Job Applications and Labor Market Flows

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Motivation

- Since 1980s, search technology has improved, enabling workers to send more applications.

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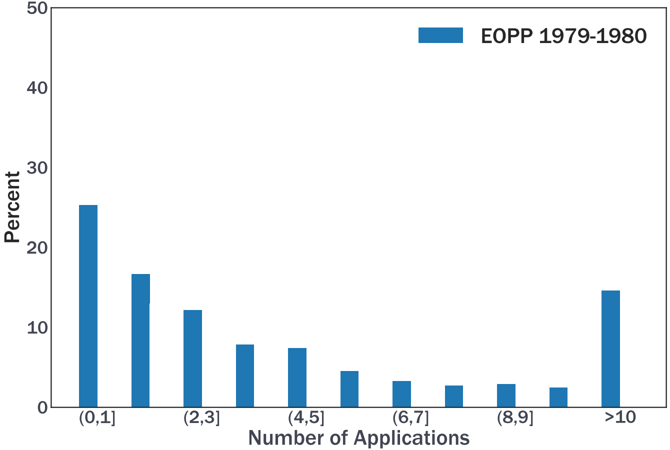
- From 1980s to 2013-2017, median worker applications ↑ from 3 to 6



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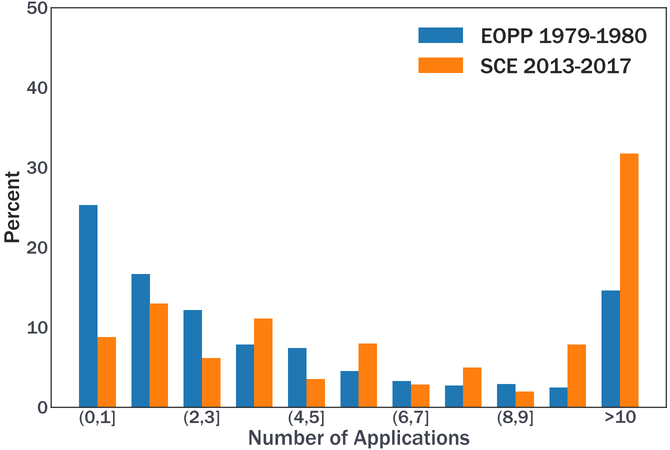

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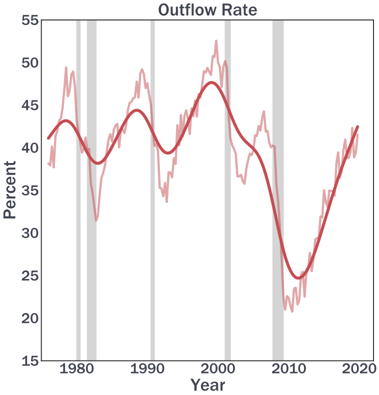
- Despite ↑ in applications, trend unemployment outflow rate relatively unchanged.



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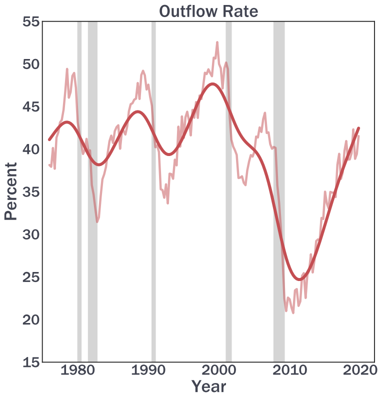
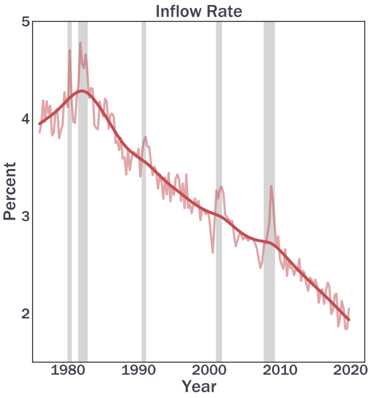
- From 1980s to 2013-2017, median worker applications ↑ from 3 to 6
- Despite ↑ in applications, trend unemployment outflow rate relatively unchanged.
- But the unemployment inflow rate has exhibited a long run *decline*





Question

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ss app

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- Answer:
  - Main benefit of rising applications has not been to $\uparrow$ job-finding rates:
  - *But* to $\uparrow$ the probability of finding a good match, as evidenced by declining separation rates

