.117) |
| Flow-unempl. rate ($\tilde{u}$) | $-0.303^{***}$ | $0.467^{***}$ | | | |
| | (0.115) | (0.115) | | | |
| Unemployment gap | | | $0.411^{**}$ | $0.482^{***}$ | $0.528^{***}$ |
| | | | (0.173) | (0.118) | (0.139) |
| Productivity | | | | | $-0.074$ |
| | | | | | (0.156) |
| Oil price inflation | | | | | 0.043 |
| | | | | | (0.071) |
| Labour part. rate | | | | | $-0.022$ |
| | | | | | (0.091) |
| Adj. $R^2$ | 0.124 | 0.266 | 0.088 | 0.266 | 0.269 |
| Num. obs. | 361 | 361 | 361 | 361 | 355 |
| RMSE | 0.822 | 0.753 | 0.839 | 0.753 | 0.752 |

*Notes:* Asteriks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$; **$p < 0.05$; *$p < 0.1$). Standard errors are NW corrected. The constant term is omitted from the table.

Back

# Unemployment rate dynamics with different slack measures

| | 12-month ahead change in unempl. rate: alternatives | | | | |
|---|---|---|---|---|---|
| | U gap | Change u rate | U gap and Change | Natural u gap | Crump et al. gap |
| Stock-unempl. rate ($u$) | $-0.302^{***}$ | $-0.339^{***}$ | $-0.283^{***}$ | 0.290 | $-0.476^{*}$ |
| | (0.086) | (0.102) | (0.083) | (0.319) | (0.279) |
| Unemployment gap | $0.382^{***}$ | | $0.438^{***}$ | | |
| | (0.073) | | (0.088) | | |
| Change in unempl. | | $-0.093$ | $-0.254^{**}$ | | |
| | | (0.284) | (0.122) | | |
| Natural u gap | | | | $-0.004^{**}$ | |
| | | | | (0.002) | |
| Crump u gap | | | | | 0.001 |
| | | | | | (0.002) |
| Adj. $R^2$ | 0.296 | 0.149 | 0.331 | 0.200 | 0.152 |
| Num. obs. | 415 | 415 | 415 | 415 | 408 |
| RMSE | 0.802 | 0.882 | 0.782 | 0.855 | 0.887 |

*Notes:* Asteriks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$; **$p < 0.05$; *$p < 0.1$). Standard errors are NW corrected. The constant term is omitted from the table.

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# Summary statistics inflation measures

| Variable | Mean | S.D. | Skew. | Kurt. | $10^{th}$ perc. | $25^{th}$ perc. | $50^{th}$ perc. | $75^{th}$ perc. | $90^{th}$ |
|---|---|---|---|---|---|---|---|---|---|
| Core CPI inflation | 2.56 | 1.1 | 1.56 | 5.56 | 1.61 | 1.9 | 2.26 | 2.85 | 4.01 |
| CPI core services infl. | 3.22 | 1.12 | 1 | 5.1 | 2.18 | 2.61 | 3.06 | 3.67 | 4.6 |
| CPI core goods infl. | 0.87 | 2.13 | 2.47 | 11.39 | −0.9 | −0.28 | 0.42 | 1.46 | 2.77 |
| Headline CPI inflation | 2.62 | 1.56 | 1.11 | 6.4 | 1.12 | 1.7 | 2.57 | 3.18 | 4.14 |
| Headline PCE inflation | 2.17 | 1.29 | 1.12 | 6.25 | 0.85 | 1.45 | 2.11 | 2.62 | 3.47 |
| Core PCE inflation | 2.11 | 0.95 | 1.77 | 6.26 | 1.25 | 1.53 | 1.86 | 2.28 | 3.37 |
| Empl. cost infl. (wages) | 2.76 | 0.96 | 0.75 | 3.02 | 1.62 | 2.04 | 2.62 | 3.2 | 4.32 |
| Empl. cost infl. (total) | 3.11 | 0.86 | 0.17 | 2.3 | 1.95 | 2.48 | 3.07 | 3.73 | 4.27 |
| ULC inflation | 1.57 | 1.66 | −0.48 | 4.63 | −0.22 | 0.7 | 1.68 | 2.5 | 3.35 |

*Notes:* This table shows the summary statistics of the various inflation measures. The numbers are in percentages.

