Learning Through Hiring: Labor Mobility as a Channel for Endogenous Growth

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Motivation – Background

- Since Romer (1986) and Lucas (1988), the diffusion of knowledge is an important mechanism in many endogenous growth models
- Labor mobility is often discussed as one of the main channels through which knowledge can spill over between firms
  - BOS – 52% of innovating firms report new workers were an important source of ideas for the innovation
- Panel data provides estimates of the spillover effects at the firm level
- But macroeconomic models don't consider this channel, or treat learning as exogenous

Research Question

This paper:

What are the macroeconomic implications of knowledge spillover through the labor mobility channel for long-run growth and heterogeneity in the economy?

- Develop a framework for assessing knowledge spillover at the macroeconomic level
- Endogenize the structure of the learning process – Labor mobility channel

Approach

- Develop a general-equilibrium endogenous growth model
- Learning occurs through knowledge spillover via labor mobility
- On-the-job search-and-matching model with heterogenous firms and workers
- Endgenized learning process:
  - Endogenous learning rate – vacancy posting rate
  - Endogenous dist. of new knowledge – dist. of worker search effort
- Calibrate the model to macro and micro data moments
- Study the BGP of the economy

Preview of Findings

- **Counterfactual** – no knowledge spillover
  - Aggregate growth declines: 2.1% to 1.4%
  - More productivity/income inequality
  - No effect on firm size distribution
- **Social planner** – chooses search efforts to max the *marginal social value* of a firm
  - Less income/productivity inequality
  - Aggregate growth rate not significantly higher
  - Due to congestions in labor market
  - No effect on firm size distribution

Related Literature

Micro Evidence

- Kirker and Sanderson (2017) – Knowledge spillover estimates at firm level
- Stoyanov and Zubanov (2012), Serafinelli (2015)

Endogenous Growth

- Endogenous search – Parrotta and Pozzoli (2012), Lucas and Moll (2012)
- Luttmer (2012, 2015)

This Paper's Contribution

To knowledge spillover between firms

- General-equilibrium framework
- Can examine long-run growth and distributional effects at the aggregate level

To endogenous growth models

- Provides a structural interpretation to the learning process
- Learning rate is endogenised (vacancy posting rate)
- Distribution of new ideas is endogenised (search effort and distribution of workers)

Model

Model Overview

1) On-the-job search-and-matching model

- Large heterogenous firms (productivity, firm size)
- Workers moving from more to less productive firms facilitate the spillover of productive knowledge between firms
  - Incentive for workers to move up *and* down the productivity ladder
  - Firms post vacancies to obtain more labor and new knowledge

2) Endogenous growth framework

- Policy choices determine rate of firm learning
- When workers meeting a less productive firm, they can facilitate knowledge spillover, improving the distribution of productivity in the economy

Learning From Knowledge Spillover

- Firm with productivity z meets a worker with productivity $\tilde{z} > z$
- $y - z$ denotes the amount of knowledge the worker can transfer. Where $z \leq y \leq \tilde{z}$ is drawn from the distribution with pdf $T(y; \tilde{z}, z)$

The distribution $T(y; \tilde{z}, z)$ reflects:

- Internal learning frictions
- External learning frictions – e.g. match between types of firms, scope of job to influence the firm
- Frictions in adapting the firm's current production methods

Firms

Hamilton-Jacobi-Bellman:

$$r\Pi(z,l,t) = \pi(z,l,t) + \frac{\partial \Pi(z,l,t)}{\partial t}$$
$$+ \max_{\nu \in [0,\nu_{max}]} \left\{ \begin{array}{l} -c_{\nu}(\nu) \\ +\nu q(\theta) \frac{\partial \Pi(z,l,t)}{\partial l} \left(\int_{\tilde{z}=0}^{\infty} \int_{\tilde{l}} \mathbf{1}_{agree} h_{\varepsilon}(\tilde{z},\tilde{l},t)\, d\tilde{l}\, d\tilde{z} \right) \\ +\nu q(\theta) \mathbb{E}[Spillover] \end{array} \right\}$$
$$+ \Psi(z,l,t) \frac{\partial \Pi(z,l,t)}{\partial l}$$

where

$$\mathbb{E}[Spillover] = \int_{\tilde{z}} \int_{\tilde{l}} \left(\int_{y} \mathbf{1}_{agree} \left[\begin{array}{c} \Pi(y,l,t) - \Pi(z,l,t) \\ -m(y;\tilde{z},z,t) \end{array} \right] T(y;\tilde{z},z)\, dy \right) h_{\varepsilon}(\tilde{z},\tilde{l},t)\, d\tilde{l}\, d\tilde{z}$$

