The Technological Origins of the Decline in Labor Market Dynamism

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Motivation

- Secular decline in Job Flows UE, EE, EU
- Across states, industry, firm size, firm age, demographics,...
- Potential explanations:
  1. Demographics: aging (Fallick e.a., Engbom; partial explan.)
  2. Shifting Skill Distribution: but little change since 1990
  3. Structural change: but flows services $>$ flows manufacturing;
  4. Decline in entrepreneurship: less young firms, why?
  5. Policy: employment at will $\downarrow$, licensing $\uparrow$ (Haltiwanger)

  $\rightarrow$ Hyatt-Speltzer: composition shifts can explain 30%

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  $\rightarrow$ Hyatt-Speltzer: composition shifts can explain 30%
- In this paper, change in the technology?
  1. complementarity between skills and job
  2. volatility: productivity shocks
  3. adjustment costs (search frictions)

Motivation

- Theory: a model with endogenous UE, EE, EU flows
  1. Two-sided heterogeneity and sorting
  2. Search intensity determines UE and EE
  3. Stochastic productivity: mismatch determines EE and EU

  ⇒ Stochastic Sorting with endogenous seperation and search intensity

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  ⇒ Stochastic Sorting with endogenous seperation and search intensity
- Quantitative Illustration:
  - Effect on flows of change in complementarity, productivity, search frictions
  - Infer technology from flows only

Model

Directed Search, Sorting, OJS

- Continuous time t
- Workers: type $x \in \mathcal{X}$, risk neutral, measure 1
  - 3 states: Unemployed, Employed no search, Employed search
  - wage w, unemployment benefit $b(x)$
  - Search intensity λ, cost $c_\lambda(\lambda)$
- Firms (=jobs): choose type $y \in \mathcal{Y}$ at production cost $c_y(y)$
  1. output $f(x, y) - c_y(y)$
  2. vacancy creation cost: k
  3. free entry
- Stochastic types
  1. arrival rate of shock γ
  2. new types $(x', y') \sim G(x', y'|x, y)$

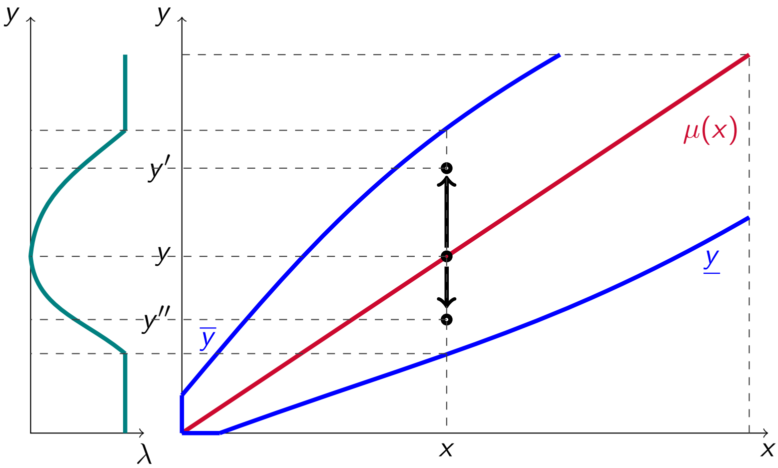
     $\rightarrow$ in quantitative exercise: $x' = x$ and $y' \sim G(y'|x)$

