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   - Topic folders, subfolders within topic folder, programming files, etc.
   - Track your steps so at the end with "one click" you can go from raw data to published tables and figures (ideally).

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6. Be purposeful in topic selection, in specification, and in writing.
   - Don't do X just because ABC did X, unless point is contrast with ABC.

Miscellaneous presentation advice

1. Keep slides clean.
   - Ideally one line per bullet.
   - Text, figures, and tables legible from the back of the room.
   - Model yourself on other presentation slides, not teaching slides.
2. Adapt presentation to presentation slot:
   - Rule of thumb: two minutes per slide.
   - Explain everything or tell us what we can gloss over.
   - Lunch presentation different format and objective from job talk.
3. Practice: I have seen senior professors give a paper multiple times using *exactly* the same "script".

COVID-19

- Has already spawned thousands of research papers.
- I doubt many of the papers that will be most read 10 years from now have yet been written.
- Your cohort will be perfectly timed to do serious research using micro data.
- Start thinking about ideas now.

Lecture VIII

Harvard Econ 2416
Professor Gabriel Chodorow-Reich
Spring 2021

Outline

Outline

Why labor search models are popular

- Explaining unemployment is one of the great challenges in economics.
- Labor search models generate equilibrium unemployment.
  - No bilateral inefficiency.
- Asymmetry of unemployment changes: firing easy, hiring hard.
- Sufficiently tractable to embed in larger scale models.
- Framework has expanded to cover different types of search (random, directed, etc.) and different applications (money, securities, housing).

Macro search verus micro search

- We will focus today on macro search questions:
  - General equilbrium.
  - Firm vacancy posting plays central role.
- Micro search questions:
  - Typically partial equilibrium: offer arrival rate taken as given.
  - What determines individuals' job search effort?
  - How do individuals and firms go about search? Open black box of matching function.
  - Can search frictions justify within-cell wage inequality?
- Obviously these approaches may intersect for many questions.

Unemployment volatility ("Shimer") puzzle

- Canonical model does not generate unemployment volatility (Shimer AER 2005).
- Basic problem: adjustment in wages smooths value to firm of hiring, which undoes negative shock.
- Lots of proposed solutions. Few empirical moments to distinguish them.

Focus on hiring margin today

- Hall (JPE 2009) and Shimer (RED 2012): separations are acyclical, changes in unemployment driven by changes in job finding rates.
- Controversial: separations roughly acyclical but layoffs strongly countercyclical, offset by procyclical quits.
- Models emphasizing separation margin:
  - Mortensen and Pissarides (RESTUD 1994): endogenous job destruction.
  - Elsby, Michaels and Solon (AEJ: Macro 2009): "traffic light" theory.
  - Coles and Kelishomi (AEJ: Macro 2018): separation shocks important if free entry condition fails.
- Focus on hiring margin means focus on vacancy creation decision.

Outline

Outline

Theoretical concepts

- Hours worked: input into production.
- Hours paid: includes vacation, sick, bad weather, etc.
- Non-employment: no hours worked or paid.
- Non-employed characterized by search effort and reservation wage.
  - Job-finding $= F$(tightness, search effort, reservation wage), $F_1 > 0, F_2 > 0, F_3 < 0$.
- Underemployment: Positive hours worked or paid but would prefer more hours worked.

Measurement: official unemployment rate

- History: developed during the 1930s at the WPA and the Census Bureau.
- Employed: People are classified as employed if they did any work at all as paid employees during the reference week; worked in their own business, profession, or on their own farm; or worked without pay at least 15 hours in a family business or farm. People are also counted as employed if they were temporarily absent from their jobs because of illness, bad weather, vacation, labor-management disputes, or personal reasons.
- Unemployed: People are classified as unemployed if they meet all of the following criteria: they had no employment during the reference week; they were available for work at that time; and they made specific efforts to find employment sometime during the 4-week period ending with the reference week. Persons laid off from a job and expecting recall need not be looking for work to be counted as unemployed.
- Unemployment rate: The civilian labor force is the sum of employed and unemployed persons. The unemployment rate is the number unemployed as a percent of the labor force.
- Survey reference week: calendar week that contains the 12th day of the month.

OTHER MEASURES

HOUSEHOLD DATA

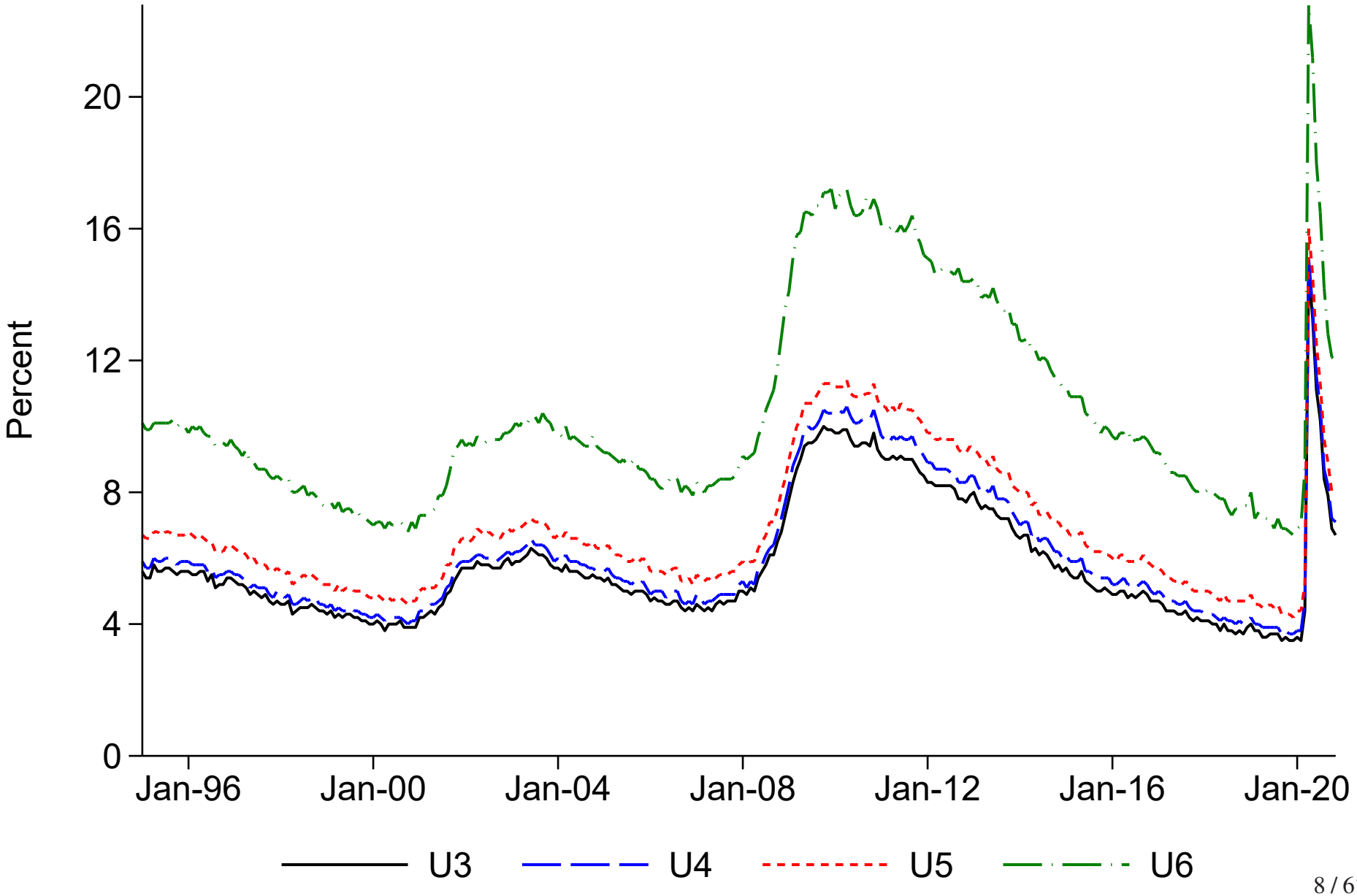
Table A-15. Alternative measures of labor underutilization

[Percent]

Measure	Not seasonally adjusted			Seasonally adjusted					
	Aug. 2015	July 2016	Aug. 2016	Aug. 2015	Apr. 2016	May 2016	June 2016	July 2016	Aug. 2016
U-1 Persons unemployed 15 weeks or longer, as a percent of the civilian labor force	2.1	1.9	1.8	2.2	2.1	1.9	2.0	2.0	1.9
U-2 Job losers and persons who completed temporary jobs, as a percent of the civilian labor force	2.5	2.4	2.4	2.6	2.4	2.3	2.4	2.3	2.4
U-3 Total unemployed, as a percent of the civilian labor force (official unemployment rate)	5.2	5.1	5.0	5.1	5.0	4.7	4.9	4.9	4.9
U-4 Total unemployed plus discouraged workers, as a percent of the civilian labor force plus discouraged workers	5.6	5.5	5.3	5.5	5.3	5.0	5.2	5.2	5.3
U-5 Total unemployed, plus discouraged workers, plus all other persons marginally attached to the labor force, as a percent of the civilian labor force plus all persons marginally attached to the labor force	6.3	6.3	6.0	6.2	6.0	5.7	6.0	6.0	5.9
U-6 Total unemployed, plus all persons marginally attached to the labor force, plus total employed part time for economic reasons, as a percent of the civilian labor force plus all persons marginally attached to the labor force	10.3	10.1	9.7	10.3	9.7	9.7	9.6	9.7	9.7

NOTE: Persons marginally attached to the labor force are those who currently are neither working nor looking for work but indicate that they want and are available for a job and have looked for work sometime in the past 12 months. Discouraged workers, a subset of the marginally attached, have given a job-market related reason for not currently looking for work. Persons employed part time for economic reasons are those who want and are available for full-time work but have had to settle for a part-time schedule. Updated population controls are introduced annually with the release of January data.