Workers

Hamilton-Jacobi-Bellman:

$$
\begin{aligned}
rV(z,l,t) = \omega(z,l,t) &+ \frac{\partial V(z,l,t)}{\partial t} \\
&+ \max_{\varepsilon\in[0,\varepsilon_{max}]}\left\{\begin{array}{l} -c_{\varepsilon}(\varepsilon) \\ +\varepsilon\theta q(\theta)\mathbb{E}[\text{Move}] \end{array}\right\} \\
&+ vq(\theta)\mathbb{E}\left[V(z',l,t) - V(z,l,t)|v(z,l,t)\right] \\
&+ \Psi(z,l,t)\frac{\partial V(z,l,t)}{\partial l}
\end{aligned}
$$

where

$$
\mathbb{E}[\text{Move}] = \int_{\tilde{z}=0}^{\infty}\int_{\tilde{l}}\left(\int_{y}\mathbf{1}_{agree}\left[\begin{array}{c} V(y,\tilde{l},t,) - V(z,l,t) \\ +m(\cdot) \end{array}\right]T(y;\tilde{z},z)\,dy\right)f_{\nu}(\tilde{z},\tilde{l},t)\,d\tilde{l}\,d\tilde{z}
$$

Worker Compensation

Worker compensation separated into a wage for labor supplied and a knowledge premium for the net learning that will occur

Wage (ω)

- Stole and Zwiebel (1996) type bargaining over marginal product of labor

$$\beta_\omega \frac{\partial \pi(z,l,t)}{\partial l} = (1-\beta_\omega)[\omega(z,l,t) - b(t)]$$

Knowledge premium payment (m)

- Nash-bargaining over joint surplus

$$\beta \left(\Pi(z',l,t) - \Pi(z,l,t) + \frac{\partial \Pi(z,l,t)}{\partial l} - m \right) =$$
$$(1-\beta)\left(V(z',l,t) + m - V(\tilde{z},\tilde{l},t) \right)$$

Kolmogorov Forward Equation

Evolution of the distribution of firms $(f(z,l,t))$ and workers depends on policy choices:

- Firm's vacancy posting choice $v(z,l,t)$
- Worker's search effort $\varepsilon(z,l,t)$
  - Distributions of search effort $h_\varepsilon(z,l,t)$

$$\frac{\partial f(z,l,t)}{\partial t} = -f(z,l,t)\nu(z,l,t)q(\theta)\left(\int_{\hat{z}=z}^{\infty}\int_{\hat{l}}\mathbf{1}_{accept}h_\varepsilon(\hat{z},\hat{l},t)\,d\hat{l}\,d\hat{z}\right)$$
$$+\int_{\tilde{z}=0}^{z} f\left(\tilde{z},l,t\right)\nu(\tilde{z},l,t)q\left(\theta\right)\left(\int_{\hat{z}=z}^{\infty}\int_{\hat{l}}\mathbf{1}_{accept}T(z,\tilde{z},\hat{z})h_\varepsilon(\hat{z},\hat{l},t)\,d\hat{l}\,d\hat{z}\right)\,d\tilde{z}$$
$$+\frac{\partial\Psi(z,l,t)}{\partial l}f(z,l,t)$$

Existence of a BGP

Sufficient, but not necessary, assumptions for a BGP:

1. The initial distribution of firms, $f(z, l, t = 0)$, has a Pareto tail with tail parameter ζ
2. Assumptions regarding the knowledge transfer function $(T(\cdot))$:
   2.1 When firm i meets a worker from firm j $(z_i < z_j)$, there is a $1/l_j$ probability the worker is able to facilitate knowledge spillover, and a $1 - 1/l_j$ probability that the worker cannot
   2.2 Conditional upon knowledge spillover occurring, there is some chance (denoted by τ) the full amount of knowledge can be transmitted
3. There is an upper bound of the search effort of workers that binds for workers at highly productive firms