▸ ss ▸ app

Mechanism

- What: Random search with multiple applications. Workers differ by match quality which is persistent. Costly information acquisition by firms

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- How (Inflows): applicant pool size affects firm's decision to acquire information
  - Higher quality matches formed $\rightarrow$ fewer separations
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- What: Random search with multiple applications. Workers differ by match quality which is persistent. Costly information acquisition by firms
- How (Inflows): applicant pool size affects firm's decision to acquire information
  - Higher quality matches formed $\rightarrow$ fewer separations
  - But if workers' outside options $\uparrow$ $\rightarrow$reservation match quality $\uparrow$ $\rightarrow$ more separations
- How (Outflows):
  - More worker applications $\rightarrow$ workers contact more vacancies $\rightarrow$ $\uparrow$ job-finding
  - But can also $\downarrow$ probability of an offer, and acceptance rate $\rightarrow$ $\downarrow$ job-finding

Related Literature

- Multiple applications: Albrecht, Gautier and Vroman (2006), Kircher(2009), Galenianos and Kircher(2009), Gautier and Wolthoff(2009), Gautier, Moraga-Gonzalez and Wolthoff (2016), Gautier, Muller, van der Klaauw, Rosholm, and Svarer (2018), Albrecht, Cai, Gautier and Vroman (2020), Wolthoff (2018), Bradley (2020),

- Secular trends in labor market flows: Crump, Eusepi, Giannoni and Sahin (2019), Hyatt and Spletzer (2016), Pries and Rogerson (2019), Molloy, Smith and Wozniak (2020), Mercan (2018), Engbom (2019), Menzio and Martellini (2020)

Contribution: investigate what an increase in worker applications does to labor market flows over time.

The Model

Model: preliminaries

- Time is discrete
- Unit measure of infinitely-lived risk-neutral workers, discount factor β
- Workers are:
  - Either employed or unemployed
  - If unemployed, home production b
  - If employed, receive wage. Wage is Nash-bargained every period
  - Probability δ employed exogenously become unemployed. Jobs can also be endogenously destroyed
  - Only unemployed workers search for jobs

Model: preliminaries

- A job is a firm-worker pair.
- Output $=$ match quality x
    - For each application, x: iid draw from $\Pi(x)$ at time of meeting, $\pi(x)$ pdf
    - Existing matches observe match quality shock $\rho(x)$ where $\frac{d\rho(x)}{dx} < 0$
    - Match quality is persistent, new draws from $\Psi(y \mid x)$ where $\frac{d\Psi(y|x)}{dx} > 0$, $\psi(y \mid x)$ pdf

Model: preliminaries

- Search is random
- Vacancies, v, cost κ_V to post
- Unemployed submits a applications $\rightarrow \frac{a}{v} =$ probability apply to particular vacancy.
- Probability firm receives j applications follows Poisson:

$$q(j) = \frac{1}{j!}\left(\frac{a}{\theta}\right)^{j}\exp\left(-\frac{a}{\theta}\right)$$

where $\theta = v/u$

Model: Timing

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- Production

Value of operating firm

$$V^F(x) = x - w(x) + \beta(1-\delta)\left([1-\rho(x)]\,V^F(x) + \rho(x)\int_{\widetilde{x}}^{\overline{x}} V^F(y)\,\psi(y \mid x)\,dy\right)$$

- current profits: $x - w(x)$
- $1-\rho(x)$: no match quality shock, get $V^F(x)$
- $\rho(x)$: shock, draw from $\Psi(y \mid x)$

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$$V^I(j) = \int_{\widetilde{x}}^{\overline{x}} \Gamma(x) V^F(x) d[\Pi(x)]^j$$

  where $[\Pi(x)]^j$ is distribution of maximum order statistic

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$$V^{I}(j) = \int_{\widetilde{x}}^{\overline{x}} \Gamma(x) V^F(x) d[\Pi(x)]^j$$

