Competing for Inventors: Market Concentration and the Misallocation of Innovative Talent

Andrea Manera (MIT)[1]

October 7, 2022

[1]This research was carried out prior to joining the International Monetary Fund. All views expressed herein are my own and do not necessarily reflect the position of the IMF, its Executive Board, or IMF management.

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- R&D is key to innovation and growth
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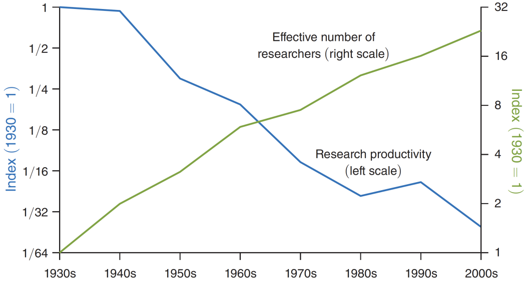

Source: Bloom et al. (2020)

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- R&D productivity and growth have fallen
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- Concerns over R&D allocation
  Acemoglu et al. (2018, 2021), Arora et al. (2020)

Tech Giants Are Paying Huge Salaries for Scarce A.I. Talent

Source: The New York Times (2017)

This Paper

Are inventors misallocated?

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Are inventors misallocated? Yes!

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3. Schumpeterian model with *defensive innovation:*
   - Explain mechanism
   - Discuss policy

Related Literature

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- *Models of Schumpeterian and Defensive innovation*

  Aghion and Howitt (1992), Acemoglu and Akcigit (2012), Abrams et al. (2018), Jo (2019)

Data Construction

Empirical Analysis Objectives

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  - Analyze how concentration and product markets’ share of inventors are related
  - Evaluate effects of increased concentration on R&D productivity

Data Sources

- USPTO (patent-year) and Goldschlag et al. (2016):
  - patent citation and disambiguated inventor id's, 1975-present;
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  - patent classification by NAICS of application (1978-2016)

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- Economic Census and Keil (2017) (5-year-NAICS)
  - NAICS 4-digit concentration measure: HHI and HHI lower bound
  - 157 NAICS 4-digit sectors out of 304 business sectors
  - Most of manufacturing, retail, warehousing, telecommunications, publishing
  - Output per worker growth

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- *Ideally*:
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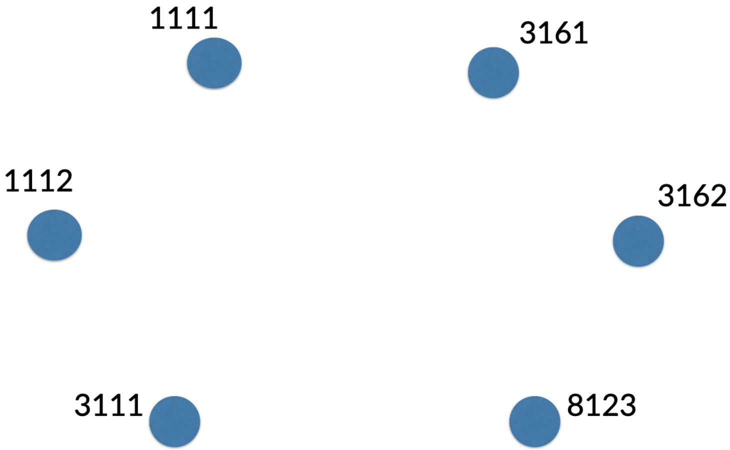
- *In practice:*
  - NAICS 4-digit sectors connected by flows of inventors
  - Identify flows from patents with disambiguated inventors
  - Group NAICS that have strongest connections

Building a Knowledge Market



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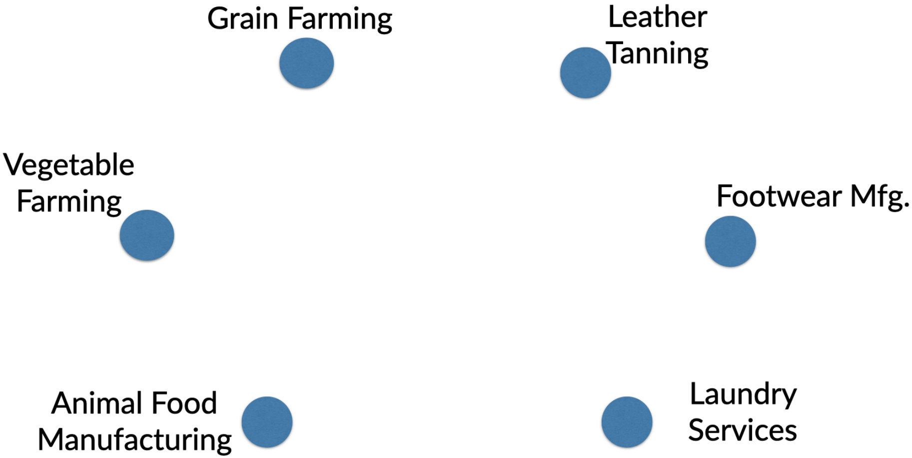

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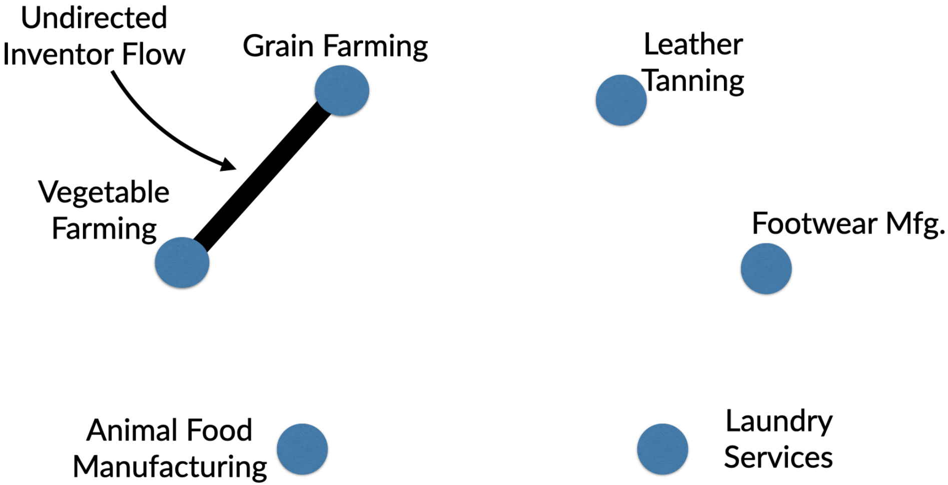

