Economic Growth when Knowledge is Concentrated

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Motivation

- The heuristic identity of endogenous growth:

$$\text{Productivity growth} = \text{R\&D spending} \times \text{R\&D efficiency}$$

- R&D efficiency → Allocation of **inventors** (who have ideas) to **firms** (who implement them):
  - Innovation outcomes depend on firms' ability to attract and retain talented inventors.
  - Growth is highest when firms with highest implementation incentives employ inventors with best ideas.

What we do:

(i) Propose macro model to study how firm-inventor sorting affects growth and welfare.

(ii) Quantify by how much inventor (mis-)allocation prevents growth-maximizing outcomes.

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Roadmap

1. Theory: Endogenous Growth Model + Frictional Labor Market for Inventors

- Key players:
  1. **Firms:**
     - Oligopolistic, compete for product market leadership by implementing innovations.
     - To innovate, they need to employ an inventor (directed search with long-term contracts).
  2. **Inventors:**
     - Choose idea creation rate (whether or not employed) $\rightarrow$ Heterogeneity in "knowledge capital".
     - Knowledge capital determines by how much a firm's productivity advances upon implementation.
- In equilibrium:
  - Firms in more competitive industries ("neck-to-neck") have higher implementation incentives.
    - High knowledge capital inventors tend to sort into such industries (because firms pay better).
  - Distribution of knowledge across industries is key for aggregate growth and welfare.

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2. Empirics: Sorting patterns of inventors across firms and industries

- Combine USPTO patent data with Compustat data.
  - Identify which inventors work for which firms and in which industries.
- Result: firms in competitive sectors have higher hiring rates for highly innovative inventors.

3. Quantitative Analysis: Growth & welfare effects of frictions in the allocation of inventors:

1. Counterfactual with no matching frictions (i.e., full inventor mobility benchmark):
   - Reallocation of high-productivity inventors to industries with high implementation intensity.
   - Fewer but more disruptive (highly "implementable") ideas $\rightarrow$ Growth rate $\approx$ 1ppt higher.
2. New allocative role of R&D subsidies:
   - Foster inventor mobility, trigger reallocation of talent, realign firm-inventor incentives.
   - Optimal subsidies $\rightarrow$ To implementation (firms): 2.9% CEW; To research (inventors): 22.5% CEW.

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Related Literature

1. **Effects of inventor mobility on technology diffusion and growth**

   Caicedo and Pearce (2024), Liu (2025), Koike-Mori, Maruyama and Okumura (2025), Baslandze and Vardishvili (2026), Babalievsky (2023)

   Contribution: Endogenize firm/inventor responses in labor market, macro implications of inventor sorting.

2. **Frictional market for ideas**

   Aghion, Akcigit, Hyytinen and Toivanen (2017), Celik (2023), Akcigit, Pearce and Prato (2025), Akcigit, Alp, Pearce and Prato (2025).

   Contribution: Focus on allocation of inventors across firms, rather than supply of inventors per se.

3. **Determinants of aggregate R&D productivity**

   Bloom, Jones, Van Reenen and Webb (2020), Ayerst (2022), Manera (2022), Akcigit and Goldschlag (2023), Lehr (2025), Fernández-Villaverde, Yu and Zanetti (2025), Kim, Olmstead-Rumsey and Wang (2026)

   Contribution: Determinants of inventor sorting into firms in the cross-section and its macro implications.

The Model

Endogenous Growth + Labor Market for Inventors

Environment

- **Preferences:**

$$\max \int_0^{+\infty} e^{-\rho t} \ln(\boldsymbol{C}_t)\, \mathrm{d}t \qquad \text{s.t. } \dot{\boldsymbol{A}}_t \leq r_t \boldsymbol{A}_t + w_t^P - \boldsymbol{C}_t$$

- **Final good:** Industry continuum, each with 2 “large firms” (i and $-i$) and a competitive fringe (c):

$$\boldsymbol{Y}_t = \exp\left(\int_0^1 \ln\left(Y_{jt}\right) \mathrm{d}j \right), \qquad \text{where } Y_{jt} = \left(\sum_{f=i,-i,c} \left(y_{fjt}\right)^{\sigma} \right)^{\frac{1}{\sigma}}, \; 0 < \sigma < 1$$

- **Technology:** Linear in “productive” (i.e., non-R&D) labor l, at competitive wage w^P:

$$y = q \cdot l$$

  - Fringe firms $\rightarrow$ All atomistic, same homogenous good, all price-takers.
  - Large firms $\rightarrow$ **(i)** Compete à la Bertrand; **(ii)** Advance q by implementing their inventor's ideas.

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Inventors

- Linear utility, endogenous measure, discount rate $\rho > 0$.
- Heterogeneous in:
  1. Employment status $\rightarrow$ **(i)** Attached to firm, or **(ii)** Unattached (no income) and searching.
  2. Knowledge capital:

$$\kappa \in \mathbb{K} \equiv \{\underline{\kappa}, \underline{\kappa}+1, \ldots, \overline{\kappa}-1, \overline{\kappa}\}$$

- Inventor type κ (whether attached or not) chooses rate $z > 0$ of new idea, pays cost:

$$\chi z^{\phi} Y_t, \qquad \text{where } \chi > 0, \phi > 1$$

- Knowledge capital transitions:
  - A new idea (rate z) increases knowledge capital $\quad \kappa \rightarrow \min(\kappa + 1, \overline{\kappa})$
  - At (exogenous) rate $\delta > 0$, ideas become obsolete $\quad \kappa \rightarrow \max(\kappa - 1, \underline{\kappa})$

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Firms

- A large firm is always attached to one inventor (matching is one-to-one).
  - The firm decides the rate $x > 0$ of implementing its inventor's latest idea, pays cost:

$$\xi x^{\phi} \boldsymbol{Y}_t, \qquad \text{where } \xi > 0$$

  - Implementation outcome $\rightarrow$ For firm with productivity q and inventor of type κ:

$$\ln(q) \;\rightarrow\; \ln(q) + \kappa \ln(\lambda), \qquad \text{where } \lambda > 1$$

- Knowledge does not diffuse across firms $\rightarrow$ Large firms i and $-i$ keep a "technology gap":

$$\frac{q_{ijt}}{q_{-ijt}} = \lambda^{n_{ijt}}, \qquad \text{where } n_{ijt} \in \{-\overline{n}, \ldots, -1, 0, 1, \ldots, \overline{n}\}$$

  - Follower catches up to leader at (exogenous) rate $\psi > 0$.
  - Fringe keeps a constant (exogenous) distance $\alpha \equiv \frac{q_c}{\max\{q_i, q_{-i}\}} > 0$ to the leader.

