Innovation Spillovers Within Firms and Within Cities

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Motivation

- Innovation is at the heart of long-run economic growth.
- A central question is how individuals' interactions within firms and within cities affect their productivity.
- **Firm Spillovers:**
  - Firms are the actual entities where R&D capital, intellectual property, and *teams* are organized.
  - Yet, a paradox persists: empirical studies consistently show that inventor productivity declines with overall firm size.
- **Spatial Spillovers (high-tech clusters):**
  - Decades of urban economics emphasize geographic agglomeration forces.
  - Knowledge leaks locally through close physical proximity, and local informal networks.
  - But tech-hubs also attract the most productive firms and inventors.
- **The Empirical Challenge:**
  - Limited availability of data that tracks inventors across time and location even when they do not innovate.

This Paper

- **Granular Panel Data of Inventors Across Jobs:**
  - Linked employment/resume histories of 500k+ inventors to **PatentsView** patent records, enabling observation of inventors across jobs even during periods without innovation.
  - Observe firm composition (inventors vs. non-inventors).

- **Empirical Strategy & Core Findings:**
  - Using granular panel regressions, a mover design, and a shift-share IV strategy based on university graduate pipeline shocks, we find that:
  - **Large within Firm Spillover:** A 10% increase in the number of firm inventors raises an individual's citation-weighted patent output by 2.2%.
  - But individual productivity is negatively correlated by a firm's non-inventor headcount, resolving the total-firm-size paradox.
  - **Almost No City-Level Spillover:** City-level agglomeration effects largely disappear once internal firm composition and firms spatial sorting are controlled for.

Literature and our contribution

1. Innovation, firm size and competition:
   - Negative impact of firm size: Acs and Audretsch (1988), Akcigit and Kerr (2018a), Akcigit and Goldschlag (2025)
     - Mechanism: competition: Aghion et al. (2005), insufficient exit: Acemoglu et al. (2018), agency problem: Edmans et al. (2017)

   ▶ Refine the findings by distinguishing firm's inventor stock from employee stock.

2. Innovation/learning spillovers
   - City-level spillover: Jovanovic and Rob (1989), Saxenian (1996), Glaeser (1999), Jaffe et al. (1993), Moretti (2021)
   - Firm-level spillover: Henderson and Cockburn (1996), Giroud et al. (2024), Jarosch et al. (2021), Kim et al. (2026), Akcigit et al. (2025)
   - Networks, co-authors and ethnic ties: Singh (2005), Kerr (2008), Azoulay et al. (2010), Jaravel et al. (2018), Almeida and Kogut (1999), Atkin et al. (2022)

   ▶ Revisit city-level spillovers controlling for firm-level spillovers.

Roadmap

1. Data
2. Innovation spillovers within firms
3. Innovation spillovers within firms and within cities

Data sources and matching procedure

Patents

- Assignee (Name, PERMNO, Location)
- Inventor (Name, Location)
- Application year

Employment Histories

- Employer (Name, CUSIP, Location)
- Worker (Name, Location)
- Start and end dates

1. **Firm match**
2. **Name match**
3. **Time match**

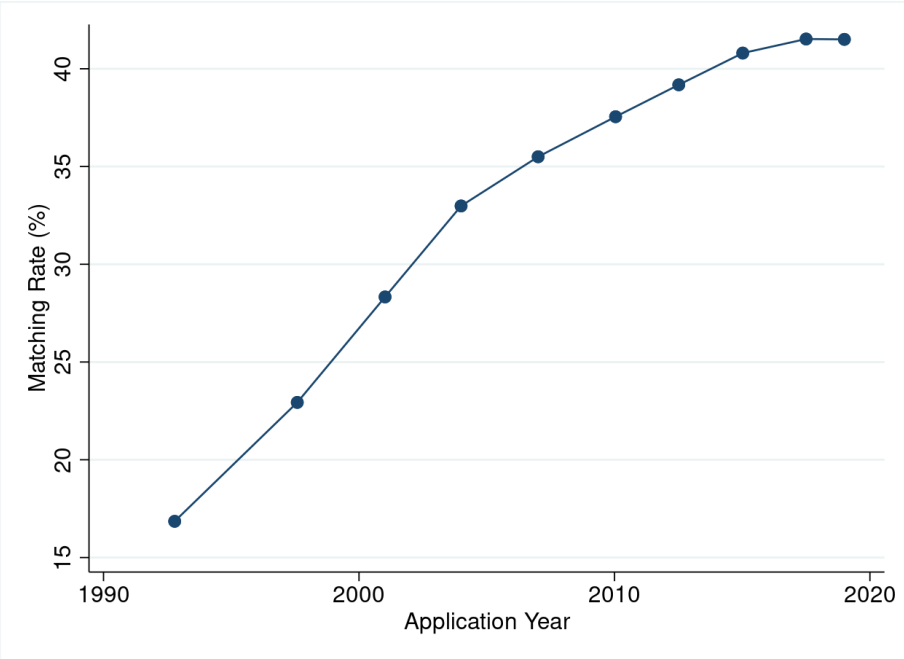
⇓

- Identify the exact **move** years of inventors
- Measure the **extensive margin** of inventor productivity

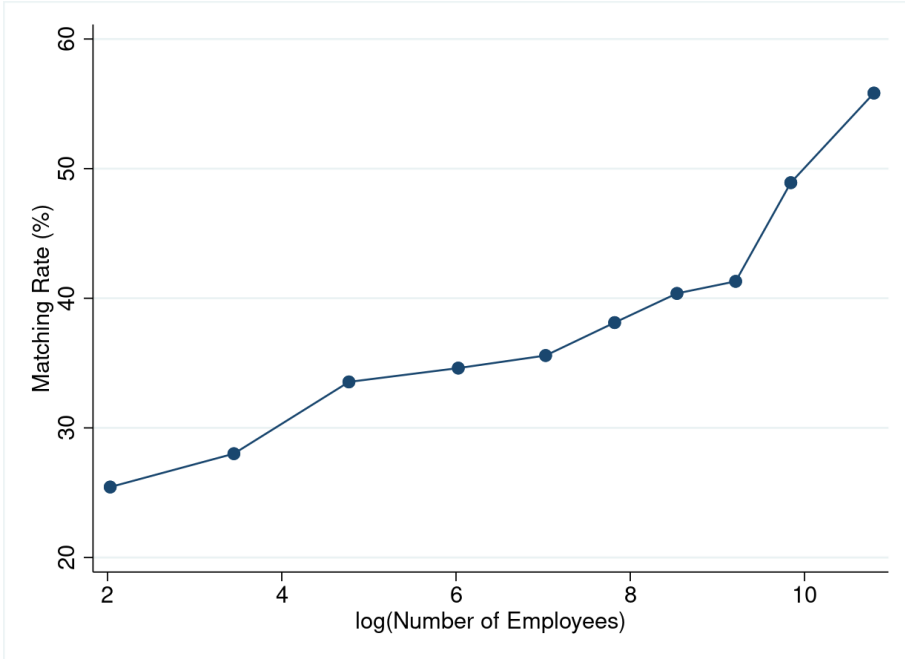
Matching quality

- Fraction of disambiguated inventors matched to employment histories: 33.03%

By application year



By firm size



By inventor's patents | Conditional matching rate

Roadmap

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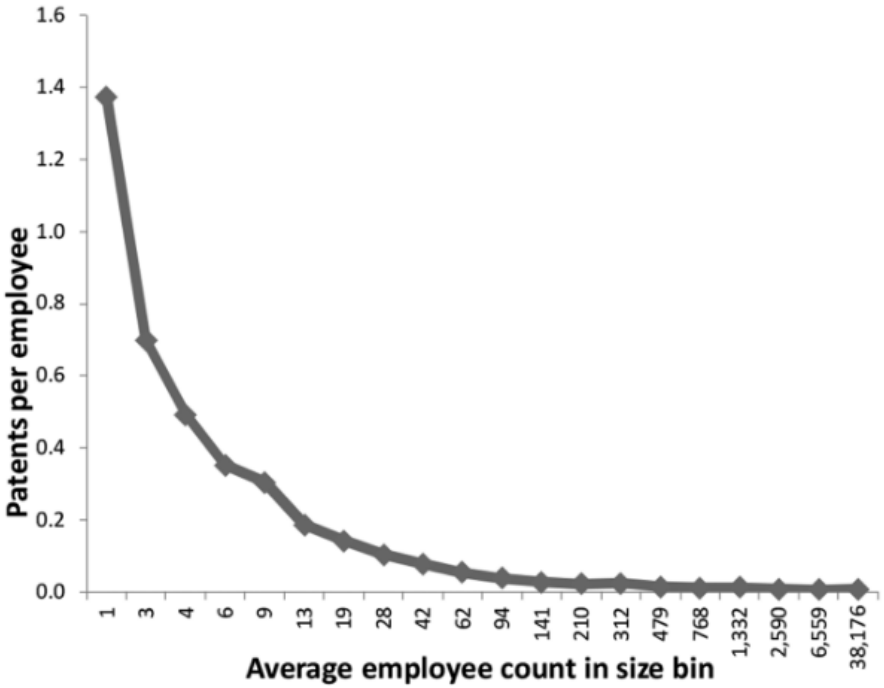
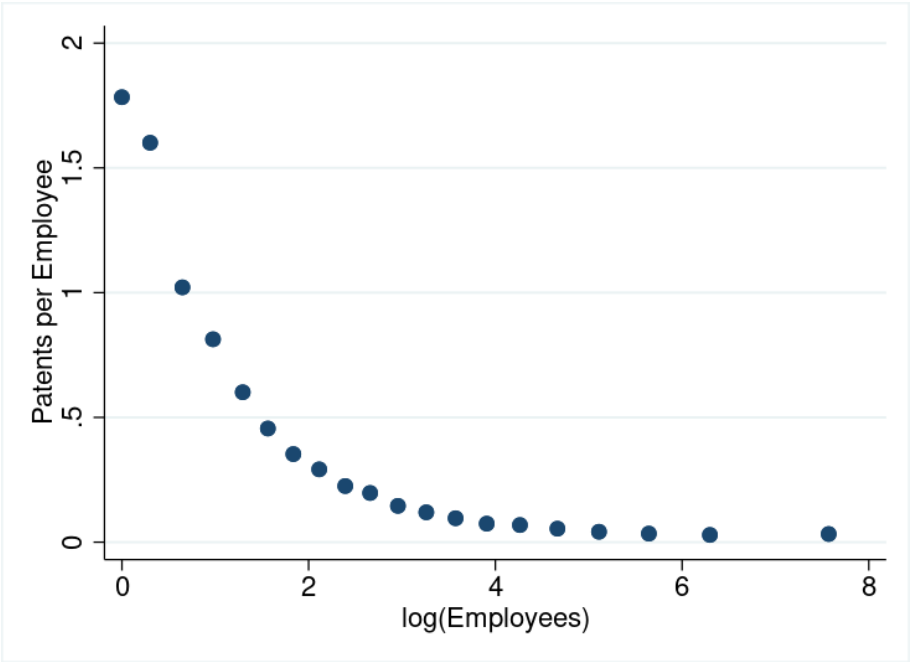
Innovation and total firm employment