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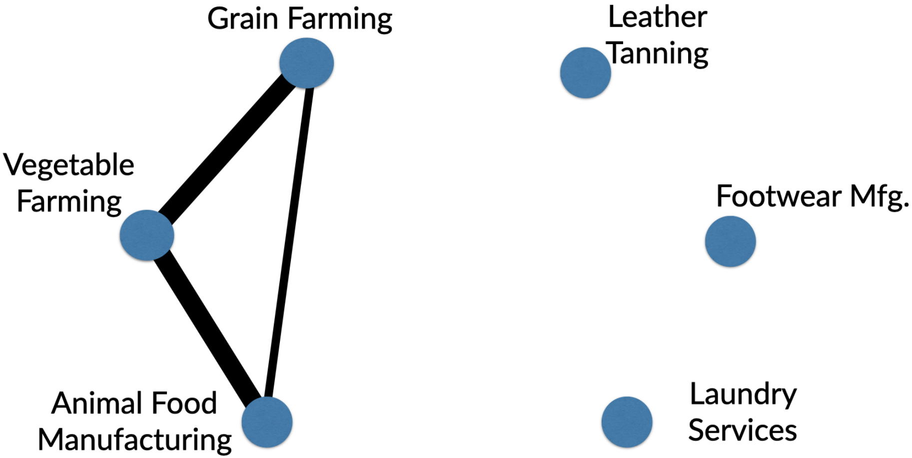

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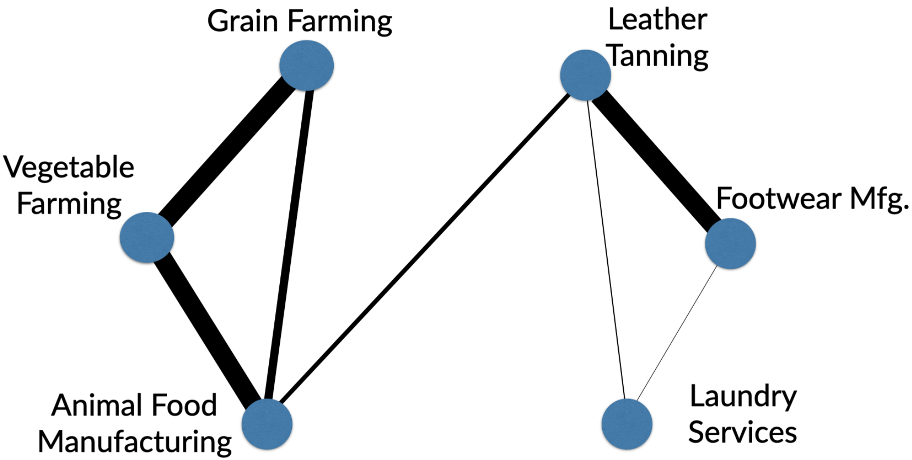

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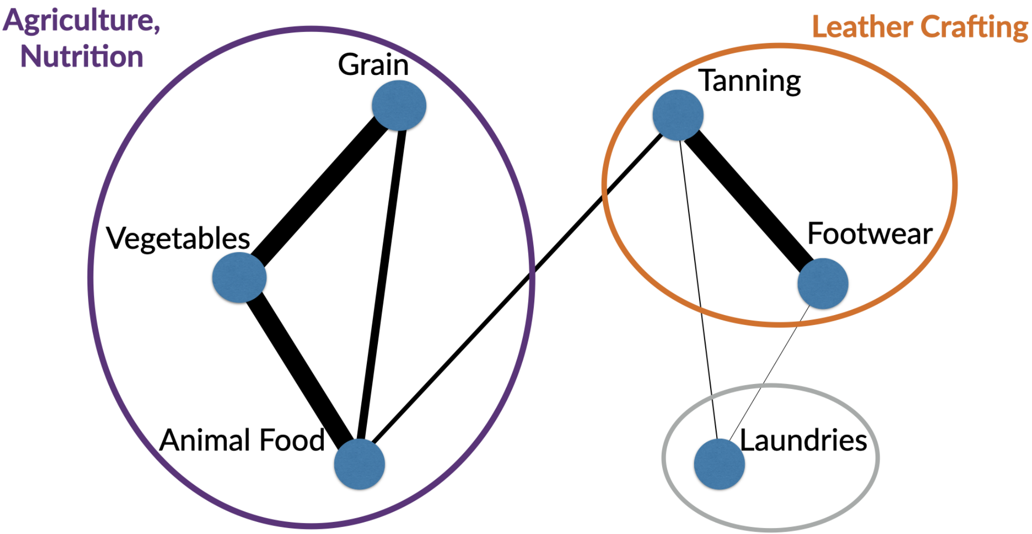

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Patent ID	Inventor ID	Goldschlag et al. (2016) NAICS	Year
US00001	00001-1	1111	1980
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- Flows shall adjust for productivity of inventors who move

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- *Effective inventor flow from sector 1 to 2:*

$$\text{flow}_{1\to 2,t} = \sum_i \#\left\{i's \text{ transitions } 1 \to 2 \text{ in } t\right\} \cdot \alpha_i$$

Detecting Knowledge Markets: Network Weights

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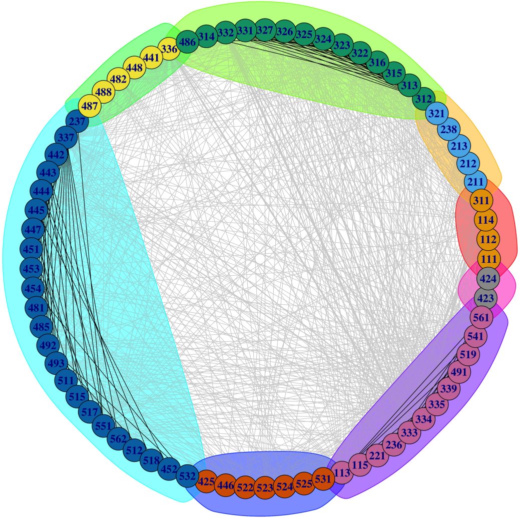
- Result: 10 non-singleton sets of NAICS 4-digit that share inventors with non-missing HHI

Visualization at 3-digit NAICS



Features of Flows and Knowledge Markets

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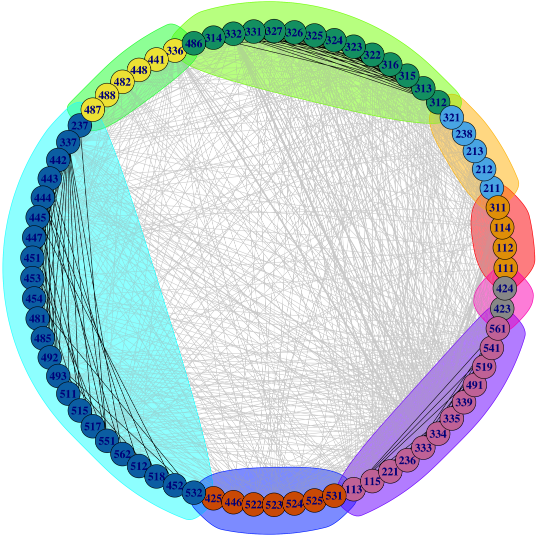

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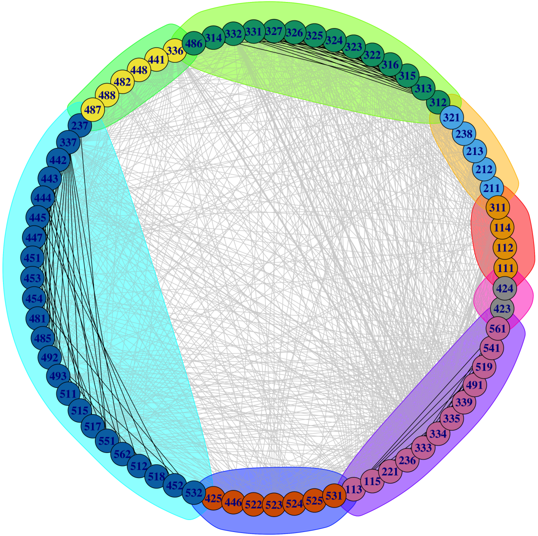