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Labor Market for Inventors

- Firms and inventors match in frictional labor markets, segmented by κ.
- Search is directed:
  - **Firms:** post, and commit to, long-term wage contracts to attract unattached inventors.
  - **Unattached inventors:** observe all contracts and choose where to search.
  - **Attached inventors:** do not search, become unattached when their firm hires new inventor.
- Contract $\rightarrow$ Summarized by $E \equiv$ NPV that firm promises to new inventor.
  - Each market segment κ is a continuum of submarkets, indexed by E.
  - Number of matches in (κ, E) determined by a Cobb-Douglas matching function:

$$\mathrm{M}_\kappa(E) = A\left(\mathrm{F}_\kappa(E)\right)^\gamma \left(\mathrm{U}_\kappa(E)\right)^{1-\gamma}, \qquad \text{where } A > 0,\ \gamma \in (0,1)$$

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Equilibrium: Unattached Inventors

- Type-κ unattached inventors direct search to best submarket $\rightarrow$ $\boldsymbol{U}_\kappa = \max_E U_\kappa(E)$.
- Free entry into markets $\rightarrow$ All active markets must yield same value ex-ante:

$$U_\kappa(E) \leq \boldsymbol{U}_\kappa, \text{ with equality iff, } \frac{\mathrm{M}_\kappa(E)}{\mathrm{U}_\kappa(E)} = A\Bigg(\underbrace{\frac{\mathrm{F}_\kappa(E)}{\mathrm{U}_\kappa(E)}}_{\equiv\, \theta_\kappa(E)}\Bigg)^\gamma > 0$$

- Optimal rate of new idea creation while unattached:

$$z_\kappa^U = \left(\frac{\boldsymbol{U}_{\min(\kappa+1,\overline{\kappa})} - \boldsymbol{U}_\kappa}{\chi\phi \boldsymbol{Y}}\right)^{\frac{1}{\phi-1}}$$

- HJB for value of being unattached:

$$r\boldsymbol{U}_\kappa - \dot{\boldsymbol{U}}_\kappa = \underbrace{A(\theta_\kappa(E))^\gamma(E - \boldsymbol{U}_\kappa)}_{\text{Match to firm promising } E} + \underbrace{\delta\Big(\boldsymbol{U}_{\max(\kappa-1,\underline{\kappa})} - \boldsymbol{U}_\kappa\Big)}_{\text{Knowledge capital depreciation}} + \underbrace{\chi(\phi-1)(z_\kappa^U)^\phi \boldsymbol{Y}}_{\text{Value of a new idea}}$$

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Equilibrium: Firms

- **Static problem:** Large firm profits are increasing and concave in the technology gap, n:

$$\pi(n) = s(n)\big(1 - M(n)^{-1}\big)\,\boldsymbol{Y}, \quad \text{where } M(n) = \frac{1-\sigma s(n)}{\sigma\big(1-s(n)\big)} > 1 \ \text{ and } \ s(n) = \frac{py}{\sum py} \in (0,1)$$

- **Dynamic problem:** In principle, a large firm has 4 state variables:
  - Technology gap between firm and its rival firm $\rightarrow n$
  - Knowledge capital of, and value promised to, own inventor $\rightarrow (\kappa, E)$
  - Knowledge capital of rival's inventor $\rightarrow \kappa^-$

- We define a recursive contract for firm in state $\vec{s} \equiv (n, \kappa, E, \kappa^-)$ as the object:

$$\mathbb{C} = \Big(\underbrace{w}_{\text{spot wage}}, \underbrace{\{E'(\vec{s}\,')\}}_{\text{Set of continuation promises}} \Big)$$

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Joint Surplus Problem

- The optimal contract $\mathbb{C}$ maximizes the (gross) **joint surplus**: (Kaas and Kircher, 2015; Schaal, 2017)

$$\boldsymbol{\Omega}(n,\kappa,\kappa^{-}) = \underbrace{\boldsymbol{V}(n,\kappa,\kappa^{-},E)}_{\text{Firm value}} + \underbrace{\boldsymbol{E}(n,\kappa,\kappa^{-})}_{\text{Inventor value}}$$

- **Three very useful properties:**

1. Ω grows linearly in Y $\rightarrow$ Admits recursive + BGP equilibrium characterization.
2. Ω is independent of E $\rightarrow$ For given surplus, inventor wages are just redistributive.
   - Backed out from maximized surplus using promise-keeping constraint (with equality):

$$E'(n',\kappa',\kappa^{-\prime}) \geq \boldsymbol{U}_{\kappa'}, \quad \forall (n',\kappa',\kappa^{-\prime})$$

3. Ω solves a simple (but long!) HJB Equation. ▸ Details
   - 3 FOCs $\rightarrow$ z (new idea rate), x (implementation rate), $\{E'(n',\kappa',\kappa^{-\prime})\}$ (new promises).

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Optimal Policies

Define stationary objects $\rightarrow$ $\boldsymbol{\omega}(n, \kappa, \kappa^-) = \frac{\boldsymbol{\Omega}(n,\kappa,\kappa^-)}{\boldsymbol{Y}}$ and $\boldsymbol{u}_\kappa = \frac{\boldsymbol{U}_\kappa}{\boldsymbol{Y}}$.

1 **New idea creation** (by the inventor):

$$z_{n,\kappa,\kappa^-} = \left(\frac{\boldsymbol{\omega}\left(n, \min(\kappa+1, \overline{\kappa}), \kappa^-\right) - \boldsymbol{\omega}\left(n, \kappa, \kappa^-\right)}{\chi\phi} \right)^{\frac{1}{\phi-1}}$$

2 **Idea implementation** (by the firm):

$$x_{n,\kappa,\kappa^-} = \left(\frac{\boldsymbol{\omega}\left(\min(n+\kappa, \overline{n}), \kappa, \kappa^-\right) - \boldsymbol{\omega}\left(n, \kappa, \kappa^-\right)}{\xi\phi} \right)^{\frac{1}{\phi-1}}$$

3 **Promises:** $e'(n, \kappa', \kappa^-)$ defines optimal rate of hiring new inventor type $\kappa' \neq \kappa$:

$$e'(n, \kappa', \kappa^-) \;=\; \gamma\, \boldsymbol{u}_{\kappa'} \;+\; (1-\gamma)\left(\boldsymbol{\omega}(n, \kappa', \kappa^-) - \boldsymbol{\omega}(n, \kappa', \kappa^-) + \boldsymbol{u}_\kappa\right)$$

Closing the Model

- **Firm entry:** ▸ Details
  - Potential entrant firms pay a fixed cost $c^e_\kappa Y$ to direct their entry to a specific κ.
  - A free entry condition determines firm entry rate $\rightarrow$ Pins down $\{u_\kappa\}_{\kappa\in\mathbb{K}}$.
- **Industry states** $\rightarrow (m, \kappa^L, \kappa^F)$, where:
  1. $m \in \{0, 1, \dots, \overline{n}\}$ $\rightarrow$ Technology gap between leader and follower.
  2. $\kappa^L \in \mathbb{K}$ $\rightarrow$ Inventor type attached to the leader.
  3. $\kappa^F \in \mathbb{K}$ $\rightarrow$ Inventor type attached to the follower.
- **Growth rate in BGP:**

$$g = \frac{\dot{Y}}{Y} = \sum_{m=0}^{\overline{n}} \sum_{\kappa^L\in\mathbb{K}} \sum_{\kappa^F\in\mathbb{K}} \varphi_{m,\kappa^L,\kappa^F} \Bigg[\overbrace{\underbrace{\ln(\lambda^{\kappa^L})}_{\text{Efficiency}} \underbrace{x_{m,\kappa^L,\kappa^F}}_{\text{Spending}}}^{\text{Leader}} + \overbrace{\mathbb{1}_{\{\kappa^F>m\}} \underbrace{\ln(\lambda^{\kappa^F-m})}_{\text{Efficiency}} \underbrace{x_{-m,\kappa^F,\kappa^L}}_{\text{Spending}}}^{\text{Follower}} \Bigg].$$