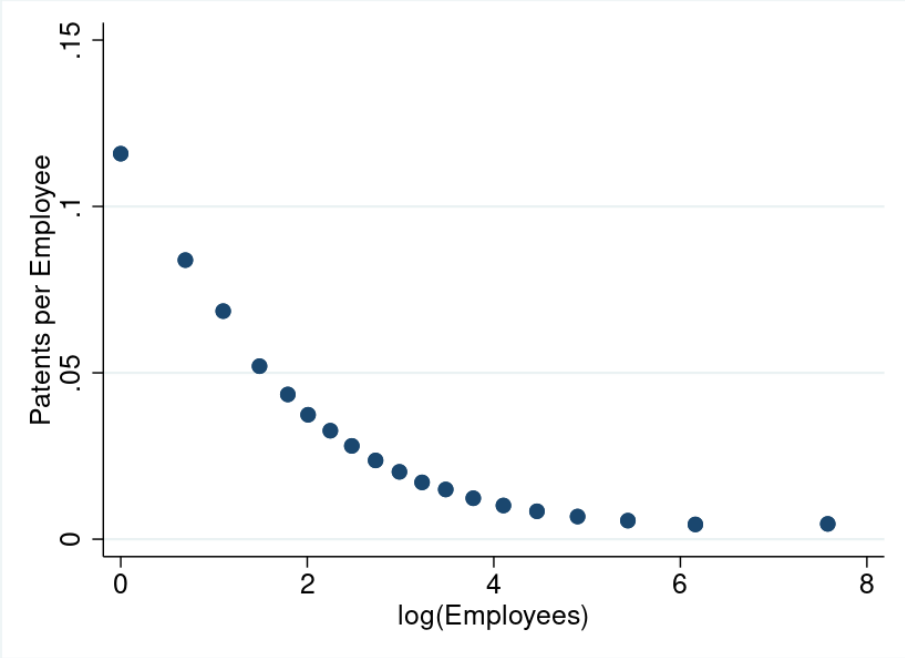


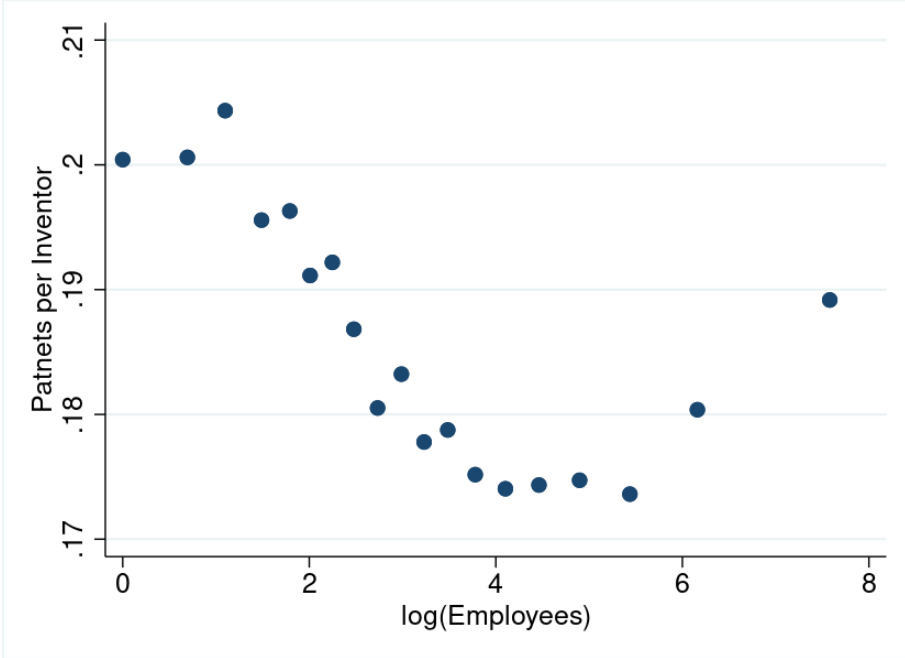


Source: Akcigit and Kerr (2018b)

Note: Patents are aggregated at firm-period level, where period is one of the five-year windows between 1982 and 1996.

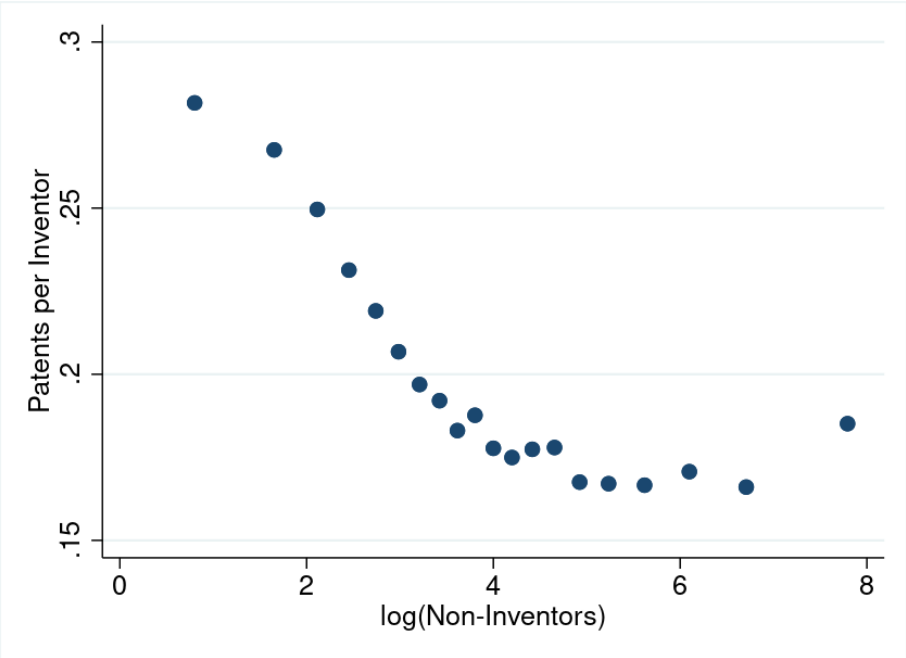
Innovation and total firm employment

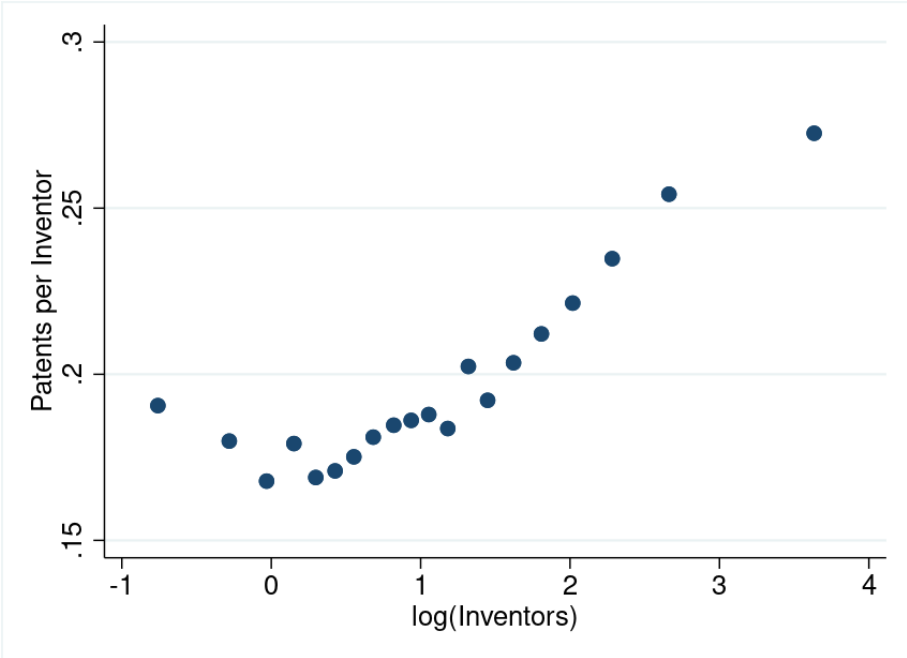




Note: Patents are aggregated at firm-year level. Sample spans from 1982 to 2019.

Innovation and total number of inventors





Notes: Number of inventors and non-inventors are controlled in both plots

No controls | PatentsView inventor counts | Corr. inventors and non-inventors

Innovation spillovers within firms

Dependent variable: Adjusted citations

	(1)	(2)	(3)	(4)
Ln(Firm_Inv)	0.044***	0.058***	0.056***	0.076***
	(0.005)	(0.004)	(0.004)	(0.010)
Ln(Firm_NonInv)	-0.059***	-0.055***	-0.053***	-0.026***
	(0.006)	(0.004)	(0.004)	(0.010)
City-field FE	Y	Y	Y	Y
Field-year FE	Y	Y	Y	Y
Inventor FE		Y	Y	Y
City-field-year FE			Y	Y
Firm FE				Y
N	5625610	5609706	5606616	5605582
Adj. R^2	0.055	0.271	0.272	0.278
Mean of y Variable	0.349			

Patent counts | log(Adjusted citations) | Matched patents | Two-step AKM | Active inventors | Active inventor-firm pairs | Alternative inventor def.

Innovation spillovers within firm and within field

Dependent variable: Adjusted citations

	(1)	(2)	(3)	(4)
Ln(Firm_FieldInv)	0.047***	0.061***	0.060***	0.060***
	(0.006)	(0.004)	(0.004)	(0.004)
Ln(Firm_OtherInv)	-0.005	-0.009**	-0.010***	-0.001
	(0.006)	(0.003)	(0.004)	(0.006)
Ln(Firm_NonInv)	-0.054***	-0.048***	-0.046***	-0.011
	(0.006)	(0.004)	(0.004)	(0.010)
City-field FE	Y	Y	Y	Y
Field-year FE	Y	Y	Y	Y
Inventor FE		Y	Y	Y
City-field-year FE			Y	Y
Firm FE				Y
N	5625610	5609706	5606616	5605582
Adj. R^2	0.056	0.272	0.272	0.278
Mean of y Variable	0.346			

Public Firms

Dependent variable: Adjusted citations

	(1)	(2)	(3)	(4)
Ln(Firm_FieldInv)	0.0553***	0.0554***	0.0554***	0.0574***
	(0.0066)	(0.0067)	(0.0074)	(0.0067)
Ln(Firm_OtherInv)	0.0067	0.0066	0.0062	0.0103
	(0.0099)	(0.0101)	(0.0120)	(0.0101)
Ln(Firm_NonInv)	-0.0222	-0.0319*	-0.0258	-0.0266
	(0.0178)	(0.0173)	(0.0188)	(0.0179)
Firm age^2		-0.0001***		
		(0.0000)		
Ln(R&D)			0.0036	
			(0.0059)	
Ln(SGA)				0.0011
				(0.0070)
Inventor FE	Y	Y	Y	Y
City-field-year FE	Y	Y	Y	Y
Industry-year FE	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y
N	3193259	3193259	2913347	2996150
Adj. R^2	0.291	0.291	0.297	0.294
Mean of y Variable	0.353	0.353	0.363	0.358

Innovation spillovers within firms: Stayers vs. Movers

Dependent variable: Adjusted citations

	Stayers	Movers
	(1)	(2)
Ln(Firm_FieldInv)	0.056***	0.057***
	(0.005)	(0.005)
Ln(Firm_OtherInv)	0.013	-0.003
	(0.009)	(0.008)
Ln(Firm_NonInv)	-0.038**	-0.031**
	(0.016)	(0.013)
City-field FE	Y	Y
Field-year FE	Y	Y
Inventor FE	Y	Y
City-field-year FE	Y	Y
Firm FE	Y	Y
N	3142849	1800378
Adj. R^2	0.329	0.292
Mean of y Variable	0.351	0.359

Event studies on movers

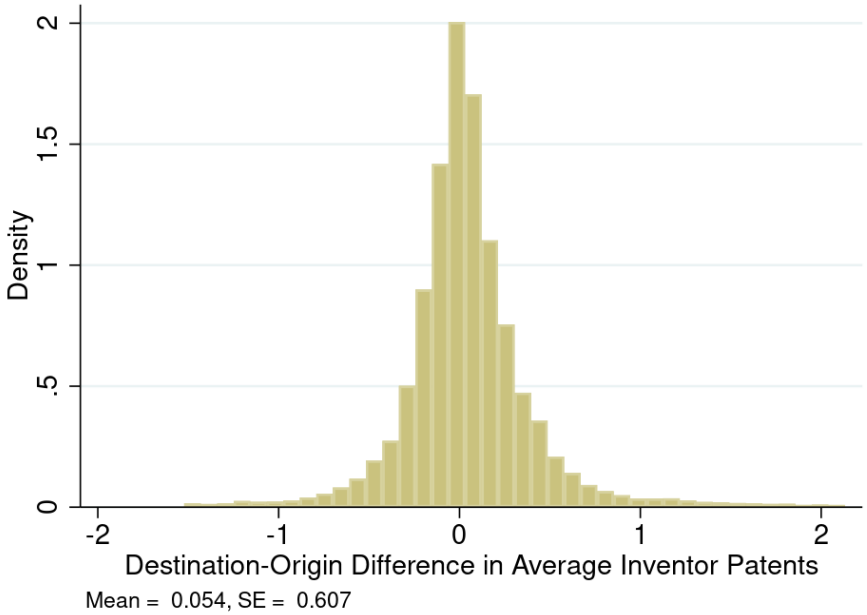
How do moves and inventor productivity relate to each other?