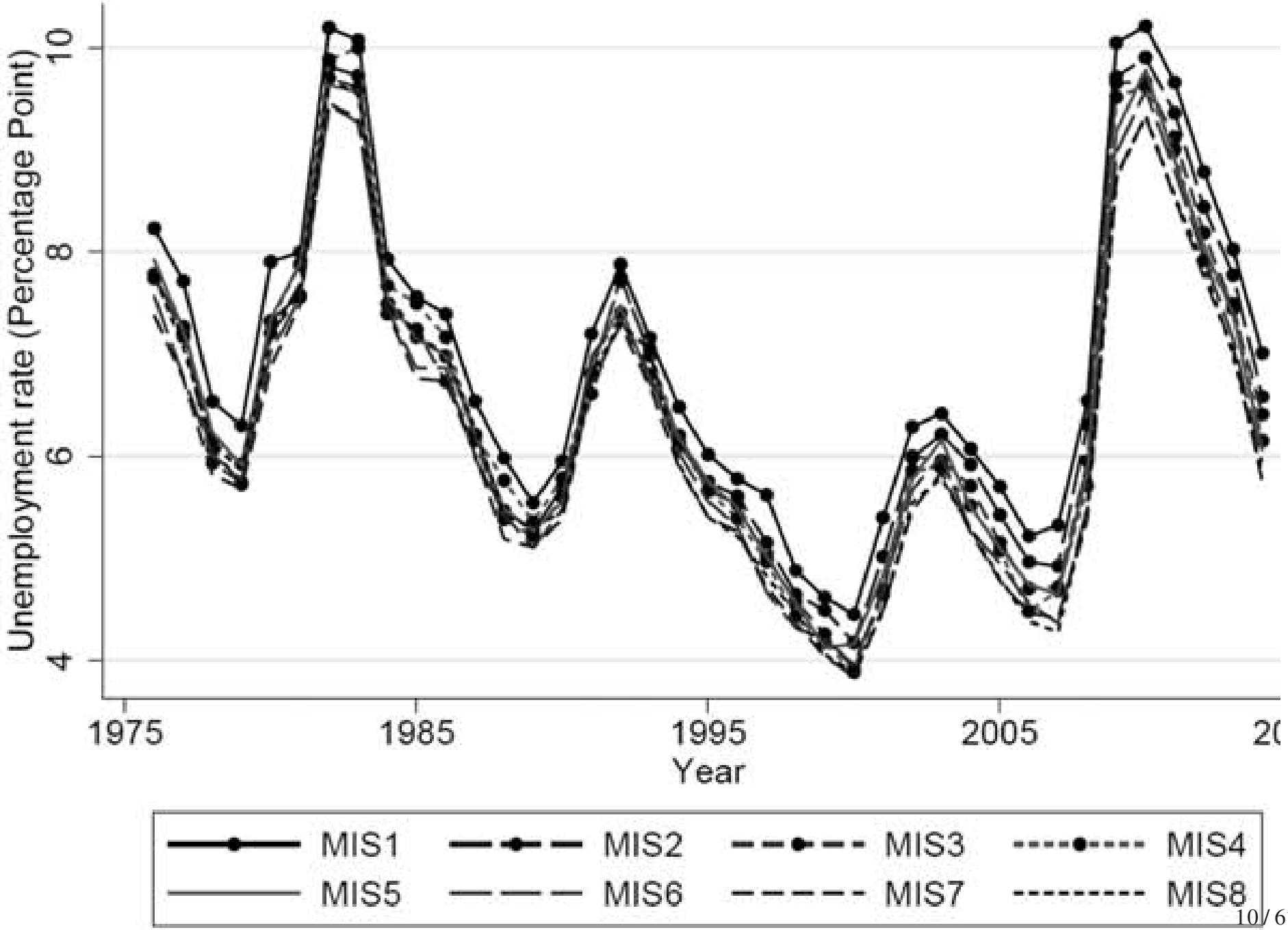
MEASURES OF UNDER-EMPLOYMENT



Making definition operational: CPS

- Roughly 60,000 households per month.
- Rotation group structure: household in sample for four months, out for eight months, in for four months.
- Since 1994, reference-dependent survey questionnaire.
- Geographic stratified sampling procedure:
  - U.S. divided into sets of contiguous counties (PSUs).
  - Large PSUs in sample w.p. 1.
  - Smaller PSUs grouped into strata and one PSU per strata in sample each decade.
  - Within PSU, clusters of geographically adjacent addresses drawn so that entering addresses replace geographically close exiting addresses.
- Official statistics based on weighted average of current level and changes among repeat respondents.
- Separate from "Establishment survey" (CES) which obtains payroll from 147,000 firms (634,000 establishments) each month. CES is larger sample (and near universe after benchmarking to administrative UI records) but no information on activity of non-employed.

ROTATION GROUP BIAS (KMX RESTAT 2017)



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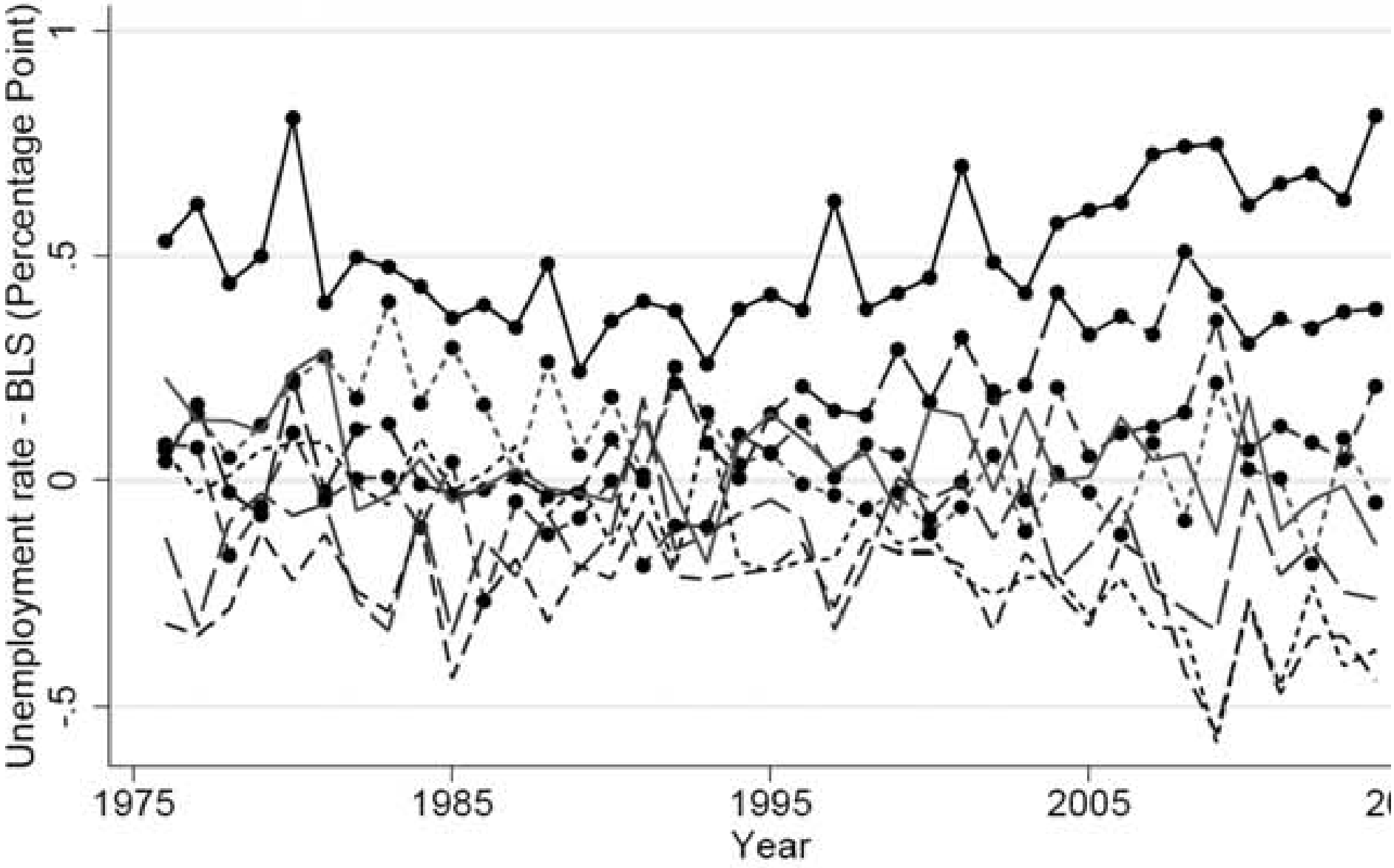
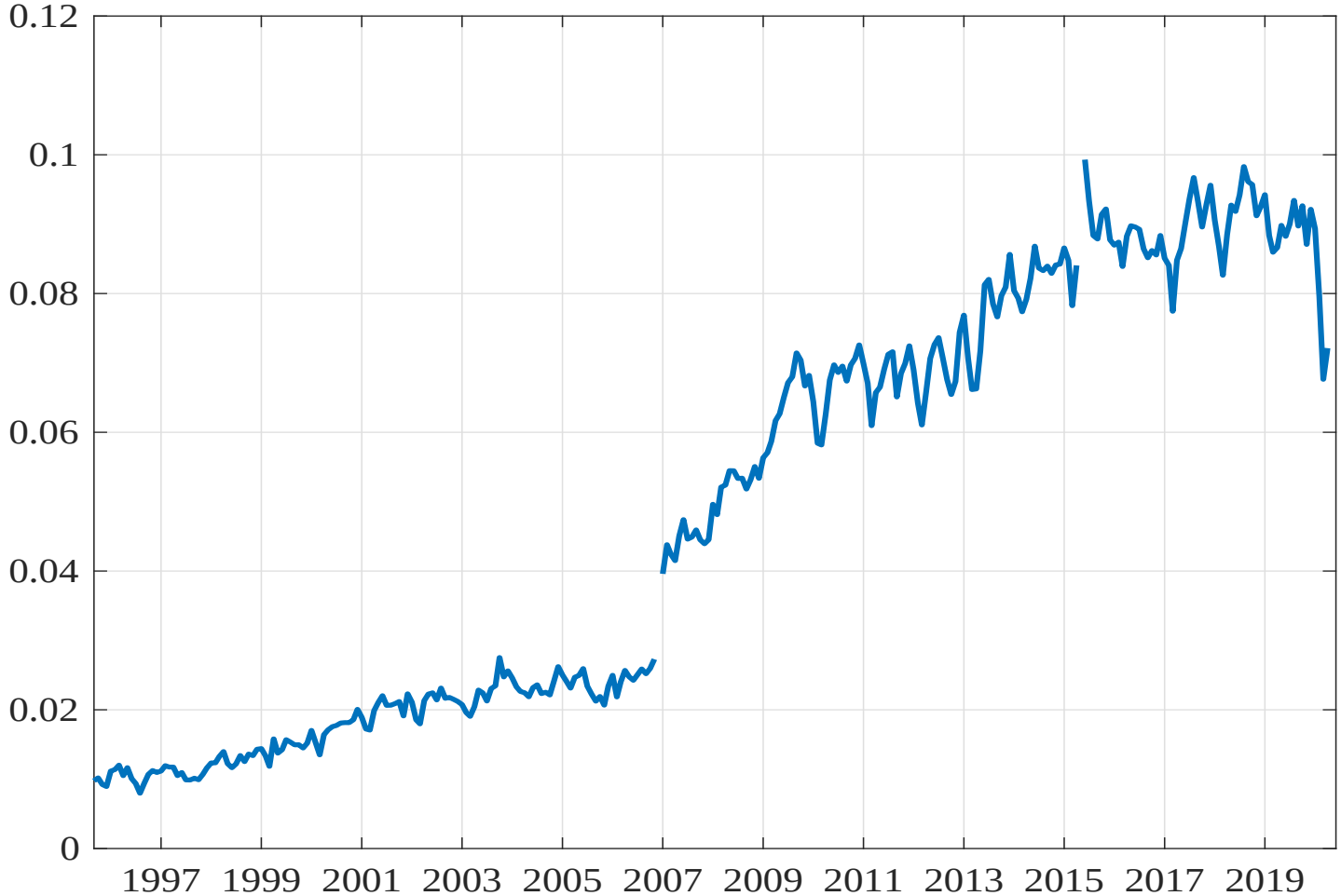