Existence of a BGP

Under the previous assumptions, the aggregate growth rate of the BGP is:

$$\gamma = \frac{1}{\zeta} q\left(\ddot{\theta}\right) \tau \frac{1}{E[\ddot{\varepsilon}]} \frac{\mathcal{F}}{\mathcal{N}} \int_l \int_{\tilde{z}} \nu(\tilde{z}, l) \phi_f(\tilde{z}, l) \, d\tilde{z} \, dl$$

Calibration

Simulation Model

Features added to the model before simulating:

- Exogenous learning (ξ) – Match dist. of productivity
- Brownian motion innovation shocks ($N(\gamma_I, \sigma^2)$) – Match growth rate
- Firm entry and exit – consequence of innovation shocks
- Unemployment state – consequence of innovation shocks

New *unique* BGP growth rate:

$$\gamma = \gamma_I + \sigma\sqrt{2q\left(\ddot{\theta}\right)\tau\frac{1}{E[\varepsilon]}\left(\frac{\mathcal{F}}{\mathcal{N}}\right)\int_l\int_{\tilde{z}=0}^{\infty}\phi_f(\tilde{z},l)\nu(\tilde{z},l)\,d\tilde{z}\,dl + \xi}$$

Fixed Parameters

	Parameter	Model value
ρ	Elasticity of substitution between goods	5
λ	Probability of death	0.0069
$F^{act}(t)$	Number of active firms	1
r	Real discount rate	0.04
q_{cd}	The Cobb-Douglas share parameter on vacancies in the matching function	0.5
v_{max}	Maximum rate of vacancy postings	1
σ	Standard deviation of Brownian innovation shocks	0.2
ξ	Rate of exogenous learning	0.05

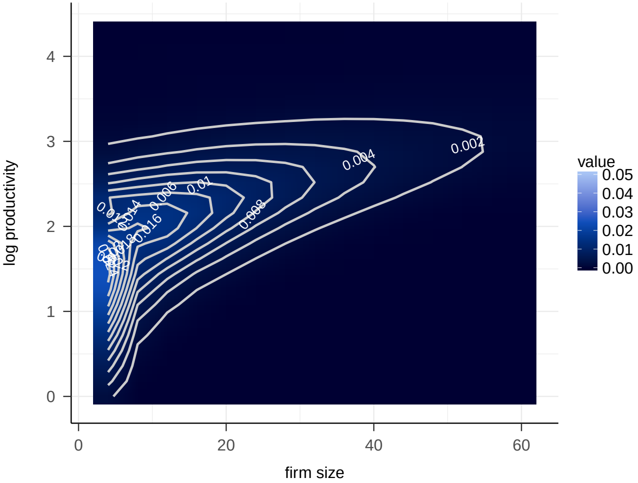
Calibrated Parameters

	Parameter	Value	Target moment	Moment value: Data	Moment value: Model
N	Number of workers in the economy	16.5	Average firm size	13.7	14.7
ψ_ν	Marginal search cost for firms	47.6	Share of firms posting vacancies	0.83	0.81
ψ_ε	Marginal search cost for workers	13.4	Share of workers searching with more than half effort	0.5	0.50
q_{norm}	Matching efficiency parameter	2.48	Share of labor supplied by new workers	0.194	0.21
γ_I	Growth rate of innovation shocks	-0.049	Aggregate growth rate (γ)	0.021	0.021
σ^2_{new}	Variance of inactive firm productivity draws	2.74	Relative productivity of new entrants	0.33	0.33
τ	Probability of transferring all knowledge	0.0347	Tail parameter in firm productivity data	1.7554	1.755
$\frac{2}{2+\kappa}$	Mean of beta distribution for knowledge spillover	0.4719	Avg. productivity gain from knowledge spillover	0.327	0.327
β	Worker's relative bargaining strength	0.1	Ratio of average wage changes for workers move to more/less productive firms	0.436	0.438
δ	Probability of becoming unemployed	0.050	Unemployment rate	0.12	0.13

Results

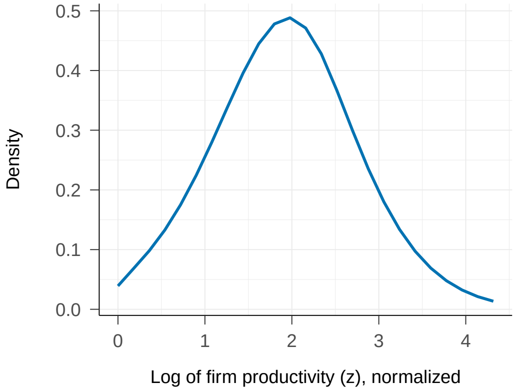
Distribution of Firms

Distribution in productivity-labor space ($\phi_f(z, l)$)