Model

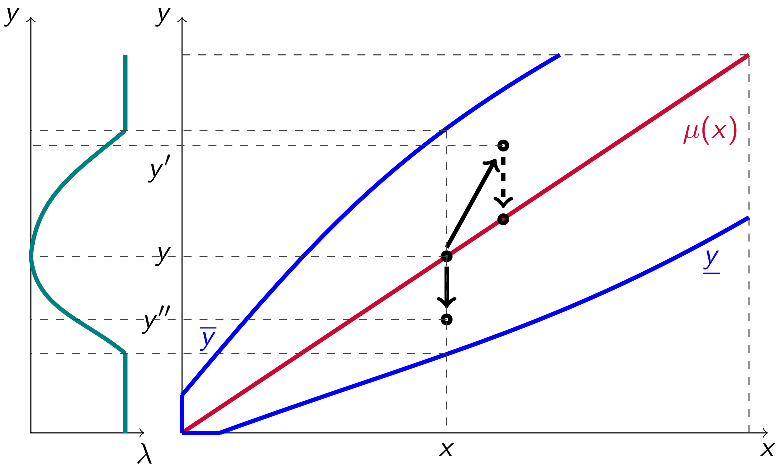
Directed Search, Sorting, OJS

- Market Frictions:
  1. Firms post promised utilities (including contingent continuation payoffs)
  2. vacancies $v(y)$
  3. efficiency units of unemployed $\Lambda u(x)$ (Λ is aggregate of individual λ)
  4. market tightness $\frac{v(y)}{\Lambda u(x)} = \frac{\tilde{\theta}}{\Lambda}$
  5. worker's matching rate $\varphi \lambda m\left(\frac{\tilde{\theta}}{\Lambda}\right)$, with $\varphi \in \{\varphi_u, \varphi_e\}$
  6. firm's matching rate $q\left(\frac{\tilde{\theta}}{\Lambda}\right) = \varphi m\left(\frac{\tilde{\theta}}{\Lambda}\right)\frac{\Lambda}{\tilde{\theta}}$
- Payoffs and Value functions
  1. discount factor ρ; exogenous separation rate δ; $r = \rho + \delta$
  2. transferable utility; $U(x), E(x, y), V(y), J(x, y)$ and $S = E + J$
  3. $P(x, y)$: transfer (penalty) upon separation
- Allocation x to y or unemployed: $\mu \in \mathcal{Y} \cup \{-1\}$

The Mechanism



The Mechanism II



Value Functions

$$
\begin{aligned}
rU(x) =& b(x) + \max_{\tilde{y},\tilde{\theta},\Lambda,\lambda} \left\{ \varphi_u \lambda m\left(\frac{\tilde{\theta}}{\Lambda}\right) [E(x,\tilde{y}) - U(x)] - c_\lambda(\lambda) \right\} \\
rE(x,y) =& w(x,y) + \gamma \int \left[\eta E(x',y') + (1-\eta)U(x') - E(x,y)\right] dG(x',y'|x,y) \\
&+ \max_{\tilde{y},\tilde{\theta},\Lambda,\lambda} \left\{ \varphi_e \lambda m\left(\frac{\tilde{\theta}}{\Lambda}\right) [E(x,\tilde{y}) - P(x,y) - E(x,y)] - c_\lambda(\lambda) \right\} \\
rJ(x,y) =& \max_{w,\eta,P} f(x,y) - c_y(y) - w(x,y) + \gamma \int \left[\eta J(x',y') - J(x,y)\right] dG(x',y'|x,y) \\
&+ \varphi_e \lambda^\star m\left(\frac{\tilde{\theta}^\star}{\Lambda^\star}\right) (P(x,y) - J(x,y)) \\
V(y) =& -k + q\left(\frac{\tilde{\theta}}{\Lambda}\right) J(x,y)
\end{aligned}
$$

where $\lambda^\star$, $\tilde{\theta}^\star$ and $\Lambda^\star$ are optimal solutions to $E(x,y)$, and where $\eta \in \{0,1\}$ is the firm's separation decision.

Equilibrium

Definition

A block-recursive equilibrium (BRE) consists of

- a market tightness function $\tilde{\theta} : \mathcal{X} \times \mathcal{Y} \times \Xi \to \mathbb{R}_+$,
- an aggregate search intensity function $\Lambda : \mathcal{X} \times \mathcal{Y} \times \Xi \to \mathbb{R}_+$,
- an individual search intensity function $\lambda : \mathcal{X} \times \mathcal{Y} \times \Xi \to \mathbb{R}_+$,
- an allocation function $\mu : \mathcal{X} \times \Xi \to \mathcal{Y}$,
- value functions $U : \mathcal{X} \to \mathbb{R}$, $E : \mathcal{X} \times \mathcal{Y} \to \mathbb{R}$, $J : \mathcal{X} \times \mathcal{Y} \to \mathbb{R}$, $V : \mathcal{Y} \to \mathbb{R}$,
- policy functions $(w, \eta) : \mathcal{X} \times \mathcal{Y} \to \mathbb{R} \times \{0, 1\}$.

