Unemployment Fluctuations, Match Quality, and the Wage Cyclicality of New Hires

Mark Gertler[1], Christopher Huckfeldt[2], Antonella Trigari[3]

[1]New York University, NBER

[2]New York University

[3]Bocconi University, CEPR, IGIER, and Baffi center

June 8, 2014

Motivation

- Less cyclical variation in aggregate wages than labor
- Conventional macro models overpredict the volatility of wages and underpredict the volatility of unemployment
- True also for the search and matching model (Shimer, 2005)
- Common solution: assume some form of wage stickiness

Motivation, cont.

- Aggregate data may not reflect the relevant measure of wage stickiness
- Critical margin for wage stickiness: new hires
- Panel data evidence going back to Bils (1985) suggestive of substantially more cyclical wages for job changers
- Pissarides (2009) interprets evidence in favor of a high degree of wage flexibility for new hires
  - "new hire contract effect"
- Questions efforts to incorporate wage rigidity into macro models

This paper

- Analyze data from 1990-2012 SIPP
- We find evidence consistent with existing literature: more cyclical wages for new hires

What's new:

1. Estimate separate cyclicality for workers changing jobs with an intervening spell of unemployment
   - No new hire effect for workers coming from unemployment
2. Introduce controls for variation in match quality across jobs
   - No evidence of excess new hire wage cyclicality

This paper, continued

- Conclusions from empirical exercise:
  1. No evidence of excess wage cyclicality for workers coming from unemployment
  2. Wage cyclicality of new hires reflects cyclicality in match quality of job changers as opposed to new hire contract effect

- Build a model consistent with micro and macro evidence

- Key mechanism: workers searching on-the-job more likely to find better jobs during expansions (Barlevy, 2002)

- Quantitative results:
  1. Model consistent with aggregate facts
  2. Simulated data from model generates spurious evidence of new hire wage flexibility comparable to micro estimates

General regression specification from the literature

$$\log w_{ijt} = x'_{ijt}\pi_x + \pi_u \cdot U_t + \pi_{nu} \cdot \mathbb{I}(new_{ijt}) \cdot U_t + \pi_n \cdot \mathbb{I}(new_{ijt}) + e_{ijt}$$

- x_{ijt}: observables for individual i in job j at time t
- U_t: unemployment rate at t
- $\mathbb{I}(\text{new}_{ijt})$: equal to one if individual i is a new hire in job j at t
- e_{ijt}: error term, s.t.
- Unobserved heterogeneity: estimate in first-differences

Key finding: $\pi_{nu} < 0$

Two observations:

1. New hire interaction does not vary by type of job transition
2. New hire wage in FD: difference of *first wage on new job* and *last wage on old job* $\Rightarrow$ scope for composition bias

Data

- Survey of Income and Program Participation, 1990-2012
  - 1990-1993, 1996, 2001, 2004, and 2008 panels
- Large, representative sample
- Interviews every four months
- High-frequency structure allows for construction of precise measurements of job tenure and wages

▸ Sample Selection

▸ Measurement

▸ Descriptive Statistics

Part I: E-E versus E-N-E

- Previous literature does not estimate new hire effect separately for workers experiencing intervening spell of non-employment
- Exception: Haefke, Sonntag, and van Rens (2013)
  - Does not control for unobserved heterogeneity
- Why does it matter?
  - New hire contract effect relevant for workers coming from unemployment
  - More scope for composition effect for workers searching on-the-job (selection)
- Estimate new hire wage cyclicality from person fixed effects, separate *E-E* from *E-N-E*

Part I: Results

	1990-2012 sample	
	(1)	(2)
UR	-0.573^{***}	-0.580^{***}
	(0.0542)	(0.0544)
$\text{UR} \cdot \mathbb{I}(\text{new} \,\&\, EE)$	-1.229^{***}	-1.247^{***}
	(0.4033)	(0.4035)
$\text{UR} \cdot \mathbb{I}(\text{new} \,\&\, ENE)$	0.278	-0.090
	(0.5285)	(0.6883)
$P(\beta_{U,n}^{EE} = \beta_{U,n}^{ENE})$	0.022	0.144
Fixed effects	Person	Person
Longterm unemployed	Yes	No
No. observations	409,759	409,759
No. of fixed effects	56,603	56,603