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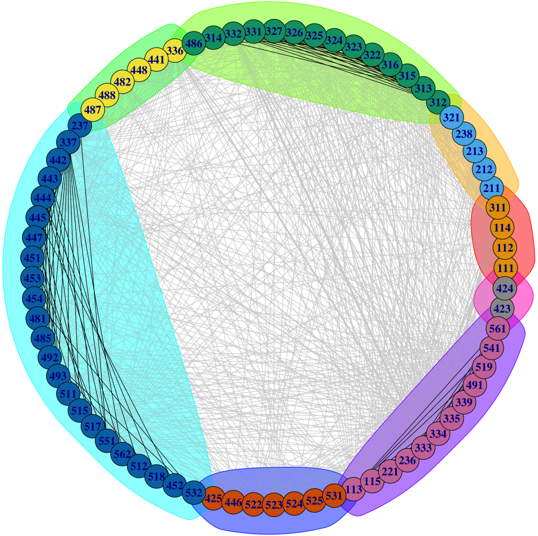

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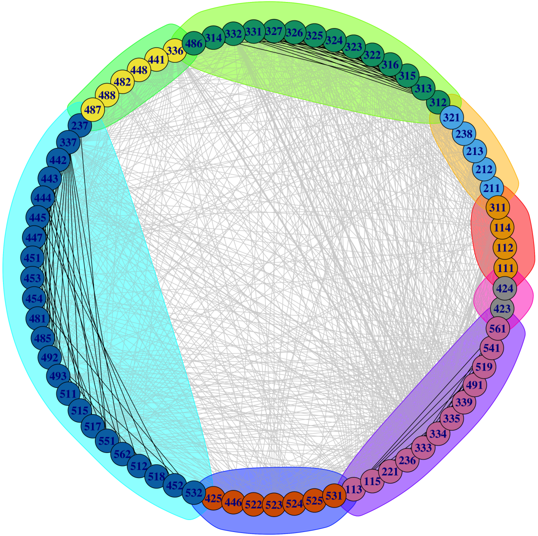
- Blue: "Retail, Data Processing"
- Violet: "Electronics, Machinery"



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- Look within *product* markets:
  - Effect of increased concentration on inventors' productivity
  - Correlation between patent metrics and changes in inventors' share

Variable Definition

- Sector p's share of effective inventors in knowledge market, k:

$$\text{Inventor Share}_{p,t} \equiv \frac{\sum_{p(i,t)=p} \alpha_i}{\sum_{k(i,t)=k} \alpha_i},$$

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- Size of sectors or firms: real sales, real sales per company (Economic Census)

Specification

- Long-difference 2012-1997 at NAICS 4-digit sector, p:

$$\Delta Share_{p,\,2012-1997} = f_k \mathbf{1}\{p \in k\} + \beta \Delta HHI_{p,\,2012-1997} + \gamma \Delta Size_{p,\,2012-1997} + \varepsilon_p,$$

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- ΔHHI$_p$: change in concentration
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- Weighted by sales, robust standard errors

Main Specification Results

‣ No Controls ‣ Census HHI ‣ Trim Outliers ‣ Raw Inventors

	Δ Inventor Share (pp)	
	(1)	(2)
$\Delta \underline{\mathrm{HHI}}$	26.093*	22.509*
	(10.696)	(10.848)
Δ log Sales	0.914**	0.548*
	(0.278)	(0.243)
Knowledge Market FE		✓
Sample	Full Sample	Full Sample
Weight	Sales	Sales
Observations	157	153

Robust standard errors in parentheses, $+\ p < 0.1,^{*}\ p < 0.05,^{**}\ p < .01,^{***}\ p < .001$

- $\Longrightarrow$1 s.d. increase in $\underline{\mathrm{HHI}}$: .033 $\Longrightarrow \uparrow$ .858pp inventor share (.55 s.d.)
- Compares to average inventors' share of 1.16pp, median .37pp

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  - Inventors' productivity (next slide)

Fall in Inventors' Productivity

▸ Robustness to Outliers

	Δ Growth/Inventor (pp)	
	(1)	(2)
$\Delta \underline{\mathrm{HHI}}$	-0.332**	-0.292*
	(0.113)	(0.123)
Δ log Sales		-0.052*
		(0.021)
Knowledge Market FE	✓	✓
Sample	Full Sample	Full Sample
Weight	Sales	Sales
Observations	101	101

Robust standard errors in parentheses, $+ \ p < 0.1$, $^{*} \ p < 0.05$, $^{**} \ p < .01$, $^{***} \ p < .001$

Back-of-the-envelope Loss from Misallocation

- Median change in annual output per worker growth in sample : -2.73pp
- Implied loss from misallocation for the median sector with Δ Inventor Share > 0:

$$\Delta \text{g} = \frac{\Delta\left(\frac{\text{g}}{\text{Inventor}}\right)}{\Delta\underline{\text{HHI}}} \times \Delta\underline{\text{HHI}} \times \text{Inventors}$$

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- Similar results regressing of inventors' productivity on Δ Inventor Share

Recap of Key Results

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- Within knowledge markets:
  - Sector that become more concentrated attract more inventors
- Within product markets, increasing concentration:
  - Lowers inventors' productivity (growth per inventor)
  - Increases share of inventors at top firms
  - Lowers forward citations

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  - Optimal to subsidize entrants' R&D in concentrated sectors
  - Cost-neutral policy gives up to .50pp higher annual growth $(+17\%)$

Single-Sector: Market Structure

Concentration v. Markup

Consumption good is C-D of intermediates:

$$\ln Y_t = \int_0^1 \ln y_t(i) di$$

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Bertrand competition, incumbent sets $p_t(i) = c_t(i)$, realizes monopoly profits:

$$\Pi_t = \left(\frac{\phi - 1}{\phi}\right) c_t(i) y_t(i) = \left(\frac{\phi - 1}{\phi}\right) Y_t.$$

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Normalized incumbents' profits are constant:

$$\pi_t \equiv \frac{\Pi_t}{Y_t} = \left(\frac{\phi - 1}{\phi}\right)$$

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- $\alpha_I \frac{x_I^{\gamma}}{\gamma}$ total incumbents' inventors
- Isoelastic R&D labor supply

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$$\rho v(1) = \max_{x_I} \left(\frac{\phi - 1}{\phi}\right) - \alpha_I \frac{x_I^\gamma}{\gamma} + x_I \left(v(\omega) - v(1)\right) - x_{e,1}\left(v(1)\right)$$

$$\rho v(\omega) = \left(\frac{\phi - 1}{\phi}\right) + \delta\left(v(1) - v(\omega)\right) - x_{e,\omega}\left(v(\omega)\right)$$

- $x_{e,1}, x_{e,\omega}$: total research intensity of entrants
- δ: depreciation of patent wall (patent protection)
- Gain from innovation depends on the difference between $x_{e,\omega}$ and $x_{e,1}$