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# Summary statistics controls

| Variable | Mean | S.D. | Skew. | Kurt. | $10^{th}$ perc. | $25^{th}$ perc. | $50^{th}$ perc. | $75^{th}$ perc. | $90^{th}$ |
|---|---|---|---|---|---|---|---|---|---|
| Infl. expectation (2y) | 2.37 | 0.77 | 0.42 | 2.46 | 1.43 | 1.69 | 2.34 | 2.92 | 3.38 |
| Oil price inflation | 5.11 | 25.41 | 0.47 | 5.21 | −23.04 | −11.18 | 4.65 | 19.1 | 35.53 |
| Productivity | 1.01 | 1.13 | 1.1 | 6.95 | −0.28 | 0.43 | 0.92 | 1.52 | 2.3 |
| Labour part. rate | 64.95 | 1.86 | −0.4 | 1.53 | 62.57 | 62.87 | 65.98 | 66.53 | 67.02 |
| Supply chain pressure | 0.01 | 0.94 | 2.24 | 8.12 | −0.73 | −0.52 | −0.25 | 0.1 | 1.08 |
| Vacancy/unemployment | 0.68 | 0.38 | 1.23 | 4.4 | 0.3 | 0.39 | 0.6 | 0.85 | 1.19 |
| Natural u gap | 75.53 | 158.75 | 1.24 | 3.8 | −78.89 | −43.18 | 28.23 | 137.69 | 338.42 |
| Output gap | −0.63 | 1.79 | −0.51 | 2.44 | −3.11 | −1.8 | −0.34 | 0.89 | 1.46 |

*Notes:* This table shows the summary statistics of the various controls. *Inflation expatiation (2y)* are the 2-year expectations of inflation calculated by the Federal Reserve Bank of Cleveland. *Oil price inflation* is calculated using the West Texas Intermediate (WTI) Crude Oil Price. *Productivity* is using the *Nonfarm Business labor productivity output per hour* index. The *Labour part. rate* is the labour participation rate of the working age population. And finally, *Supply chain pressure* is the *Global supply chain pressure index* published by the Federal Reserve Bank of New York (Benigno et al., 2022). Since vacancy data (i.e., the number of job openings) from the BLS is only available starting in December 2000, we extend the series back to 1990 using historical estimates constructed by Barnichon (2010). The *Natural u gap* and the *Output gap* are both based on series provided by the Congressional Budget Office. The variables shown are either 6-month growth rates or 6-month moving averages.

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# CPI core inflation across different periods

| | Core CPI inflation - 12-months ahead | | | | |
|---|---|---|---|---|---|
| | Whole (91-24) | Great Mod. (91-07) | Great Rec. (07-19) | Post GFC (10-19) | Pre COV. (91-19) |
| Unemployment gap | −0.412*** | −0.185** | −0.082* | −0.071 | −0.125** |
| | (0.057) | (0.090) | (0.042) | (0.152) | (0.048) |
| Infl. expectation (2y) | 0.223 | 0.780*** | 0.289 | 0.270 | 0.672*** |
| | (0.186) | (0.194) | (0.186) | (0.239) | (0.115) |
| Productivity | 0.079 | 0.126** | −0.217*** | −0.215** | −0.052 |
| | (0.053) | (0.057) | (0.080) | (0.090) | (0.061) |
| Oil price inflation | 0.036 | 0.066 | −0.031 | −0.039 | −0.022 |
| | (0.071) | (0.049) | (0.034) | (0.044) | (0.038) |
| Labour part. rate | −0.096 | −0.487*** | −0.111** | −0.134 | −0.112** |
| | (0.066) | (0.150) | (0.047) | (0.083) | (0.045) |
| Lagged inflation | 1.098*** | 0.387 | 0.037 | −0.057 | 0.364** |
| | (0.207) | (0.248) | (0.205) | (0.159) | (0.161) |
| Adj. $R^2$ | 0.698 | 0.776 | 0.545 | 0.224 | 0.736 |
| Num. obs. | 409 | 207 | 141 | 120 | 354 |
| RMSE | 0.560 | 0.296 | 0.262 | 0.257 | 0.329 |

*Notes:* Asteriks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$; **$p < 0.05$; *$p < 0.1$). Standard errors are NW corrected. The constant term is omitted from the table.