Robust standard errors in parenthesis

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

Part II: Control for composition

1. *Person Fixed Effects*: we allow for one fixed effect per individual across multiple job spells
   - Identification of new hire interaction coefficient subject to composition bias
2. *Person-Job Fixed Effects*: we allow for a separate fixed effect for each job held by an individual
   - Identification of new hire interaction coefficient constrained to wage variation within a job $\Rightarrow$ no composition bias

▸ Identification

Part II: Person-Job Fixed Effects

	1990-2012 sample	
	(1)	(2)
Unemployment rate	-0.564^{***}	-0.378^{***}
	(0.0541)	(0.0523)
Unemp. rate $\cdot\ \mathbb{I}$(new)	-0.843^{***}	-0.266
	(0.2293)	(0.2616)
Fixed effects	Person	Person-Job
No. observations	417,404	399,690
No. of fixed effects	57,450	66,260

Robust standard errors in parenthesis

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

Interpretation

- Evidence consistent with cyclical composition interpretation.
  - No evidence of new hire wage cyclicality from person-job fixed effects estimator
  - No evidence of new hire wage cyclicality for E-N-E job changers from either estimator

    ▸ ENE w/ PJFE

- Next: interpret wage growth of job changers with model of equilibrium unemployment

Model

- Questions:
  1. What forces generate procyclical match quality for job movers?
  2. Are there other aggregate implications stemming from job changer wage cyclicality?
- Model characteristics
  - Essential structure: Gertler and Trigari (2009)
  - Additional ingredients: match quality + on-the-job search (Barlevy, 2002)
- Transmission mechanism:

$$\begin{array}{c}\text{aggregate}\\ \text{match composition}\end{array} + \begin{array}{c}\text{variable}\\ \text{search intensity}\end{array} \rightarrow \begin{array}{c}\text{share of job changers}\\ \text{making bad-to-good transitions}\end{array}$$

$$\rightarrow \text{job changer wage cyclicality}$$

Search environment

- Random matching
- Firm i employs n_i good workers, b_i bad workers, and posts v_i vacancies
- $\bar{u}$ workers in unemployment
- Workers in bad matches search with variable intensity, ς_b
- Workers in good matches search with fixed intensity, ς_n
  - Jolivet, Postel-Vinay, Robin (2006); Lentz and Mortensen (2012)
- Exogenous separation probability $1 - \nu$ for all workers
  - Search after separation with intensity ς_u
- *i.i.d.* probability ξ that a match is good

Search environment, cont.

- Conditional on posting a vacancy, firms accept good and bad matches
- Unemployed accept all matches
- Workers searching on-the-job accept only good matches
- Total searchers

$$\bar{s} = \underbrace{\bar{u}}_{\substack{\text{unemployed at} \\ \text{beginning of period } t \\ \text{accept good and bad}}} + \underbrace{(1-\nu)\,\varsigma_u\left(\bar{n}+\bar{b}\right)}_{\substack{\text{separated in } t, \\ \text{searching from } t \\ \text{accept good and bad}}} + \underbrace{\nu\bar{\varsigma}_b\bar{b} + \nu\varsigma_n\bar{n}}_{\substack{\text{conditional on not separating in } t \\ \text{searching on the job in } t \\ \text{accept only good}}}$$

- Denote $\bar{\gamma}^h \equiv \bar{b}^h/\bar{n}^h$ to be the composition of new hires