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- Finite demand IFF:

$$x_{e,\Omega} = \frac{v(1)}{\zeta \boldsymbol{\Omega}}$$

Growth and Inventors' Productivity ▸ Equilibrium Definition

Stationary distribution with constant growth: ▸ Derivation

$$\boldsymbol{\mu} = \begin{bmatrix} \mu_1 & \mu_\omega & \mu_{e,1} & \mu_{e,\omega} \end{bmatrix}$$

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Inventors' productivity (growth per inventor):

$$\frac{g}{L^{RD}} = \eta \frac{x_{e,\omega} \mu_{e,\omega} + x_{e,1} \mu_{e,1} + \lambda x_I \mu_1}{\zeta \left(\omega x_{e,\omega} \mu_{e,\omega} + x_{e,1} \mu_{e,1} \right) + \alpha_I \frac{x_I^\gamma}{\gamma} \mu_1}.$$

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Proposition

Around and equilibrium with constant growth, an increase in the markup ϕ raises incumbents' and entrants' research efforts, and the share of R&D labor employed by incumbents.

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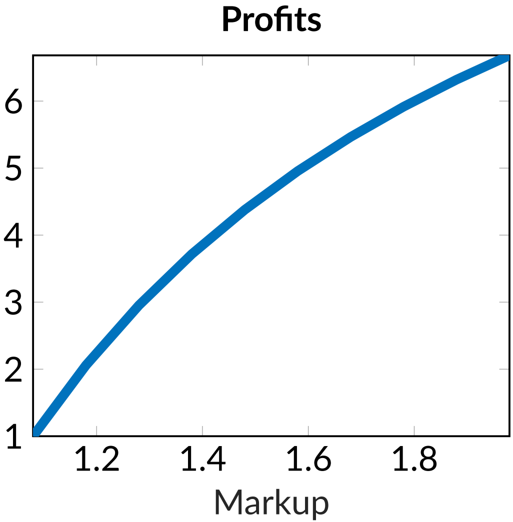
If (i) inventor supply to the sector is elastic; (ii) $\lambda = 0$; and (iii) the model parameters are such that equilibrium incumbents' research effort is more elastic than entrants'

$$\frac{\partial x_I^\star}{\partial \phi}\frac{\phi}{x_I^\star} > \frac{\partial x_{e,\omega}^\star}{\partial \phi}\frac{\phi}{x_{e,\omega}^\star},$$

an increase in the markup, ϕ, lowers equilibrium inventors' productivity.

Single Sector Comparative Statics: Markup Increase



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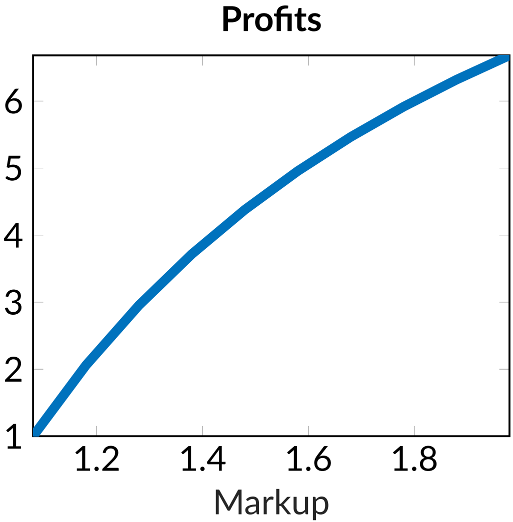

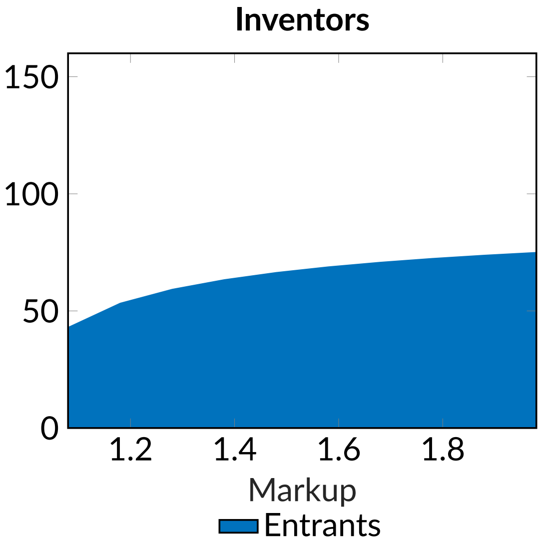

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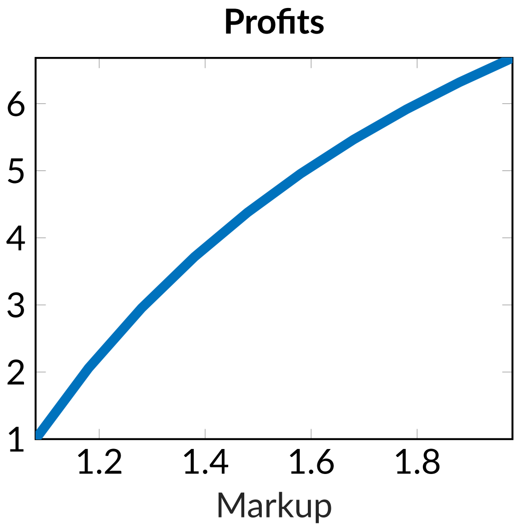