- Firm's information choice problem conditional on j applicants:

$$\Xi(j) = \max\left\{V^I(j) - \kappa_I, V^{NI}\right\}$$

where κ_I is fixed cost of information

Higher j, higher incentive to acquire information

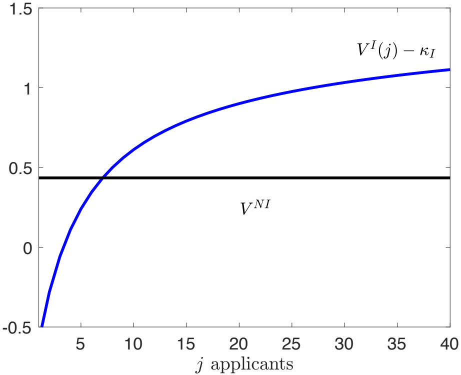
- $V^I(j)$ is ↑ in j as: $[\Pi(x)]^j$ FOSD $[\Pi(x)]^{j-1}$

$$V^I(j) = \int_{\widetilde{x}}^{\overline{x}} \Gamma(x) V^F(x) d[\Pi(x)]^j$$

▸ mc

Higher j, higher incentive to acquire information

- $V^I(j)$ is $\uparrow$ in j as: $[\Pi(x)]^j$ FOSD $[\Pi(x)]^{j-1}$
- Exists a $j^* > 1$ such that for all $j \geq j^*$, $V^I(j) - \kappa \geq V^{NI}$



- As $j \uparrow$, more likely that at least 1 has high x. Info more valuable

▸ mc

Value of a vacancy

- Under free entry, firms enter until value of a vacancy is zero:

$$\kappa_V = \sum_{j=1}^{\infty} q(j)\Xi(j)$$

where $q(j)$ = probability of j applicants and $\Xi(j) = \max\{V^I(j) - \kappa_I, V^{NI}\}$

What is $\Gamma(x)$?

- If $x \geq \widetilde{x}$, a worker accepts an offer of match quality x if:
  - 1) Best match quality drawn
  - 2) OR no offers from application with higher match quality $y > x$
    - Example with $a = 2$

$$\Gamma(x) = \underbrace{\Pi(x)}_{\text{event 1}} + \underbrace{[1 - \Pi(x)][Pr(\text{no offer} \mid y > x)]}_{\text{event 2}}$$

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  - More generally,

$$\Gamma(x) = [\Pi(x)]^{a-1} + \sum_{i=1}^{a-1} (a-i)[1-\Pi(x)]^{i}[\Pi(x)]^{a-1-i}[Pr(\text{no offer} \mid y > x)]^{i}$$

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- If $x < \widetilde{x}$, $\Gamma(x) = 0$

Worker's values

- Denote $\phi(x)$ as probability of being hired with match quality x

$$\phi(x) = \Gamma(x) \times Pr(\text{offer} \mid x)$$

where

$$Pr(\text{offer} \mid x, j) = \mathbb{I}(j < j^*)(1/j) + \mathbb{I}(j \geq j^*)[\Pi(x)]^{j-1}$$

and

$$Pr(\text{offer} \mid x) = \sum_{j=1}^{\infty} \widehat{q}(j) Pr(\text{offer} \mid x, j)$$

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- Value of unemployed

$$U = b + \beta\, \underbrace{a\int_{\widetilde{x}}^{\overline{x}}\phi(x)\pi(x)V^W(x)dx}_{\text{expected value of finding job}} + \beta \underbrace{\left[1 - \int_{\widetilde{x}}^{\overline{x}} a\phi(x)\pi(x)dx\right]}_{\text{fail to find job}} U$$

- Value of employed with x

$$\begin{aligned} V^W(x) &= w(x) + \beta \overbrace{(1-\delta)(1-\rho(x))}^{\text{no shocks}} V^W(x) \\ &\quad + \beta \underbrace{\left[\delta + (1-\delta)\rho(x)\Psi(\widetilde{x} \mid x)\right]}_{\text{total separation rate}} U + \beta(1-\delta)\rho(x) \underbrace{\int_{\widetilde{x}}^{\overline{x}} V^W(y)\psi(y \mid x)dy}_{\text{expected new match value}} \end{aligned}$$

Equilibrium

Equilibrium characterized by

- Information threshold, j^*
- Reservation match quality, $\widetilde{x}$, determined by indifference condition $S(\widetilde{x}) = 0$ where $S(x) = V^F(x) + V^W(x) - U$
- Free entry condition (θ)

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Quantitative results

Calibration Strategy

Qn: How does an increase in a affect flows?