Equilibrium

These functions satisfy the following conditions:

1. value functions are given by U, E, V, J;
2. policy functions are optimal solutions to the equations above;
3. $V(y) = 0$ for all y and $\lambda = \Lambda$.

Planner's Solution

$$rS(x,y) = f(x,y) - c_y(y) + \gamma \int \left[\max\{S(x',y'), U(x')\} - S(x,y)\right] dG(x',y'|x,y)$$
$$+ \max_{\lambda,\theta,\tilde{y}} \{\varphi_e \lambda m(\theta) [S(x,\tilde{y}) - S(x,y)] - c_\lambda(\lambda) - k\lambda\theta\}$$

$$rU(x) = b(x) + \max_{\lambda,\theta,\tilde{y}} \{\varphi_u \lambda m(\theta) [S(x,\tilde{y}) - U(x)] - c_\lambda(\lambda) - k\lambda\theta\}$$

where $S(x,y) = E(x,y) + J(x,y)$, as well as the flow equations

▸ steady state flow equations

Equilibrium Solution

Proposition

In any BRE, there exist $U(x)$ and $S(x, y)$ where the policy functions λ, θ, μ are optimal solutions.

- This requires $P(x, y) = J(x, y)$
- There is an externality from OJS effort
- Equilibrium is efficient only if firms take this into account in the contract they offer

Equilibrium Solution: FOC

Employed Worker

$$\lambda: \ \ \varphi_e m(\theta)\left[S(x,\tilde{y}) - S(x,y)\right] = c'_\lambda + k\theta$$

$$\tilde{\theta}: \ \ \varphi_e m'(\theta)\left[S(x,\tilde{y}) - S(x,y)\right] = k$$

$$\tilde{y}: \ \ \varphi_e \lambda m(\theta) \frac{\partial S(x,\tilde{y})}{\partial \tilde{y}} = 0$$

Unemployed Worker:

$$\lambda: \ \ \varphi_u m(\theta)\left[S(x,\tilde{y}) - U(x)\right] = c'_\lambda + k\theta$$

$$\tilde{\theta}: \ \ \varphi_u m'(\theta)\left[S(x,\tilde{y}) - U(x)\right] = k$$

$$\tilde{y}: \ \ \varphi_u \lambda m(\theta) \frac{\partial S(x,\tilde{y})}{\partial \tilde{y}} = 0$$

$\lambda, \tilde{\theta}$ only depends on $\Delta = S(x,\tilde{y}) - S(x,y)$ or $S(x,\tilde{y}) - U(x)$

Wages

Different wage contracts are consistent with BRE. For example:

1. Zero Penalty Contract ($P = 0$)
2. Constant Share of Surplus Contract
3. Constant Wage Contract

Wage Contracts

Free entry implies all contracts satisfy: $J(x, \mu(x)) = \frac{k}{q}$

1. Zero Penalty Contract: "Sell Job to Worker"

   $P(x, y) = 0 \Rightarrow J(x, y) = 0 \rightarrow E(x, y) = S(x, y)$. The wage:

$$w(x, y) = rS(x, y) - \gamma \int \left[\eta S(x', y') + (1-\eta)U(x') - S(x, y)\right] dG(x', y'|x, y)$$
$$- \max_{\tilde{y}, \tilde{\theta}, \Lambda, \lambda} \left\{ \varphi_e \lambda m\left(\frac{\tilde{\theta}}{\Lambda}\right) \left[S(x, \tilde{y}) - \frac{k}{q} - S(x, y)\right] - c_\lambda(\lambda) \right\}.$$

   and the initial wage upon newly matching is:

$$w(x, \mu(x)) = rS(x, \mu(x)) - \frac{k}{q}$$
$$- \gamma \int \left[\eta S(x', y') + (1-\eta)U(x') - S(x, y)\right] dG(x', y'|x, \mu(x))$$