Firms

- Technology: $y = zk^{\alpha}l^{1-\alpha}$
- Labor quality: $l = n + \phi b = (1 + \phi\gamma)n$
  - Firm composition: $\gamma = b/n$
  - Inverse productivity premium for bad workers, ϕ
- Total wage bill: $(1 + \phi\gamma)wn$
- Quadratic hiring costs, proportional to total quality of existing labor force
- Value of a firm, $F(\gamma, w; \mathbf{s})$ is homogeneous in total units of labor quality:

$$F(n, \gamma, w, \mathbf{s}) = (1 + \phi\gamma)n \; J(\gamma, w, \mathbf{s})$$

- $J(\gamma, w, \mathbf{s})$ is the firm's value of a unit of labor quality Firm problem
- Vacancy posting decision summarized by hiring rate, $x(\gamma, w, \mathbf{s})$

Workers

- Worker value functions
  - Value of a good match, $V^n(\gamma, w, \mathbf{s})$
  - Value of a bad match, $V^b(\gamma, w, \mathbf{s})$
  - Value of unemployment, $U(\mathbf{s})$
- Worker surplus functions
  - Good worker surplus, $H^n(\gamma, w, \mathbf{s}) \equiv V^n(\gamma, w, \mathbf{s}) - U(\mathbf{s})$
  - Bad worker surplus, $H^b(\gamma, w, \mathbf{s}) \equiv V^b(\gamma, w, \mathbf{s}) - U(\mathbf{s})$
- FOC for search policy of workers in bad matches, ς_b:

$$\varsigma_0 {\varsigma_b}^{\eta_\varsigma} = \beta \mathbb{E}\left\{ \Lambda(\mathbf{s}, \mathbf{s}') \bar{p} \xi \left[\bar{V}_x^n(\mathbf{s}') - \bar{V}_x^b(\mathbf{s}') \right] \right\}$$

▸ Worker value functions

Staggered Nash bargaining

- Probability $1 - \lambda$ of re-bargaining every period
- Firms bargain with good workers over the wage per unit of labor quality

Contract wage $w^*(\gamma, \mathbf{s})$ solves

$$\max_w H^n(\gamma, w, \mathbf{s})^\eta J(\gamma, w, \mathbf{s})^{1-\eta}$$

s.t.

$$w' = \begin{cases} w^*(\gamma, \mathbf{s}) \text{ with probability } \lambda \\ w^*(\gamma', \mathbf{s}') \text{ with probability } 1 - \lambda \end{cases}$$

Wage growth of job changers

$$\widehat{\overline{g}}_t^{JC} = \underbrace{\omega_c \, \widehat{\overline{g}}_t^w}_{\substack{\text{fundamental}\\ \text{component}}} + \underbrace{(1-\omega_c)\ \widehat{\overline{c}}_t^w}_{\substack{\text{compositional}\\ \text{component}}}$$

where

$$\widehat{\overline{g}}_t^w = \widehat{\overline{w}}_t - \widehat{\overline{w}}_{t-1}, \quad \partial\omega_c/\partial\phi > 0$$

and

$$\begin{aligned}\widehat{\overline{c}}_t^w &= \frac{1}{\tilde{\delta}_{BG} - \tilde{\delta}_{GB}} \left(\tilde{\delta}_{BG}\ \widehat{\delta}_{BG,t-1} - \tilde{\delta}_{GB} \widehat{\delta}_{GB,t-1} \right) \\ &= \frac{\tilde{\delta}_{BG} + \tilde{\gamma}\tilde{\delta}_{GB}}{(1+\tilde{\gamma})\left(\tilde{\delta}_{BG} - \tilde{\delta}_{GB}\right)}\ \widehat{\overline{\gamma}}_{t-1} + \frac{1 - \left(\tilde{\delta}_{BG} - \tilde{\delta}_{GB}\right)}{\left(\tilde{\delta}_{BG} - \tilde{\delta}_{GB}\right)} \tilde{\delta}_{BGS}\ \widehat{\overline{\varsigma}}_{bt-1}\end{aligned}$$

- Average firm labor force composition, $\overline{\gamma}_{t-1}$, is countercyclical
- Average search intensity of bad workers, $\overline{\varsigma}_{bt-1}$, is procyclical