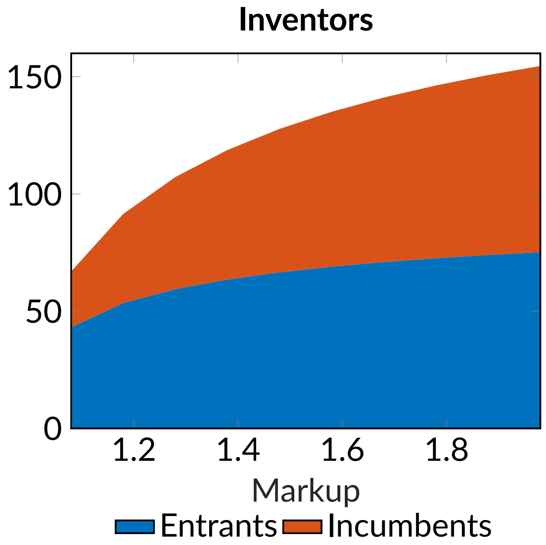

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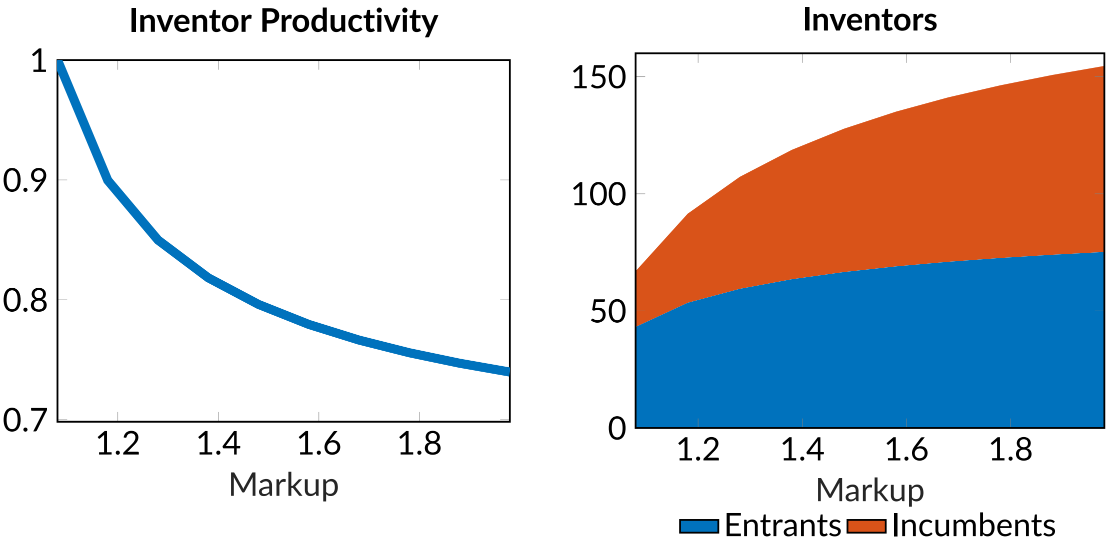

Calibration and Policy

Two-Sectors, Inventor Market Equilibrium

- Two Cobb-Douglas sectors as above:

$$\ln Y = \beta_1 \int_0^1 \ln y_{1,t}(i)di + (1-\beta_1)\int_0^1 \ln y_{2,t}(i)di$$

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$$L^{RD,s}\left(w^{RD}\right) = \sum_{i=1,2}\left\{\mu_{1,i}\left(w^{RD}\right)\alpha_I \frac{x_{I,i}^{\gamma}\left(w^{RD}\right)}{\gamma} + \right.$$

$$\left. +\mu_{\omega,i}\left(w^{RD}\right)\zeta_i\omega_i x_{e,\omega,i}\left(w^{RD}\right) + \mu_{1,e,i}\left(w^{RD}\right)\zeta_i x_{e,1,i}\left(w^{RD}\right)\right\}$$

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- Normalize $L^{RD,s} = 100$.
- $\Rightarrow$ Misallocation only from flows across sectors.

External Calibration

Parameter Name	Symbol	Value	Source/Target
Discount rate	ρ	.04	$r \approx 7\%$ pre-1997, $g = 3\%$
Value Added Share	β	.5	Share of sectors with $\uparrow$ HHI
Average Sectors' Markup	ϕ	1.08	De Loecker et al., 2020; Eggertsson et al., 2018

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Patent Expiration Rate	δ	.05	Uruguay Round Agreements Act (1994)
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- τ, s: corp. tax 23% and R&D subsidy 19% (Akcigit et al., 2019)

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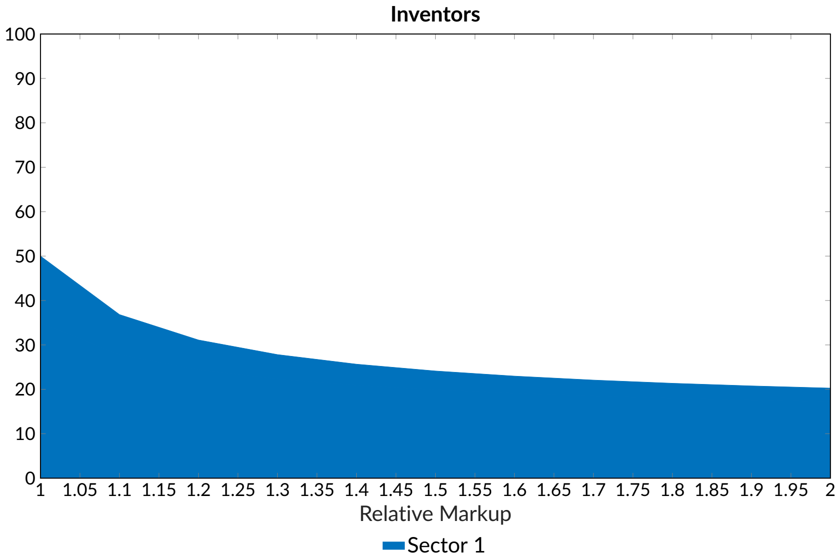
Parameter Name	Symbol	Value	Target
Incumbent Costs	α_I	21.97	Top 10% Firms' Inventor Share, 1997: 30.3%
Entrants' Costs	ζ	4.75	Business R&D Share over GDP, 1997: 1.81%
Innovation Step	η	0.0047	Average Output per Worker Growth, 1997: 3.03%

CS: Increase in Sector 2 Markup



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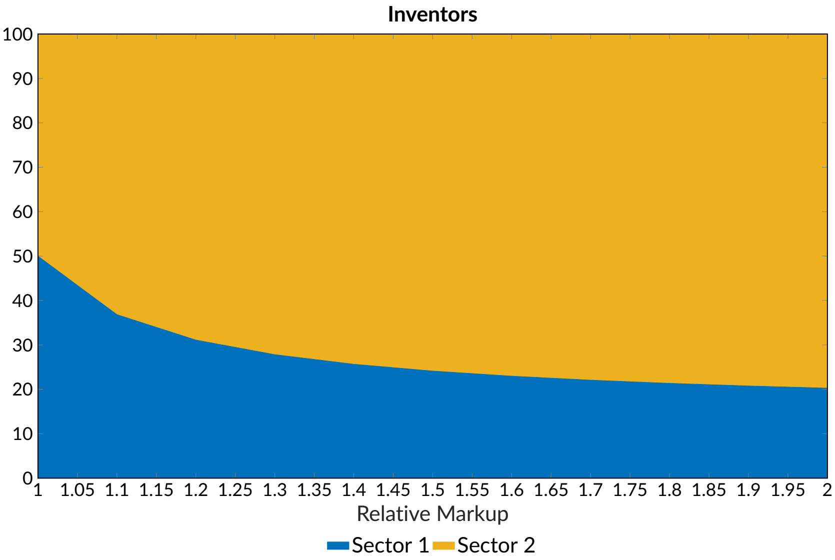

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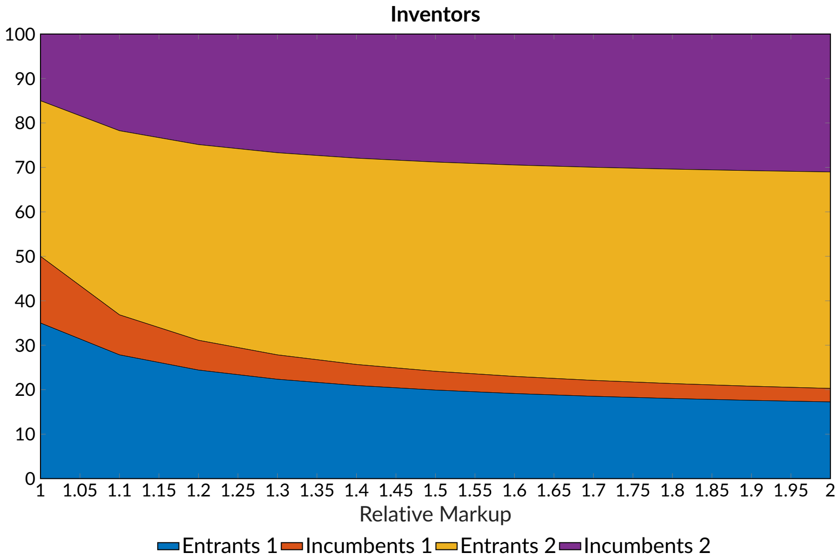