Follow Finkelstein et al. (2016) and conduct a mover analysis: For mover i

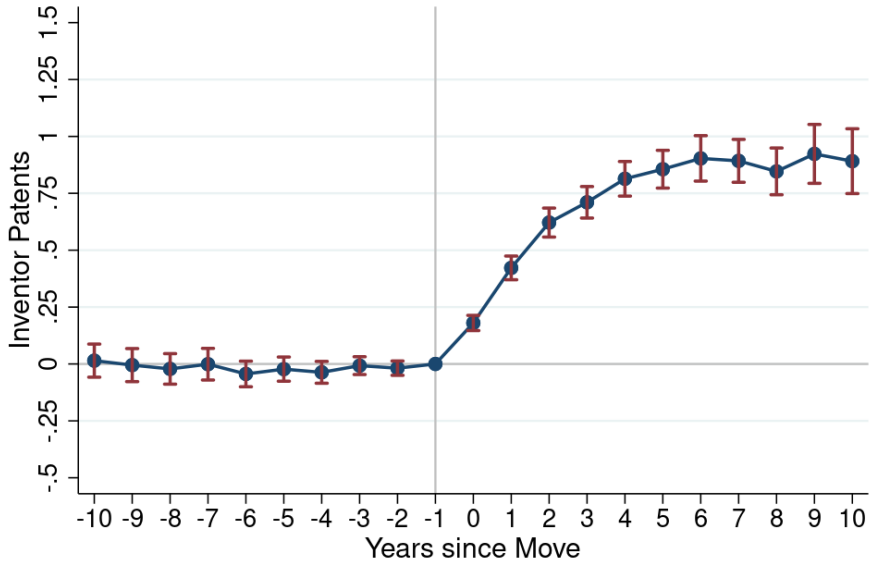
- Define δ_i as the destination-origin difference in average inventor productivity
- Measure changes in patent productivity of i over time, relative to δ_i

Event studies on movers

Distribution of δ_i



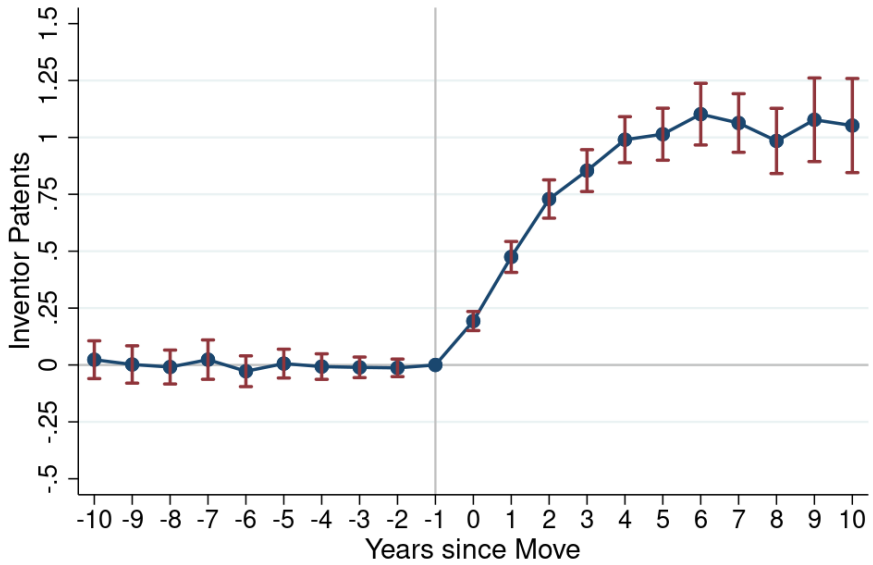
Event study



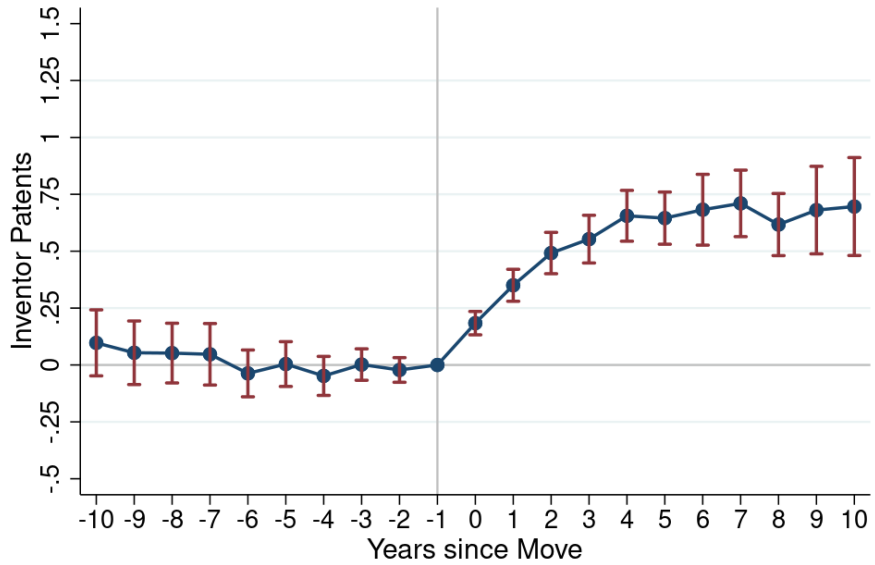
Raw means | Technology patents | Disruptive technology patents | Size event study

Event studies on movers

Up moves



Down moves



Raw means | Technology patents | Disruptive technology patents | Size event study

Shift-share instruments

$$\widehat{Firm\_Inv}_{f,t} = \sum_{p \in \mathcal{P}} w_{p \to f}^{2001-2005} \times \frac{Grad\_Inv_{p,t}}{Grad\_Emp_{p,t}}$$

- Share $w_{p \to f}^{2001-2005}$
  - Share of inventors graduating from program p and worked in firm f from 2001 to 2005
- Shift $Grad\_Inv_{p,t}/Grad\_Emp_{p,t}$
  - $Grad\_Inv_{p,t}$: Graduating inventors from program p in year t
  - $Grad\_Emp_{p,t}$: Graduates from program p in year t
  - Exclude graduates working in the same industry as the focal firm f
- Instrument:

$$\ln(Firm\_Inv_{f,t}) \overset{IV}{\leftarrow} \ln(1 + \widehat{Firm\_Inv}_{f,t})$$

Detailed definition

Innovation spillovers within firms: IV results

	OLS	IV	First Stage	Reduced Form
	(1)	(2)	(3)	(4)
	Adjusted citations	*Adjusted citations*	*Ln(Firm_Inv)*	*Adjusted citations*
Ln(Firm_Inv)	0.052***	0.213***		
	(0.010)	(0.054)		
$Ln(\widehat{Firm\_Inv})$			0.368***	0.078***
			(0.043)	(0.020)
City-field-year FE	Y	Y	Y	Y
Inventor FE	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y
N	3248152	3248152	3248152	3248152
Adj. R^2	0.327	0.326	0.989	0.327
First-stage F		74.615		
Mean of y Variable	0.395			

Alternative instrument | Alternative clustering | Field inventors

Roadmap

1. Data
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3. Innovation spillovers within firms and within cities

Innovation spillovers within cities a la Moretti (2021)

Dependent variable: Adjusted citations

	(1)	(2)	(3)
Ln(City_FieldInv)	0.086**	0.113***	0.084***
	(0.036)	(0.025)	(0.026)
Ln(City_OtherInv)	0.017	-0.025	-0.057*
	(0.042)	(0.030)	(0.030)
City-field FE	Y	Y	Y
Field-year FE	Y	Y	Y
Inventor FE		Y	Y
Firm FE			Y
N	5624654	5608747	5607711
Adj. R^2	0.055	0.271	0.277
Mean of y Variable	0.349		

Note: The number of inventors in the same city *includes* those in the same firm

Moretti (2021) replication | Moretti (2021) sample

Innovation spillovers within firms and within cities

Dependent variable: Adjusted citations

	(1)	(2)	(3)
Ln(Firm_Inv)	0.047***	0.058***	0.082***
	(0.005)	(0.004)	(0.011)
Ln(Firm_NonInv)	-0.060***	-0.055***	-0.036***
	(0.006)	(0.004)	(0.011)
Ln(City_Inv)	0.115***	0.046**	-0.024
	(0.033)	(0.022)	(0.022)
City-field FE	Y	Y	Y
Field-year FE	Y	Y	Y
Inventor FE		Y	Y
Firm FE			Y
N	5624014	5608106	5607070
Adj. R^2	0.056	0.271	0.278
Mean of y Variable	0.349		

Note: The number of inventors in the same city *excludes* those in the same firm

Field inventors | Active inventor-firm pairs | Moretti (2021) sample | Within-city moves

Innovation spillovers within firms and within cities

Dependent variable: Adjusted citations

	(1)	(2)	(3)
Ln(Firm_Inv)	0.047***	0.058***	0.082***
	(0.005)	(0.004)	(0.011)
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	(0.033)	(0.022)	(0.022)
City-field FE	Y	Y	Y
Field-year FE	Y	Y	Y
Inventor FE		Y	Y
Firm FE			Y
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	(0.033)	(0.022)	(0.022)
City-field FE	Y	Y	Y
Field-year FE	Y	Y	Y
Inventor FE		Y	Y
Firm FE			Y
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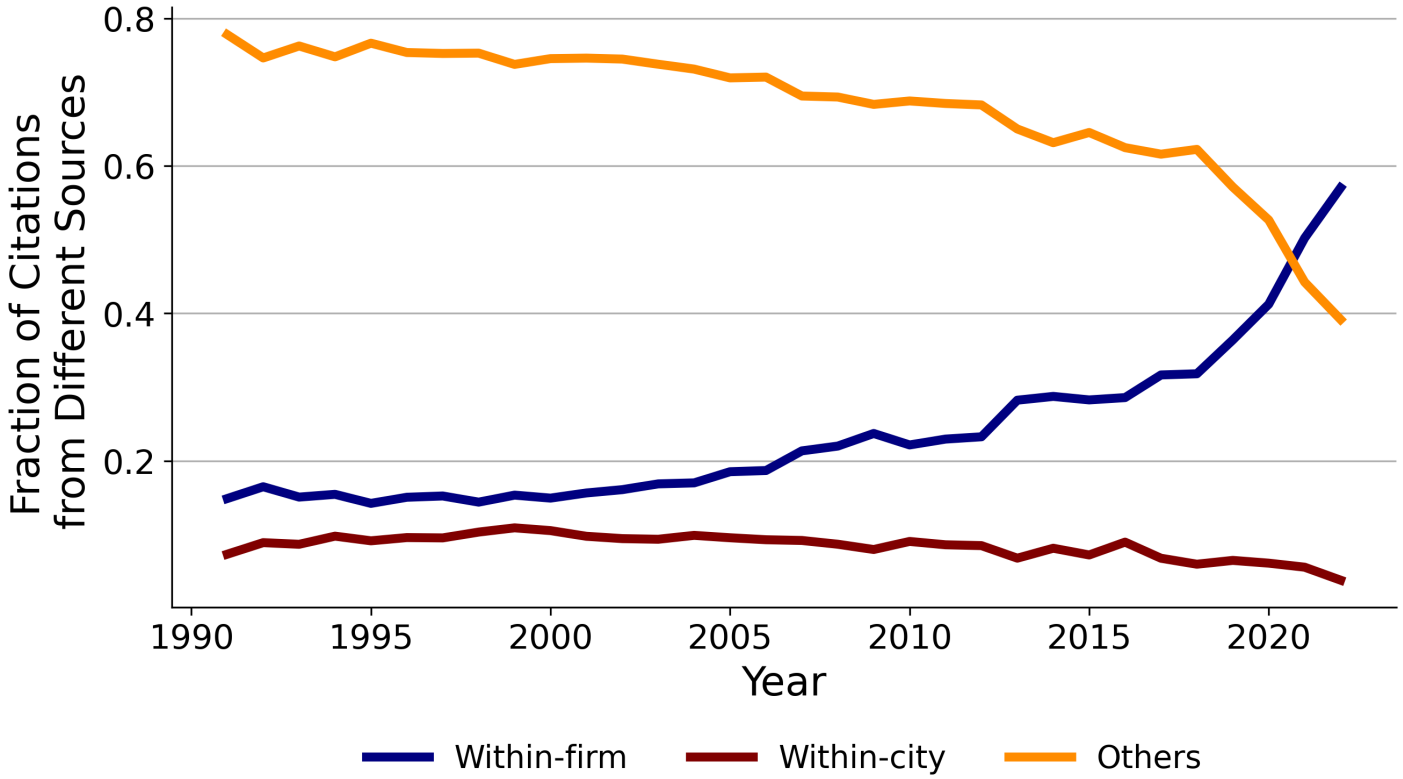
Field inventors | Active inventor-firm pairs | Moretti (2021) sample | Within-city moves

Forward Citations Decomposition



Inventor concentration

Inventor spin-offs

	$Founder_{t+1}$	$Founder_{[t+1,t+3]}$	$Founder_{[t+1,t+5]}$
	(1)	(2)	(3)
Ln(Firm_Inv)	0.00030***	0.00048***	0.00076***
	(0.00007)	(0.00015)	(0.00023)
Ln(Firm_NonInv)	-0.00078***	-0.00091***	-0.00190***
	(0.00009)	(0.00017)	(0.00023)
Year FE	Y	Y	Y
Firm FE	Y	Y	Y
N	6368828	6368828	6368828
Adj. R^2	0.061	0.127	0.156
Mean of y Variable	0.0011	0.0033	0.0052

Spin-off performance

Conclusion

- Innovation spillovers operate primarily **within firms** rather than within cities.
- Productivity is positively correlated with a firm's inventor stock, despite a negative correlation with overall employee scale.
- Apparent city-level agglomeration effects are largely explained by the selective sorting of high-productivity firms and inventors.
  - Cities can still have many other benefits like higher pool of skilled workers, thick market effect, lower monopsony power.