▸ Evolution of composition ▸ Job flows

Calibration

Parameter values		
Discount factor	β	$0.997 = 0.99^{1/3}$
Capital depreciation rate	δ	$0.008 = 0.025/3$
Production function parameter	α	0.33
Technology autoregressive parameter	ρ_z	$0.983 = 0.95^{1/3}$
Technology standard deviation	σ_z	0.0075
Elasticity of matches to unemployment	σ	0.4
Bargaining power parameter	η	0.5
Matching function constant	σ_m	1.0
Search cost elasticity	η_ς	1.0
Renegotiation frequency	λ	0.889 (3 quarters)

Jointly calibrated parameters

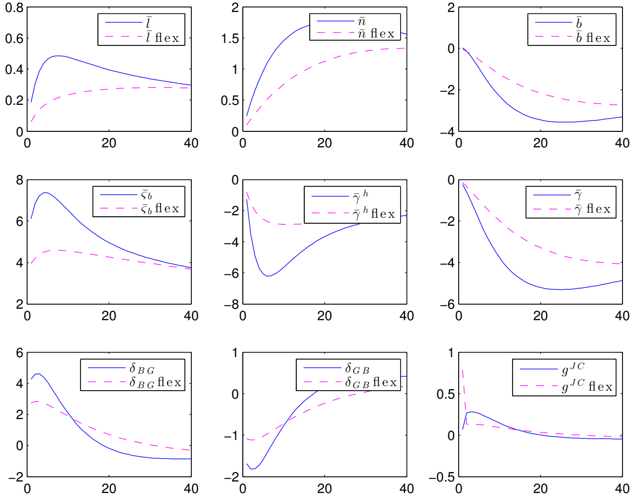
Parameter	Description	Value	Target
ϕ	Inverse productivity premium	0.84	Average E-E wage increase (4.5%)
ξ	Prob. of good match	0.42	Fraction E-E with $\Delta w \approx 0$ (0.31)
κ	Hiring cost parameter	48.93	UE probability (0.45)
ς_0	Search cost parameter	2.62	E-E probability (0.029)
u_b	Flow value of unemployment	2.70	Replacement rate (0.75)
ν	Separation probability	0.97	E-U probability (0.026)

- Steady state/parameter restriction: $\varsigma_u = \varsigma_n = \tilde{\varsigma}_b$
- (Note that $\varsigma_0 \Rightarrow \varsigma_i$)

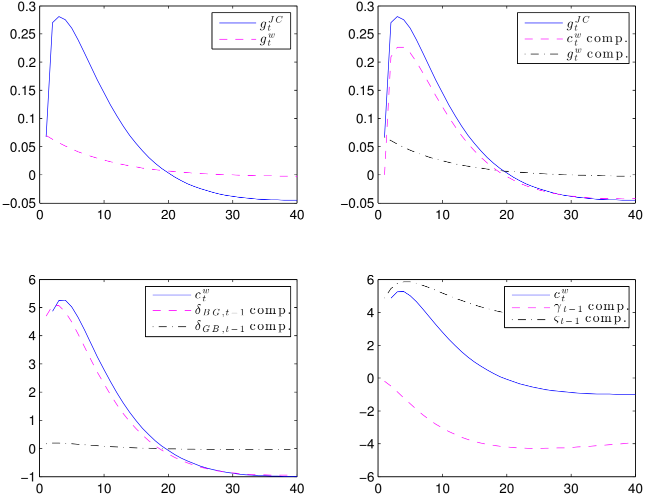
Aggregate statistics

	y	w	$n+b$	u	v
	U.S. Economy, 1964:1-2005:01				
Relative St. Dev.	1.00	0.52	0.60	5.15	6.30
Autocorrelation	0.87	0.91	0.94	0.91	0.91
Correlation with y	1.00	0.56	0.78	−0.86	0.91
	Model Economy, $\lambda = 8/9$ (3 quarters)				
Relative St. Dev.	1.00	0.37	0.31	5.35	9.26
Autocorrelation	0.83	0.94	0.83	0.83	0.76
Correlation with y	1.00	0.74	0.81	−0.81	0.92