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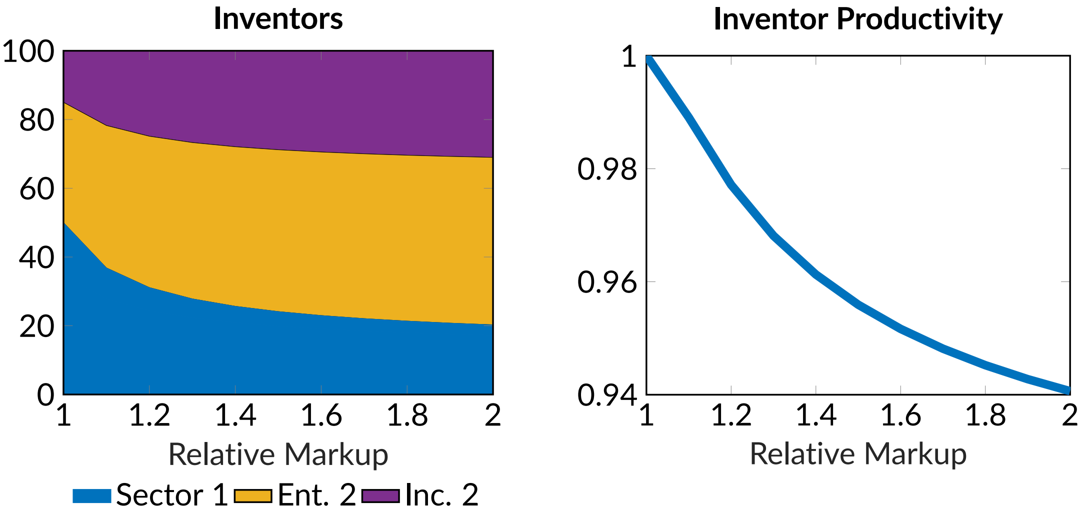

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Policy Results

	Baseline		Optimal Cost-Neutral	Cost-Neutral Sector	Cost-Neutral Entry
	$Sector$ 1	$Sector$ 2			
	(1)	(2)			
R&D Subsidies:					
s_I	19%	19%			
s_e	19%	19%			
Aggregates:					
L_I^{RD}	6.70	24.87			
L_e^{RD}	24.41	44.02			
L_{TOT}^{RD}	31.11	68.89			
Sector Growth	2.12%	3.74%			
GDP Growth	2.93%				

Policy Results

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	Sector 1	Sector 2	Sector 1	Sector 2		
	(1)	(2)	(3)	(4)		
R&D Subsidies:						
s_I	19%	19%	0%	0%		
s_e	19%	19%	0%	41.78%		
Aggregates:						
L_I^{RD}	6.70	24.87	6.37	15.95		
L_e^{RD}	24.41	44.02	23.87	53.81		
L_{TOT}^{RD}	31.11	68.89	30.25	69.75		
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GDP Growth	2.93%		3.43%			

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R&D Subsidies:							
s_I	19%	19%	0%	0%	46.17%	0%	
s_e	19%	19%	0%	41.78%	46.17%	0%	
Aggregates:							
L_I^{RD}	6.70	24.87	6.37	15.95	10.83	19.51	
L_e^{RD}	24.41	44.02	23.87	53.81	30.24	39.42	
L_{TOT}^{RD}	31.11	68.89	30.25	69.75	41.07	58.93	
Sector Growth	2.12%	3.74%	2.08%	4.78%	2.61%	3.36%	
GDP Growth	2.93%		3.43%		2.99%		

Policy Results

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	Sector 1	Sector 2	Sector 1	Sector 2	Sector 1	Sector 2	Sector 1	Sector 2
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
R&D Subsidies:								
s_I	19%	19%	0%	0%	46.17%	0%	0%	0%
s_e	19%	19%	0%	41.78%	46.17%	0%	29%	29%
Aggregates:								
L_I^{RD}	6.70	24.87	6.37	15.95	10.83	19.51	4.83	18.45
L_e^{RD}	24.41	44.02	23.87	53.81	30.24	39.42	27.41	49.30
L_{TOT}^{RD}	31.11	68.89	30.25	69.75	41.07	58.93	32.25	67.75
Sector Growth	2.12%	3.74%	2.08%	4.78%	2.61%	3.36%	2.45%	4.31%
GDP Growth	2.93%		3.43%		2.99%		3.38%	

Policy Results

	Baseline		Optimal Cost-Neutral		Cost-Neutral Sector		Cost-Neutral Entry	
	Sector 1	Sector 2	Sector 1	Sector 2	Sector 1	Sector 2	Sector 1	Sector 2
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
R&D Subsidies:								
s_I	19%	19%	0%	0%	46.17%	0%	0%	0%
s_e	19%	19%	0%	41.78%	46.17%	0%	29%	29%
Aggregates:								
L_I^{RD}	6.70	24.87	6.37	15.95	10.83	19.51	4.83	18.45
L_e^{RD}	24.41	44.02	23.87	53.81	30.24	39.42	27.41	49.30
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Sector Growth	2.12%	3.74%	2.08%	4.78%	2.61%	3.36%	2.45%	4.31%
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Policy Results

	Baseline		Optimal Cost-Neutral		Cost-Neutral Sector		Cost-Neutral Entry	
	Sector 1 (1)	Sector 2 (2)	Sector 1 (3)	Sector 2 (4)	Sector 1 (5)	Sector 2 (6)	Sector 1 (7)	Sector 2 (8)
R&D Subsidies:								
s_I	19%	19%	0%	0%	46.17%	0%	0%	0%
s_e	19%	19%	0%	41.78%	46.17%	0%	29%	29%
Aggregates:								
L_I^{RD}	6.70	24.87	6.37	15.95	10.83	19.51	4.83	18.45
L_e^{RD}	24.41	44.02	23.87	53.81	30.24	39.42	27.41	49.30
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Sector Growth	2.12%	3.74%	2.08%	4.78%	2.61%	3.36%	2.45%	4.31%
GDP Growth	2.93%		3.43%		2.99%		3.38%	

$\Longrightarrow$ **Subsidizing entrants' R&D** is most effective: .45-.50pp higher growth

Conclusion

- Concentrating sectors attracted inventors away from competitive
- Incumbents increasingly deployed inventors to defensive projects
- Misallocation can explain 28% of 1997-2012 fall in annual output/worker growth
- Key model mechanism: *defensive innovation*
- Policy: entrant subsidies in *less competitive sectors*
- Cost-neutral entry subsidies give .50pp higher annual growth

Headlines

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Deals

Big Tech Swallows Most of the Hot AI Startups

An acquisition spree by Apple, Amazon, Facebook, Google and Microsoft eliminated potential rivals and concentrated brain power in this critical field.