  - Distribution of industries ($\{\varphi_{m,\kappa^L,\kappa^F}\}$) and inventors ($\{\varphi^U_\kappa\}$) solve Kolmogorov equations. ▸ Go

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Empirics

Inventor Sorting and Mobility Patterns

Data

- Merge two data sources:
  1. **Patents:** USPTO's PatentsView database.
     - All patents granted by USPTO, 1976–2018.
     - Information: application/grant dates, citations, patent assignees and inventors.
  2. **Firms:** Compustat North America Fundamentals.
- Map patent assignees from PatentsView to firms using crosswalk (Dyèvre and Seager (2023))
  - Relate inventors' characteristics to firms' balance sheet information.
- **Final sample:**
  - 2.56M patents (41% of all patents granted from 1976 to 2018).
  - 8,182 unique Compustat firms, and 1.27M unique inventors attached to them.

Variable Construction I

1. **Inventor productivity:** (Hall, Jaffe and Trajtenberg (2001))

- Quality of patent p:

$$q(p) \equiv \#\text{citations received within 5 years since granting date.}$$

- Flow productivity of inventor j in year t (where $\mathcal{P}_{jt} \equiv$ Stock of j's granted patents as of time t)

$$q_{jt} = \sum_{p \in \mathcal{P}_{jt}} q(p)$$

- **Baseline measure:** Cumulative productivity of inventor j: (where $t_0(j) \equiv$ Date of 1st patent app.)

$$Q_{jt} = \frac{1}{t - t_0(j)} \sum_{s=t_0(j)}^{t-1} q_{js}$$

▸ Descriptive Statistics

Variable Construction II

2. **Inventors' employment histories:** (Akcigit, Caicedo, Miguelez, Stantcheva and Sterzi (2025))

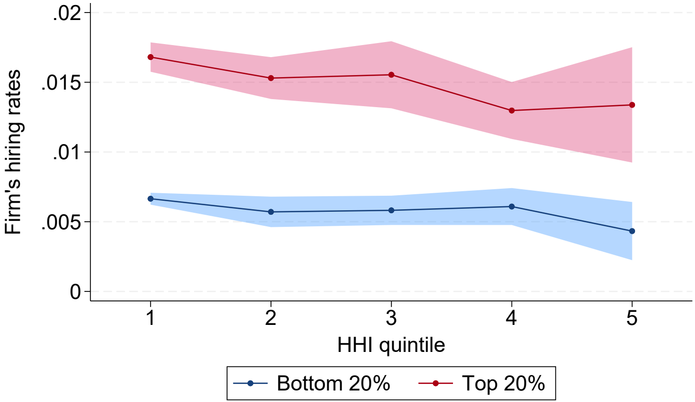
- Inventor j is employed by firm i in year t if majority of j's patent applications that year are assigned to firm i.
- *Employment spell* $\rightarrow$ Starts from 1st year this holds, and ends on either ...
  1. ... the year before the majority of j's patents are assigned to firm $k \neq i$. **("job move")**
  2. ... the last year the majority of j's patents are assigned to i, and no further patenting activity afterwards. **("career end")**
- We construct j's employment history by tracking his/her job moves.

▸ Some Stylized Facts

Results I: Hiring Rates

Net Hiring Rates

- Firms in competitive sectors have higher hiring rates of high-productivity inventors.

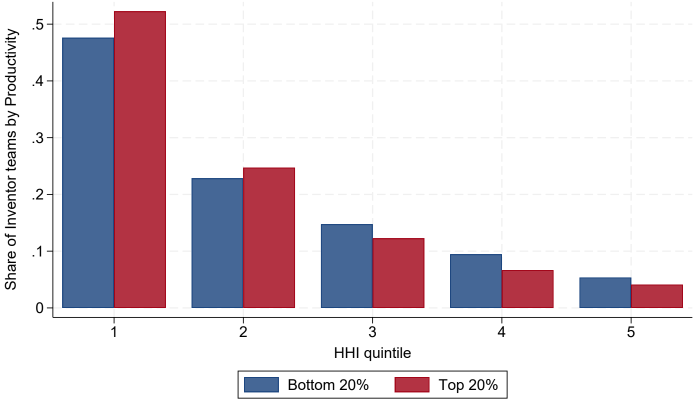


Notes: Firm hiring rates of inventors in the top (red) and bottom (blue) quintiles of the distribution of inventor productivity (Q_{jt}). Fitted values from regression: $\text{HiringRate}_{it} = \beta_0 + \sum_{k=1}^{5} \beta_k \mathbf{1}\{quint(HHI_{s(i),t}) = k\} + \mathbf{X}'_{it}\gamma + \tau_t + u_{it}$.

Controls: firm's age, employment, number of employed inventors, R&D stock, profitability, leverage and market-to-book ratio; year fixed effects. Standard errors are clustered at firm and year level. Numbers are scaled using the mean of the omitted group (first quintile HHI), keeping controls at their means.

Results II: Distribution of Inventors across Industries

- Highly innovative inventors more likely to work in competitive industries.
- But many of them also employed in highly concentrated sectors.



Notes: Bars represent shares of inventor teams of a given productivity quintile in a given year (bottom 20%, blue; top 20% red) employed in different 4-digit NAICS industries, grouped by HHI index. Inventor's productivity is measured by Q_{jt}. Team productivity is computed as the average productivity of the inventors employed by the firm.

Calibration

Model Fit and Key Features

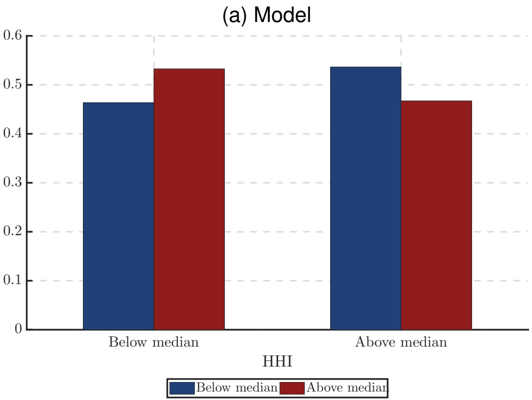
Calibration Strategy

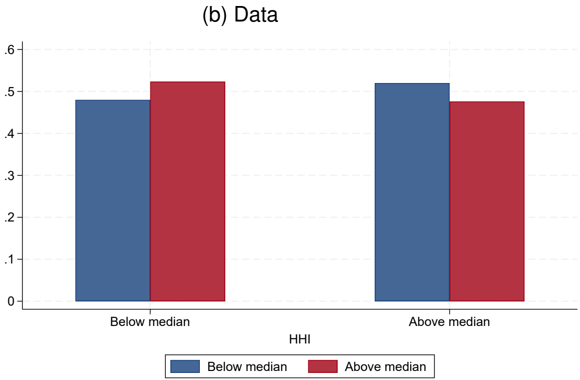
- Bringing model to data:
  - Leader/follower firm → 2 largest firms (in sales) within NAICS-4 sector in Compustat.
  - Attached/unattached inventor → Attached when patent assignee is a top-2 Compustat firm.