Employment composition and wage growth



Wage growth and components



Wage semi-elasticities

Semi-elasticities of wages w/r.t. unemployment

	SIPP	Model, flex	Model, 3Q
Continuing	−0.56	−5.73	−0.45
New hires	−1.41	−9.44	−1.59

Conclusion

- Evidence consistent with "cyclical composition" interpretation
- No evidence in favor of "new hire cyclical contract" interpretation
- Existing literature has not adequately taken into account compositional effects
- Model is successful at explaining variation in micro data while also capturing aggregate labor market dynamics

Supplementary Slides

Sample selection

- Men, ages 20-60; drop individuals attending school full-time, self employed, armed forces, permanent disabilities; hours $\in [10, 100]$
- We only use wage observation from last month of wave (SIPP seam effect)
- Drop observations where individual holds multiple jobs
- Drop observations with top-coded or imputed wages

Return

Measurement

- We use direct measure of hourly wage when available
- Otherwise construct hourly wage from job-specific earnings divided by hrs/wk $\times$ wks/mth
- Wages deflated with CPI
- Unemployment: Males, 20 yrs+
- Longterm unemployed: duration > 4 months
- Job tenure: beginning of period retrospective information, then update for each month observed working for pay
- EE transitions: change in job ID across two months, both months worked for pay
- ENE transitions: change in job ID, intervening month(s) w/o work for pay
- New hire: tenure < 4 months

Return

Descriptive statistics

Variable	Mean	SD
Log hourly wage (2000 dollars)	2.70	0.519
Years of education	13.56	2.802
Union dummy	0.21	0.404
Never married	0.20	0.397
Job tenure (years)	8.04	8.373
Unemployment rate	0.06	0.018
New hire indicator	0.07	0.252

Summary statistics: job transitions

	EE		ENE		Total	
Panel	Ind.	Obs.	Ind.	Obs.	Ind.	Obs.
1990	1,767	8,647	1,099	4,759	7,111	46,172
1991	1,170	5,767	848	3,547	5,045	32,178
1992	1,633	8,866	1,238	5,649	6,645	46,884
1993	1,634	9,033	1,096	5,342	6,499	46,198
1996	3,806	21,829	2,406	13,352	9,692	81,110
2001	2,017	9,832	1,699	7,752	8,176	51,893
2004	1,545	8,994	1,268	6,922	4,578	38,503
2008	2,812	16,536	2,537	13,029	9,965	75,171
Total	16,384	89,504	12,191	60,352	57,711	418,109

Return

Identification

- Source of identification: wage cyclicality of new hires relative wage cyclicality of continuing workers
- Identifying assumption: new hires are treated as "continuing workers" subsequent to first wage on job
- Data requirement: wage observations after new hire wage
- Average new hire + subsequent wage observations: 4.28
  - EE only: 4.45
  - ENE only: 4.06

◂ Return

Person-Job Fixed Effects, panel time trends

	1990-2011 sample	
	(1)	(2)
Unemployment rate	-0.457^{***}	-0.337^{***}
	(0.0565)	(0.0545)
Unemp. rate $\cdot$ $\mathbb{I}$(new)	-0.762^{***}	-0.216
	(0.2286)	(0.2613)
Fixed effects	Person	Person-Job
No. observations	417,404	399,690
No. of fixed effects	57,450	66,260