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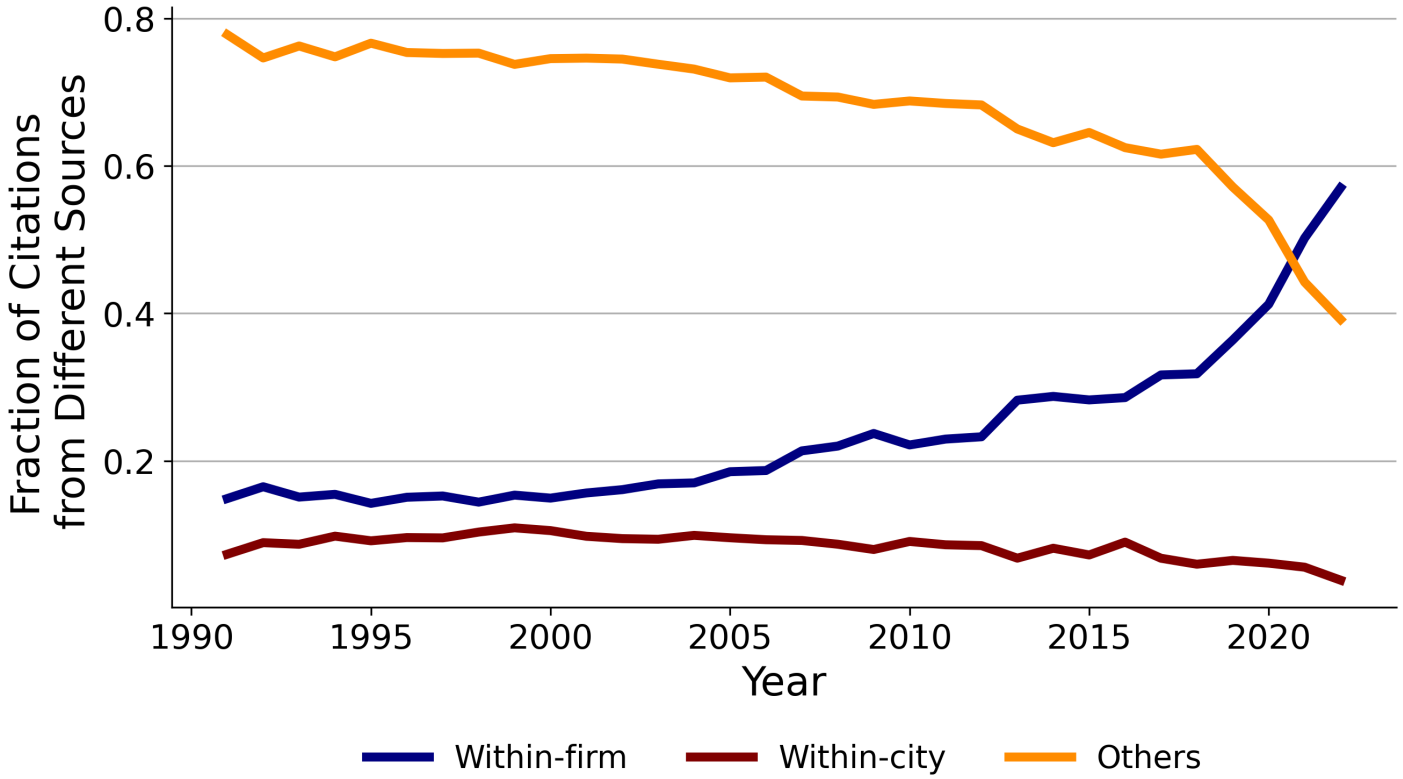
Innovation spillovers interacting citation sources



Inventor concentration

Innovation spillovers interacting citation sources

Dependent variable: Per-patent citations from different sources

	Total	Within-Firm	Within-City	Others
	(1)	(2)	(3)	(4)
Ln(Firm_Inv)	1.277***	0.274***	0.140***	0.827***
	(0.182)	(0.038)	(0.032)	(0.133)
Ln(Firm_NonInv)	2.261***	0.280***	0.285***	1.651***
	(0.329)	(0.052)	(0.074)	(0.215)
City-field-year FE	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y
N	358500	358500	358500	358500
Adj. R^2	0.224	0.275	0.176	0.196
Mean of y Variable	7.403	1.024	0.739	5.490

Inventor spin-offs

	$Founder_{t+1}$	$Founder_{[t+1,t+3]}$	$Founder_{[t+1,t+5]}$
	(1)	(2)	(3)
Ln(Firm_Inv)	0.00030***	0.00048***	0.00076***
	(0.00007)	(0.00015)	(0.00023)
Ln(Firm_NonInv)	-0.00078***	-0.00091***	-0.00190***
	(0.00009)	(0.00017)	(0.00023)
Year FE	Y	Y	Y
Firm FE	Y	Y	Y
N	6368828	6368828	6368828
Adj. R^2	0.061	0.127	0.156
Mean of y Variable	0.0011	0.0033	0.0052

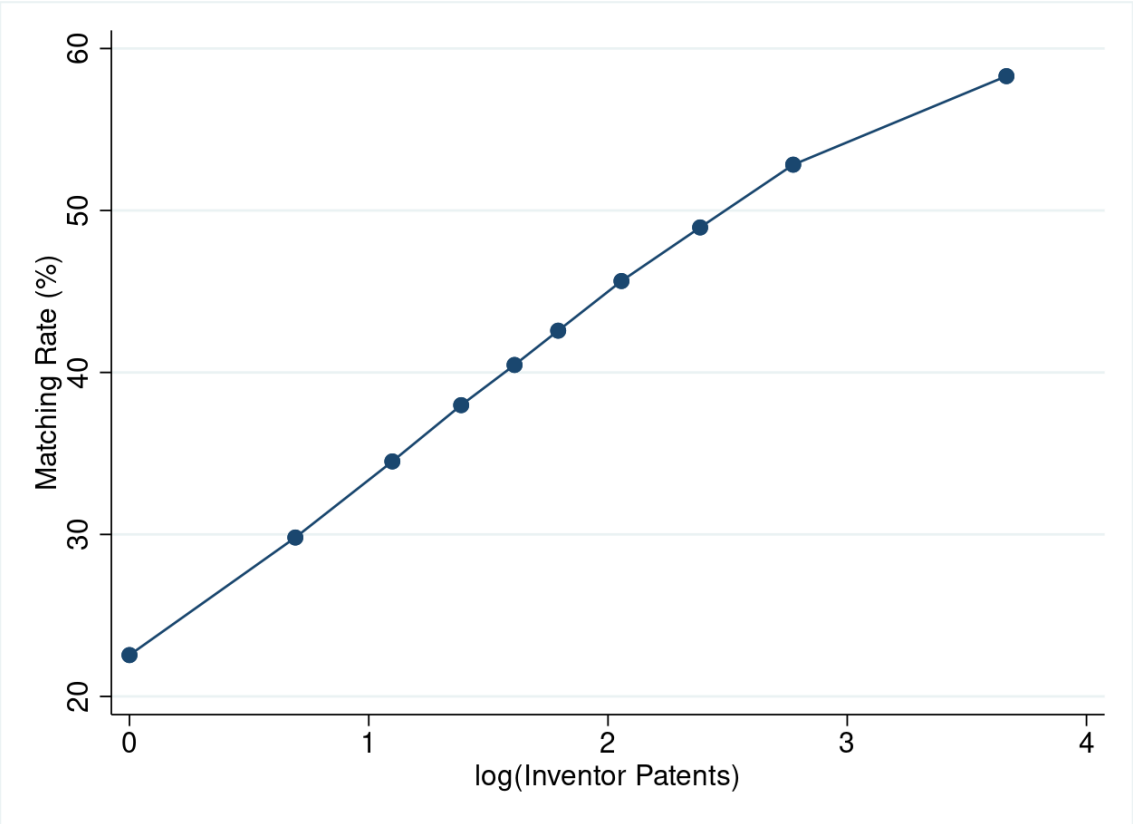
Spin-off performance

Heterogeneity

	All	Large firms	Star inventors
	(1)	(2)	(3)
Ln(Firm_Inv)	0.076***	0.107***	0.157***
	(0.010)	(0.017)	(0.029)
Ln(Firm_NonInv)	-0.026***	-0.059***	-0.060**
	(0.010)	(0.019)	(0.029)
Inventor FE	Y	Y	Y
City-field-year FE	Y	Y	Y
Firm FE	Y	Y	Y
N	5605582	4589274	1594656
Adj. R^2	0.278	0.280	0.285
Mean of y Variable	0.349	0.349	0.952

Matching quality

- By inventor's patents:



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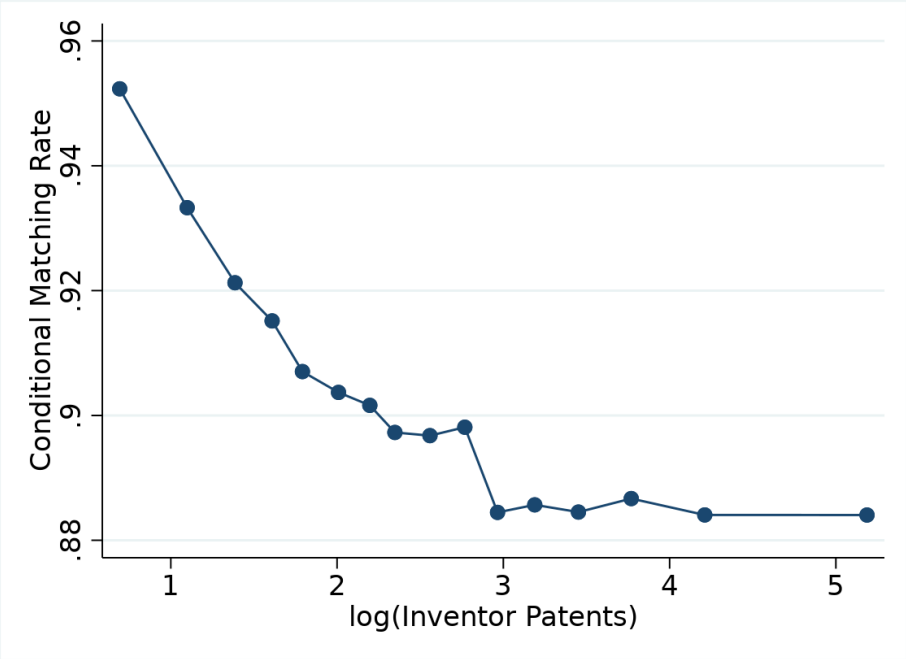
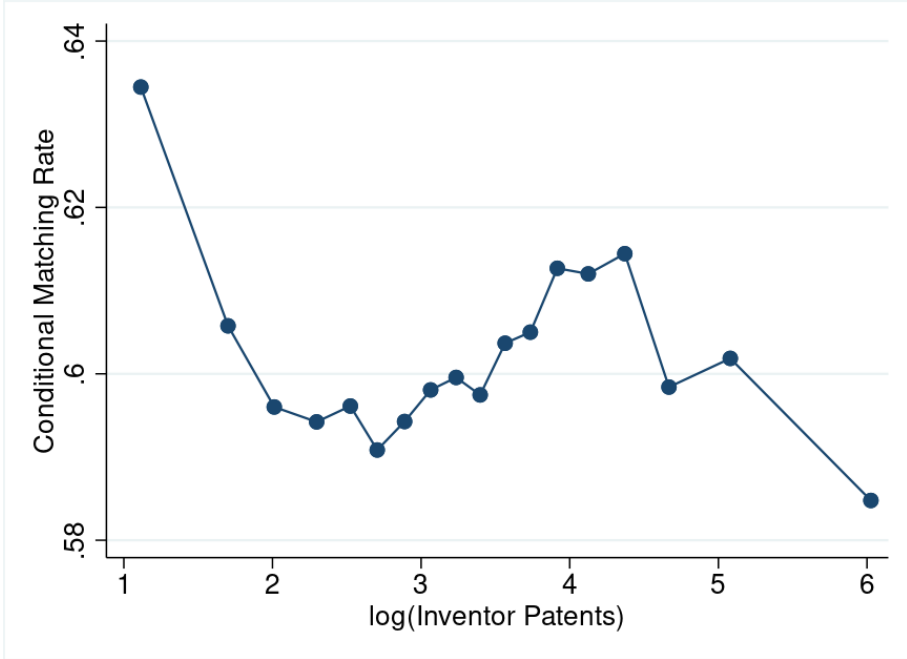
Matching quality