Parameter		Value	Target/Source	Data	Model
ρ	Discount rate	0.02	4% annual interest rate		
σ	CES parameter	5/6	Elasticity of substitution $= 6$		
γ	Matching elasticity	0.5	Petrongolo and Pissarides (2001)		
λ	Innovation step size	1.0261	Growth rate	0.02	0.02
A	Matching efficiency	0.1118	A-to-U inventors' transition rate	0.0863	0.0858
χ	Research cost shifter	913.129	Share of patenting inventors	0.4556	0.4556
ξ	Implementation cost shifter	116.562	R&D share	0.0215	0.0215
δ	Depreciation rate of κ	0.2004	Average inventor productivity	2.8689	2.4062
ψ	Exogenous catch-up rate	0.0309	Misallocation loss from markups	0.018	0.018
α	Fringe's distance to leader	0.5563	Average markup	1.30	1.30
$\mathtt{m}^{\mathtt{P}}$	Mass of potential entrants	0.0043	Firm entry rate	0.102	0.102
ϕ	R&D cost curvature	5.6459	Elasticity of innovation to R&D	0.5	0.5

Notes: The average markup is cost-weighted. Inventor productivity computed in the data as the simple average of year-level means of our inventor productivity measure (cumulative forward citations in 5-year window). A-to-U computed in the data as the transition frequency from top-2 Compustat to non-top-2 Compustat firms.

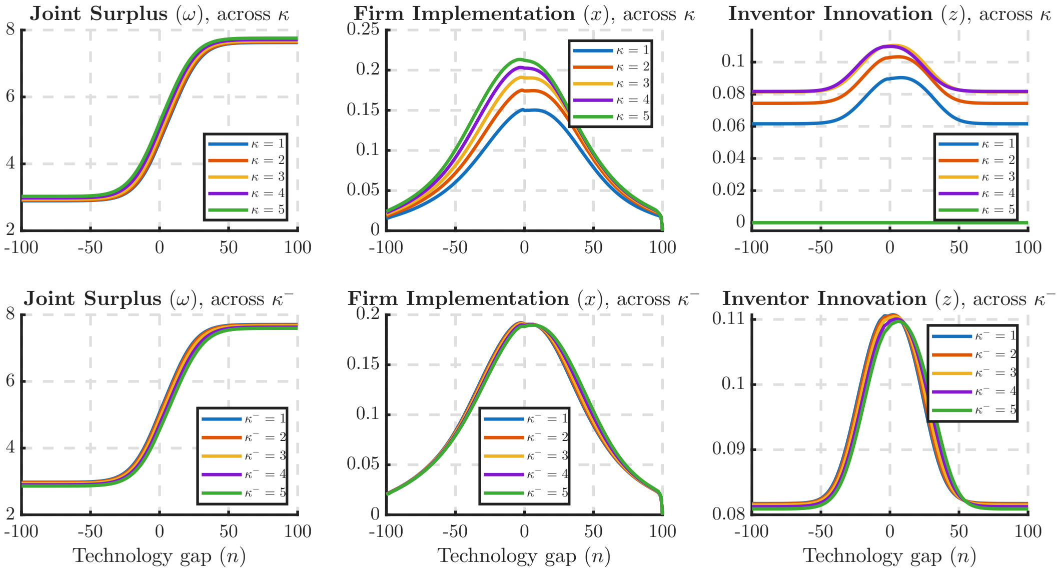
Validation: Distribution of inventors across industries





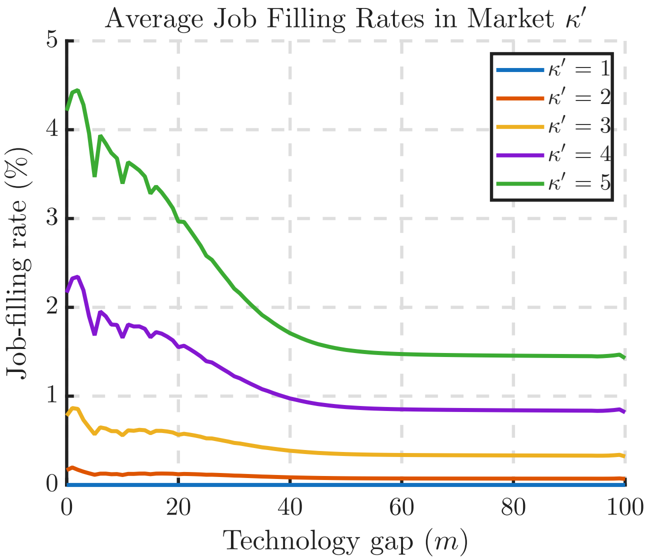
Notes: In panel (a), bars represent shares of below-median and above-median productivity (κ) inventors attached to firms in industries with below-median and above-median HHI index. In the data, we compute the distribution of inventor teams' productivity employed by the two largest firms in each NAICS-4 digit sector. Team productivity is computed as the average productivity of the inventors employed by the firm. In panel (b), bars represent shares of below-median and above-median productivity inventor teams employed by firms in industries with below-median and above-median HHI index.

Calibration Features: Innovation and Implementation Policies



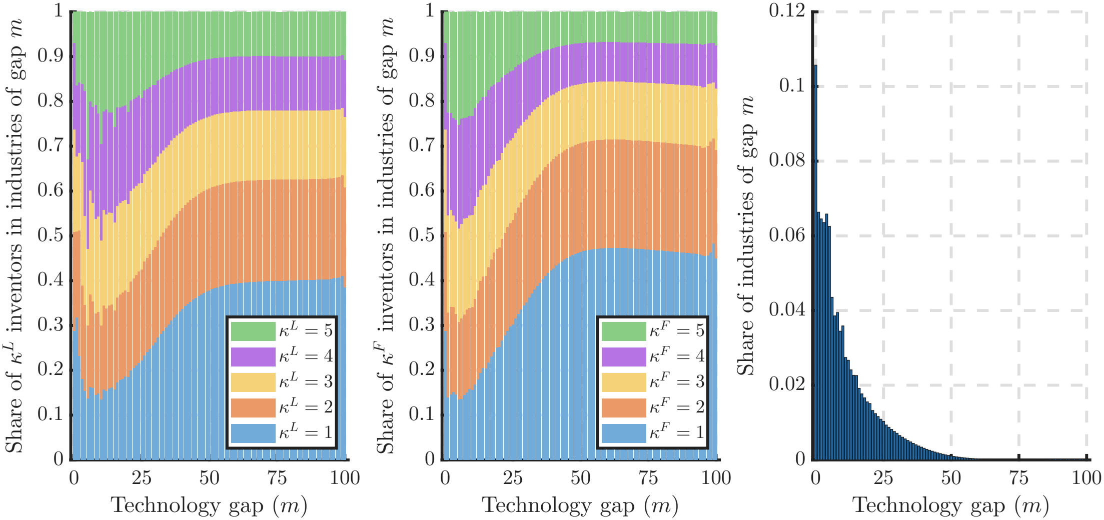
Notes: Joint surplus, implementation and innovation policies, as a function of firm states.