Robust standard errors in parenthesis

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

E-E and E-N-E, panel time trends

	1990-2011 sample	
	(1)	(2)
UR	-0.465^{***}	-0.473^{***}
	(0.0564)	(0.0566)
$\text{UR} \cdot \mathbb{I}(\text{new} \ \& \ EE)$	-1.285^{***}	-1.302^{***}
	(0.4044)	(0.4045)
$\text{UR} \cdot \mathbb{I}(\text{new} \ \& \ ENE)$	0.174	-0.168
	(0.5290)	(0.6908)
$P(\beta^{EE}_{U,n} = \beta^{ENE}_{U,n})$	0.027	0.153
Fixed effects	Person	Person
Longterm unemployed	Yes	No
No. observations	409,759	409,759
No. of fixed effects	56,603	56,603

Robust standard errors in parenthesis

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

Return

ENE: PFE vs. PJFE

	1990-2011 sample	
	(1)	(2)
UR	-0.580^{***}	-0.376^{***}
	(0.0544)	(0.0525)
UR $\cdot$ $\mathbb{I}$(new & EE)	-1.247^{***}	-0.231
	(0.4035)	(0.5132)
UR $\cdot$ $\mathbb{I}$(new & ENE)	-0.090	1.095
	(0.6883)	(0.8593)
$P(\beta_{U,n}^{EE} = \beta_{U,n}^{ENE})$	0.144	0.185
$P(\beta_{U,n}^{EE} = \beta_{U,n}^{ENE} = 0)$	0.008	0.401
Fixed Effects	Person	Job
No. observations	409,759	393,780
No. of fixed effects	56,603	65,097

Robust standard errors in parenthesis

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

Return

Firm problem

$$
\begin{aligned}
F(n,\gamma,w,\mathbf{s}) \quad &= \quad \max_{k,x}\Big\{zk^{\alpha}\big[(1+\phi\gamma)n\big]^{1-\alpha} - \frac{\kappa}{2}x^{2}(1+\phi\gamma)n \\
&\qquad -\big(1+\phi\gamma\big)wn - rk + \beta\mathbb{E}\big\{\Lambda(\mathbf{s},\mathbf{s}')F(n',\gamma',w',\mathbf{s}')|w,\mathbf{s})\big\}\Big\}
\end{aligned}
$$

- Hiring rate:

$$
x = \frac{\left(1+\phi\bar{\gamma}^{h}\right)}{(1+\phi\gamma)}\frac{\bar{q}\xi\upsilon}{n}
$$

- Perfectly mobile capital:

$$
r = \alpha z\check{k}^{\alpha-1}, \text{ where } \check{k} = \frac{k}{(1-\phi\gamma)n}
$$

- F homogeneous in $l \equiv (1+\phi\gamma)n$:

$$
F(n,\gamma,w,\mathbf{s}) = (1+\phi\gamma)n \; J(\gamma,w,\mathbf{s})
$$

Firm problem, cont.

- $J(w, \gamma, \mathbf{s})$ is the value of a unit of labor force quality at firm i

$$J(\gamma, w, \mathbf{s}) = \max_{\check{k},x} \Big\{ z\check{k}^{\alpha} - \frac{\kappa}{2}x^2 - w - r\check{k} + (\rho + x)\beta\mathbb{E}\{\Lambda(\mathbf{s}, \mathbf{s}')J(\gamma', w', \mathbf{s}')|w, \mathbf{s}\} \Big\}$$

where ρ is the survival rate of a unit of labor force quality

- Optimal hiring:

$$\kappa x = \beta\mathbb{E}\left\{\Lambda\left(\mathbf{s}, \mathbf{s}'\right) J\left(\gamma', w', \mathbf{s}'\right)|w, \mathbf{s}\right\} + \omega$$

where

$$\omega = (\rho + x)\beta\mathbb{E}\left\{ \frac{\partial J(\gamma', w', \mathbf{s}')}{\partial \gamma'} + (1 - \lambda)\frac{\partial J(\gamma', w^{*\prime}, \mathbf{s})}{\partial w^{*\prime}}\frac{\partial w^{*\prime}}{\partial \gamma'} \right\} \frac{\partial \gamma'}{\partial x}$$