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# Alternative slack measures - core CPI

| | Core CPI inflation 12m ahead: alternatives | | | | | | |
|---|---|---|---|---|---|---|---|
| | U gap | Change u rate | U gap and Change | V/U | U gap and V/U | Natural u gap | Output gap |
| Unemployment gap | $-0.412^{***}$ | | $-0.452^{***}$ | | $-0.409^{***}$ | | |
| | (0.057) | | (0.054) | | (0.055) | | |
| Change in unempl. | | $-0.015$ | $0.182^{**}$ | | | | |
| | | (0.174) | (0.079) | | | | |
| Vacancy/unemployment | | | | $-0.236$ | $-0.074$ | | |
| | | | | (0.282) | (0.173) | | |
| Natural u gap | | | | | | 0.001 | |
| | | | | | | (0.001) | |
| Output gap | | | | | | | $-0.006$ |
| | | | | | | | (0.052) |
| Infl. expectation (2y) | 0.223 | $0.424^{*}$ | 0.195 | $0.460^{**}$ | 0.237 | $0.523^{**}$ | $0.429^{*}$ |
| | (0.186) | (0.226) | (0.172) | (0.234) | (0.182) | (0.238) | (0.238) |
| Productivity | 0.079 | 0.118 | $-0.007$ | 0.122 | 0.082 | 0.102 | 0.110 |
| | (0.053) | (0.119) | (0.072) | (0.146) | (0.052) | (0.128) | (0.135) |
| Oil price inflation | 0.036 | 0.113 | 0.068 | 0.113 | 0.035 | 0.107 | 0.117 |
| | (0.071) | (0.088) | (0.065) | (0.089) | (0.071) | (0.088) | (0.094) |
| Labour part. rate | $-0.096$ | $-0.245^{**}$ | $-0.081$ | $-0.274^{**}$ | $-0.106$ | $-0.254^{**}$ | $-0.245^{**}$ |
| | (0.066) | (0.109) | (0.061) | (0.124) | (0.071) | (0.103) | (0.108) |
| Lagged inflation | $1.098^{***}$ | $0.893^{***}$ | $1.128^{***}$ | $0.947^{***}$ | $1.113^{***}$ | $0.910^{***}$ | $0.896^{***}$ |
| | (0.207) | (0.276) | (0.190) | (0.285) | (0.215) | (0.275) | (0.276) |
| Adj. $R^2$ | 0.698 | 0.570 | 0.708 | 0.574 | 0.697 | 0.586 | 0.570 |
| Num. obs. | 409 | 409 | 409 | 409 | 409 | 409 | 409 |
| RMSE | 0.560 | 0.668 | 0.550 | 0.665 | 0.560 | 0.656 | 0.668 |

*Notes:* Asteriks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$; **$p < 0.05$; *$p < 0.1$). Standard errors are NW corrected. The constant term is omitted from the table.

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# Further wage inflation measures

| | Regression results for other price inflation measures | | | | |
|---|---|---|---|---|---|
| | Headline CPI | Core PCE | Headline PCE | Core good CPI | Core service CPI |
| Unemployment gap | $-0.530^{***}$ | $-0.278^{***}$ | $-0.363^{***}$ | $-0.775^{**}$ | $-0.287^{***}$ |
| | (0.122) | (0.100) | (0.132) | (0.305) | (0.084) |
| Infl. expectation (2y) | 0.411 | $-0.015$ | 0.054 | 0.118 | $0.461^{***}$ |
| | (0.308) | (0.176) | (0.254) | (0.463) | (0.142) |
| Productivity | 0.179 | $0.160^{***}$ | $0.239^{**}$ | $0.411^{**}$ | $-0.069$ |
| | (0.124) | (0.052) | (0.096) | (0.194) | (0.079) |
| Oil price inflation | 0.109 | $-0.011$ | $-0.033$ | 0.012 | 0.069 |
| | (0.141) | (0.074) | (0.105) | (0.220) | (0.067) |
| Labour part. rate | $-0.142$ | $-0.049$ | $-0.080$ | $-0.038$ | $-0.158^{**}$ |
| | (0.129) | (0.056) | (0.110) | (0.159) | (0.074) |
| Lagged inflation | 0.182 | $1.232^{***}$ | 0.560 | $0.848^{***}$ | $0.932^{***}$ |
| | (0.408) | (0.207) | (0.408) | (0.193) | (0.148) |
| Adj. $R^2$ | 0.211 | 0.616 | 0.248 | 0.423 | 0.646 |
| Num. obs. | 409 | 408 | 408 | 409 | 409 |
| RMSE | 1.320 | 0.562 | 1.073 | 1.540 | 0.615 |

*Notes:* Asteriks indicate significance at the 1%, 5%, and 10% level ($^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$). Standard errors are NW corrected. The constant term is omitted from the table.