The New York Times https://www.nytimes.com/2017/10/22/technology/artificial-intelligence-experts-salaries.html

Tech Giants Are Paying Huge Salaries for Scarce A.I. Talent

Total Inventor Flows ▸ Back

- Strength of connection between two sectors
- Build directed flows for each inventor i (avoid double counting):

$$\mathrm{flow}_{1\to 2,i,t} \equiv \frac{\sum \mathbf{1}\{i \text{ moves } 1 \to 2 \text{ in } t\}}{\sum_{j,k} \mathbf{1}\{i \text{ moves } j \to k \text{ in } t\}} \times \alpha_i$$

- Compute total outflows and inflows for each NAICS 4-digit sector:

$$\mathrm{inflow}_{\mathrm{NAICS}} = \sum_n \sum_t \sum_i \mathrm{flow}_{n\to \mathrm{NAICS},i,t},$$

Network Weights ▸ Back

- Compute share of inflows and outflows, e.g.:

$$share_{1\leftarrow 2} = \frac{\sum_t \sum_i flow_{2\rightarrow 1,i,t}}{inflow_1}$$

- Define weight:

$$W_{12} = W_{21} = \min\left\{\frac{share_{1\leftarrow 2} + share_{1\rightarrow 2}}{2}, \frac{share_{2\leftarrow 1} + share_{2\rightarrow 1}}{2}\right\}$$

- Average tends to overstate flows from small sectors to large

Problem: Maximize Modularity ▸ Back

- Assigns sectors i to N *non-overlapping* communities c_i to maximize modularity

$$\max_{N} \max_{(c_1,\ldots,c_N)} Q \equiv \frac{1}{2\boldsymbol{W}} \sum_{ij} \left[W_{ij} - \frac{\boldsymbol{W}_i \boldsymbol{W}_j}{2\boldsymbol{W}} \right] \mathbf{1}\left\{c_i = c_j\right\},$$

  - W_{ij}, weight of edge connecting node i to j
  - $\boldsymbol{W}_i = \sum_i W_{ik}$, sum of weights for edges with one end in node i, $\boldsymbol{W}$ sum of all weights in the graph
  - $\frac{\boldsymbol{W}_i \boldsymbol{W}_j}{2\boldsymbol{W}}$ is the expected number of weighted edges between nodes i and j

Louvain Algorithm ▸ Back

- Louvain method (Blondel et al., 2008). Assign each node to its own community. Then, repeat iteratively:
  1. Compute local deviations in modularity from reassigning the node to neighboring communities
  2. Move node in highest modularity direction
  3. Redefine a network with new communities as nodes

HHI Lower Bound Back

- Keil, 2017:

$$\underline{\text{HHI}}_{p,t} = 4\left[\frac{\text{Top-4 Share}_{p,t}}{4}\right]^2 + 4\left[\frac{\text{Top-8 Share}_{p,t} - \text{Top-4 Share}_{p,t}}{4}\right]^2 + 12\left[\frac{\text{Top-20 Share}_{p,t} - \text{Top-8 Share}_{p,t}}{12}\right]^2 + 30\left[\frac{\text{Top-50 Share}_{p,t} - \text{Top-20 Share}_{p,t}}{30}\right]^2$$

- Coincides with actual if:
  - Sector has 50 or less firms
  - Shares are distributed equally between firms in brackets 0-4, 5-8, 9-20, 21-50
- Correlation with actual HHI is .93

IV Analysis: Regulation measure ▸ Back

- Regulation measure from Mercatus RegData 4.0
- Counts of regulation affecting NAICS 4d using text analysis
- Extended to all sectors with HHI using cosine-similarity between sector descriptions
- For all pairs NAICS 4-d sectors:
  - Build cosine similarity between descriptions
- For each NAICS 4-d without missing data:
  - Rank 5 most similar sectors with regulation data
  - Attribute regulations of top 5 most similar sectors, weighted by cos. similarity
  - If highest cos-similarity is smaller than .2, use only most similar sector.

IV Regression: Reduced Form and First Stage

	Δ Inventor Share (pp)	$\Delta \underline{\text{HHI}}$
	(1)	(2)
Δ log Restrictions	0.478*	0.016*
	(0.220)	(0.007)
Δ log Sales	0.539+	-0.000
	(0.274)	(0.005)
Knowledge Market FE	✓	✓
Sample	Full Sample	Full Sample
Weight	Sales	Sales
Observations	153	153

Robust standard errors in parentheses, $+$ $p < 0.1$,* $p < 0.05$,** $p < .01$,*** $p < .001$

IV Regression: 2SLS Results

	Ch. 4d K.M. Eff. Inv. Share (%)	
	(1)	(2)
Ch. HHI lower bound	30.560+	30.096+
	(15.904)	(15.819)
Ch. Log Real Sales	0.544*	0.525*
	(0.244)	(0.247)
4D Knowledge Market FE	✓	✓
Sample	Full Sample	Mahalanobis 5%
Weight	Sales	Sales
Observations	157	150
First-Stage F	4.587229	4.753009
Anderson-Rubin p-value	.0281448	.0321185

Robust standard errors in parentheses, $+\ p < 0.1,^{*}\ p < 0.05,^{**}\ p < .01,^{***}\ p < .001$

No Controls ▸ Back

	Δ Inventor Share (pp)	
	(1)	(2)
$\Delta \underline{HHI}$	27.293*	
	(11.569)	
ΔHHI		22.399***
		(6.345)
Knowledge Market FE		
Sample	Full Sample	Full Sample
Weight	Sales	Sales
Observations	157	80

Robust standard errors in parentheses, $+ \; p < 0.1,^{*} \; p < 0.05,^{**} \; p < .01,^{***} \; p < .001$

Main Specification: Actual HHI

Back

	Δ Inventor Share (pp)					
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta\underline{\mathrm{HHI}}$	27.293*		27.183*		27.326*	
	(11.569)		(11.941)		(11.620)	
$\Delta\mathrm{HHI}$		22.399***		22.399***		22.350***
		(6.345)		(6.345)		(6.343)
Knowledge Market						
Sample	Full Sample	Full Sample	Trim Outliers	Trim Outliers	Mahalanobis 5%	Mahalanobis 5%
Weight	Sales	Sales	Sales	Sales	Sales	Sales
Observations	157	80	155	80	150	71

Robust standard errors in parentheses, $+\ p < 0.1,^{*}\ p < 0.05,^{**}\ p < .01,^{***}\ p < .001$

Main Specification: Robustness to Outliers ▸ Back

	Δ Inventor Share (pp)					
	(1)	(2)	(3)	(4)	(5)	(6)
ΔHHI	26.093*	22.509*	25.904*	22.716*	26.111*	22.554*
	(10.696)	(10.848)	(11.124)	(10.948)	(10.725)	(11.019)
Δ log Sales	0.914**	0.548*	0.881**	0.539*	0.918**	0.562*
	(0.278)	(0.243)	(0.275)	(0.242)	(0.283)	(0.261)
Knowledge Market FE		✓		✓		✓
Sample	Full Sample	Full Sample	Trim Outliers	Trim Outliers	Mahalanobis 5%	Mahalanobis 5%
Weight	Sales	Sales	Sales	Sales	Sales	Sales
Observations	157	153	155	152	150	139