Wage Contracts

2. Constant Share of Surplus Contract. Share $\beta(x)$:

$$(1-\beta(x))[S(x,\mu(x))-U(x)]=\frac{k}{q} \quad \Rightarrow \quad \beta(x)=1-\frac{k}{q[S(x,\mu(x))-U(x)]},$$

$$\begin{aligned} E(x',y) =& U(x')+\beta(x)[S(x',y)-U(x')] \\ =& U(x')+\left(1-\frac{k}{q[S(x,\mu(x))-U(x)]}\right)[S(x',y)-U(x')] \end{aligned}$$

and we can substitute E into the wage equation. The optimal penalty equals value of job loss: $P(x',y)=J(x',y)$:

$$P(x',y)=(1-\beta(x))[S(x',y)-U(x')]$$

Wage Contracts

3. Constant Wage Contract. Invariant wage w until the worker leaves:

$$rJ(x,\mu(x)) = f(x,y) - c_y(y) - w + \gamma \int \left[\eta J(x',y') - J(x,y)\right] dG(x',y'|x,\mu(x)).$$

Need to solve numerically to determine $J(x',y)$.

Results

Assumption (1)

The shocks are independent of y : $G(x', y'|x)$.

- $\frac{\partial S(x,\tilde{y})}{\partial \tilde{y}} = 0$ is equivalent to $f_y(x, \tilde{y}) - c_y'(\tilde{y}) = 0$

$\Rightarrow$ optimal $\tilde{y}$ in $S(x, \tilde{y})$ will be exclusively determined by $f_x(x, y) = c_y'(y)$

$\Rightarrow$ $\tilde{y} = \mu(x, \xi)$ independent of state ξ (firm y or unemployment), and only depends on the worker type x.

Proposition

Under Assumption 1, the BRE is unique: there exists a unique pair of $(S(x, y), U(x))$ satisfying the equilibrium value functions

Results

Assumption (2)

(i) c_y *is an increasing, convex function:* $c_y' > 0$ *and* $c_y'' \geq 0$;

(ii) f *is increasing and concave in each element:* $f_x > 0$, $f_y > 0$, $f_{xx} < 0$ *and* $f_{yy} < 0$.

Proposition

Under Assumptions 1 and 2, there is positive assortative matching ($\mu'(x) \geq 0$) *if and only if* $f(x, y)$ *is supermodular*

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Proposition

Under Assumptions 1 and 2, there exist $\overline{y}(x) \geq \underline{y}(x) \geq 0$ *such that* $y \in \mathcal{M}(x)$ *if and only if* $y \in [\underline{y}(x), \overline{y}(x)]$.

Results

Functional Form Assumptions

- Production technology

$$f(x,y) - c_y(y) = \omega\left(x^{\beta}y^{1-\beta} - (1-\beta)y\right) + (1-\omega)\beta x$$

- Matching function: $m(\theta) = \varphi\theta^{\alpha}$
- Type distribution $x \sim \mathcal{N}(\underline{x}, 0.125)$ truncated $x \in [\underline{x}, 1]$
- Normal shocks $y \sim \mathcal{N}(x, \sigma)$, truncated $y \in [0, 2]$
- Unemployment benefit: $b(x) = bx$
- Search cost: $c_{\lambda} = c\frac{1}{2}\lambda^2$

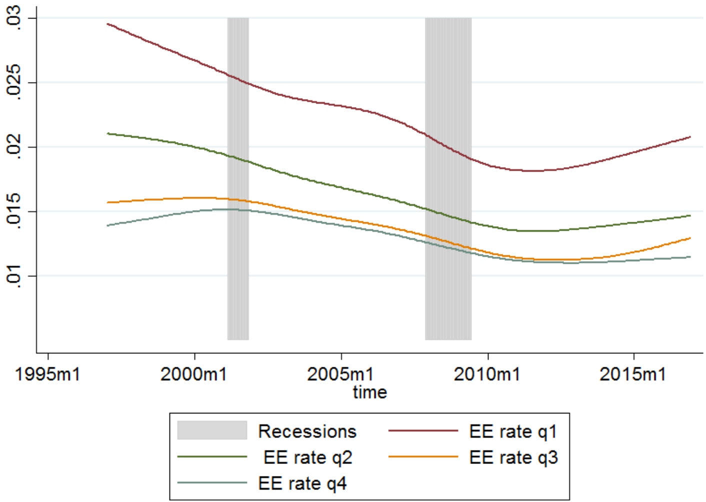
Quantitative Exercise

- Partition flows by earnings quartile $q_i, i \in \{1, 2, 3, 4\}$
- Match 12 moments: UE_{q_i}, EE_{q_i}, EU_{q_i} ($u = \frac{EU}{UE+EU}$ endog.)
- Data moment is trend
- Separately estimate 2 steady state economies:

  January 1997 and December 2016
- GMM (simulated annealing for global max)

CPS Data

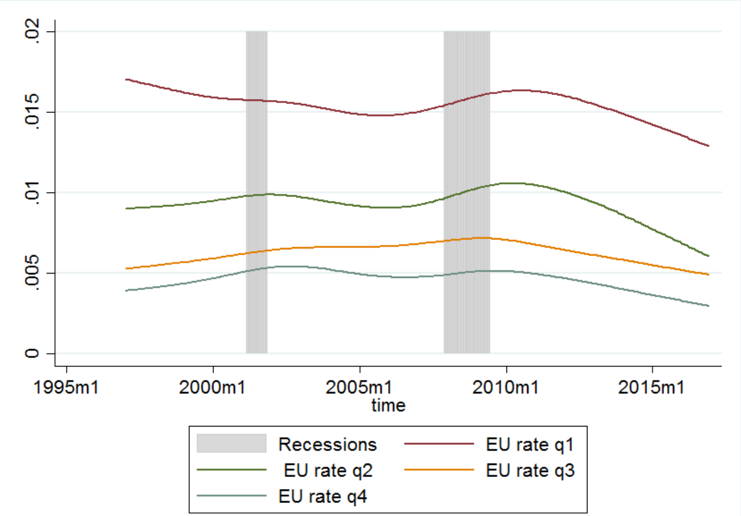
EE



.03
.025
.02
.015
.01
1995m1
2000m1
2005m1
2010m1
2015m1
time
Recessions
EE rate q1
EE rate q2
EE rate q3
EE rate q4

CPS Data

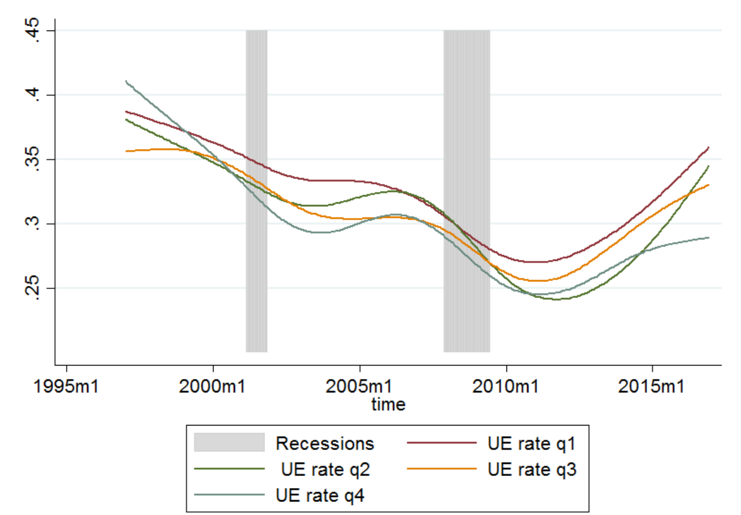
EU



0
.005
.01
.015
.02
1995m1
2000m1
2005m1
2010m1
2015m1
time
Recessions
EU rate q1
EU rate q2
EU rate q3
EU rate q4

CPS Data

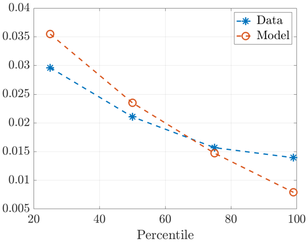
UE



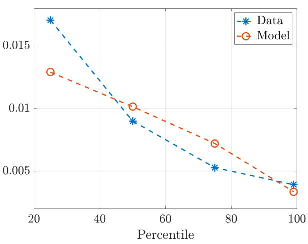
.45
.4
.35
.3
.25
1995m1
2000m1
2005m1
2010m1
2015m1
time
Recessions
UE rate q1
UE rate q2
UE rate q3
UE rate q4