Table 4
Discrepancies in Employment Status between CPS and UI Data

	Not In-Scope Worker in UI	In-Scope Worker in UI
Not in-scope worker in CPS	$X_{NH,NE}$	$X_{NH,E}$
Overall share	.371	.034
	(.001)	(.000)
Row share	.917	.083
	(.001)	(.001)
Column share	.779	.064
	(.001)	(.001)
In-scope worker in CPS	$X_{H,NE}$	$X_{H,E}$
Overall share	.105	.491
	(.000)	(.001)
Row share	.176	.824
	(.001)	(.001)
Column share	.221	.936
	(.001)	(.001)

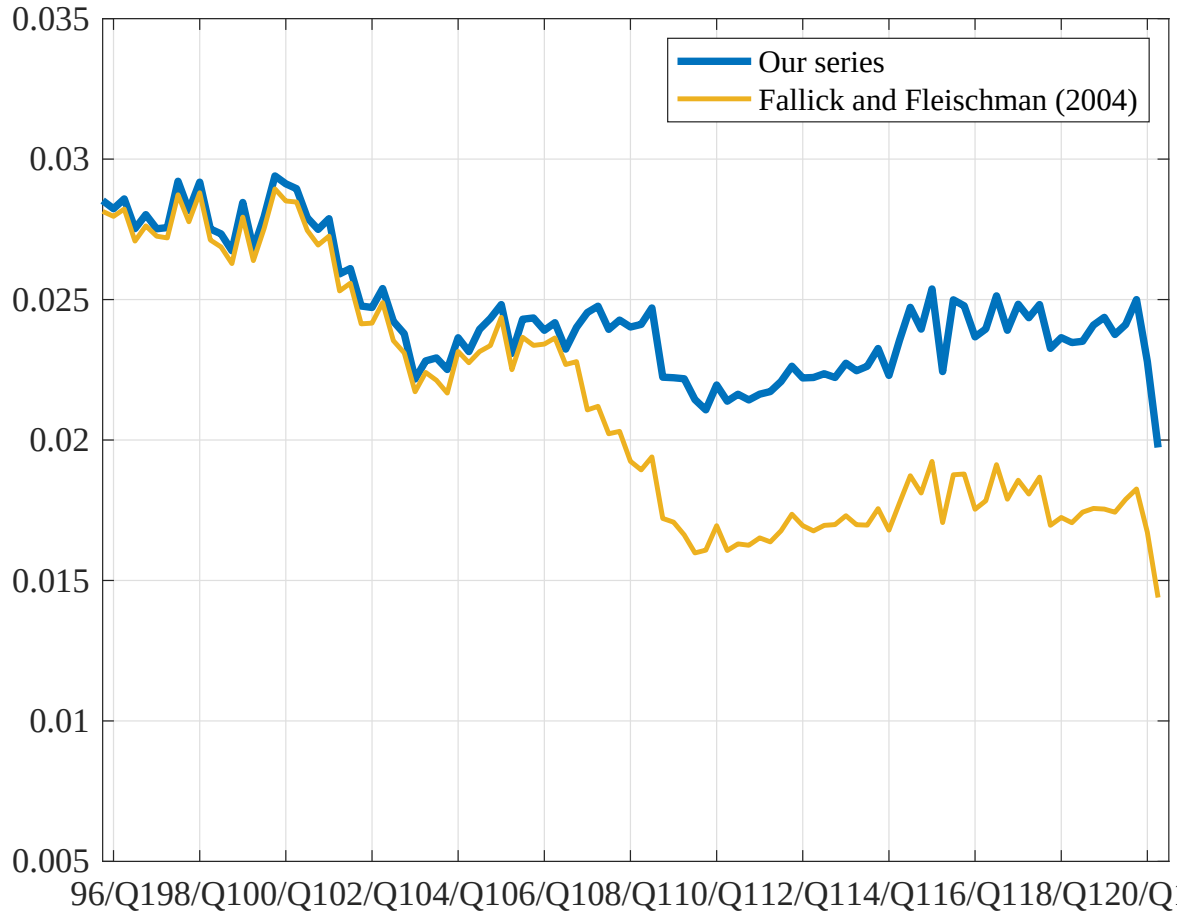
NOTE.—Weighted shares of the CPS-UI overlap sample described in the text. In-scope is defined as wage and salary employment in the private sector excluding agriculture and private household jobs, plus state and local government employment. Pooled data for all years 1996–2003. Standard errors in parentheses.

Non-response share to J2J question



- Question: "Last month it was reported that (name/you) worked for __. (Do/Does) (you/he/she) still work for __?"
- Beginning in January 2008 respondents could opt not to share their answers with future household members answering questionnaire.

Job-to-job transitions



Missing observations non-random. Adjusted series from Fujita, Moscarini, Postel-Vinay, "Measuring Employer-to-Employer Reallocation".

Other sources of labor market data

1. Census/ACS: larger sample than CPS but less coverage of job search.
2. LDB/QCEW: monthly employment and quarterly payroll by county-industry based on administrative UI tax records.
3. LBD/CBP: annual (March) employment by county-industry based on Business Register.
4. LEHD/QWI: employer-employee matched panel of employment and quarterly earnings based on administrative UI tax records.
5. LAUS: state/city/county employment and unemployment based on CPS, QCEW, UI claims, and hidden-state model.

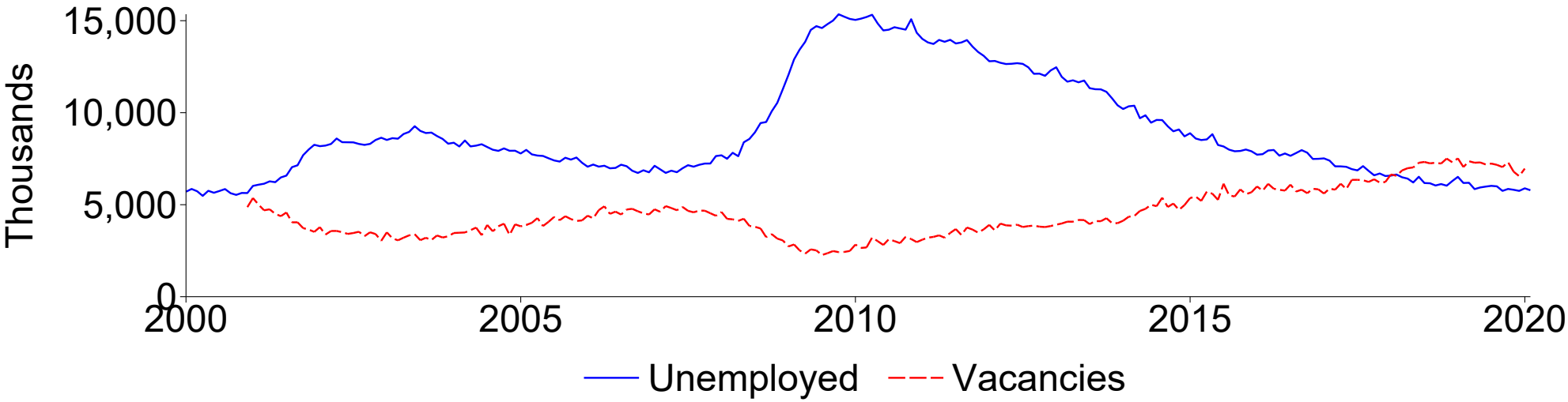
Lessons

- You don't need to go into this amount of detail for every data set you use in a paper.

- Depends why you're using the data. If it's a VAR in u, π, and i, probably okay. If you're interested in arma properties of u it matters.

Outline

PRIMA FACIE EVIDENCE OF MATCHING FRICTIONS



- Median unemployment duration: 5-25 weeks.
- Average vacancy duration: 1 month.

Large gross flows

Share of working-age population making labor force status transition:

	E_t	U_t	N_t	All
E_{t-1}	59.15	0.77	1.65	61.58
U_{t-1}	0.88	1.95	0.83	3.66
N_{t-1}	1.54	0.84	32.40	34.77
All	61.57	3.56	34.88	100.00

Fallick and Fleischman, `http://www.federalreserve.gov/pubs/feds/2004/200434/200434abs.html`.

- Flows from N to E *larger* than flows from U to E.
- Transitions into and out of labor force historically viewed as acyclical.
- Transition *hazard* much larger for U than N.

Heterogeneity within unemployed

Table 1 Nonemployment by BLS Categories

	1	2	3	4	5	6
	Share of Working-Age Population			Employment Probability		
	1994–2013	2007	2010	1994–2013	2007	2010
	Unemployed					
Short-term	3.0	2.5	3.5	28.0	29.7	21.8
Long-term	1.0	0.5	2.7	14.4	15.5	10.3
	OLF, Want a Job					
Marginally attached, discouraged	0.2	0.2	0.5	13.1	16.5	10.7
Marginally attached, other	0.4	0.3	0.3	12.7	14.9	10.2
Other	1.8	1.5	1.7	14.5	15.7	12.1
	OLF, Do Not Want a Job					
Other, in school	4.1	4.5	5.0	8.5	8.2	6.2
Other, not in school	7.4	7.2	7.0	7.5	8.1	6.9
Disabled	4.6	4.8	5.2	1.7	1.7	1.4
Retired	15.4	15.2	15.4	1.4	1.5	1.4

Source: Hornstein, Kudlyak, Lange (EQ, 2014).