Robust standard errors in parentheses, $+\ p < 0.1, ^{*}\ p < 0.05, ^{**}\ p < .01, ^{***}\ p < .001$

Robustness to Individual Firm Size ▸ Back

	Δ Inventor Share (pp)					
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta \underline{HHI}$	35.230**	20.783+	35.230**	20.783+	35.154**	22.854*
	(12.759)	(10.615)	(12.759)	(10.615)	(12.647)	(11.197)
Δ log Size	0.175	-0.040	0.175	-0.040	0.300	-0.055
	(0.382)	(0.253)	(0.382)	(0.253)	(0.460)	(0.346)
Knowledge Market FE		✓		✓		✓
Sample	Full Sample	Full Sample	Trim Outliers	Trim Outliers	Mahalanobis 5%	Mahalanobis 5%
Weight	Sales	Sales	Sales	Sales	Sales	Sales
Observations	81	79	81	79	75	67

Robust standard errors in parentheses, $+ \; p < 0.1, ^{*} \; p < 0.05, ^{**} \; p < .01, ^{***} \; p < .001$

Robustness to Raw Inventors ▸ Back

	Δ Inventor Share (pp)					
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta \underline{\text{HHI}}$	71.724+	67.160+	72.123+	67.736+	71.772+	68.398+
	(39.265)	(37.176)	(39.530)	(37.504)	(39.316)	(37.717)
Δ log Sales	1.864*	1.422*	1.852*	1.402+	1.878*	1.443+
	(0.766)	(0.717)	(0.764)	(0.712)	(0.774)	(0.745)
Knowledge Market FE		✓		✓		✓
Sample	Full Sample	Full Sample	Trim Outliers	Trim Outliers	Mahalanobis 5%	Mahalanobis 5%
Weight	Sales	Sales	Sales	Sales	Sales	Sales
Observations	157	156	156	155	150	142

Robust standard errors in parentheses, $+\ p < 0.1,^{*}\ p < 0.05,^{**}\ p < .01,^{***}\ p < .001$

Within-Sector Distribution ▸ Back

	Δ Top 10%/Bottom 50%	Δ Top 10%	Δ Bottom 50%
	(2)	(4)	(5)
$\Delta \underline{\mathrm{HHI}}$	0.243*	0.018**	-0.008*
	(0.097)	(0.006)	(0.004)
Δ log Sales	0.328	0.026	0.005
	(0.294)	(0.020)	(0.007)
Knowledge Market FE	✓	✓	✓
Sample	Full Sample	Full Sample	Full Sample
Weight	Sales	Sales	Sales
Observations	118	118	118

Robust standard errors in parentheses, $+\ p < 0.1,^{*}\ p < 0.05,^{**}\ p < .01,^{***}\ p < .001$

Forward Citations

Back

	Δ log citations/patent		Δ patent generality
	(1)	(2)	(3)
Δ Inventor Share (pp)	-0.545***		-0.025*
	(0.113)		(0.012)
Δ log Sales	-0.232*		0.008
	(0.109)		(0.012)
4D Knowledge Market FE	✓		✓
Sample	Full Sample		Full Sample
Weight			
Observations	144		144

Results for $\Delta Share_p \in [-2, 2]$. Robust standard errors in parentheses, $+\ p < 0.1, ^{*}\ p < 0.05, ^{**}\ p < .01, ^{***}\ p < .001$

Robustness for Inventor Productivity ▸ Back

	Δ Growth/Inventor (pp)			
	(1)	(2)	(3)	(4)
$\Delta \underline{\text{HHI}}$	-0.332**	-0.292*	-0.332**	-0.290*
	(0.113)	(0.123)	(0.114)	(0.126)
Δ log Sales		-0.052*		-0.053*
		(0.021)		(0.022)
Knowledge Market FE	✓	✓	✓	✓
Sample	Full Sample	Full Sample	Mahalanobis 5%	Mahalanobis 5%
Weight	Sales	Sales	Sales	Sales
Observations	101	101	98	94

Robust standard errors in parentheses, $+\ p < 0.1,^{*}\ p < 0.05,^{**}\ p < .01,^{***}\ p < .001$

Lerner Index v. Concentration in Sample ▸ Back

	Δ Lerner Index
	(2)
$\Delta\underline{\text{HHI}}$	1.652***
	(0.257)
Observations	258
R-squared	.14

Robust standard errors in parentheses, $+\ p < 0.1,^{*}\ p < 0.05,^{**}\ p < .01,^{***}\ p < .001$

Constant-Growth Equilibrium

Back

Definition

A constant-growth equilibrium is a set of prices $p(i)$, investment intensities $x_I, x_{e,\omega}, x_{e,1}$, and normalized values $v(\omega), v(1)$, such that, given a wage for production and R&D workers, incumbent and entrants optimally choose research intensities, the stationary distribution satisfies:

$$
\begin{aligned}
0 &= -\left(x_I + x_{e,1}\right)\mu_1 + \delta\mu_\omega + x_{e,\omega}\mu_{e,\omega} + x_{e,1}\mu_{e,1}, \\
0 &= -\left(x_{e,\omega} + \delta\right)\mu_\omega + x_I\mu_1, \\
0 &= -\left(x_{e,1} + x_I\right)\mu_{e,1} + x_{e,1}\mu_1 + \delta\mu_{e,\omega}, \\
0 &= -\left(x_{e,\omega} + \delta\right)\mu_{e,\omega} + x_{e,\omega}\mu_\omega + x_I\mu_{e,1}.
\end{aligned}
$$

and output grows at a constant rate, g.

Stationary Distribution ▸ Back

LOM:

$$
\begin{aligned}
\dot{\mu}_1 &= -\left(x_I + x_{e,1}\right)\mu_1 + \delta\mu_\omega + x_{e,\omega}\mu_{e,\omega} + x_{e,1}\mu_{e,1},\\
\dot{\mu}_\omega &= -\left(x_{e,\omega} + \delta\right)\mu_\omega + x_I\mu_1,\\
\dot{\mu}_{e,1} &= -\left(x_{e,1} + x_I\right)\mu_{e,1} + x_{e,1}\mu_1 + \delta\mu_{e,\omega},\\
\dot{\mu}_{e,\omega} &= -\left(x_{e,\omega} + \delta\right)\mu_{e,\omega} + x_{e,\omega}\mu_\omega + x_I\mu_{e,1}.
\end{aligned}
$$

$$
\mu_\omega = \frac{x_I}{x_I + x_{e,\omega} + \delta}, \qquad \mu_1 = \frac{x_{e,\omega} + \delta}{x_I + x_{e,\omega} + \delta},
$$

$$
\mu_{e,\omega} = \frac{\omega x_I \mu_1 + \left(\omega x_{e,\omega} + x_I\right)\mu_\omega}{\omega\left(x_{e,\omega} + \delta\right) + x_I}, \qquad \mu_{e,1} = \frac{\omega\left(x_{e,\omega} + \delta\right)\mu_1 + \delta\mu_\omega}{\omega\left(x_{e,\omega} + \delta\right) + x_I}.
$$