Return

Worker value functions

- Value of a worker in unemployment

$$U(\mathbf{s}) = u_b + \beta \mathbb{E}\left\{ \Lambda(\mathbf{s}, \mathbf{s}') \left[\bar{p}\xi \bar{V}_x^n(\mathbf{s}') + \bar{p}\left(1-\xi\right) \bar{V}^b(\mathbf{s}') + \left(1-\bar{p}\right) U(\mathbf{s}') \right] | \mathbf{s} \right\}$$

  - u_b is flow benefit of unemployment
  - Costless search for unemployed

- Value of worker in a good match

$$\begin{aligned} V^n(\gamma, w, \mathbf{s}) \quad = \quad & w - \left[\nu c(\varsigma_n) + (1-\nu) c(\varsigma_u) \right] \\ & + \beta \mathbb{E} \Big\{ \Lambda(\mathbf{s}, \mathbf{s}') \Big[\nu (1 - \varsigma_n \bar{p}\xi) V^n(\gamma', w', \mathbf{s}') + \nu \varsigma_n \bar{p}\xi \bar{V}_x^n(\mathbf{s}') \\ & + (1-\nu)\varsigma_u \bar{p}\xi \bar{V}_x^n(\mathbf{s}') + (1-\nu)\varsigma_u \bar{p}(1-\xi) \bar{V}^b(\mathbf{s}') \\ & + (1-\nu)(1-\varsigma_u \bar{p}) U(\mathbf{s}') \Big] | w, \mathbf{s} \Big\} \end{aligned}$$

Worker value functions, cont.

- Value of a worker in a bad match

$$
\begin{aligned}
\bar{V}^b(\mathbf{s}) \quad = \quad & \max_{\varsigma_b} \Big\{ \phi\bar{w} + (1-\phi)b - \Big[\nu c(\varsigma_b) + (1-\nu)c(\varsigma_u)\Big] \\
& + \beta\mathbb{E}\Big\{ \Lambda(\mathbf{s},\mathbf{s}')\big[\nu(1-\bar{\varsigma}_b\bar{p}\xi)\bar{V}^b(\mathbf{s}') + \nu\bar{\varsigma}_b\bar{p}\xi\bar{V}^n_x(\mathbf{s}') \\
& + (1-\nu)\varsigma_u\bar{p}\xi\bar{V}^n_x(\mathbf{s}') + (1-\nu)\varsigma_u\bar{p}(1-\xi)\bar{V}^b(\mathbf{s}') \\
& + (1-\nu)(1-\bar{p})U(\mathbf{s}')\big]|\mathbf{s}\Big\}\Big\}
\end{aligned}
$$

  - $c(\varsigma)$ is the cost of on-the-job search:

$$
c(\varsigma) = \frac{\varsigma_0}{1+\eta_\varsigma}\varsigma^{1+\eta_\varsigma}
$$

- Optimal search decision:

$$
\varsigma_0\varsigma_b^{\eta_\varsigma} = \beta\mathbb{E}\Big\{\Lambda(\mathbf{s},\mathbf{s}')\bar{p}\xi\Big[\bar{V}^n_x(\mathbf{s}') - \bar{V}^b(\mathbf{s}')\Big]\Big\}
$$

- Assumption: worker receives union transfer, $\tau(w,\bar{w}) = \phi(\bar{w}-w)$

Worker surplus functions

- Worker surplus at good match

$$
\begin{aligned}
H^n(\gamma, w, \mathbf{s}) &= w - u_b - \Big[\nu c(\varsigma_n) + (1-\nu)c(\varsigma_u)\Big] \\
&+\beta\mathbb{E}\Big\{\Lambda(\mathbf{s},\mathbf{s}')\Big[\nu(1-\varsigma_n\bar{p}\xi)H^n(\gamma',w',\mathbf{s}') + \nu\varsigma_n\bar{p}\xi\bar{H}^n_x(\mathbf{s}') \\
&-\Big(1-(1-\nu)\varsigma_u\Big)\bar{p}\bar{H}_x(\mathbf{s}')\Big]\Big|\gamma, w, \mathbf{s}\Big\}
\end{aligned}
$$