Heterogeneity within unemployed

Table 2 Nonemployment by Labor Force Status Histories

	1	2	3	4	5	6	7	8
	Share of Working-Age Population				Employment Probability			
	1976–2014	1994–2014	2007	2010	1976–2014	1994–2014	2007	2010
	Currently Unemployed							
Recent employment	1.3	1.2	1.1	1.4	38.8	39.2	40.7	34.2
No recent employment	1.1	1.1	0.8	1.5	17.1	16.0	17.2	9.6
Continuously unemployed	1.4	1.3	0.8	2.8	17.7	17.2	19.0	11.0
	Currently OLF							
Recent employment	2.9	2.8	3.0	2.6	27.7	27.1	27.8	27.6
No recent employment	1.3	1.3	1.0	1.9	9.6	9.5	9.6	7.1
Continuously OLF	30.9	30.2	30.4	31.1	2.0	1.8	1.8	1.5

Notes: The first set of rows covers those nonemployed who are unemployed in the current month and the second set covers those nonemployed who are OLF in the current month. For each group, the first row (Recent employment) denotes those who have been employed at least once in the previous two months; the second row denotes those who have not been employed in any of the previous two months but also not unemployed/OLF in both months; and the last row denotes those who have been unemployed/OLF in both of the previous two months. The share of working-age population and the employment probability are in percent.

Active literature on heterogeneity

- Kroft, Notowidigdo, and Lange (2013); Fujita and Moscarini (2013); Krueger and Cho (2014); Hornstein, Kudlyak, and Lange (2014); Hall and Schoefer-Wohl (2015); Alvarez, Borovickova, and Shimer (2015); Ahn and Hamilton (2015); Jarosch (2015).

- May be important for quantitative interpretation of models.

- May be important for issues such as hysteresis.

- Ignore it for rest of today.

UNEMPLOYMENT VERSUS TEMPORARY WORK

Month	*Out of labor force*	*Unemployment*	*Short-term job*	*Long-term job*
0	0	100	0	0
1	26	39	17	18
2	31	21	18	29
3	32	15	18	35
4	32	13	17	38
∞	29	10	18	44

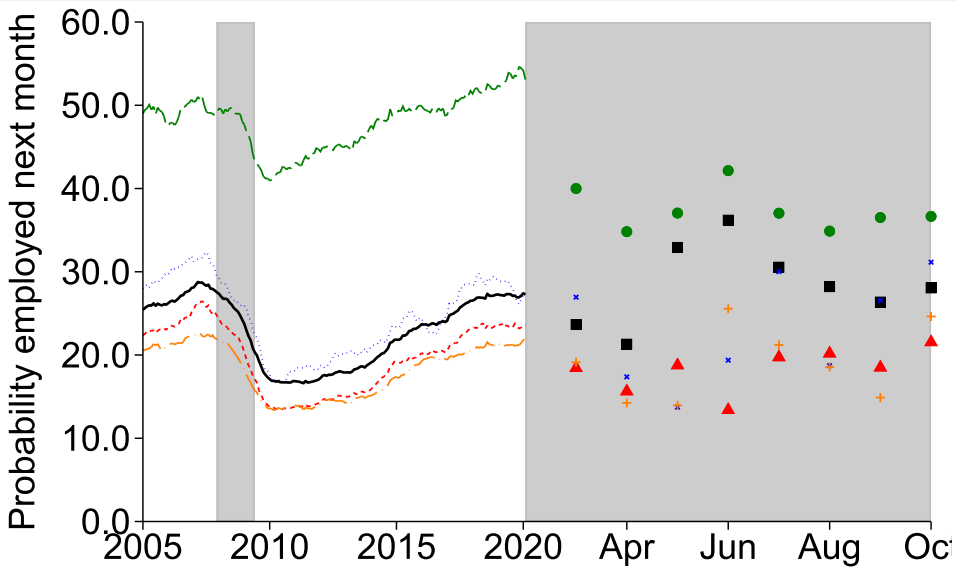
Source: Hall and Kudlyak (WP).

Other margins we'll ignore

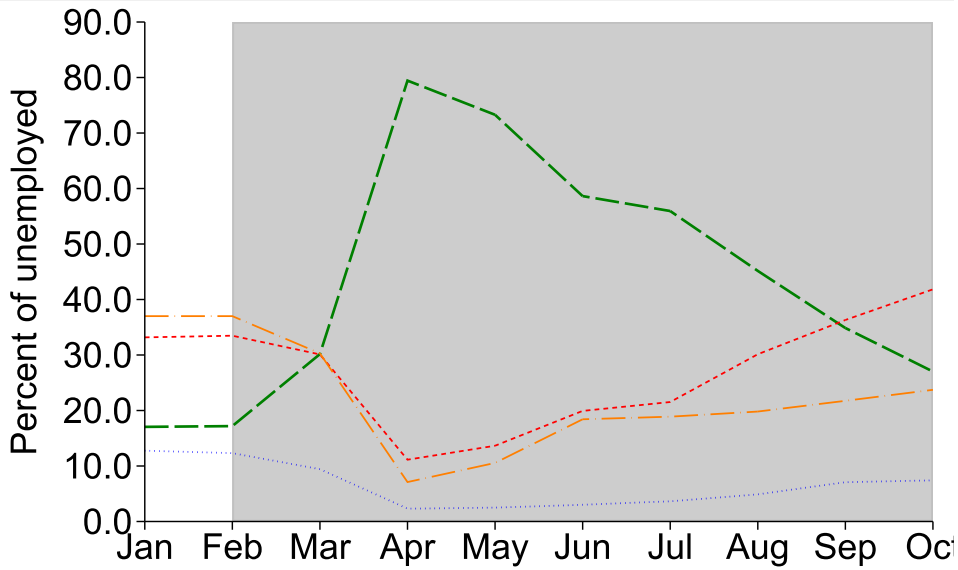
- On-the-job search.
  - Important for quantifying total search effort and estimating matching functions.
  - Important for income dynamics.
- Labor force participation.
  - Trend decline in data.

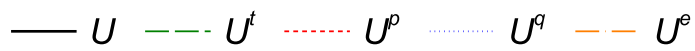
COVID IS DIFFERENT

Re-employment hazards



2020 unemployment distribution





Source: Chodorow-Reich and Coglianese (JPUBE, 2021).

Outline

Ingredients

- Agents employed (mass e) or unemployed (mass u), $e+u=1$.
- Mass v of vacancies posted at cost c per vacancy.
- Matching function $m(u,v)=Mu^{1-\eta}v^{\eta}$.
- Market tightness: $\theta=v/u$.
- Exogenous separation probability s.
- Agent produces p if employed or z if unemployed.
- Discount future with factor δ.

Model equations

- Value functions:

$$\text{Unemployment:} \quad U = z + \delta\left\{f(\theta)\, E\left[W'\right] + [1 - f(\theta)]\, E\left[U'\right]\right\}. \tag{1}$$

$$\text{Employment:} \quad W = w + \delta\left\{[1-s]\, E\left[W'\right] + sE\left[U'\right]\right\}. \tag{2}$$

$$\text{Job:} \quad J = p - w + \delta\left\{[1-s]\, E\left[J'\right] + sE[V']\right\}, \tag{3}$$

$$\text{Vacancy:} \quad V = -c + \delta\left\{q(\theta)\, E\left[J'\right] + [1 - q(\theta)]\, E\left[V'\right]\right\}. \tag{4}$$

- Free entry condition:

$$V = 0. \tag{5}$$

- Endogenous transition probabilities:

$$\text{Job-finding:} \quad f(\theta) = \frac{m(u,v)}{u} = M\theta^{\eta}. \tag{6}$$

$$\text{Vacancy-filling:} \quad q(\theta) = \frac{m(u,v)}{v} = M\theta^{\eta-1} = \frac{f(\theta)}{\theta}. \tag{7}$$

Next steps

1. Treat w as free parameter and solve model in steady state as $\delta \to 1$.
2. Comparative statics of this model.
3. Comparative statics with Nash bargaining.
4. Chodorow-Reich and Karabarbounis critique.

Solution

$$
\begin{aligned}
\text{(3) and (5):} \quad & J = (p-w)/s, \\
\text{(4) and (5):} \quad & q = c/J \\
\text{Combine:} \quad & = \frac{cs}{p-w}, \\
\text{(7):} \quad & q = M\theta^{\eta-1}, \\
\text{Combine:} \quad & \theta = \left(\frac{cs}{M(p-w)}\right)^{\frac{1}{\eta-1}}, \\
\text{(1) and (2):} \quad & W-U = (w-z)+(1-s-f)(W-U) \\
& = \frac{w-z}{s+f}, \\
\text{Match surplus:} \quad & S = J+W-U.
\end{aligned}
$$

Unemployment volatility

- We solved the model assuming time-invariant parameters.
- To consider volatility, we will take a short-cut and compare across steady-states.
- This turns out to be okay because labor market converges very quickly to steady state in this model.
- Not okay in richer models with more dynamics such as due to capital or other slow moving state variables.
- Formally, comparative static of θ w.r.t. p allowing for wage to change endogenously in response to p.

Comparative static

$$\theta = \left(\frac{cs}{M(p-w)} \right)^{\frac{1}{\eta-1}},$$

$$\frac{d\ln\theta}{d\ln p} = \left(\frac{1}{1-\eta} \right) \frac{d\ln(p-w)}{d\ln p} \propto \frac{1}{p-w} \frac{d(p-w)}{d\ln p} = \frac{p - w\left(\frac{d\ln w}{d\ln p}\right)}{p-w}.$$

- If wages increase one-for-one with p, $dw/dp = 1$, no extra incentive for firms to hire and no change in unemployment: $w \times d\ln w/d\ln p = w \times p/w \times dw/dp = p \Rightarrow d\ln\theta/d\ln p = 0$.
- If wages are sticky, $d\ln w/d\ln p = 0$, then job-finding increases by $p/(p-w)$. Ljungvist and Sargent call this *fundamental surplus*.
- Closer is w to p, larger is percent increase in firm profits if p increases.

Nash wage equation

- Nash assumption: $J = (1-\beta)S, (W-U) = \beta S$.
- Worker, firm, match surplus out of steady state:

$$W - U = [w - z] + [1 - s - f(\theta)]\beta E\left[S'\right].$$
$$J = [p - w] + [1 - s][1 - \beta] E\left[S'\right].$$
$$S = [p - z] + [1 - s - \beta f(\theta)] E\left[S'\right].$$

- Free entry condition: $E[J'] = \frac{c}{q(\theta)} = \frac{c\theta}{f(\theta)} \Rightarrow E[S'] = \frac{c\theta}{(1-\beta)f(\theta)}$.
- Substitute into worker surplus:

$$\beta\left[[p - z] + [1 - s - \beta f(\theta)]\frac{c\theta}{(1-\beta)f(\theta)}\right]$$
$$= [w - z] + [1 - s - f(\theta)]\beta\frac{c\theta}{(1-\beta)f(\theta)}.$$

- Solve for w:

$$w = (1-\beta)z + \beta p + (1-\beta)\beta f(\theta)\frac{c\theta}{(1-\beta)f(\theta)}$$
$$= z + (1-\beta)(p - z) + \beta\theta c.$$

Nash wage interpretation

$$w = z + (1-\beta)(p-z) + \beta\theta c.$$

- Period wage is worker's flow opportunity cost z, plus share of surplus $(1-\beta)(p-z)$, plus labor market tightness term.
- Nash wage is procyclical (comoves with p), because flow surplus is procyclical and because labor market tightness comoves with p.
- Intuition: worker's threat point in bargain is to return to unemployment pool. Value of unemployment depends on flow value z and likelihood of finding another job soon, which is increasing in labor market tightness.