Conditional matching rate

$\geq$2 Patents
1 Assignee



$\geq$ 2 Patents
$\geq$ 2 Assignees



Notes:
X-axis measures the number of patents of a disambiguated inventor
Y-axis measures the fraction of patents matched to employment histories data

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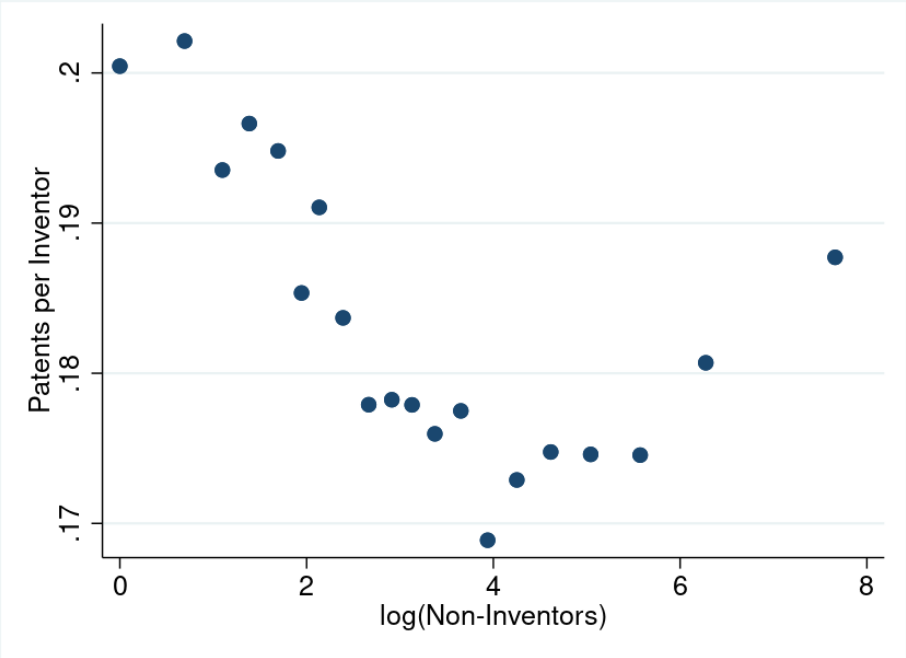
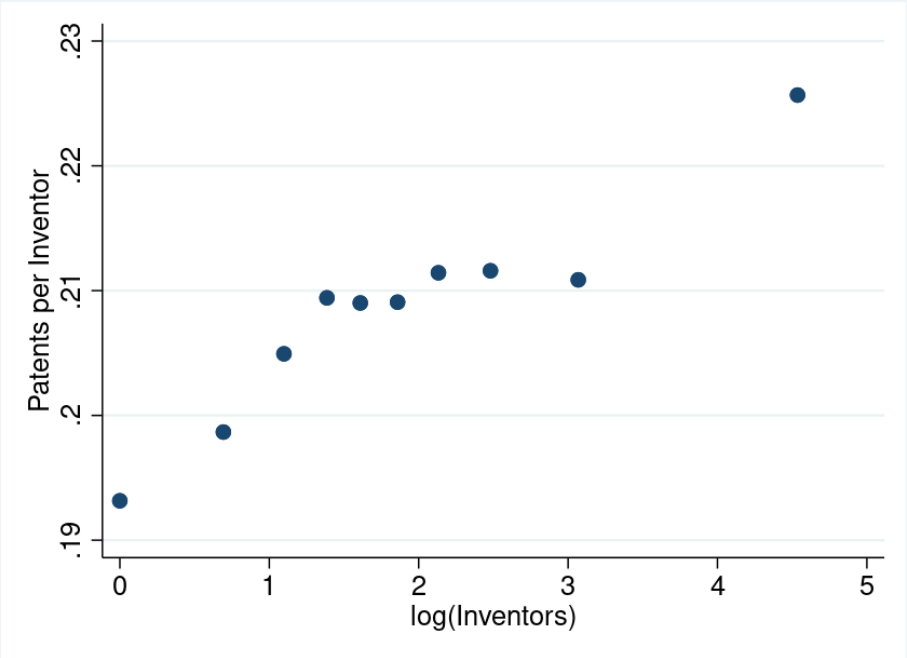
Innovation and total number of inventors

Not controlling for the other





Notes: Number of inventors (non-inventors) are not controlled in the right (left) plot

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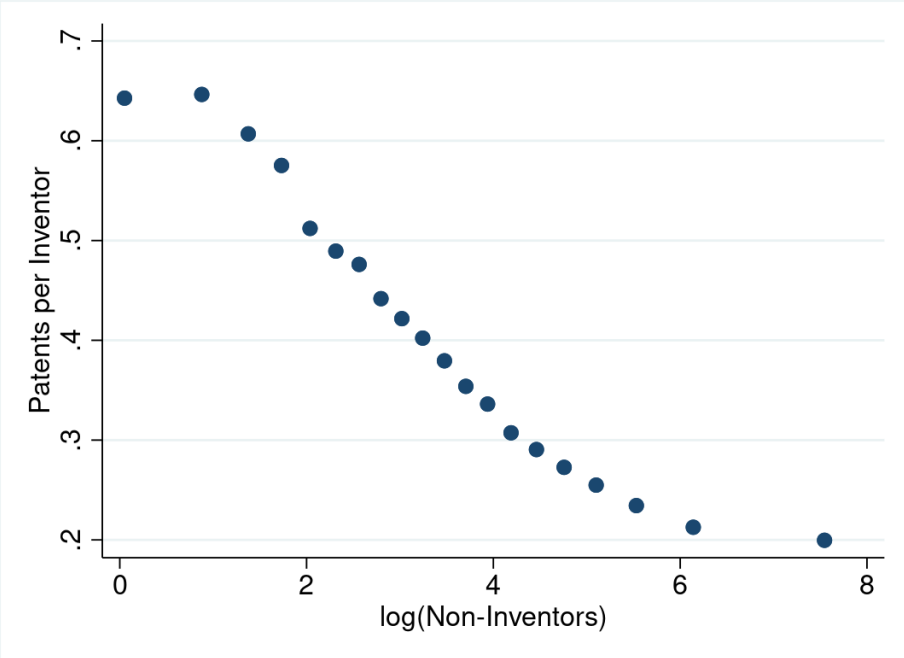
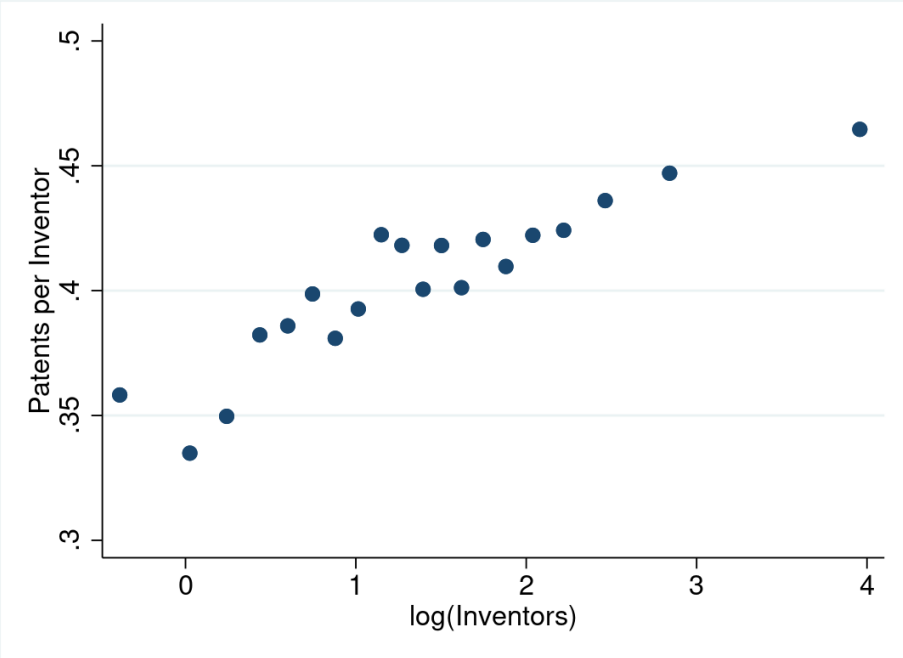
Innovation and total number of inventors

Counting number of inventors from PatentsView data





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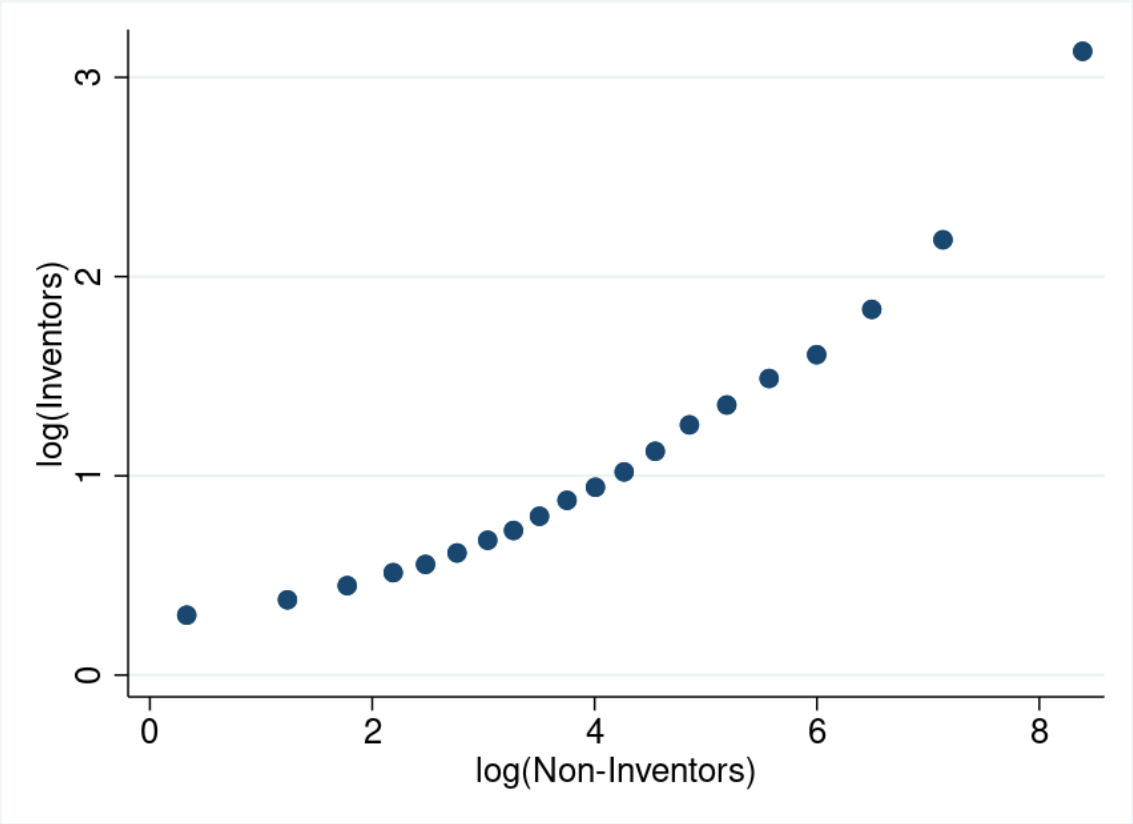
Correlation between numbers of inventors and non-inventors