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# ECI wages inflation across different periods

| | Employment cost (wage) inflation - 12-months ahead | | | | |
|---|---|---|---|---|---|
| | Whole (91-24) | Great Mod. (91-07) | Great Rec. (07-19) | Post GFC (10-19) | Pre COV. (91-19) |
| Unemployment gap | $-0.244^{***}$ | $-0.259^{***}$ | $0.180^{***}$ | 0.169 | $-0.062$ |
| | (0.072) | (0.090) | (0.054) | (0.141) | (0.069) |
| Infl. expectation (2y) | 0.129 | $1.106^{***}$ | $0.572^{**}$ | $0.716^{***}$ | $0.940^{***}$ |
| | (0.297) | (0.210) | (0.257) | (0.139) | (0.282) |
| Productivity | 0.002 | $-0.113^{***}$ | $-0.017$ | 0.046 | 0.032 |
| | (0.065) | (0.039) | (0.069) | (0.046) | (0.054) |
| Oil price inflation | $0.128^{**}$ | $-0.209^{***}$ | $0.100^{**}$ | $0.108^{**}$ | 0.039 |
| | (0.052) | (0.050) | (0.041) | (0.041) | (0.045) |
| Labour part. rate | $-0.084^{**}$ | 0.128 | $-0.413^{***}$ | $-0.445^{***}$ | $-0.156^{***}$ |
| | (0.034) | (0.174) | (0.047) | (0.049) | (0.051) |
| Lagged inflation | $1.371^{***}$ | $-0.391^{***}$ | $0.542^{**}$ | 0.376 | $0.562^{*}$ |
| | (0.224) | (0.119) | (0.255) | (0.227) | (0.305) |
| Adj. $R^2$ | 0.801 | 0.647 | 0.780 | 0.810 | 0.612 |
| Num. obs. | 92 | 25 | 47 | 40 | 74 |
| RMSE | 0.417 | 0.208 | 0.246 | 0.220 | 0.364 |

*Notes:* Asteriks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$; **$p < 0.05$; *$p < 0.1$). Standard errors are NW corrected. The constant term is omitted from the table.

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# Alternative slack measures - employment cost

| | Employment cost (wage) inflation 12m ahead: alternatives | | | | | | |
|---|---|---|---|---|---|---|---|
| | U gap | Change u rate | U gap and Change | V/U | U gap and V/U | Natural u gap | Output gap |
| Unemployment gap | −0.244*** | | −0.241*** | | −0.288*** | | |
| | (0.072) | | (0.071) | | (0.063) | | |
| Change in unempl. | | −0.094 | −0.029 | | | | |
| | | (0.086) | (0.072) | | | | |
| Vacancy/unemployment | | | | −0.197 | 0.614 | | |
| | | | | (0.662) | (0.680) | | |
| Natural u gap | | | | | | 0.000 | |
| | | | | | | (0.001) | |
| Output gap | | | | | | | 0.018 |
| | | | | | | | (0.069) |
| Infl. expectation (2y) | 0.129 | 0.170 | 0.119 | 0.259 | −0.059 | 0.226 | 0.170 |
| | (0.297) | (0.370) | (0.310) | (0.301) | (0.228) | (0.332) | (0.309) |
| Productivity | 0.002 | 0.140 | 0.016 | 0.096 | −0.009 | 0.094 | 0.105 |
| | (0.065) | (0.096) | (0.063) | (0.077) | (0.065) | (0.067) | (0.069) |
| Oil price inflation | 0.128** | 0.154* | 0.122** | 0.170** | 0.128** | 0.170** | 0.172** |
| | (0.052) | (0.079) | (0.052) | (0.070) | (0.057) | (0.068) | (0.079) |
| Labour part. rate | −0.084** | −0.178*** | −0.082** | −0.218* | 0.027 | −0.189*** | −0.186*** |
| | (0.034) | (0.048) | (0.034) | (0.128) | (0.103) | (0.052) | (0.053) |
| Lagged inflation | 1.371*** | 1.301*** | 1.377*** | 1.372*** | 1.097** | 1.300*** | 1.252*** |
| | (0.224) | (0.248) | (0.230) | (0.490) | (0.500) | (0.304) | (0.299) |
| Adj. $R^2$ | 0.801 | 0.732 | 0.799 | 0.729 | 0.808 | 0.728 | 0.729 |
| Num. obs. | 92 | 92 | 92 | 92 | 92 | 92 | 92 |
| RMSE | 0.417 | 0.484 | 0.419 | 0.486 | 0.409 | 0.487 | 0.487 |