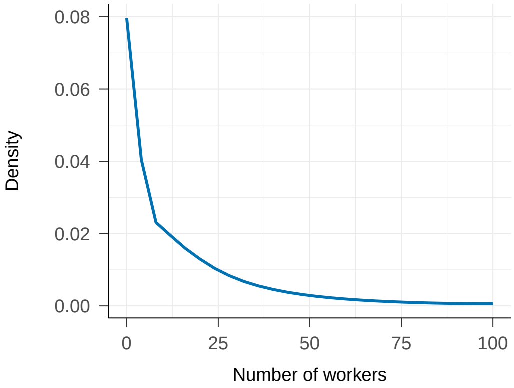


Distribution of Firms

Dist. in prod. space ($\phi_f(z)$)

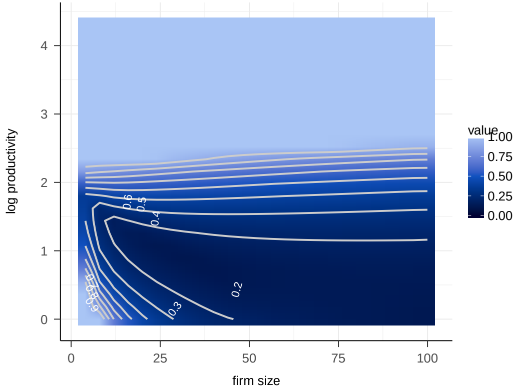


Dist. of firm size ($\phi_f(l)$)

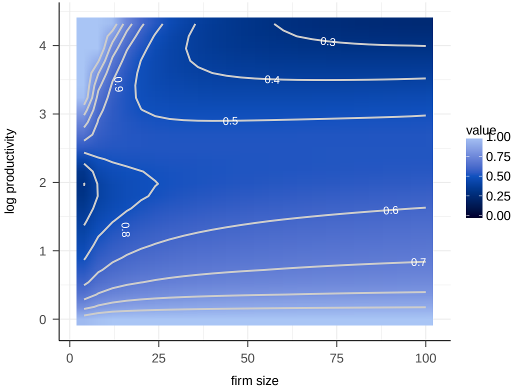


Policy Choices

Firms
Vacancy posting rate ($\nu(z, l)$)



Workers
Search effort choice ($\varepsilon(z, l)$)



Labor Movement Pattern

Data

Hiring firm's prod. decile	1	2	3	4	5	6	7	8	9	10
	Source of new employee hires: PFP productivity decile									
1	0.14	0.17	0.1	0.1	0.09	0.08	0.08	0.1	0.07	0.08
2	0.13	0.17	0.11	0.11	0.09	0.08	0.08	0.09	0.06	0.06
3	0.1	0.15	0.18	0.12	0.09	0.08	0.07	0.08	0.06	0.06
4	0.11	0.15	0.12	0.12	0.11	0.09	0.08	0.1	0.07	0.07
5	0.1	0.14	0.11	0.11	0.1	0.09	0.09	0.11	0.07	0.07
6	0.1	0.14	0.09	0.1	0.1	0.09	0.09	0.11	0.08	0.09
7	0.1	0.13	0.09	0.1	0.1	0.09	0.11	0.11	0.09	0.09
8	0.09	0.12	0.08	0.09	0.09	0.09	0.11	0.11	0.1	0.11
9	0.1	0.1	0.07	0.08	0.08	0.08	0.09	0.12	0.12	0.14
10	0.09	0.09	0.06	0.07	0.07	0.07	0.08	0.1	0.13	0.24