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Innovation spillovers within firms: Patent counts

Dependent variable: Patent counts

	(1)	(2)	(3)	(4)
Ln(Firm_Inv)	0.024***	0.034***	0.032***	0.052***
	(0.002)	(0.002)	(0.002)	(0.005)
Ln(Firm_NonInv)	-0.021***	-0.025***	-0.024***	-0.016**
	(0.002)	(0.002)	(0.002)	(0.006)
City-field FE	Y	Y	Y	Y
Field-year FE	Y	Y	Y	Y
Inventor FE		Y	Y	Y
City-field-year FE			Y	Y
Firm FE				Y
N	5625610	5609706	5606616	5605582
Adj. R^2	0.165	0.370	0.372	0.375
Mean of y Variable	0.257			

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Innovation spillovers within firms: Log adjusted citations

Dependent variable: log(Adjusted citations)

	(1)	(2)	(3)	(4)
Ln(Firm_Inv)	0.002	0.023***	0.022***	0.048***
	(0.009)	(0.007)	(0.007)	(0.017)
Ln(Firm_NonInv)	-0.049***	-0.043***	-0.039***	-0.098***
	(0.008)	(0.006)	(0.006)	(0.014)
City-field FE	Y	Y	Y	Y
Field-year FE	Y	Y	Y	Y
Inventor FE		Y	Y	Y
City-field-year FE			Y	Y
Firm FE				Y
N	1086526	956967	952357	949957
Adj. R^2	0.098	0.302	0.307	0.313
Mean of y Variable	-0.516			

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Innovation spillovers within firms: Active inventors

Dependent variable: Adjusted citations

	(1)	(2)	(3)	(4)
Ln(Firm_ActiveInv)	0.026**	0.053***	0.050***	0.055***
	(0.011)	(0.004)	(0.004)	(0.005)
Ln(Firm_IdleInv)	0.016	0.002	0.002	0.026***
	(0.011)	(0.005)	(0.005)	(0.007)
Ln(Firm_NonInv)	-0.058***	-0.054***	-0.052***	-0.035***
	(0.006)	(0.004)	(0.004)	(0.010)
City-field FE	Y	Y	Y	Y
Field-year FE	Y	Y	Y	Y
Inventor FE		Y	Y	Y
City-field-year FE			Y	Y
Firm FE				Y
N	5521885	5505231	5502061	5500739
Adj. R^2	0.056	0.273	0.273	0.279
Mean of y Variable	0.349			

Note: *ActiveInv* are inventors who applied for at least one patent in the past five years. *IdleInv* are inventors who didn't applied for any patent in the past five years.

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Innovation spillovers within firms: Active inventor-firm pairs

Dependent variable: Adjusted citations

	(1)	(2)	(3)	(4)
Ln(Firm_Inv)	0.041***	0.064***	0.060***	0.095***
	(0.008)	(0.007)	(0.006)	(0.015)
Ln(Firm_NonInv)	-0.070***	-0.060***	-0.057***	-0.015
	(0.008)	(0.007)	(0.007)	(0.015)
City-field FE	Y	Y	Y	Y
Field-year FE	Y	Y	Y	Y
Inventor FE		Y	Y	Y
City-field-year FE			Y	Y
Firm FE				Y
N	4263453	4236274	4232977	4231443
Adj. R^2	0.055	0.276	0.277	0.284
Mean of y Variable	0.349			

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Innovation spillovers within firms: Matched patents

Dependent variable: Adjusted citations

	(1)	(2)	(3)	(4)
Ln(Firm_Inv)	0.049***	0.078***	0.075***	0.104***
	(0.004)	(0.004)	(0.004)	(0.010)
Ln(Firm_NonInv)	-0.066***	-0.073***	-0.071***	-0.040***
	(0.005)	(0.004)	(0.004)	(0.010)
City-field FE	Y	Y	Y	Y
Field-year FE	Y	Y	Y	Y
Inventor FE		Y	Y	Y
City-field-year FE			Y	Y
Firm FE				Y
N	5437035	5423301	5420245	5419275
Adj. R^2	0.046	0.234	0.234	0.243
Mean of y Variable	0.227			

Note: Only patents matched to employment histories are counted in the dependent variable.

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Innovation spillovers within firms: Ex-ante inventor definition

Dependent variable: Adjusted citations

	Actual Inventors	*Predicted Inventors*	*Predicted Inventors*
	(1)	(2)	(3)
Ln(Firm_Inv)	0.077***	0.032**	0.040***
	(0.011)	(0.014)	(0.014)
Ln(Firm_NonInv)	-0.017	0.017	0.009
	(0.012)	(0.012)	(0.011)
Inventor FE	Y	Y	Y
City-field-year FE	Y	Y	Y
Firm FE	Y	Y	Y
Inputs for Prediction:			
Education		Y	Y
Job Seniority		Y	Y
Job Title and Description			Y
N	4838116	4838116	4838116
Adj. R^2	0.291	0.291	0.291
Mean of y Variable	0.374		

Note: We perform logistic regressions with different inputs to predict the inventors.

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Innovations spillovers within firms: Two-step AKM

$$y_{it} = \alpha_i + \eta_{ft} + \lambda_{ckt} + X_{it}\beta + \varepsilon_{it} \quad (1)$$

$$\eta_{ft} = Size_{ft}\delta + \mu_f + \xi_t + u_{ft} \quad (2)$$

	(1)	(2)	(3)
Ln(Firm_Inv)	0.037***	0.037***	0.043***
	(0.003)	(0.003)	(0.005)
Ln(Firm_NonInv)	-0.026***	-0.026***	0.008
	(0.003)	(0.003)	(0.006)
Year FE		Y	Y
Firm FE			Y
N	347529	347529	345059
Adj. R^2	0.001	0.002	0.328

Note: Individual, firm-year, and city-field-year FEs are included in equation (1).

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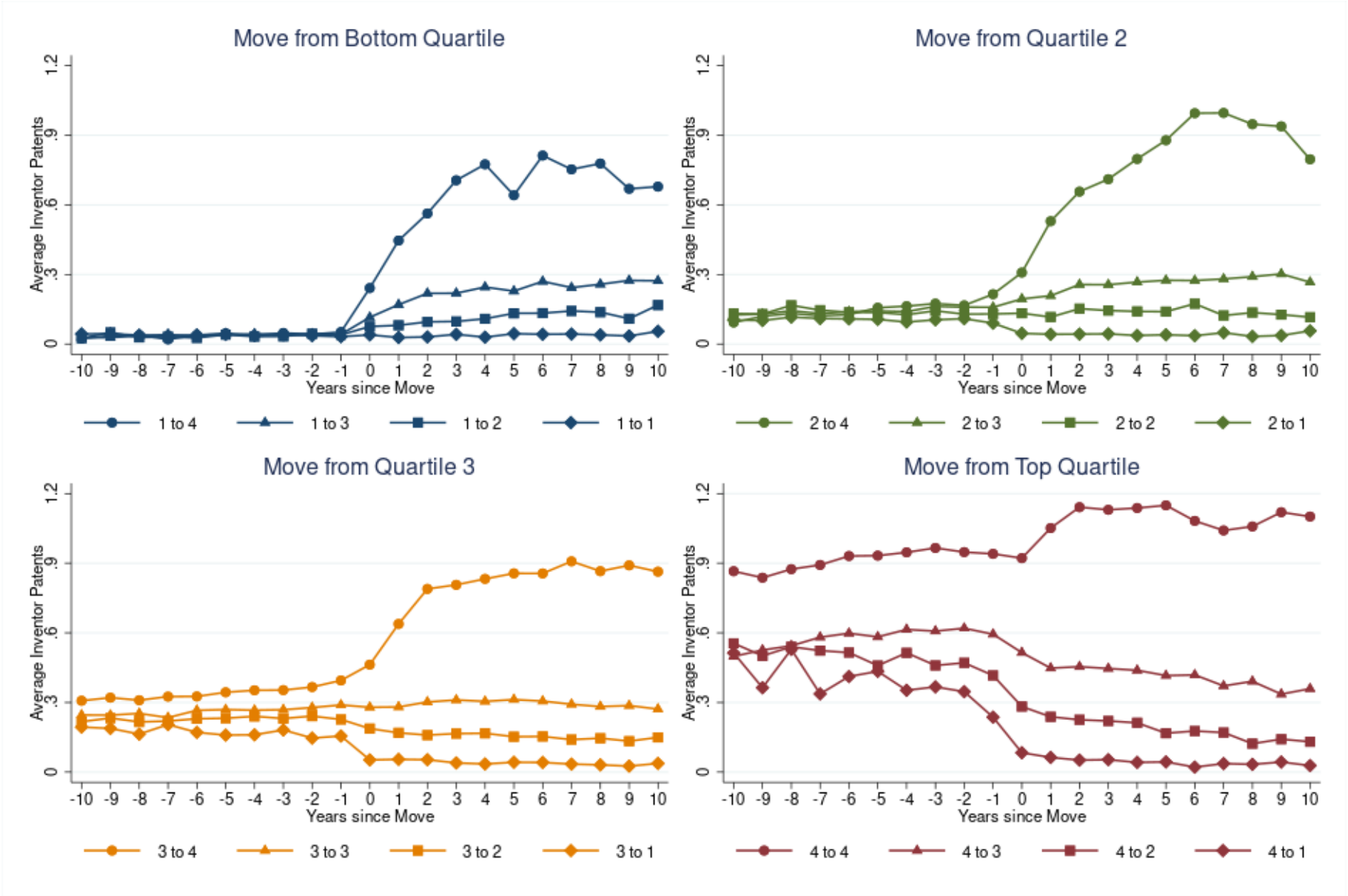
Event studies on movers



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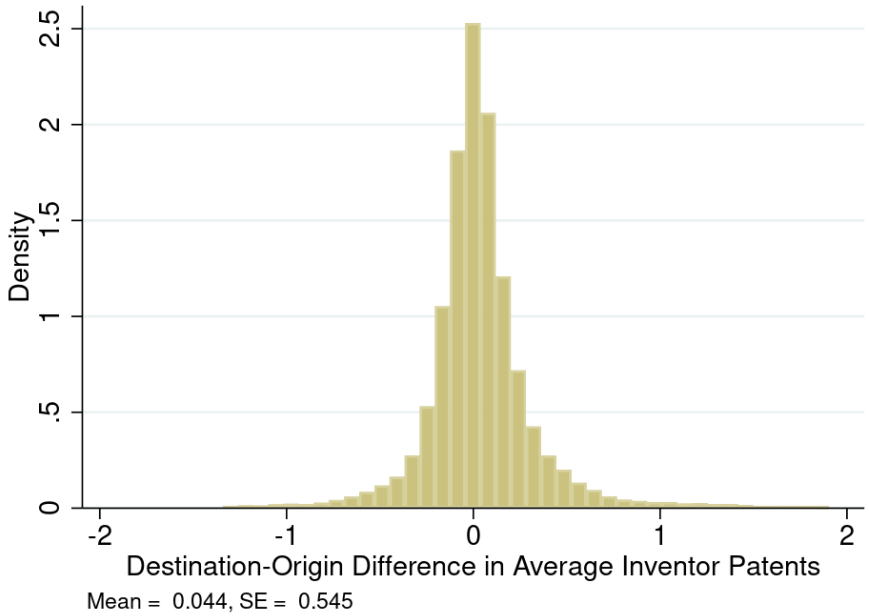
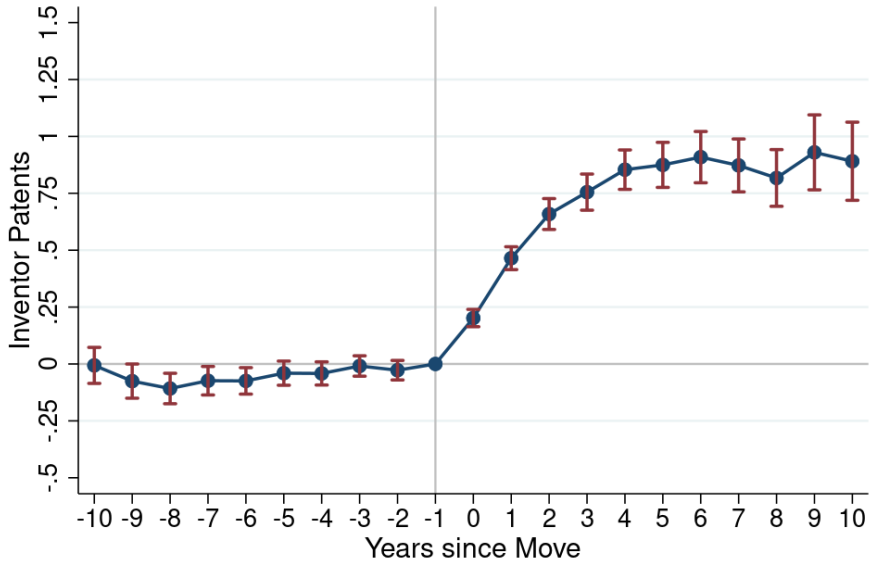
Event studies: Technology patents