Calibration Features: Job-Filling Rates



Notes: Average job-filling rate for an inventor of type κ', by industry state.

Calibration Features: Distribution of inventors across industries



Notes: Equilibrium distribution of inventors across industry states.

Quantitative Analysis

Aggregate Effects of Inventor Sorting

The Role of Inventor Mobility

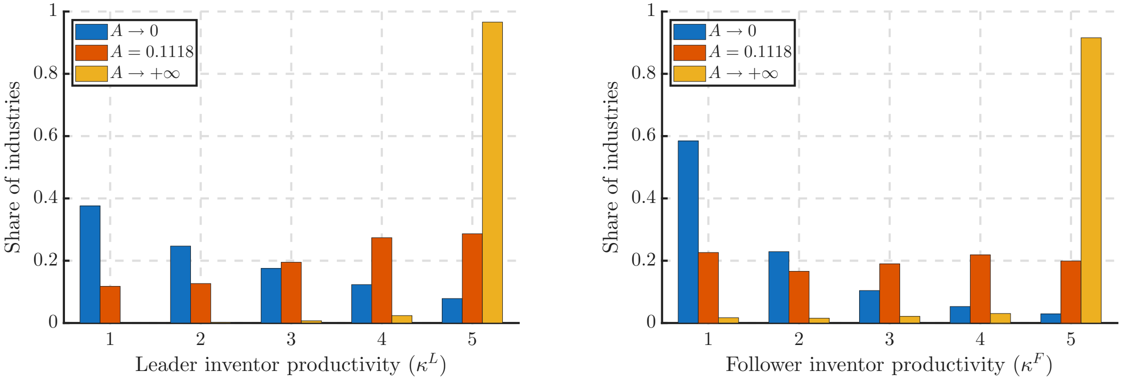
- **Counterfactuals:** Change A (matching efficiency) to control for degree of matching frictions.

	No mobility ($A \to 0$)	Baseline ($A = 0.1118$)	Full mobility ($A \to +\infty$)
Inventor mobility (A-to-U) rate	0.26%	8.63%	$+\infty$
Average inventor productivity	1.91	2.41	4.37
Probability of innovation by inventors	95.73%	45.56%	1.95%
Initial output (baseline = 1)	1.0235	1	0.9909
Consumption share	91.91%	91.39%	92.97%
Implementation spending share	1.07%	1.80%	2.51%
Research spending share	0.55%	0.34%	0.00%
Growth rate	**1.19%**	**2.00%**	**2.94%**

Notes: BGP equilibrium values for key variables in the baseline calibration, a counterfactual economy with no inventor mobility, and a counterfactual with full mobility.

The Role of Inventor Mobility

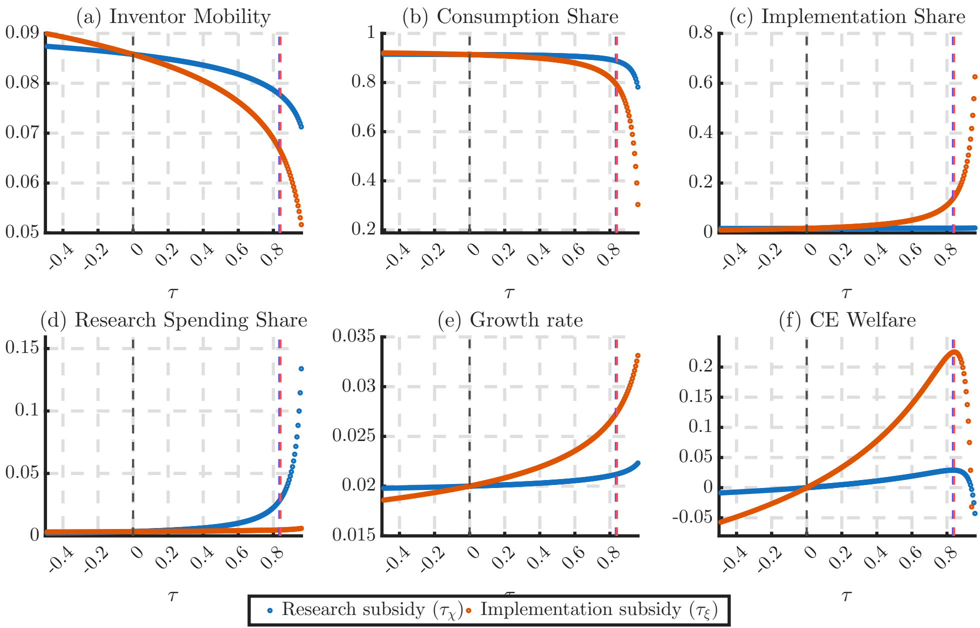
- **Counterfactuals:** Change *A* (matching efficiency) to control for degree of matching frictions.



Notes: Distribution of industries by type of inventor attached to leader (left-hand panel) or follower (right-hand panel) firms, across the three counterfactual experiments.

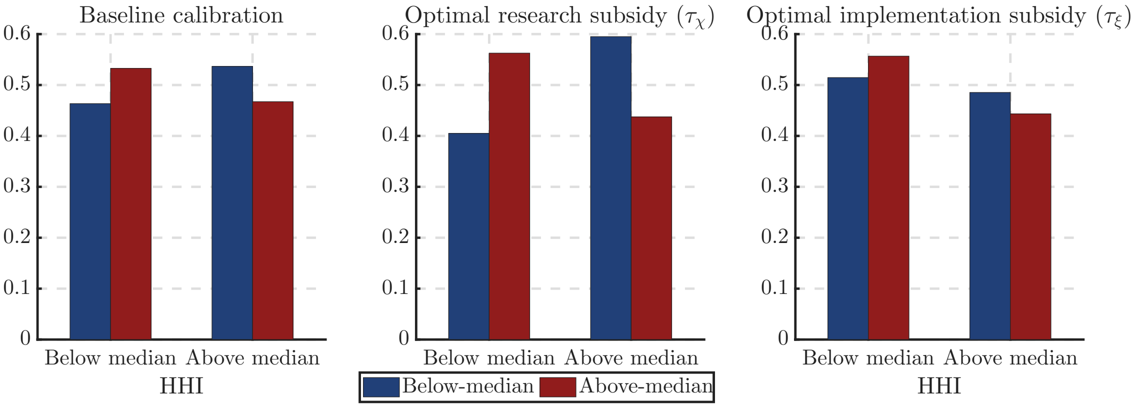
Policy: Research and Implementation Subsidies

▸ Computing Welfare



Policy: Research and Implementation Subsidies

‣ Computing Welfare



Notes: Distribution of inventors across industries, for the baseline calibration (left), the optimal research subsidy (τ_χ), and the optimal implementation subsidy (τ_ξ).

→ More: Effects on ‣ distribution of inventors

Conclusion

- Study the market for inventors to assess aggregate implications of inventor-firm matching.
  - Endogenous growth model with a frictional labor market for inventors.
  - Calibrated to moments about inventors' mobility and inventor-firm sorting.
  - Productive inventors disproportionately employed in competitive sectors.
- Key insights:
  - Frictions misallocate talented inventors away from high-implementation-incentive industries.
  - With weaker frictions:
    - Less frequent but more radical new ideas $\rightarrow$ Lower R&D spending but better allocated.
  - R&D policy has an allocative role:
    - Fosters inventor mobility and reallocates talent where it is most socially valued.