Model Fit

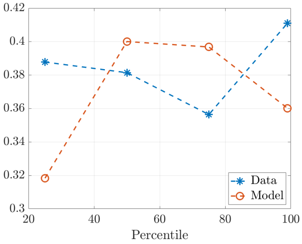
1997



(A) EE flow rate



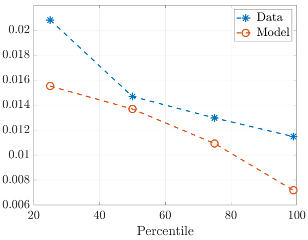
(B) EU flow rate



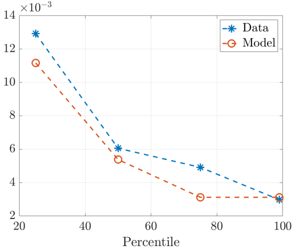
(C) UE flow rate

Model Fit

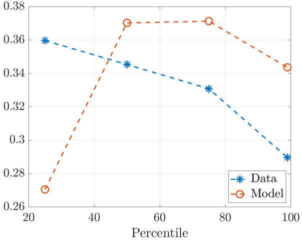
2016



(A) EE flow rate



(B) EU flow rate



(C) UE flow rate

Estimated Parameters

		1997	2016	%Δ
ω	Complementarity	5.95	7.73	29.92
β_0	Worker share intercept	0.38	0.61	58.77
β_1	Worker share slope	0.18	0.37	107.76
σ_0	shock var. intercept	0.61	0.17	-72.05
σ_1	shock var. slope	0.63	0.27	-57.41
γ_0	shock freq. intercept	0.10	0.04	-56.76
γ_1	shock freq. slope	0.71	0.34	-51.90
φ_0	match eff. intercept	15.67	11.85	-24.40
φ_1	match eff. slope	0.33	0.25	-23.62
c	search cost	7.74	11.36	46.64
kk	entry cost	17.62	6.40	-63.66

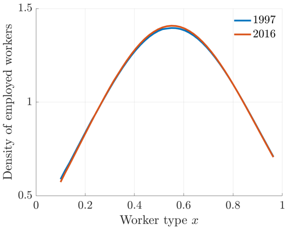
Estimated Parameters

- increase in complementarity
- lower variance and frequency of shocks
- increase in cost of search

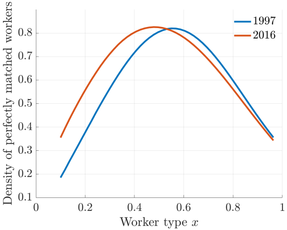
Acceptance Region

Figure: Acceptance Region

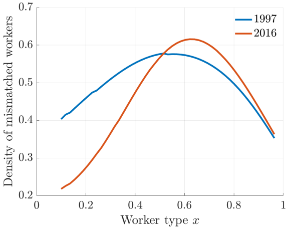
Distribution of Workers



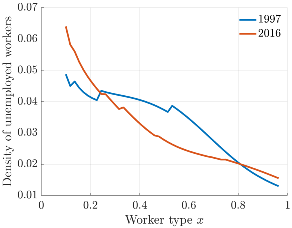
(A) Density of employed workers



(B) Measure of perfectly matched workers

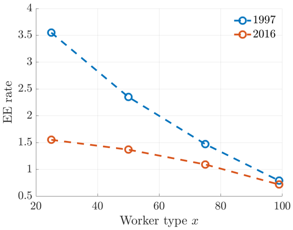


(C) Density of mismatch workers

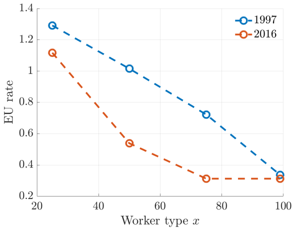


(D) Measure of unemployed workers

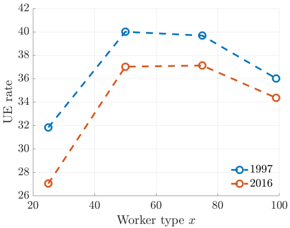
Flows and Unemployment Rate



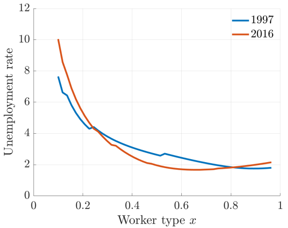
(A) EE rate (in %)