Distribution of δ_i



Event study



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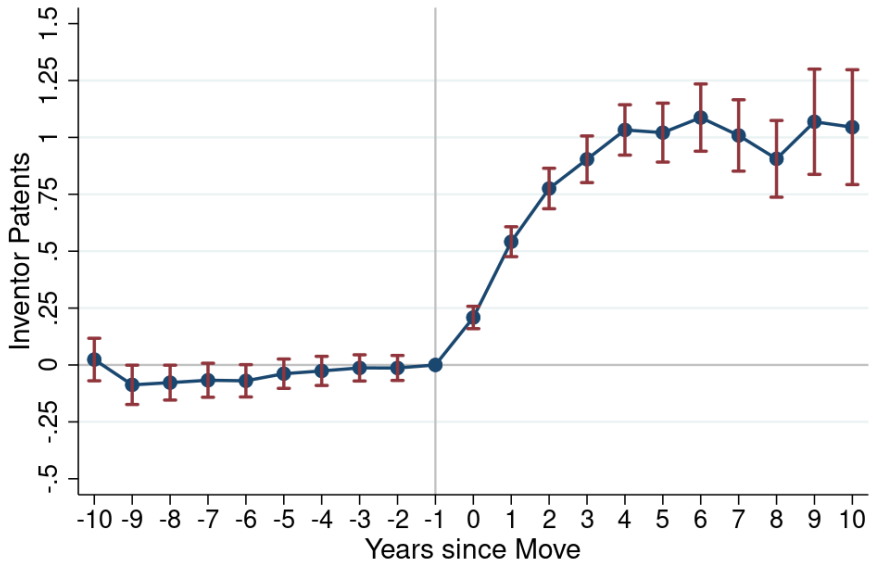
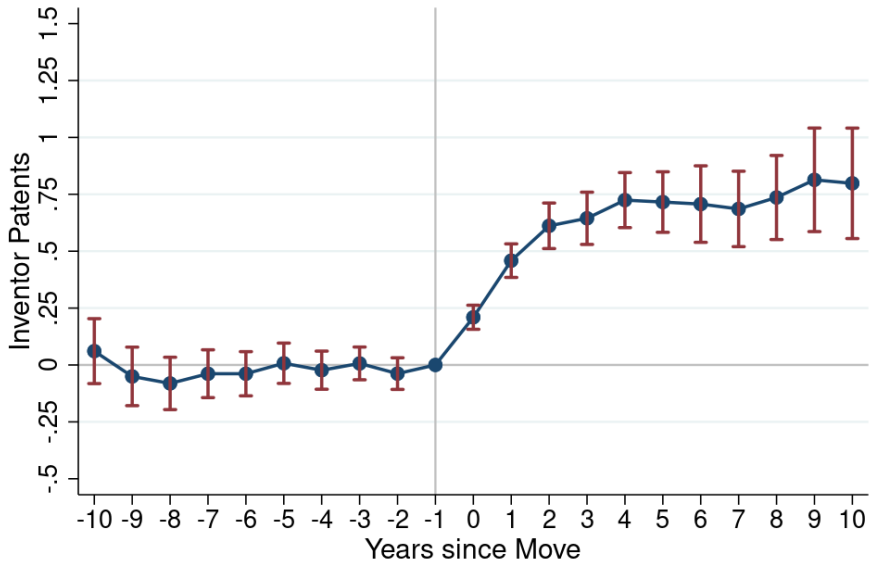
Event studies: Technology patents

Up moves



Down moves



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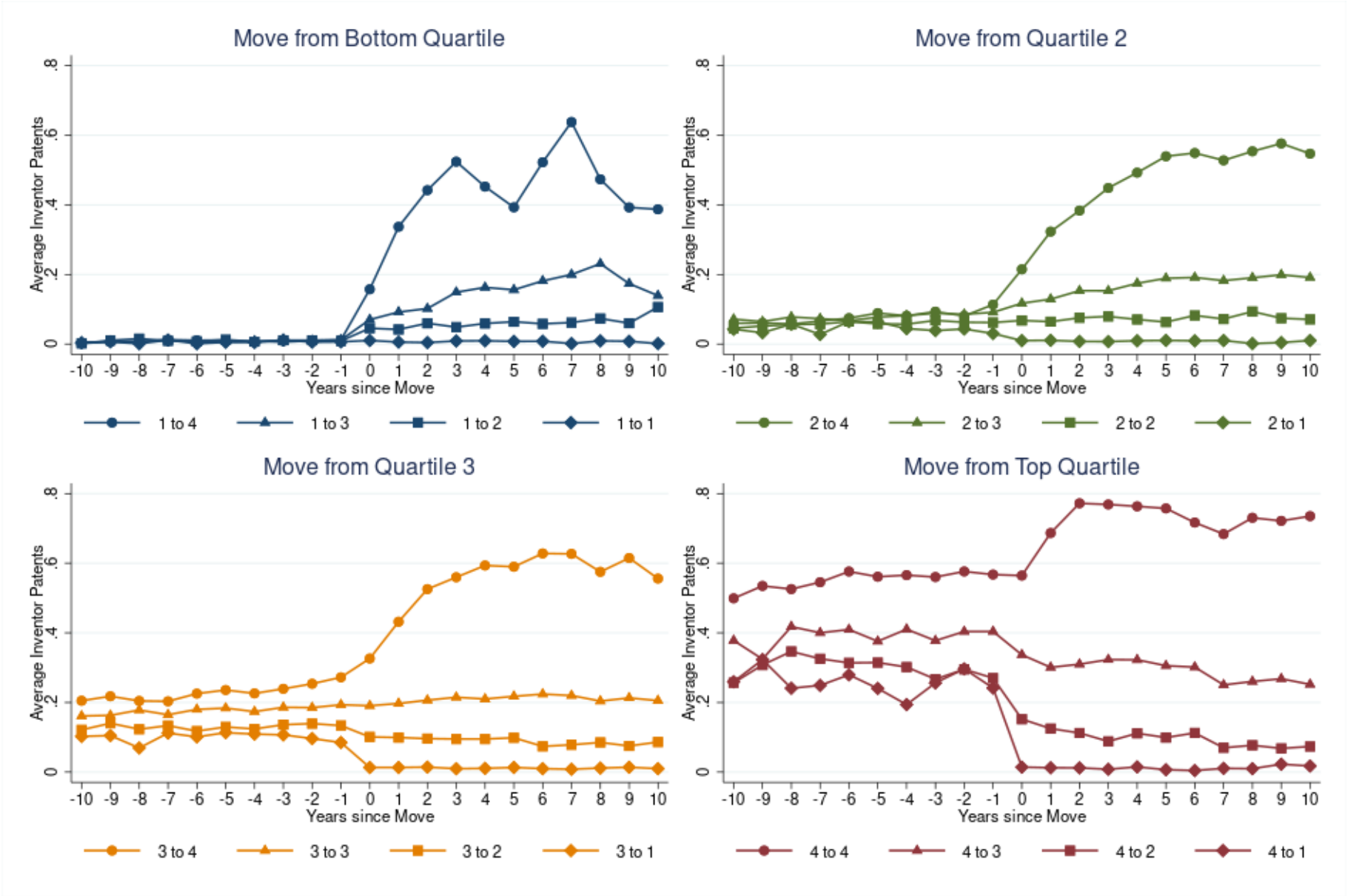
Event studies: Technology patents



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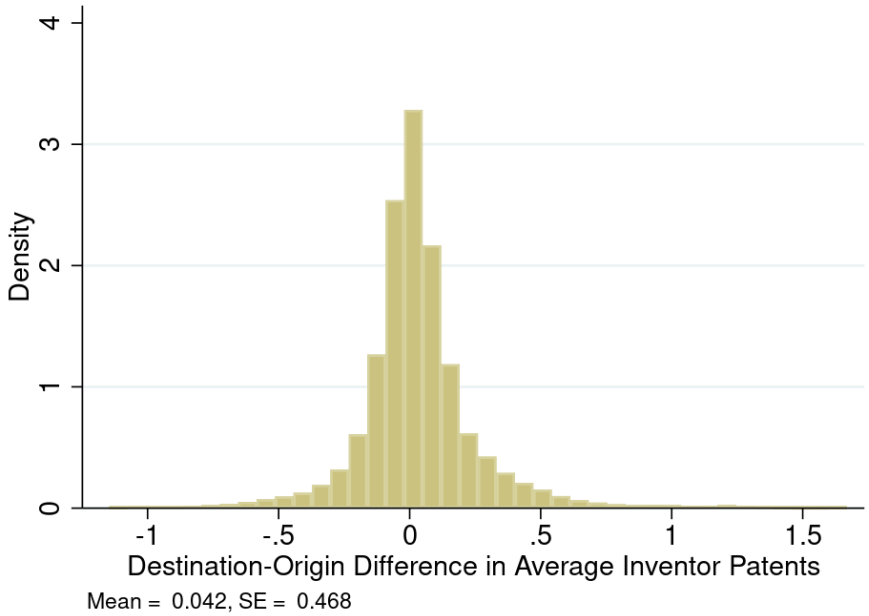
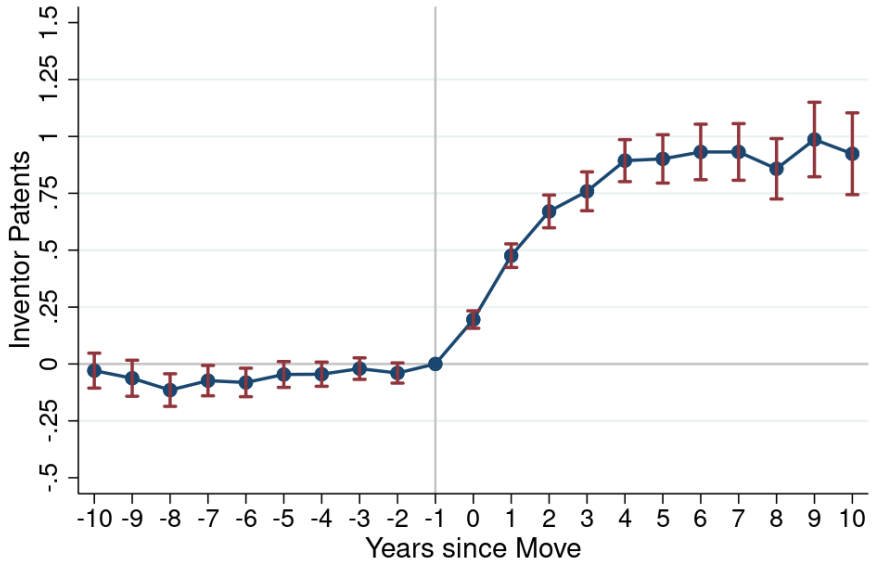
Event studies: Disruptive technology patents