Comparative static with Nash

- Surplus: $S = [p-z] + [1-s-\beta f(\theta)]S = \frac{p-z}{s+\beta f(\theta)}$.
- Substitute into free entry condition $[1-\beta]S = \frac{c}{q(\theta)}$:

$$\frac{[1-\beta][p-z]}{s+\beta f(\theta)} = \frac{c}{q(\theta)}.$$

- One equation in parameters β, c, z exogenous processes p, s, and endogenous variable θ.
- Implicitly differentiate w.r.t. p and solve:

$$\varepsilon_{\theta,p} = \frac{\beta f(\theta)+s}{\beta f(\theta)+s(1-\eta)}\left[\frac{p}{p-z}\right].$$

- Data: $\varepsilon_{\theta,p} \approx 20$.
- First term varies between about 1 and 2 for $\beta \subseteq [0,1]$ and plausible parameter values.
- Shimer (AER 2005) sets $p = 1, z = 0.4 \Longrightarrow \varepsilon_{\theta,p} \leq 3.33 << 20$.

SHIMER (AER, 2005) PUZZLE INTERPRETATION

- Shimer sets $p = 1, z = 0.4 \Longrightarrow \varepsilon_{\theta,p} \leq 3.33 << 20$.
- Present value of wages at hiring depends on present value of productivity and the worker's threat point.
- With Nash bargaining, worker's threat point is the value of the unemployment state:

$$U_t = z + \delta \left\{ f(\theta_t) E[W_{t+1}] + (1 - f(\theta_t)) E[U_{t+1}] \right\}$$
$$= E_t \sum_{s=t}^{\infty} \delta^{s-t} \pi_{s|t} z + E_t \sum_{s=t+1}^{\infty} \delta^{s-t} \pi_{s-1|t} f(\theta_{s-1}) W_s.$$

  - $\pi_{s|t}$: survival probability of remaining unemployed in period s.
- Second term is highly procyclical: job-finding probability and value of job are higher in good states.
- z low and constant $\Longrightarrow$ U_t highly procyclical $\Longrightarrow$ wages procyclical.
- z low $\Longrightarrow$ steady state wage low $\Longrightarrow$ steady state profits high.
- Large steady state profits and procyclical wages $\Longrightarrow$ log profits weakly cyclical $\Longrightarrow$ dampened vacancy creation.

Hagedorn & Manovskii (AER, 2008) calibration

$$\varepsilon_{\theta,p} = \left[\beta f(\theta) - \frac{[1-\delta(1-s)][\eta-1]}{\delta}\right]^{-1}\left[\frac{1-\delta[1-s]}{\delta} + \beta f(\theta)\right]\left[\frac{p}{p-z}\right].$$

- As $z \to p, \varepsilon_{\theta,p} \to \infty$.
- Discount rate δ, separation rate s, job finding rate f, $\eta =$ elasticity of f w.r.t θ directly calibrated.
- β, z chosen to match average labor market tightness given vacancy creation cost and cyclicality of wages.
- Wage rigidity matched by z high.
- Endogenous wage rigidity: value of leisure is large component of worker's outside option, and fixed.
- If terms in brackets ≈ 1, $z = 0.95p \Rightarrow \varepsilon_{\theta,p} \approx 20$.
- Example of small *fundamental surplus*.

Chodorow-Reich & Karabarbounis (JPE, 2016) critique

$$\varepsilon_{\theta,p} = [\text{Constant} \approx 1] \left[\frac{p - z\varepsilon_{z,p}}{p - z} \right].$$

Chodorow-Reich & Karabarbounis (JPE, 2016) critique

$$\varepsilon_{\theta,p} = [\text{Constant} \approx 1] \left[\frac{p - z\varepsilon_{z,p}}{p - z} \right].$$

- $\varepsilon_{z,p} = 0$:

Chodorow-Reich & Karabarbounis (JPE, 2016) critique

$$\varepsilon_{\theta,p} = [\text{Constant} \approx 1] \left[\frac{p}{p - z} \right].$$

- $\varepsilon_{z,p} = 0$:
  - $\varepsilon_{\theta,p}$ is large if $z \approx p$ (Hagedorn-Manovskii AER 2008).

Chodorow-Reich & Karabarbounis (JPE, 2016) critique

$$\varepsilon_{\theta,p} = [\text{Constant} \approx 1] \left[\frac{p - z\varepsilon_{z,p}}{p - z} \right].$$

- $\varepsilon_{z,p} = 0$:
  - $\varepsilon_{\theta,p}$ is large if $z \approx p$ (Hagedorn-Manovskii AER 2008).

- $\varepsilon_{z,p} = 1$:

Chodorow-Reich & Karabarbounis (JPE, 2016) critique

$$\varepsilon_{\theta,p} = [\text{Constant} \approx 1] \left[\frac{p - z}{p - z} \right].$$

- $\varepsilon_{z,p} = 0$:
  - $\varepsilon_{\theta,p}$ is large if $z \approx p$ (Hagedorn-Manovskii AER 2008).

- $\varepsilon_{z,p} = 1$:
  - $\varepsilon_{\theta,p}$ is independent of z.

Interpretation: endogenous wage rigidity

- With Nash bargaining, worker's threat point is the value of the unemployment state:

$$\begin{aligned}\tilde{U}_t^u =& z_t + \beta E_t \left[f_t \tilde{U}_{t+1}^e + (1 - f_t) \tilde{U}_{t+1}^u \right] \\ =& E_t \sum_{s=t}^{\infty} \beta^{s-t} \pi_{s|t} z_s + E_t \sum_{s=t+1}^{\infty} \beta^{s-t} \pi_{s-1|t} f_{s-1} \tilde{U}_s^e,\end{aligned}$$

- Large, fixed z partially insulates $\tilde{U}_t^u$ from business cycle, generating wage rigidity.
- If z is also procyclical, insulation goes away.
- Recall Nash wage equation:

$$w_t = \left(\frac{1}{N_t} \right) (\mu p_t^e + (1 - \mu) z_t + \mu \kappa_t \theta_t).$$

Overview

- What is z?
  1. Foregone government benefits.
  2. Foregone value of leisure and home production.
- Measurement of z allowing for curvature in utility function and explicit value of non-working time.

HOUSEHOLD'S PROBLEM

$$W^h(e_0; Z_0) = \max E_0 \sum_{t=0}^{\infty} \beta^t \left[e_t U^e(C_t^e, N_t) + (1 - e_t) U^u(C_t^u, 0) - TUC_t \right],$$

s.t.

$$(1+\tau_t^C)(e_t C_t^e + (1-e_t) C_t^u) + I_t + T_t = (1-\tau_t^w) w_t e_t N_t + (1-e_t) B_t + R_t K_t,$$

$$u_{t+1} = s_t (1-u_t) + (1-f_t) u_t,$$

$$K_{t+1} = (1-\delta) K_t + I_t.$$

- U^e, U^u: flow utility of employed and unemployed household members.
- C_t^e, C_t^u: per capita market consumption.
- N_t, w_t: market hours per employed and wage per hour.
- B_t: government benefits per unemployed worker.
- K_t, I_t: Capital stock, gross investment.
- e_t, u_t, s_t, f_t: Stock of employed, unemployed, exogenous separation rate, endogenous job finding rate.
- TUC_t: cost of taking up government benefits.

Value of an additional employed worker J_t^h

$$\frac{J_t^h}{\lambda_t} = \left(\frac{1-\tau_t^w}{1+\tau_t^C}\right) w_t N_t - z_t + (1-s_t-f_t) E_t \left(\frac{\beta \lambda_{t+1}}{\lambda_t}\right) \frac{J_{t+1}^h}{\lambda_{t+1}}.$$

- z_t: average opportunity cost of employment,

$$z_t = \underbrace{[B_t - TUC \text{ term}]}_{b_t} + \underbrace{\left(\frac{U_t^u}{\lambda_t} - C_t^u\right) - \left(\frac{U_t^e}{\lambda_t} - C_t^e\right)}_{\xi_t}.$$

Value of time in the opportunity cost

$$z_t = b_t + \xi_t$$

$$\xi_t = \frac{[U_t^u(C_t^u, 0) - \lambda_t C_t^u] - [U_t^e(C_t^e, N_t) - \lambda_t C_t^e]}{\lambda_t}.$$

- ξ_t gives the difference in the contribution of non-working time to utility, converted into units of market consumption.