- Consider two time periods: 1976-1985, 2010-2019
- Exogenous variable: a increases from 3 to 6 (as per in the data)
- Calibrate model to first time period (1976-1985), model period is a month
- Fixed parameters: $\beta = 0.993$,$\eta = 0.5$
- $\Pi(x) \sim$ Beta(A, B), $\rho(x) = \min\{\exp(x_{ref} - x), 1\}$ where $x_{ref} =$ mean of $\Pi(x)$
- Joint distribution of shocks $\Psi(x', x)$ follows Gumbel copula, λ is parameter governing how x' depends on x.
- Parameters to calibrate: $\{\kappa_V, \kappa_I, \delta, \lambda, b, A, B\}$.

Model Fit

Parameter	Description	Value	Target	Model	Data
κ_V	Vacancy posting cost	0.49	Outflow rate	0.43	0.41
κ_I	Cost of information	0.71	Recruiting cost/mean wage	0.97	0.93
δ	Exog. separation rate	0.025	Inflow rate	0.043	0.041
λ	Persistence of x	6.99	EU_{20}/EU_{80}	4.41	4.05
A	Beta distribution	1.66	Fraction with no offers	0.34	0.38
B	Beta distribution	1.17	Fraction accept given > 1 offer	0.82	0.84
b	Home production	0.22	Reservation wage/mean wage	0.86	0.66

Model eqm going form $a = 3$ to $a = 6$

- $a \uparrow \implies$ workers contact more vacancies $\rightarrow$ more firms want information $\rightarrow$ vacancy creation $\downarrow$ due to $\uparrow$ in expected recruiting cost as more firms acquire info.

	$a = 3$	$a = 6$	Log Diff (%)
Information threshold j^*	5	7	-
Percent firms informed	44.1	95.3	79
Labor market tightness θ	0.69	0.50	32
Reservation match quality $\widetilde{x}$	0.67	0.74	10

Decline in vacancy creation causes $\widetilde{x}$ to observe modest rise

Model eqm going form $a = 3$ to $a = 6$

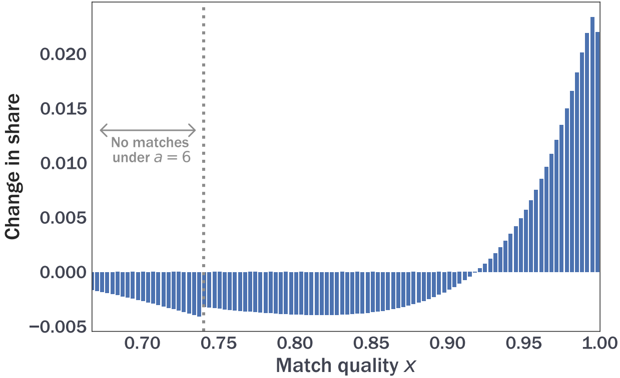
- $\uparrow$ in a explains 1/3 of decline in inflow rate. Outflow rate small $\downarrow$.

$$\text{outflow rate} = \overbrace{a}^{\text{direct}} \underbrace{\int_{\tilde{x}}^{\bar{x}} \phi(x)\pi(x)\,dx}_{\text{indirect}}$$

	$a = 3$		$a = 6$		Log Diff (%)	
	Model	Data	Model	Data	Model	Data
Inflow rate	0.043	0.041	0.035	0.023	-20	-58
Outflow rate	0.426	0.408	0.404	0.318	-5	-25
Outflow rate (2019)		0.408		0.409		0
direct a effect	3		6		69	
indirect a effect	0.142		0.067		74	

Unemployment inflows

- Larger share of high quality matches, $G(x)_{a=6}$ FOSD $G(x)_{a=3}$



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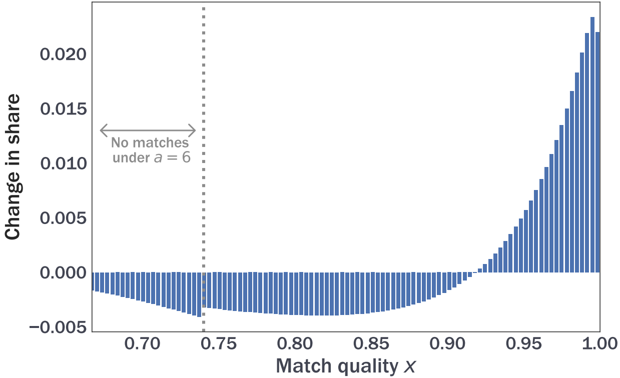

- Greater formation of high quality matches leads to 4.5% $\downarrow$ in freq. of shock. Conditional on shock, 51% $\downarrow$ in $P(x' < \widetilde{x})$.
- Key takeaway: Although $\widetilde{x} \uparrow$, effect from improved firm selection dominates.