- Worker surplus at bad match

$$
\begin{aligned}
\bar{H}^b(\mathbf{s}) &= \phi\big(\bar{w} - u_b\big) - \Big[\nu c(\varsigma_b) + (1-\nu)c(\varsigma_u)\Big] \\
&+\beta\mathbb{E}\Big\{\Lambda(\mathbf{s},\mathbf{s}')\Big[\nu(1-\varsigma_b\bar{p}\xi)\bar{H}^b(\mathbf{s}') + \nu\varsigma_b\bar{p}\xi\bar{H}^n_x(\mathbf{s}') \\
&-\Big(1-(1-\nu)\varsigma_u\Big)\bar{p}\bar{H}_x(\mathbf{s}')\Big]\Big|\gamma, w, \mathbf{s}\Big\}
\end{aligned}
$$

Return

Evolution of aggregate composition

- Aggregate composition:

$$\hat{\tilde{\gamma}}_{t+1} = \tilde{\rho}\hat{\tilde{\gamma}}_t + (1-\tilde{\rho})\hat{\tilde{\gamma}}_t^h - (\tilde{\rho}-\nu)\hat{\tilde{\varsigma}}_{bt}$$

- Composition of new hires:

$$\hat{\tilde{\gamma}}_t^h = \frac{\big(1-(1-\nu)\varsigma_u\big)\tilde{\bar{u}}}{(1-\nu)\varsigma_u + \big(1-(1-\nu)\big)\tilde{\bar{u}}}\hat{\bar{u}}_t - \hat{\bar{s}}_t$$

- Search intensity:

$$\eta_\varsigma \hat{\tilde{\varsigma}}_t = \mathbb{E}\left\{\hat{\Lambda}_{t,t+1} + \hat{\bar{p}}_t + \frac{\tilde{H}^n}{\tilde{H}^n - \tilde{H}^b}\hat{\tilde{H}}_{t+1} - \frac{\tilde{H}^b}{\tilde{H}^n - \tilde{H}^b}\hat{\tilde{H}}^b_{t+1}\right\}$$

Return

Job flows

- Two types of job-to-job flows:
  1. on-the-job search
  2. separation shock and job finding within same period
- Flow shares:

$$
\begin{aligned}
\delta_{BB} &= \frac{(1-\nu)(1-\xi)\varsigma_u\bar{\gamma}}{(1-\nu)\left(1+\bar{\gamma}\right)\varsigma_u+\nu\xi\left(\varsigma_n+\bar{\varsigma}_b\bar{\gamma}\right)} \\
\delta_{BG} &= \frac{[(1-\nu)\varsigma_u+\nu\bar{\varsigma}_b]\xi\bar{\gamma}}{(1-\nu)\left(1+\bar{\gamma}\right)\varsigma_u+\nu\xi\left(\varsigma_n+\bar{\varsigma}_b\bar{\gamma}\right)} \\
\delta_{GB} &= \frac{(1-\nu)(1-\xi)\varsigma_u}{(1-\nu)\left(1+\bar{\gamma}\right)\varsigma_u+\nu\xi\left(\varsigma_n+\bar{\varsigma}_b\bar{\gamma}\right)} \\
\delta_{GG} &= \frac{\left[(1-\nu)\varsigma_u+\nu\varsigma_n\right]\xi}{(1-\nu)\left(1+\bar{\gamma}\right)\varsigma_u+\nu\xi\left(\varsigma_n+\bar{\varsigma}_b\bar{\gamma}\right)}
\end{aligned}
$$

- Share of bad-to-good from on-the-job search:

$$
\delta_{BGS} = \frac{\nu\bar{\varsigma}_b\xi\bar{\gamma}}{(1-\nu)\left(1+\bar{\gamma}\right)\varsigma_u+\nu\xi\left(\varsigma_n+\bar{\varsigma}_b\bar{\gamma}\right)}
$$

Return