- Separable example: $U_t(C_t, N_t) = u(C_t) - v(N_t),\ v(0) = 0$:

$$\xi_t = \frac{v(N_t)}{\lambda_t}.$$

Intuition: why value of time is procyclical

- Separable preferences: $U_t(C_t, N_t) = u(C_t) - v(N_t),\ v(0) = 0$:

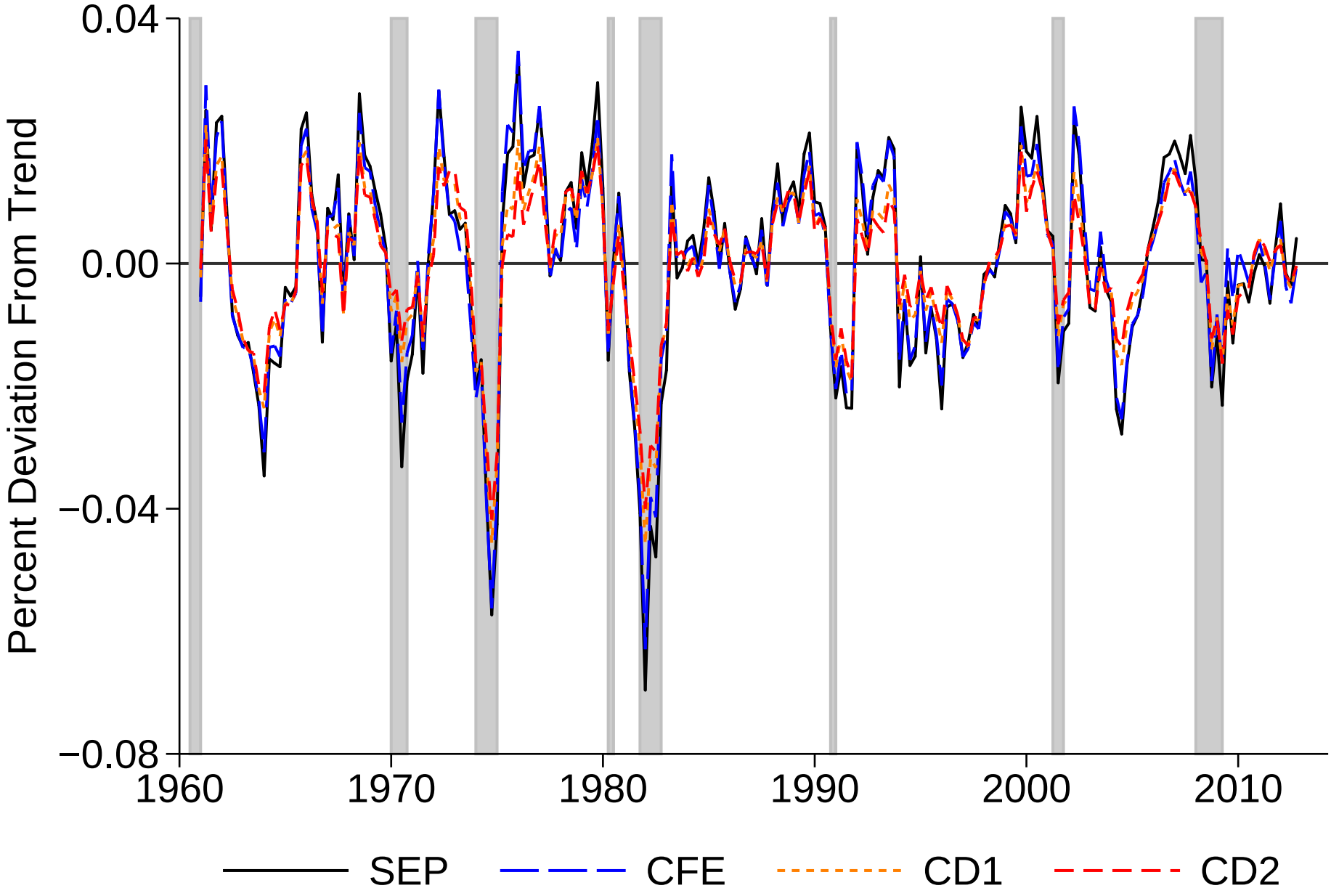
$$\xi_t = \frac{v(N_t)}{\lambda_t}.$$

- Hours procyclical, λ countercyclical.
- Compare to RBC first order condition:

$$\left(\frac{1+\tau_t^C}{1-\tau_t^w}\right)\frac{v'(N_t)}{\lambda_t} = w_t = \frac{\partial F(K_t, e_t N_t)}{e_t N_t} = x_t.$$

- RBC FOC equates MRS along intensive hours margin to wage. Relevant object in search model is MRS along intensive margin.
- In recession, value of market wage, which can be used to purchase market consumption, rises relative to return to other time uses.
- $\lambda_t = \lambda$ and $v(N_t) = v(N)$, or $v(N) = 0, \Longrightarrow \xi$ is constant.

z TIME SERIES



Takeaways

- Source of wage rigidity has to be consistent with micro evidence.
- Can't generate wage rigidity from large and fixed opportunity cost.
- Similar problem arises with Hall and Milgrom (AER 2008) alternating offers bargaining and any other mechanism which depends on household's opportunity cost.

Aside: matching functions

- Analytically convenient?
- Realistic?
- Properties?

$$m(u,v) = M\frac{uv}{\left(u^{\rho}+v^{\rho}\right)^{1/\rho}},$$

$$\begin{aligned}
\frac{\partial \ln m}{\partial \ln u} &= \frac{\left(u^{\rho}+v^{\rho}\right)^{1/\rho}}{v}\frac{\partial}{\partial u}\left(\frac{uv}{\left(u^{\rho}+v^{\rho}\right)^{1/\rho}}\right) \\
&= \frac{\left(u^{\rho}+v^{\rho}\right)^{1/\rho}}{v}\left(\frac{\left(u^{\rho}+v^{\rho}\right)^{1/\rho}v - uv\left(u^{\rho-1}\left(u^{\rho}+v^{\rho}\right)^{1/\rho-1}\right)}{\left(u^{\rho}+v^{\rho}\right)^{2/\rho}}\right) \\
&= 1-\frac{u^{\rho}}{u^{\rho}+v^{\rho}} \\
&= \frac{1}{1+\theta^{-\rho}}
\end{aligned}$$

Outline

Overview

- Does search model need a mechanism to generate wage rigidity, or does it need to generate volatile unemployment despite wage flexibility?
- Relevant wage is of new hires, not ongoing matches.
- Pissarides argues that wage of new hires is highly procyclical.
- Introduces instead fixed cost of recruiting.

Discrete time, linear utility setup

- Length of period: Δ.
- Discount rate: $\frac{1}{1+r\Delta} = \delta$.
- Value functions:

$$J = [p - w]\Delta + \frac{1}{1+r\Delta}[1 - s\Delta]E\left[J'\right],$$
$$V = -c\Delta + \frac{1}{1+r\Delta}\left\{q(\theta)\Delta E\left[J'\right] + [1 - q(\theta)\Delta]E\left[V'\right]\right\},$$
$$U = z\Delta + \frac{1}{1+r\Delta}\left\{f(\theta)\Delta E\left[W'\right] + (1 - f(\theta)\Delta)E\left[U'\right]\right\},$$
$$W = w\Delta + \frac{1}{1+r\Delta}\left\{[1 - s\Delta]E\left[W'\right] + s\Delta E\left[U'\right]\right\}.$$

Continuous time limit, $\Delta \to 0$, J

Note: $E[x'] = x + \Delta \frac{dx}{dt} = x + \Delta \dot{x}$. Then:

$$\text{Prev. slide:} \quad J = [p-w]\Delta + \frac{1}{1+r\Delta}[1-s\Delta]E\left[J'\right],$$

$$\text{Subst. expectation:} \quad = [p-w]\Delta + \frac{1}{1+r\Delta}[1-s\Delta]\left[J + \Delta \dot{J}\right],$$

$$\text{Mult. by } [1+r\Delta]: \quad J + r\Delta J = [1+r\Delta][p-w]\Delta + [1-s\Delta]\left[J + \Delta \dot{J}\right],$$

$$\text{Simplify:} \quad [r+s]\Delta J = [1+r\Delta][p-w]\Delta + [1-s\Delta]\Delta \dot{J},$$

$$\text{Divide by } \Delta: \quad [r+s]J = [1+r\Delta][p-w] + [1-s\Delta]\dot{J},$$

$$\lim_{\Delta \to 0}: \quad [r+s]J = [p-w] + \dot{J}.$$

Continuous time limit, $\Delta \to 0$

$$
\begin{aligned}
rJ &= p - w - sJ + \dot{J}, \\
rV &= -c + q[J - V] + \dot{V}, \\
rU &= z + f[W - U] + \dot{U}, \\
rW &= w - s[W - U] + \dot{W}.
\end{aligned}
$$

Asset pricing interpretation

Total return	Dividend	Capital gain
rJ	Firm profit $(p-w)$	Job disappears $(-sJ)$ + appreciation $(\dot{J})$
rV	Vacancy cost $(-c)$	Filled vacancy $(q[J-V])$ + appreciation $(\dot{V})$
rU	Leisure (z)	Find job $(f[W-U])$ + appreciation $(\dot{U})$
rW	Wage (w)	Lose job $(-s[W-U])$ + appreciation $(\dot{W})$

New and continuing jobs

- From now assume no aggregate shock steady state.
- Approach is to take local elasticities around steady state.
- New job (n) converts to continuing job (c) with probability λ:

$$[r+s]\,J^c = [p^c - w^c], \tag{1}$$
$$[r+s]\,J^n = [p^n - w^n] + \lambda\,[J^c - J^n], \tag{2}$$
$$rU = z + f\,[W^n - U], \tag{3}$$
$$[r+s]\,[W^c - U] = w^c - rU, \tag{4}$$
$$[r+s]\,[W^n - U] = w^n + \lambda\,[W^c - W^n] - rU, \tag{5}$$
$$rV = -c + q[J^n - V]. \tag{6}$$

- Nash bargaining holds for new hires, but not continuing workers.

Job creation decision

Manipulate Bellmans:

$$\text{(4)-(5):} \quad [r+s+\lambda]\,[W^c - W^n] = [w^c - w^n], \tag{7}$$

$$\text{(1)-(2):} \quad [r+s+\lambda]\,[J^c - J^n] = [(p^c - w^c) - (p^n - w^n)], \tag{8}$$

$$\text{(7)+(8):} \quad [r+s+\lambda]\,[S^c - S^n] = [p^c - p^n], \tag{9}$$

$$\text{(2)+(5):} \quad [r+s]\,S^n = p^n + \lambda\,[S^c - S^n] - rU \tag{10}$$

$$\text{Use (9):} \quad = [p^n - rU] + \frac{\lambda}{r+s+\lambda}\,[p^c - p^n]. \tag{11}$$

Impose free entry and Nash bargaining:

$$\begin{aligned}
\frac{c}{q(\theta)} &= J^n = (1-\beta)\,S^n \\
&= \frac{[1-\beta]\,[p^n - rU]}{r+s} + \frac{[1-\beta]\,\lambda\,[p^c - p^n]}{[r+s+\lambda]\,[r+s]} \\
&= \frac{[1-\beta]\,[p^n - z] - \beta c\theta}{r+s} + \frac{[1-\beta]\,\lambda\,[p^c - p^n]}{[r+s+\lambda]\,[r+s]}.
\end{aligned}$$

Last line: $[1-\beta]\,rU = [1-\beta]\,[z + f\,(W^n - U)] = [1-\beta]\,[z + f\beta S^n] =$
$[1-\beta]\left[z + f\beta\,\frac{c}{q(1-\beta)}\right] = [1-\beta]\,z + \beta c\theta.$

Irrelevancy result

$$\frac{c}{q(\theta)} = \frac{[1-\beta][p^n - z] - \beta c\theta}{r+s} + \frac{[1-\beta]\lambda[p^c - p^n]}{[r+s+\lambda][r+s]}.$$

- Free entry condition uniquely determines labor market tightness θ given parameters and exogenous variables $c, p^n, p^c, z, \beta, r, s, \lambda$.
  - Free entry condition identical to period-by-period Nash bargaining.
  - If initial surplus is Nash-bargained, subsequent wage path is irrelevant.
  - Intuition: worker and firm bargain over present value of wage payments. Timing of payments irrelevant.
  - Key is that initial Nash bargain is over total expected surplus.