Testable implications: inflows

	$a = 3$		$a = 6$		Log Diff (%)	
	Model	Data	Model	Data	Model	Data
Share < 1 quarter	0.014	0.080	0.007	0.049	-70	-49
Share $1 < t < 3$ years	0.16	0.18	0.11	0.16	-36	-12
Median tenure (years)	3.28	4	3.28	4	0	0

- Short duration jobs in the data declined the most
- Median tenure unchanged in data

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- Shift from low to high x matches: short duration jobs $\downarrow$, drop in inflow rate driven by change in realized distribution of x
- $\widetilde{x} \uparrow \implies \Psi(\widetilde{x} \mid x)$ higher: x jobs that continue to exist observe marginally higher separation rate $\rightarrow$ median tenure unchanged:

Testable implications: outflows

$$\text{outflow rate} = \overbrace{a}^{\text{direct}} \underbrace{\int_{\tilde{x}}^{\bar{x}} \Gamma(x) Pr(\text{offer}|x) \pi(x)\, dx}_{\text{indirect}}$$

	$a = 3$		$a = 6$		Log Diff (%)	
	Model	Data	Model	Data	Model	Data
Fraction with offers	0.66	0.62	0.44	0.55	-41	-12
Acceptance rate	0.35	0.80	0.22	0.43	-45	-62
Res. wage	0.71	5.83	0.78	6.92	8	17

- More congestion, higher selectivity: Offer probabilities $\downarrow$, res. wage $\uparrow$, acceptance rates $\downarrow$ ($\int_{\widetilde{x}}^{\overline{x}} \Gamma(x)\pi(x)dx$),
- If $\widetilde{x}$ held fixed at $a = 3$ level: acceptance rates decline by 30% with $\uparrow$ in a

The role of costly information

The importance of costly information acquisition

- Model nests full information (FI) $\kappa_I = 0$, and no information (NI) $\kappa_I \to \infty$
- Recalibrate FI and NI model and ask how $a \uparrow$ from 3 to 6 affects flows
- Under FI, firms can always rank workers and extend offer to highest match quality applicant
- Under NI, firm engages in random hiring

The importance of costly information acquisition

- Constant cost of job creation leads to higher vacancy creation under FI and NI when $a \uparrow$, causing $\theta \uparrow$
- However, FI firms can identify best worker while NI firms can't: benefit of higher a negated for worker in N, $\uparrow a$ adds to congestion since $\%\Delta\theta < \%\Delta a$
- Hence $\widetilde{x} \downarrow$ in NI, but $\uparrow$ in FI.

	FI			NI		
	$a=3$	$a=6$	Log Diff	$a=3$	$a=6$	Log Diff
θ	0.69	0.76	10	0.70	0.77	9
$\widetilde{x}$	0.54	0.61	13	0.55	0.53	-5

The importance of costly information acquisition

- Counterfactual flows under FI and NI

	FI			NI		
	$a = 3$	$a = 6$	Log Diff	$a = 3$	$a = 6$	Log Diff
Inflow rate	0.046	0.043	-6	0.042	0.038	-10
Outflow rate	0.44	0.50	12	0.45	0.34	-28
direct a effect	3	6	69	3	6	69
indirect a effect	0.15	0.08	-57	0.15	0.06	-97

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- Under FI, $Pr(\text{offer}|x, j) = [\Pi(x)]^{j-1} \rightarrow dPr(\text{offer}|x, j)/dx \geq 0$. Since $a \uparrow \implies \uparrow$ probability of drawing high $x \implies$ UE $\uparrow$

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- Under NI, $Pr(\text{offer} \mid x, j) = \frac{1}{j}$. Since $\%\Delta a > \%\Delta\theta \implies q(j)$ shifts rightward $\implies$ UE $\downarrow$

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- Higher $\widetilde{x}$ in FI mitigates decline in EU, lower $\widetilde{x}$ in NI contributes to decline in EU.