Labor Movement Pattern

Model

Hiring firm's prod. decile	Source of new employee hires: Productivity decile 1	2	3	4	5	6	7	8	9	10
1	0.09	0.01	0.03	0.05	0.07	0.1	0.26	0.12	0.19	0.08
2	0.39	0.04	0	0.02	0.04	0.06	0.18	0.08	0.13	0.06
3	0.3	0.3	0.08	0	0.02	0.03	0.1	0.05	0.08	0.04
4	0.19	0.19	0.31	0.18	0	0.01	0.04	0.02	0.04	0.02
5	0.11	0.11	0.17	0.29	0.28	0	0.01	0.01	0.01	0.01
6	0.06	0.06	0.1	0.16	0.26	0.35	0	0	0.01	0
7	0.03	0.03	0.05	0.08	0.12	0.2	0.5	0	0	0
8	0.02	0.02	0.03	0.05	0.08	0.13	0.42	0.25	0	0
9	0.01	0.01	0.02	0.03	0.06	0.09	0.29	0.17	0.3	0.01
10	0.01	0.01	0.02	0.02	0.04	0.07	0.22	0.13	0.3	0.19

Counterfactual Scenario

Counterfactual – No Knowledge Spillover

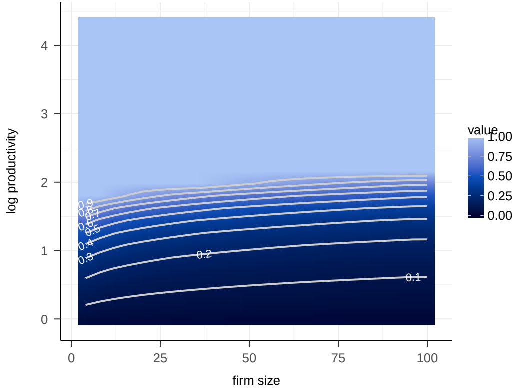
Question:

What effect does knowledge spillover have on the BGP of the economy?

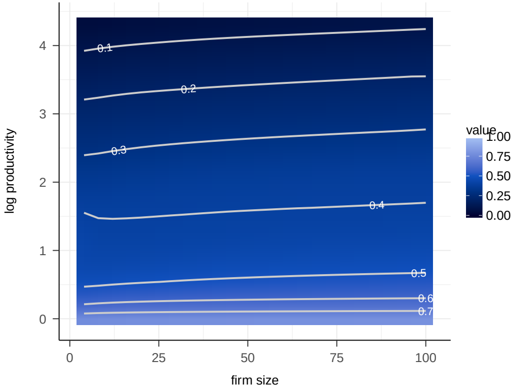
- Assume no knowledge spills over.
  - Only benefit of new workers is additional labor
  - productivity improvement only occurs through innovation shocks and exogenous learning
- Recompute BGP and compare to previous results

Counterfactual – Policy Choices

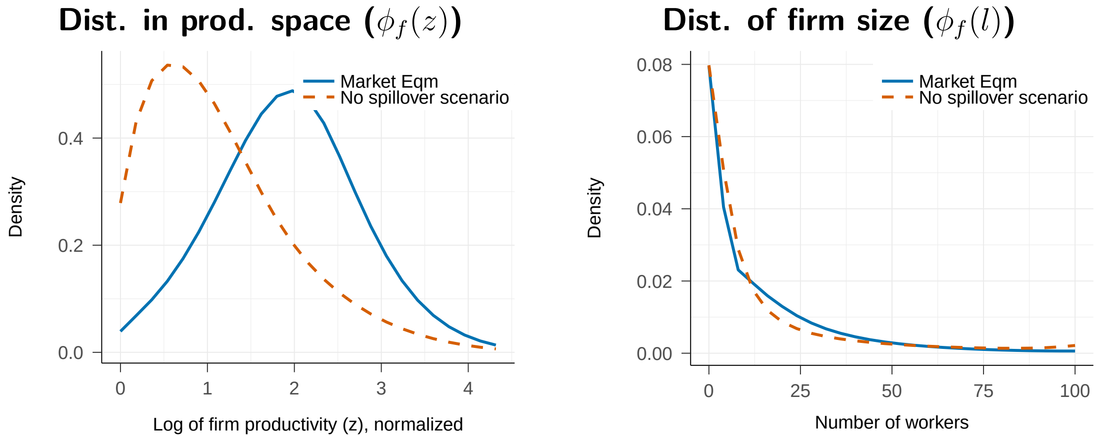
Firms
Vacancy posting rate ($\nu(z,l)$)



Workers
Search effort choice ($\varepsilon(z,l)$)



Counterfactual – Distribution of Firms



Aggregate growth rate: $\gamma = 1.4\%$ vs 2.1% baseline

Social Planner

Social Planner

- Firms and workers split the surplus from knowledge spillover (through knowledge premium payment)
- Private returns from search $<$ Social returns
- Encouraging firms and workers to under-search

Question:

How much better would the economy be under the socially optimal search effort choices?