Thank you!

Appendices

Joint Surplus Problem

▸ Back

$$\rho \boldsymbol{\omega}(n,\kappa,\kappa^{-}) = \max_{\substack{\{e'(n',\kappa',\kappa^{-\prime})\} \\ x>0, z>0}} \Bigg\{ \underbrace{\pi(n)}_{\text{Flow profits}} - \underbrace{\chi z^{\phi}}_{\substack{\text{Innovation} \\ \text{costs}}} - \underbrace{\xi x^{\phi}}_{\substack{\text{Implementation} \\ \text{costs}}}$$

Own inventor's κ depreciates $\quad + \delta\Big(\boldsymbol{\omega}\big(n, \max(\kappa - 1, \underline{\kappa}), \kappa^{-}\big) - \boldsymbol{\omega}(n,\kappa,\kappa^{-})\Big)$

Competitor's inventor's κ depreciates $\quad + \delta\Big(\boldsymbol{\omega}\big(n, \kappa, \max(\kappa^{-} - 1, \underline{\kappa})\big) - \boldsymbol{\omega}(n,\kappa,\kappa^{-})\Big)$

Firm's inventor finds new idea $\quad + z\Big(\boldsymbol{\omega}\big(n, \min(\kappa + 1, \overline{\kappa}), \kappa^{-}\big) - \boldsymbol{\omega}(n,\kappa,\kappa^{-})\Big)$

Firm replaces its own inventor $\quad + \sum_{\kappa' \in \mathbb{K}} \zeta_{\kappa'}\Big(e'(n,\kappa',\kappa^{-})\Big)\Big(\boldsymbol{\omega}(n,\kappa',\kappa^{-}) - \boldsymbol{\omega}(n,\kappa,\kappa^{-}) + \boldsymbol{u}_{\kappa} - e'(n,\kappa',\kappa^{-})\Big)$

Competitor's inventor finds new idea $\quad + \widetilde{z}\Big(\boldsymbol{\omega}\big(n, \kappa, \min(\kappa^{-} + 1, \overline{\kappa})\big) - \boldsymbol{\omega}(n,\kappa,\kappa^{-})\Big)$

Competitor replaces its inventor $\quad + \sum_{\kappa^{-\prime} \in \mathbb{K}} \zeta_{\kappa^{-\prime}}\Big(\widetilde{e}'(-n,\kappa^{-\prime},\kappa)\Big)\Big(\boldsymbol{\omega}(n,\kappa,\kappa^{-\prime}) - \boldsymbol{\omega}(n,\kappa,\kappa^{-})\Big)$

$$+ \dots$$

Joint Surplus Problem

Back

$$
\begin{aligned}
& + \dots \\
\textit{Firm implements own inventor's ideas} \quad & + x\Big(\boldsymbol{\omega}\Big(\min(n+\kappa,\overline{n}),\kappa,\kappa^{-}\Big) - \boldsymbol{\omega}(n,\kappa,\kappa^{-})\Big) \\
\textit{Competitor implements ideas} \quad & + \widetilde{x}\Big(\boldsymbol{\omega}\Big(\max(n-\kappa^{-},-\overline{n}),\kappa,\kappa^{-}\Big) - \boldsymbol{\omega}(n,\kappa,\kappa^{-})\Big) \\
\textit{Follower catches up to leader} \quad & + \psi\Big(\boldsymbol{\omega}(0,\kappa,\kappa^{-}) - \boldsymbol{\omega}(n,\kappa,\kappa^{-})\Big) \\
\textit{A potential entrant enters} \quad & + \mathrm{m}^{P} \sum_{\kappa' \in \mathbb{K}} \boldsymbol{\omega}^{E}(n,\kappa,\kappa^{-};\kappa')\Big\}
\end{aligned}
$$

subject to the promise-keeping constraint:

$$
e'(n',\kappa',\kappa^{-\prime}) \geq \boldsymbol{u}_{\kappa'} \quad \forall (n',\kappa',\kappa^{-\prime}),
$$

Entry Problem

Back

- State of an industry $\rightarrow (m, \kappa^L, \kappa^F)$, where:
  1. $m \in \{0, 1, \ldots, \overline{n}\}$ $\rightarrow$ Technology gap between leader and follower.
  2. $\kappa^L \in \mathbb{K}$ $\rightarrow$ Inventor type attached to the leader.
  3. $\kappa^F \in \mathbb{K}$ $\rightarrow$ Inventor type attached to the follower.
- Potential entrants pay a flow cost $c^e_\kappa \boldsymbol{Y}$ to enter labor market segment κ.
- By free entry:

$$c^e_\kappa = \max_{\{e^E_\kappa(m,\kappa^L,\kappa^F)\}} \Bigg\{ \sum_{\kappa^L \in \mathbb{K}} \sum_{\kappa^F \in \mathbb{K}} \zeta_\kappa \left(e^E_\kappa(0, \kappa^L, \kappa^F) \right) \left[\frac{1}{2} \sum_{h=F,L} \boldsymbol{\omega}(0, \kappa, \kappa^h) - e^E_\kappa(0, \kappa^L, \kappa^F) \right]$$
$$+ \sum_{m=1}^{\overline{n}} \sum_{\kappa^L \in \mathbb{K}} \sum_{\kappa^F \in \mathbb{K}} \zeta_\kappa \left(e^E_\kappa(m, \kappa^L, \kappa^F) \right) \left(\boldsymbol{\omega}(-m, \kappa, \kappa^L) - e^E_\kappa(m, \kappa^L, \kappa^F) \right) \Bigg\}.$$

$$\text{subject to} \;\; e^E_\kappa(m, \kappa^L, \kappa^F) \geq \boldsymbol{u}_\kappa, \quad \forall (m, \kappa^L, \kappa^F). \tag{1}$$

Distribution of Industries

▸ Back

- Law of motion for the share of industries in state (m, κ^L, κ^F):