Wage equation

- Substitute into worker surplus using previous slides:

$$[r+s]\beta S^n = w^n + \lambda[W^c - W^n] - rU,$$

$$\beta[p^n - z] - \frac{\beta^2}{1-\beta}c\theta + \frac{\beta\lambda[p^c - p^n]}{[r+s+\lambda]} = w^n + \lambda\frac{w^c - w^n}{r+s+\lambda} - z - \frac{\beta}{1-\beta}c\theta.$$

- Solve:

$$\begin{aligned} w^n &= \beta p^n + [1-\beta]z + \beta c\theta + \frac{\beta\lambda[p^c - p^n]}{r+s+\lambda} - \frac{\lambda[w^c - w^n]}{r+s+\lambda} \\ &= w^{\text{Nash}} + \frac{\beta\lambda}{r+s+\lambda}[p^c - p^n] - \frac{\lambda}{r+s+\lambda}[w^c - w^n]. \end{aligned}$$

New hire wage cyclicality

$$w^n = w^{\text{Nash}} + \frac{\beta\lambda}{r+s+\lambda}[p^c - p^n] - \frac{\lambda}{r+s+\lambda}[w^c - w^n].$$

- New hire wage adjusted by difference between expected productivity growth and expected wage growth as worker gains tenure.
- Can reinterpret w^c as new wage when economy stochastically jumps from state n to state c.
- If wages in existing matches are sticky, then given cyclicality in initial wage generates more volatility in job creation.
- Intuition: if wage is sticky, then a low initial wage in a weak labor market persists. Cyclicality of present value of wages is amplified if ongoing wage is sticky (Kudlyak JME 2014).
- Pissarides finds an elasticity of new hire wage to marginal revenue of as low as 0.6 is equivalent to an elasticity of 1 with period-by-period Nash bargaining.

Outline

Measurement problem

- Model-theoretic relevant wage is payment for marginal hour/worker at a particular job at a particular establishment.
- Requires data on hourly pay, job title, and establishment.
- Ideally requires present value of wages to recover user cost.

Gertler and Trigari (JPE, 2009), Gertler, Huckfeldt, Trigari (RESTUD,2020)

- GT critique: cyclicality could come from heterogeneous match quality.
- Example: banker who becomes barista in a recession has procyclical earnings, but this cyclicality is irrelevant from perspective of bank or coffee shop.
- GHT use new hires out of unemployment to control for cyclicality of match quality:

$$\ln w_{i,t} = \psi_u u_t + \alpha_i + \alpha_{i,t} + \varepsilon_{i,t},$$

$$\Delta \bar{\alpha}_{i,t} = \mathbb{I}\{EE_{i,t}\}\left[\psi_n^{EE} + \psi_{nu}^{EE}\Delta u_t\right] + \mathbb{I}\{ENE_{i,t}\}\psi_n^{ENE},$$

$$\Delta \ln w_{i,t} = \psi_u \Delta u_t + \mathbb{I}\{EE_{i,t}\}\left[\psi_n^{EE} + \psi_{nu}^{EE}\Delta u_t\right] + \mathbb{I}\{ENE_{i,t}\}\psi_n^{ENE} + \Delta\varepsilon_{i,t}$$

- Key assumption: unemployed workers draw from same distribution in recession and boom.

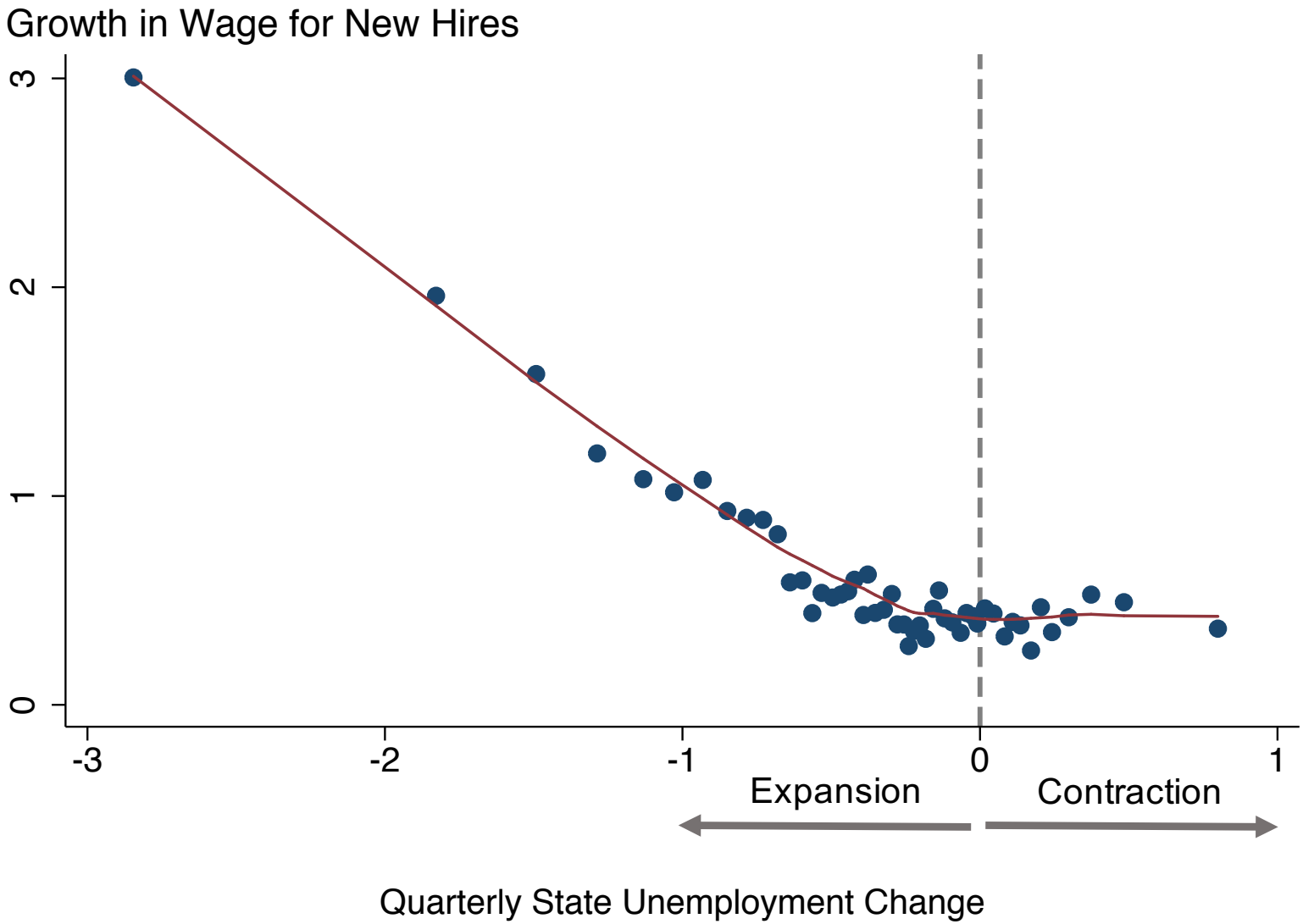
	First differences		Fixed-effects	
	(1)	(2)	(3)	(4)
UR	-0.426^{***}	-0.421^{***}	-0.145^{**}	-0.146^{**}
	(0.0967)	(0.0966)	(0.0609)	(0.0609)
UR $\cdot$ $\mathbb{I}(EE)$	-1.868^{***}	-1.667^{***}	-1.972^{***}	-1.933^{***}
	(0.6793)	(0.6218)	(0.5027)	(0.4724)
UR $\cdot$ $\mathbb{I}(ENE)$	-0.437	-0.547	-0.334	0.047
	(0.6636)	(0.7342)	(0.5399)	(0.5954)
$\mathbb{I}(EE)$	0.045^{***}	0.038^{***}	0.004^{*}	0.001
	(0.0048)	(0.0046)	(0.0023)	(0.0022)
$\mathbb{I}(ENE)$	-0.047^{***}	-0.065^{***}	-0.030^{***}	-0.034^{***}
	(0.0066)	(0.0074)	(0.0029)	(0.0034)
$P(\pi_{nu}^{EE} = \pi_{nu}^{ENE})$	0.127	0.239	0.023	0.008
Unemp. spell for ENE	0+	1+	0+	1+
No. observations	318,763	318,763	375,642	375,642
No. individuals	56,879	56,879	56,879	56,879
No. EE new hires	8,719	10,129	9,861	10,129
No. ENE new hires	5,333	3,923	6,439	4,860

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

Dependent variable: log hourly real wage. Controls for education, union coverage, marital status, a quadratic in tenure, and a linear time trend. Robust standard errors in parenthesis, clustered by individual

Hazel and Taska, WP

- Burning Glass online vacancy data with job titles, establishment identifiers.
- Subset (17%) of online vacancies include posted wage.
- Wages for new hires rigid downwards but flexible upwards.
- Data 2010-16, so limited business cycle variation if measure is unemployment rate change.
- Aside: unclear that wage growth should be related to the change rather than the level of unemployment.



Notes: the graph plots binned wage growth for new hires, from Burning Glass, and binned state by quarter unemployment changes, from the Local Area Unemployment Statistics. To construct wage growth, we take the mean wage within each job and quarter, and then take log differences at the job level. We use 50 bins, partial out time fixed effects, and add a non-parametric regression line.