*Notes:* Asteriks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$; **$p < 0.05$; *$p < 0.1$). Standard errors are NW corrected. The constant term is omitted from the table.

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# Further wage inflation measures

| | Regression results for other wage inflation measures | |
|---|---|---|
| | Employment cost (total) | ULC |
| Unemployment gap | −0.703*** | −0.158*** |
| | (0.254) | (0.032) |
| Infl. expectation (2y) | 0.883*** | 0.104 |
| | (0.224) | (0.079) |
| Productivity | 0.151 | 0.089 |
| | (0.200) | (0.076) |
| Oil price inflation | 0.462*** | 0.115** |
| | (0.148) | (0.053) |
| Labour part. rate | −0.413*** | −0.021 |
| | (0.105) | (0.042) |
| Lagged inflation | −0.123 | 1.300*** |
| | (0.130) | (0.140) |
| Adj. $R^2$ | 0.404 | 0.654 |
| Num. obs. | 136 | 136 |
| RMSE | 1.334 | 0.482 |

*Notes:* Asteriks indicate significance at the 1%, 5%, and 10% level (***$p < 0.01$; **$p < 0.05$; *$p < 0.1$). Standard errors are NW corrected. The constant term is omitted from the table.

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# RMSE: Out-of-sample fit for post-GFC & post-COVID period

| Inflation | Core CPI | Empl. Cost |
|---|---|---|
| (Stock) U rate | 0.123*** | 0.23** |
| | (0) | (0.022) |
| Natural u gap | 0.172*** | 0.296** |
| | (0) | (0.011) |
| Output gap | 0.258*** | 1.869*** |
| | (0) | (0) |
| V/U ratio | 0.666*** | -0.242 |
| | (0) | (0.995) |

(a) GFC period

| Inflation | Core CPI | Empl. Cost |
|---|---|---|
| (Stock) U rate | 0.118*** | 0.915*** |
| | (0) | (0) |
| Natural u gap | 0.114*** | 0.94*** |
| | (0) | (0) |
| Output gap | 0.117*** | 0.33*** |
| | (0) | (0) |
| V/U ratio | 0.155*** | 0.413*** |
| | (0) | (0.007) |

(b) COVID period

*Notes:* Values represent percentage deviations from benchmark RMSE. Asterisks indicate whether an alternative model performs worse. Statistical significance is assessed using the Diebold and Mariano (1995) test. CBO = Congressional Budget Office, V/U = vacancy-to-unemployment ratio.

- Improvement of out-of-sample RMSE by $> 10\%$

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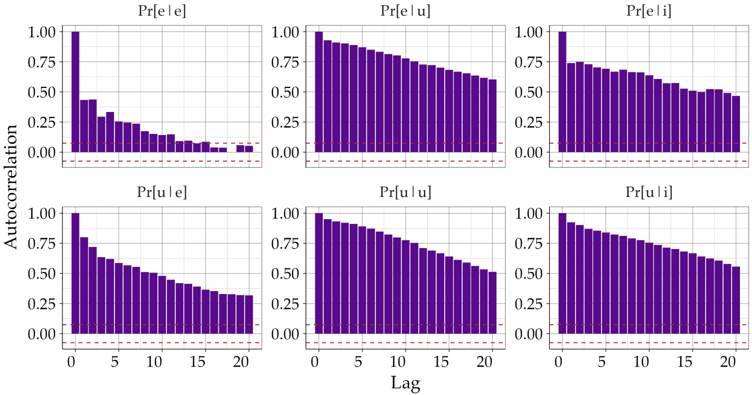
# Persistence in transition probabilities (data)




- Transition probabilities very persistent (except for E-to-E)
- Hiring rate $h$, i.e. job-finding $\Pr[e|u]$, very persistent

Note: Two observations dropped March and April 2020.

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