Social Planner

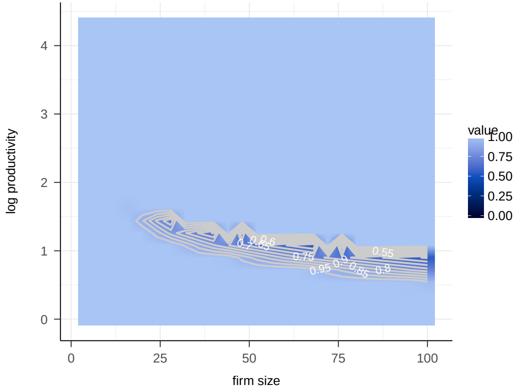
Social Planner:

Objective function: Maximize aggregate output net of search costs

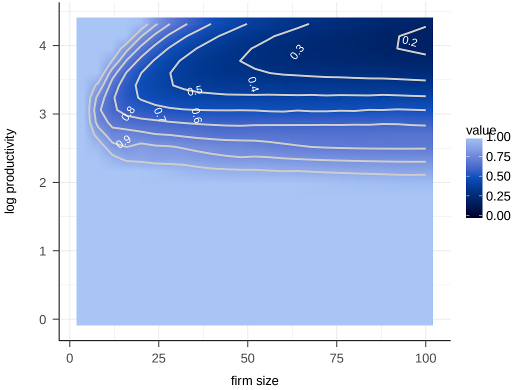
- Unconstrained social planner problem is infinitely-dimensional
  - Policy choice for one firm depends upon distribution of policy choices in economy.
- Follow Lucas and Moll (2014) – Maximize the *marginal social value* of a firm
  - Choose policy rules to maximise the value of an additional firm at each (z, l) combination

Social Planner – Policy Choices

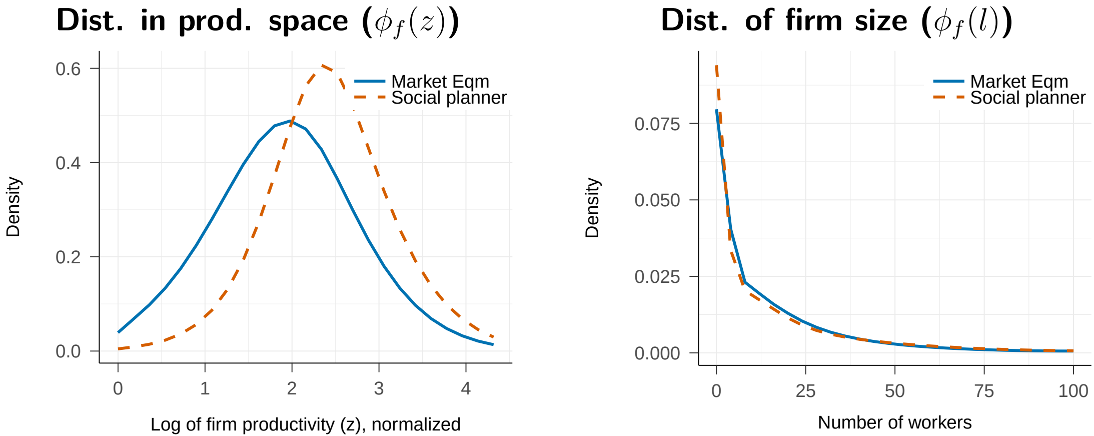
Firms
Vacancy posting rate ($\nu(z,l)$)



Workers
Search effort choice ($\varepsilon(z,l)$)



Social Planner – Distribution of Firms



Aggregate growth rate: $\gamma = 2.11\%$ vs 2.1% baseline

Conclusions

Conclusions

Contribution

- General-equilibrium framework for analysing knowledge spillover between firms at the aggregate level
- On-the-job search-and-matching model embedded within an endogenous growth framework

Counterfactual Scenario

- Knowledge spillover affects aggregate growth and dist. of productivity
- But not the distribution of firm size

Social Planner

- Labor market matching technology is very important
- congestion in labor market limits aggregate growth