$$
\begin{aligned}
\frac{\partial \varphi_{m,\kappa^L,\kappa^F,t}}{\partial t} = {} & \varphi_{m-\kappa^L,\kappa^L,\kappa^F,t} x_{(m-\kappa^L),\kappa^L,\kappa^F,t} + \varphi_{m,\kappa^L-1,\kappa^F,t} z_{m,\kappa^L-1,\kappa^F,t} \\
& + \sum_{\kappa' \in \mathbb{K}} \varphi_{m,\kappa',\kappa^F,t} \zeta_{\kappa^L} \left(e'_{m,\kappa',\kappa^F}(m,\kappa^L,\kappa^F) \right) + \varphi_{m+\kappa^F,\kappa^L,\kappa^F,t} x_{-(m+\kappa^F),\kappa^F,\kappa^L,t} \\
& + \varphi_{\kappa^F-m,\kappa^L,\kappa^F,t} x_{-(\kappa^F-m),\kappa^F,\kappa^L,t} + \varphi_{m,\kappa^L,\kappa^F-1,t} z_{-m,\kappa^F-1,\kappa^L,t} \\
& + \sum_{\kappa' \in \mathbb{K}} \varphi_{m,\kappa^L,\kappa',t} \zeta_{\kappa^F} \left(e'_{-m,\kappa',\kappa^L}(-m,\kappa^F,\kappa^L) \right) + \sum_{\kappa' \in \mathbb{K}} \varphi_{m,\kappa^L,\kappa',t} \mathrm{m}^P \zeta_{\kappa^F}(e^E_{\kappa^F}(m,\kappa^L,\kappa')) \\
& - \varphi_{m,\kappa^L,\kappa^F,t} \Bigg[x_{m,\kappa^L,\kappa^F,t} + x_{-m,\kappa^F,\kappa^L,t} + z_{m,\kappa^L,\kappa^F,t} + z_{-m,\kappa^F,\kappa^L,t} \\
& \qquad + \sum_{\kappa' \in \mathbb{K}} \zeta_{\kappa'} \left(e'_{m,\kappa^L,\kappa^F}(m,\kappa',\kappa^F) \right) + \sum_{\kappa' \in \mathbb{K}} \zeta_{\kappa'} \left(e'_{-m,\kappa^F,\kappa^L}(-m,\kappa',\kappa^L) \right) \\
& \qquad + \sum_{\kappa' \in \mathbb{K}} \mathrm{m}^P \zeta_{\kappa'} \left(e^E_{\kappa'}(m,\kappa^L,\kappa^F) \right) \Bigg]
\end{aligned}
$$

Distribution of Inventors

▸ Back

- Law of motion for the share of unattached inventors of type κ:

$$
\begin{aligned}
\frac{\partial \varphi^U_{\kappa,t}}{\partial t} &= \varphi^U_{\kappa-1,t} z^U_{\kappa-1,t} + \varphi^U_{\kappa+1,t}\delta \\
&+ \sum_{n=-\bar{n}}^{\bar{n}} \sum_{\kappa^-\in\mathbb{K}} \varphi^E_{n,\kappa,\kappa^-} \left(\sum_{\kappa'\in\mathbb{K}} \zeta_{\kappa'}(e'_\kappa(n,\kappa',\kappa^-)) + \mathbb{1}_{\{n<0\}}\mathrm{m}^P \sum_{\kappa'\in\mathbb{K}} \zeta_{\kappa'}(e^E_{\kappa'}(-n,\kappa,\kappa^-)) \right) \\
&- \varphi^U_{\kappa,t} \left(z^U_{\kappa,t} + \delta + \sum_{m,\kappa^L,\kappa^F} \varphi_{m,\kappa^L,\kappa^F} \left(\mu(\theta_\kappa(e'_{m,\kappa^L,\kappa^F}(m,\kappa,\kappa^F))) + \mu(\theta_\kappa(e'_{-m,\kappa^F,\kappa^L}(-m,\kappa,\kappa^L))) \right) \right)
\end{aligned}
$$

where $\varphi^E_{n,\kappa,\kappa^-} \equiv$ measure of type-κ inventors attached to firm in state (n,κ,κ^-):

$$
\varphi^E_{n,\kappa,\kappa^-} \equiv \begin{cases} \varphi_{n,\kappa,\kappa^-} & \text{if } n > 0 \\ \varphi_{-n,\kappa,\kappa^-} & \text{if } n < 0 \\ 2\varphi_{0,\kappa,\kappa^-} & \text{if } n = 0 \end{cases}
$$

Inventor Productivity: Descriptive Statistics

Back

Panel A: Patenting years

	Mean	Median	St. Dev.	Min	Max	N
Patents per year	1.73	1	2.3	1	709	9,113,923
Total patents	4.98	2	13.6	1	5,850	3,159,756
Forward citations (5y) per year	5.68	2	50.7	0	67,515	9,113,923
Forward non-self-citations (5y) per year	2.67	1	14	0	6,468	5,923,556
Forward citations (5y) per author per year	2.08	0.5	15.3	0	20,014	9,113,923
Cumulative forward citations (5y)	4.63	1.6	23.8	0	19,273	6,000,594
Cumulative forward non-self-citations (5y)	1.33	0.47	4.06	0	1,212	4,020,648
Cumulative forward citations (5y) per author	1.7	0.59	7.62	0	6,194	6,000,594

Panel B: Full inventor careers

	Mean	Median	St. Dev.	Min	Max	N
Patents per year	0.81	0	1.79	0	709	19,503,529
Total patents	4.98	2	13.6	1	5,850	3,159,756
Forward citations (5y) per year	2.66	0	34.8	0	67,515	19,503,529
Forward non-self-citations (5y) per year	0.97	0	8.52	0	6,468	16,313,162
Forward citations (5y) per author per year	0.97	0	10.5	0	20,014	19,503,529
Cumulative forward citations (5y)	2.95	1	15.3	0	19,273	16,343,773
Cumulative forward non-self-citations (5y)	0.81	0.13	3.14	0	2,597	14,388,210
Cumulative forward citations (5y) per author	1.13	0.36	4.96	0	6,194	16,343,773

Some Stylized Facts

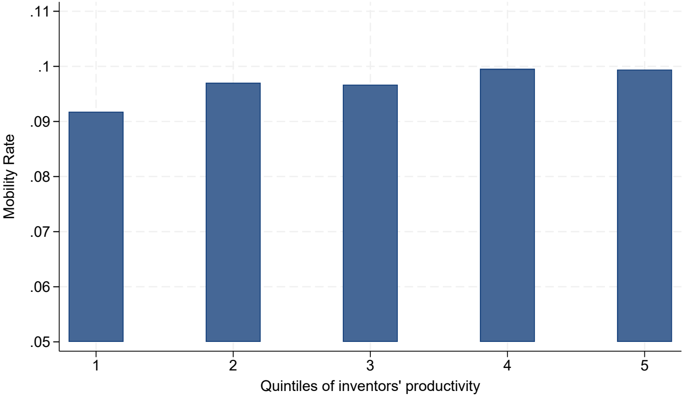
▸ Back

1. In the full USPTO sample, on average:
   - 7.5% of inventors change employer every year (trend: from 5% in the 1980s to 12% in the 2010s).
   - Number of years between an inventor's first and last patent is 6.2.
   - Inventors have 5.3 patents across 1.45 firms over their career (i.e., 4.3 years tenure per employer).
2. Mobility rates are higher for more productive inventors. ▸ Go
3. Hump-shaped relationships between (i) market share and (ii) hiring rates, inventor pvity. ▸ Go
4. Inventor productivity predicts firm innovation outcomes: ▸ Go
   - Firms with better inventors spend more in R&D, are granted more patents, these are cited more.
5. AKM decomposition of q_{jt}: ▸ Go
   - Inventor-specific knowledge capital most important factor to explain variation in inventor output.

Mobility Rates

Back

- Mobility rates are higher among inventors with better past innovation outcomes:



Notes: For each productivity quintile, the mobility rate is a weighted average of year-level mobility rates across years, where each year's mobility rate is weighted by the number of inventors in that quintile-year cell.