(B) EU rate (in %)

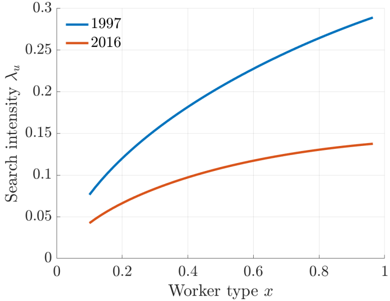


(C) UE rate (in %)

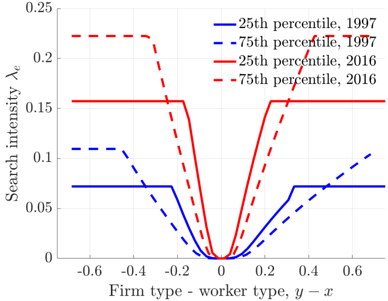


(D) Unemployment rate (in %)

Search Intensity



(A) Unemployed Search Intensity



(B) Employed Search Intensity

Conclusion

- Propose a theory of sorting:
  - mismatch shocks $\Rightarrow$ directed search with search intensity
  - endogenous UE, EE, EU flows (extensive and intensive margin)
  - higher mismatch $\Rightarrow$ higher search intensity (or separation)
- Quantitative illustration: decline in dynamism driven by
  - increase in complementarity
  - lower variance and frequency of shocks
  - increase in cost of search

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Notation

x	type of the worker
y	type of the firm
$\tilde{\theta}$	market tightness
λ	search intensity
Λ	aggregate search intensity
δ	death rate
ρ	discount rate
$r = \delta + \rho$	effective discount rate
$f(x, y)$	output function
$c_y(y)$	operation cost
$c_\lambda(\lambda)$	search cost
k	entry cost
$m\left(\frac{\tilde{\theta}}{\Lambda}\right)$	matching function
$U(x)$	value of an unemployed worker
$E(x, y)$	value of an employed worker
$J(x, y)$	value of a matched firm
$S(x, y)$	value of a firm-worker pair, gross of $U(x)$; $S = E + J$
$V(y)$	value of vacancy
$G(x', y'\|x)$	transition distribution function
$\phi(x, y)$	density of mismatched workers
$u(x)$	density of unemployed workers
$\psi(x)$	density of perfectly matched workers
$v(y)$	density of vacant firms
$\nu(y)$	density of vacant firms to be matched with unemployed workers

Steady State Flow Equations

$$
\begin{aligned}
(\gamma+\delta)\psi(x) =& \varphi_u \lambda_u m(\theta_u)\, u(x) + \int \phi(x,y)\varphi_e \lambda_y m(\theta_y)\, dy \\
(\varphi_u \lambda_u m(\theta_u) + \delta) u(x) =& \gamma \int \int_{y \notin \mathcal{M}(x)} g(x,y|\tilde{x},\tilde{y}) dxdy \phi(\tilde{x},\tilde{y}) d\tilde{x} d\tilde{y} \\
& + \gamma \int \int_{y \notin \mathcal{M}(x)} g(x,y|\tilde{x},\mu(\tilde{x})) dxdy \psi(\tilde{x}) d\tilde{x} + \delta f_0(x) \\
(\gamma+\delta+\varphi_e \lambda_y m(\theta_y))\, \phi(x,y) =& \gamma \int g(x,y|\tilde{x},\tilde{y}) \phi(\tilde{x},\tilde{y}) d\tilde{x} d\tilde{y} \\
& + \gamma \int g(x,y|\tilde{x},\mu(\tilde{x})) v(\tilde{x}) d\tilde{x}.
\end{aligned}
$$

return