Grigsby, Hurst, Yildirmaz, AER, 2021

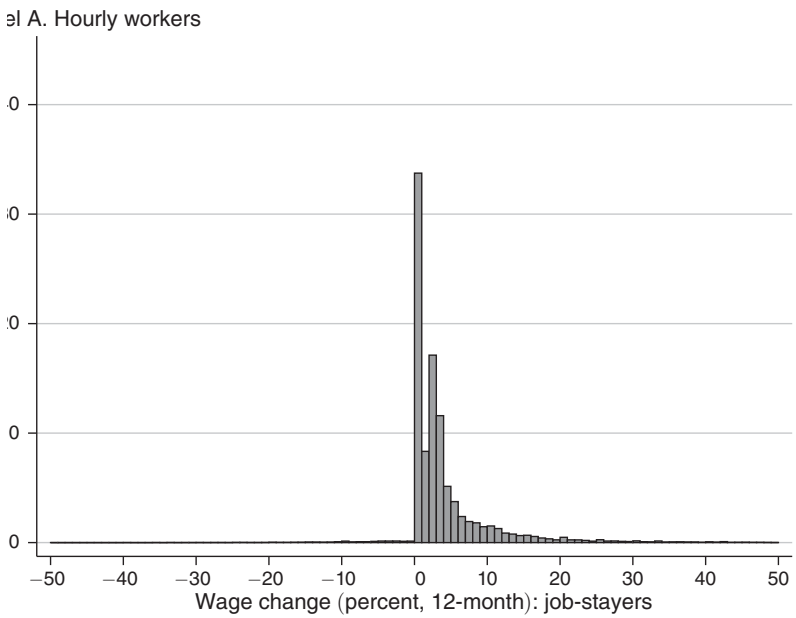
- Administrative data from payroll processor ADP over 2008-16.
- Base wages are macro-relevant object because bonuses and overtime acyclical.
- Base wages of job-stayers are downwardly rigid.
- New hires wages no more cyclical than job-stayers (composition adjusted).

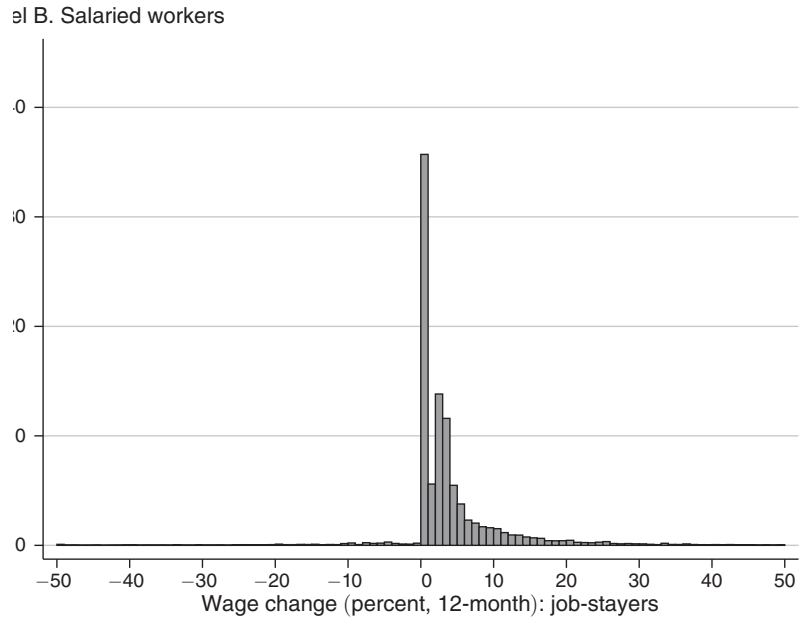
BASES WAGES ARE MACRO-RELEVANT OBJECT

TABLE 2—CYCLICALITY OF VARIOUS FORMS OF COMPENSATION

	Percent base wage change (1)	Percent with overtime (2)	Percent with overtime (3)	Percent with bonus (4)	Percent with bonus (5)
Panel A. Compensation components					
Δ Unemployment rate (percent)	−0.34	−0.60	−0.27	−0.33	−0.55
	(0.02)	(0.25)	(0.10)	(0.11)	(0.11)
Workers included	All	Hourly	Hourly	All	All
State and industry fixed effects	Yes	Yes	Yes	Yes	Yes
Individual fixed effects	No	No	Yes	No	Yes
Observations (1,000s)	619	415	415	673	673
Mean of dependent variable	3.82	62.5	62.5	49.2	49.2
	Base earnings	Base earnings	Base earnings	Base plus overtime	Base plus bonus
Panel B. Annual percent change in compensation					
Δ Unemployment rate (percent)	−0.41	−0.46	−0.39	−0.37	−0.37
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
Workers included	All	Salaried	Hourly	Hourly	All
State and industry fixed effects	Yes	Yes	Yes	Yes	Yes
Individual fixed effects	No	No	No	No	No
Observations (1,000s)	321	104	217	217	320
Mean of dependent variable	3.83	4.29	3.63	3.69	4.37

Downward rigidity





JOB SWITCHERS WAGES ARE MORE CYCLICAL...

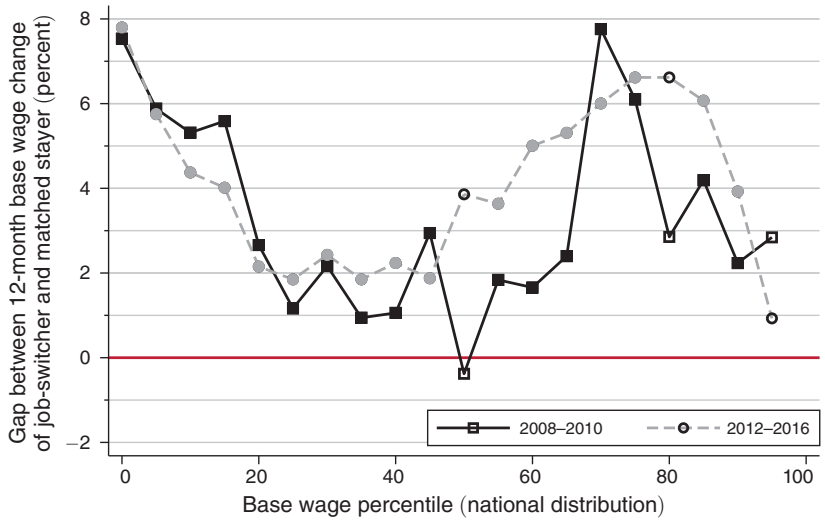
TABLE 6—CYCLICALITY OF NEW HIRE WAGES

	(1)	(2)	(3)	(4)
ΔU_{st} (percentage points)	−0.33	−0.22	−0.35	−0.35
	(0.03)	(0.02)	(0.03)	(0.03)
$\Delta U_{st} \times$ *Switcher*	−0.77	−0.80	−0.69	−0.18
	(0.24)	(0.21)	(0.12)	(0.17)
State fixed effects	Yes	Yes	Yes	Yes
Demographic and wage percentile controls	Yes	Yes	Yes	Yes
Firm fixed effects	No	Yes	Yes	Yes
Interacted controls	No	No	Yes	Yes
Tenure control	No	No	No	Yes
Observations (thousands)	12,514	12,514	12,514	12,514

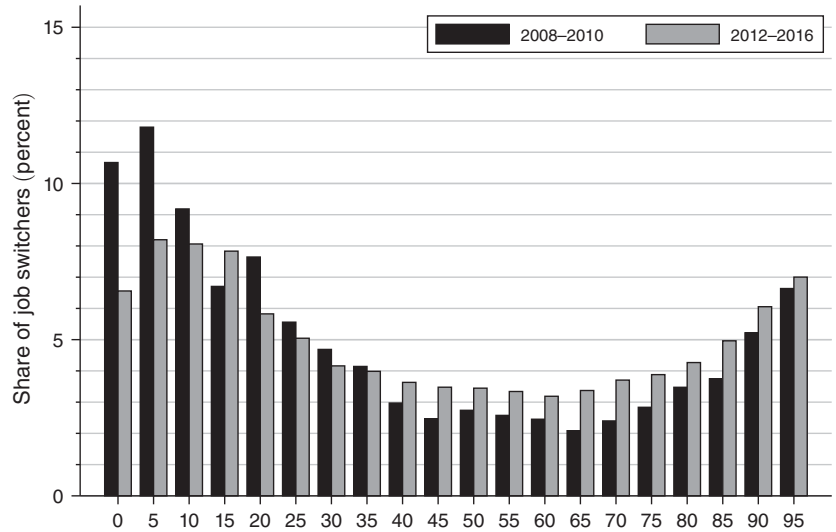
Notes: Table reports cyclicality of wage growth for job-stayers and job-changers, estimated from equation (3). The dependent variable in columns 1–5 is the percentage base wage growth between month t and month $t + 12$, while the independent variable is the change, in percentage points, in state unemployment rates between t and $t + 12$. All columns include controls for demographics, namely fixed effects for 5-year age bins and worker sex, and the worker's percentile in the national base wage distribution as of month t. Columns 2–4 additionally include firm fixed effects, while columns 3–4 include fully interacted controls for firm, demographics, and wage percentile. Column 4 additionally controls for worker tenure in period t. Standard errors, clustered at the month level, are reported in parentheses.

BUT DUE TO COMPOSITION

Panel A. Gap between job-changer and matched job-stayer wage growth



Panel B. Share of job-changers by initial wage percentile



Other informative moments

- Rather than looking at wage cyclicality, can also examine conditional response of wages or unemployment, for example to UI.
- If wages and match surplus are sensitive to opportunity cost, then UI extensions should have large effect.
- Empirical evidence:
  - Hagedorn, Karahan, Manovskii, Mitman (2013), Hagadorn, Manovskii, Mitman (2016): UI has large effect on unemployment.
  - HKMM/HMM approach challenged by Hall (2013), Amaral and Ice (2014), Dieterle, Bartalotti, Brummet (2016), Boone, Dube, Goodman, Kaplan (2016).
  - Chodorow-Reich, Coglianese and Karabarbounis (QJE, 2019), Boone, Dube, Goodman, Kaplan (WP) find much smaller effects.
- Jäger, Schoefer, Young, Zweimüller (QJE, 2020): wages do not respond to benefit increases in Austrian data.
- Doesn't reject wage cyclicality. Does discipline possible sources of rigidity.

Outline

If wages are rigid, then why?

- Hall (AER 2005): any wage remaining in bargaining set satisfies bilateral efficiency and is valid outcome. So assume rigid wages, for example due to social norms.
- Hagedorn and Manovskii (AER 2008): high value of leisure. Runs into CRK critique.
- Hall and Milgrom (AER 2008): alternating offer wage bargaining protocol. Runs into CRK critique.
- Problem: very little systematic evidence on wage determination process. Bargaining? Wage posting? Other?

If wages are flexible, then what?

- Fixed cost of recruitment: $J = \frac{c}{q(\theta)} + H$. Fixed cost H reduces sensitivity of hiring cost to labor market tightness, allowing vacancies to rise more in response to positive shock (Pissarides, ECMA 2009).

- Countercyclical r: Hiring cost $= \frac{p-w}{r+s}$. Even if $p-w$ is acyclical due to wage procyclicality, higher discount rate reduces job value (Hall, AER 2017; Nadeu and Wasmer, AEJ:Macro 2013; Schoefer, WP; Kehoe, Lopez, Midrigan, Pastorino, WP).

- Reintroduce separation rate shocks (Mortensen and Nagypal, RED 2007; Coles and Kelishomi, AEJ: Macro 2018)).