Hump-Shaped Relationships

▸ Back

	(1) Hiring rate	(2) Separation rate	(3) Net hiring rate
Market Share	0.198***	-0.011	0.209***
	(0.070)	(0.017)	(0.069)
Market Share Squared	-0.188**	0.009	-0.197**
	(0.083)	(0.024)	(0.085)
N	32,236	32,236	32,236
R^2	0.090	0.087	0.087
Controls	Yes	Yes	Yes
Year-industry FE	Yes	Yes	Yes

Notes: Standard errors clustered at firm and year level in parentheses.

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

Firm Innovation Outcomes

▸ Back

	(1) R&D exp.	(2) Patents	(3) Citations
Inventors' productivity	0.238***	0.661***	1.078***
	(0.014)	(0.049)	(0.039)
Market Share	4.513***	4.434***	2.647*
	(1.121)	(1.472)	(1.521)
Market Share Squared	-5.727***	-6.788***	-4.731**
	(1.725)	(1.872)	(2.082)
N	18,076	21,370	21,336
R^2	0.752	0.850	0.841
Controls	Yes	Yes	Yes
Year-industry FE	Yes	Yes	Yes

Notes: Standard errors clustered at firm and year level in parentheses.

Poisson Poisson regressions in (2), (3).

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

Decomposing Inventors' Productivity

Back

- Disentangle q_{jt}: (using Abowd, Kramarz, Margolis (1999))
  - Inventor knowledge capital (inventor fixed-effects).
  - Firm-specific innovation capabilities (firm fixed effects).
- Specification:

$$q_{jt} = \psi_i + \phi_{i(j,t)} + \gamma_t + \mathbf{X}'_{jt}\beta + \mathbf{W}'_{i(j,t)}\delta + u_{jt}$$

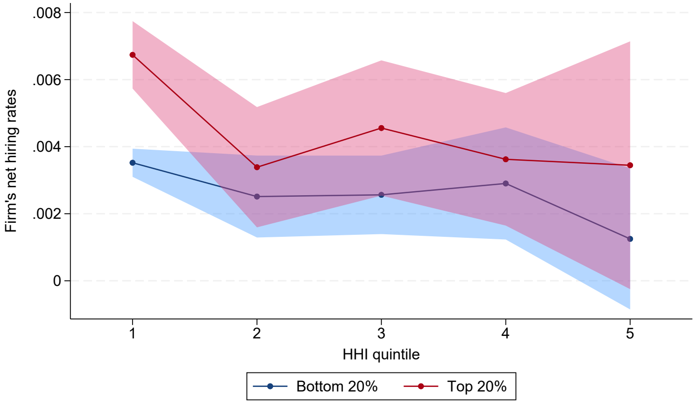
with

  - $\mathbf{X}_{jt}$: Inventor age, inventor age squared.
  - $\mathbf{W}_{i(j,t)}$: # inventors, employment, age, R&D expenditure, leverage, profitability, mkt share and square.
- Variance decomposition results:
  1. Inventor fixed effects account for 91.6% of explained variance in q_{jt}.
  2. Firm fixed effects account for 7.4% of the variance.
  3. Inventor and firm-level time-varying characteristics account for the remaining 1%.

Net Hiring Rates

Back

- Firms in competitive sectors have higher hiring rates of high-productivity inventors.



Notes: Firm net hiring rates of inventors in the top (red) and bottom (blue) quintiles of the distribution of inventor productivity (Q_{jt}). Fitted values from regression: $\text{NetHiringRate}_{it} = \beta_0 + \sum_{k=1}^{5} \beta_k \mathbf{1}\{quint(HHI_{s(i),t}) = k\} + \mathbf{X}'_{it}\gamma + \tau_t + u_{it}$.

Controls: firm's age, employment, number of employed inventors, R&D stock, profitability, leverage and market-to-book ratio; year fixed effects. Standard errors are clustered at firm and year level. Numbers are scaled using the mean of the omitted group (first quintile HHI), keeping controls at their means.

Computing Welfare

▸ Back

- Social welfare is the weighted sum of the lifetime utilities of the representative consumer, the attached inventors and the unattached inventors:

$$W \equiv \int_0^{+\infty} e^{-\rho t}\left[\varpi^C \underbrace{\left(\ln\left(\frac{C_t}{Y_t}\right) + \ln(Y_0) + gt\right)}_{=\ln(C_t)} + \sum_{\kappa\in\mathbb{K}} \varpi_\kappa^E W_\kappa^E Y_0 e^{gt} + \sum_{\kappa\in\mathbb{K}} \varpi_\kappa^U u_\kappa Y_0 e^{gt}\right] dt$$

$$= \varpi^C \frac{1}{\rho}\left[\ln\left(\frac{C_0}{Y_0}\right) + \ln(Y_0) + \frac{g}{\rho}\right] + \frac{Y_0}{\rho - g}\sum_{\kappa\in\mathbb{K}}\left(\varpi_\kappa^E W_\kappa^E + \varpi_\kappa^U u_\kappa\right)$$

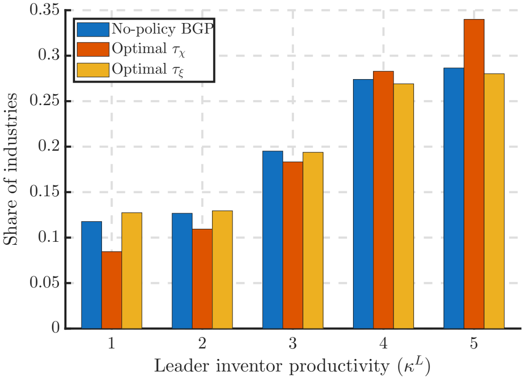
where

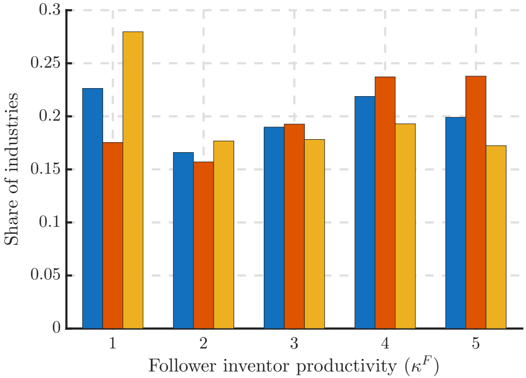
$$W_\kappa^E \equiv \sum_{m=0}^{\overline{n}} \sum_{\kappa^L=\underline{\kappa}}^{\overline{\kappa}} \sum_{\kappa^F\in\mathbb{K}} \varphi_{m,\kappa^L,\kappa^F}\left(e'_\kappa(m,\kappa^L,\kappa^F) + e'_\kappa(-m,\kappa^F,\kappa^L)\right)$$

and $\{\varpi^C, \{\varpi_\kappa^E\}_\kappa, \{\varpi_\kappa^U\}_\kappa\}$, with $\varpi^C + \sum_\kappa \varpi_\kappa^E + \sum_\kappa \varpi_\kappa^U = 1$, are the welfare weights.

Policy: Research and Implementation Subsidies

▸ Back





Notes: Distribution of industries by type of inventor attached to leader (left-hand panel) or follower (right-hand panel) firms, for the baseline calibration (blue bars), the optimal research subsidy τ_χ (orange bars), and the optimal implementation subsidy τ_ξ (yellow bars).