Conclusion

- Built model to see how rise in worker applications can affect flows
- Showed how rising a can raise share of informed firms
- Leading to improvement in realized match quality distribution
- Model can explain why outflows don't change but inflows decline
- Key takeaway: increased applications lead to better matches not necessarily higher job-finding rates.

THE END

BACKUP SLIDES

Shift-Share Analysis

Fraction of change accounted by	Inflows	Outflows
Within-group change	70.7	89.8
Between-group: education composition change	11.1	0.5
Between-group: gender composition change	-0.1	0.1
Between-group: age composition change	17.1	12.2
Between-group: industry composition change	1.2	-2.6

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Applications across groups and time

	EOPP 1979-1980		SCE 2013-2017		Log difference	
	Mean	Median	Mean	Median	Mean	Median
All	6.82	2.70	14.11	6.00	0.73	0.80
College	4.98	2.46	11.73	6.00	0.86	0.89
Non-college	7.36	2.82	15.11	7.00	0.72	0.91
Male	7.44	2.50	12.88	6.00	0.55	0.88
Female	6.13	2.86	15.11	6.00	0.90	0.74
Young	7.24	2.86	14.39	9.00	0.69	1.15
Old	4.27	1.67	13.94	6.00	1.18	1.28

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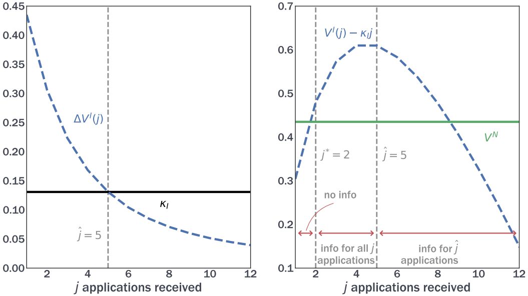
Marginal cost version

Firm's information choice problem: $\max\left\{V^{NI},\overline{V}^{I}(j)\right\}$ where

$$\overline{V}^{I}(j)=\max_{n\in\{1\ldots j\}}V^{I}(n)-k_{I}n$$



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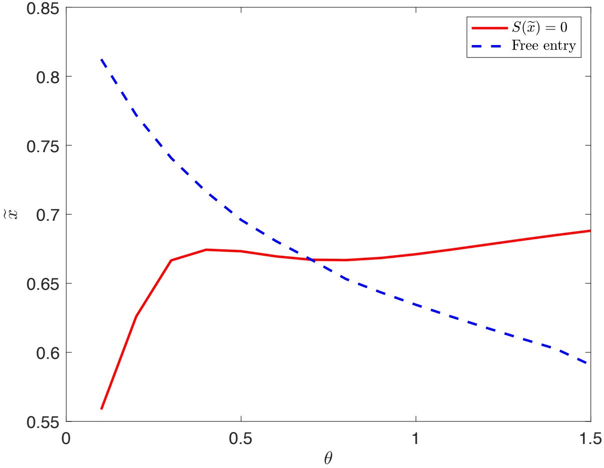
Marginal cost version

	Baseline		MC		Log Diff (%)	
	$a = 3$	$a = 6$	$a = 3$	$a = 6$	Baseline	MC
Inflow rate	0.043	0.035	0.041	0.037	-20	-8
Outflow rate	0.426	0.404	0.488	0.486	-5	-0
direct a effect	3	6	3	6	69	69
indirect a effect	0.142	0.193	0.162	0.081	-74	-70

▸ fc

Unique equilibrium



▸ eqm

Variable applications

- Applicants search with intensity ξ and draw a applications from Poisson distribution with parameter ξ.

$$p\left(a\right) = \frac{1}{a!}\xi^{n} \exp\left(-\xi\right)$$

- A vacancy receives j applications drawn from Poisson distribution with parameter ξ/θ

$$q(j) = \frac{1}{j!}\left(\frac{\xi}{\theta}\right)^{j} \exp\left(-\frac{\xi}{\theta}\right)$$

- Firm's problem unchanged, Worker's problem: prior to realizing a, all values now take expectation over a

Variable applications

	Baseline		Variable a		Log Diff (%)	
	$a = 3$	$a = 6$	$a = 3$	$a = 6$	Baseline	Var. a
Inflow rate	0.043	0.035	0.039	0.033	-20	-18
Outflow rate	0.426	0.404	0.403	0.392	-5	-3
direct a effect	3	6	3	6	69	69
indirect a effect	0.142	0.193	0.150	0.070	-74	-76