Distribution of δ_i



Event study



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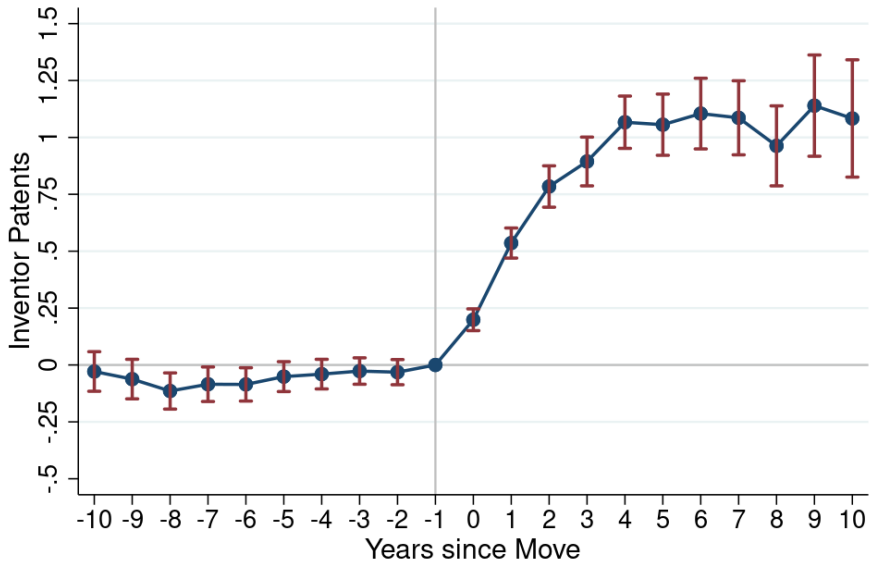
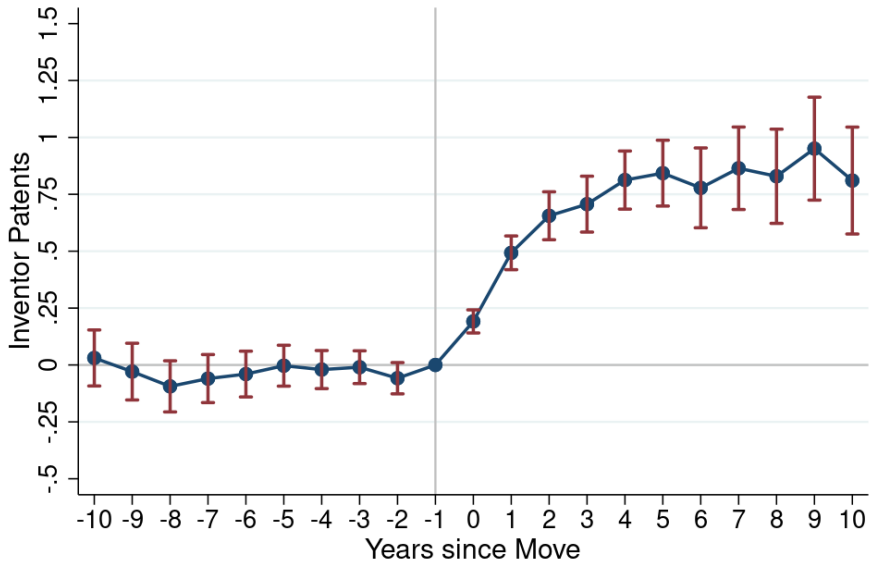
Event studies: Disruptive technology patents

Up moves



Down moves



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Event studies: Disruptive technology patents

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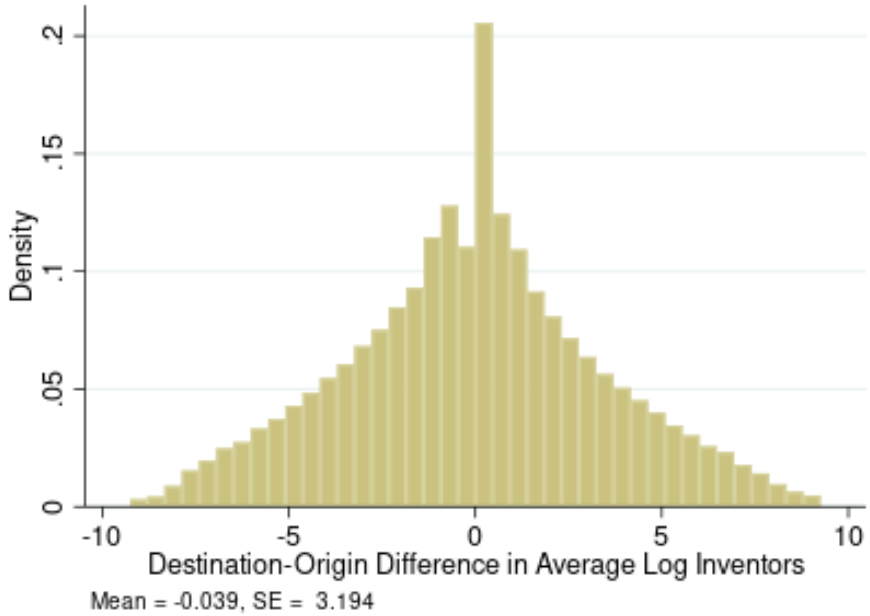
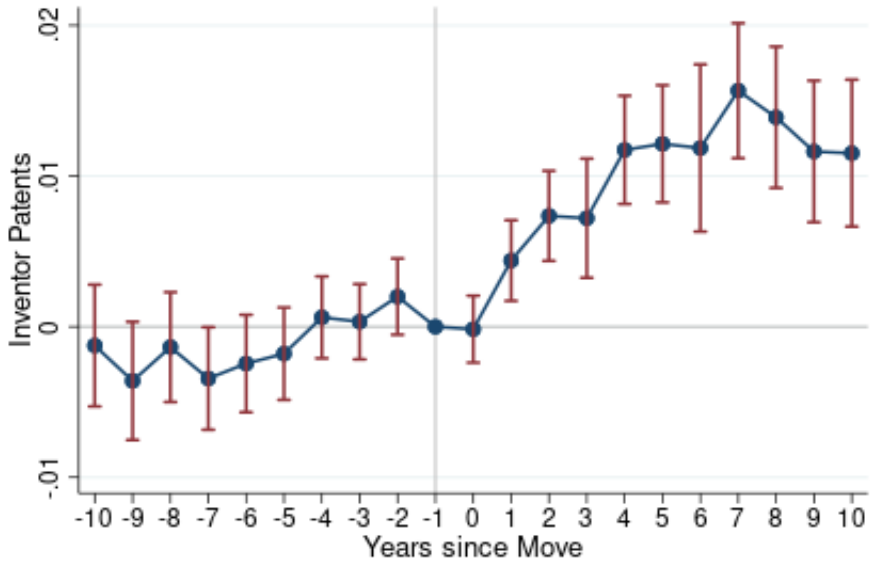
Event studies: Average size differences as independent variable

Distribution of $\delta_{size,i}$



Event study



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Detailed definition of the IV

- University program p: A university-major-degree combination
  - Major: STEM major vs. non-STEM major
  - Degree: PhD vs. non-PhD
- Instrumented number of inventors:

$$\widehat{Firm\_Inv}_{f,t} = \sum_{p \in \mathcal{P}} w_{p \to f}^{2001-2005} \times \frac{Grad\_Inv_{p \to -ind(f),t}}{Grad\_Emp_{p \to -ind(f),t}}$$

  - $w_{p \to f}^{2001-2005}$: (# inventors from program p in firm f in 2001-2005) / (# inventors from program p in 2001-2005)
  - $Grad\_Inv_{p \to -ind(f),t}$: Number of graduating inventors from program g in year t working in different industries than the focal firm f
  - $Grad\_Emp_{p \to -ind(f),t}$: Number of graduates from program g in year t working in different industries than the focal firm f
- Instrumented log number of inventors: $\ln(1 + \widehat{Firm\_Inv}_{f,t})$

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Alternative IV definition

- Inventor accounting

$$Firm\_Inv_{f,t} = Pr\_Inv_{f,t} \times Firm\_Emp_{f,t}$$

- Instrumented Pr_Inv:

$$\widehat{Pr\_Inv}_{f,t} = \sum_{p \in \mathcal{P}} s_{p \to f}^{2001-2005} \times \frac{Grad\_Inv_{p \to -f,t}}{Grad\_Emp_{p \to -f,t}}$$

  - $s_{p \to f}^{2001-2005}$: (# Employees from program p in firm f in 2001-2005) / (# Employees in firm f in 2001-2005)
  - $\frac{Grad\_Inv_{p \to -f,t}}{Grad\_Emp_{p \to -f,t}}$: Fraction of graduating inventors over all graduates of program p in year t working in other firms than f

- Instrumented log number of inventors: $Pr\_Inv_{f,t}$

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IV results with alternative instrument

	OLS	IV	First Stage	Reduced Form
	(1)	(2)	(3)	(4)
	Adjusted citations	*Adjusted citations*	*Ln(Firm_Inv)*	*Adjusted citations*
Ln(Firm_Inv)	0.069***	0.257**		
	(0.010)	(0.115)		
$\widehat{Pr\_Inv}$			7.386***	1.897**
			(1.165)	(0.794)
City-field-year FE	Y	Y	Y	Y
Inventor FE	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y
N	3345082	3345082	3345082	3345082
Adj. R^2	0.328	0.327	0.989	0.328
First-stage F		40.209		
Mean of y Variable	0.395			

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IV results with firm clustering

	OLS	IV	First Stage	Reduced Form
	(1)	(2)	(3)	(4)
	Adjusted citations	*Adjusted citations*	*Ln(Firm_Inv)*	*Adjusted citations*
Ln(Firm_Inv)	0.052***	0.213***		
	(0.013)	(0.081)		
$Ln(\widehat{Firm\_Inv})$			0.368***	0.078***
			(0.056)	(0.028)
City-field-year FE	Y	Y	Y	Y
Inventor FE	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y
N	3248152	3248152	3248152	3248152
Adj. R^2	0.327	0.326	0.989	0.327
First-stage F		42.878		
Mean of y	0.395			

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IV results with city-field-year by firm clustering

	OLS	IV	First Stage	Reduced Form
	(1)	(2)	(3)	(4)
	Adjusted citations	*Adjusted citations*	*Ln(Firm_Inv)*	*Adjusted citations*
Ln(Firm_Inv)	0.052***	0.213***		
	(0.007)	(0.034)		
$Ln(\widehat{Firm\_Inv})$			0.368***	0.078***
			(0.014)	(0.012)
City-field-year FE	Y	Y	Y	Y
Inventor FE	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y
N	3248152	3248152	3248152	3248152
Adj. R^2	0.327	0.326	0.989	0.327
First-stage F		699.408		
Mean of y	0.395			

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IV results with field inventors as the independent variable

	OLS	IV	First Stage	Reduced Form
	(1)	(2)	(3)	(4)
	Adjusted citations	*Adjusted citations*	*Ln(Firm_FieldInv)*	*Adjusted citations*
Ln(Firm_FieldInv)	0.051***	0.198***		
	(0.005)	(0.051)		
$Ln(\widehat{Firm\_Inv})$			0.386***	0.076***
			(0.057)	(0.020)
City-field-year FE	Y	Y	Y	Y
Inventor FE	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y
N	3169390	3169390	3169390	3169390
Adj. R^2	0.327	0.326	0.963	0.327
First-stage F		45.276		
Mean of y	0.395			

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Replication of Moretti (2021)

Dependent variable: log(Patent counts)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Ln(City_FieldInv_Density)	-0.008	0.063***	0.065***	0.061***	0.041**	0.032*	0.095***	0.096***
	(0.010)	(0.024)	(0.022)	(0.019)	(0.017)	(0.019)	(0.027)	(0.028)
Year	Y	Y	Y	Y	Y	Y	Y	Y
City	Y	Y	Y	Y	Y	Y	Y	Y
Field	Y	Y	Y	Y	Y	Y	Y	Y
Class	Y	Y	Y	Y	Y	Y	Y	Y
City × field		Y	Y	Y	Y	Y	Y	Y
City × class			Y	Y	Y	Y	Y	Y
Field × year				Y	Y	Y	Y	Y
Class × year					Y	Y	Y	Y
Inventor						Y	Y	Y
City × year							Y	Y
Firm								Y
N	834154	834128	831667	831667	831364	826535	825808	822412
Adj. R^2	0.022	0.025	0.032	0.034	0.036	0.254	0.256	0.259
Mean of Dep. Variable	0.025							

Note: (1) *City_FieldInv_Density* is defined as the ratio of the number of inventors in the same city and field over the number of inventors in the same field. (2) Sample is restricted to star inventors, who are at or above the ninetieth percentile in the total number of patents.

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Innovation spillovers within cities: Star inventors

Dependent variable: log(Patent counts)

	(1)	(2)	(3)
Ln(City_FieldInv)	0.027	0.052**	0.051**
	(0.031)	(0.025)	(0.025)
Ln(City_OutInv)	-0.016	-0.066**	-0.068*
	(0.031)	(0.030)	(0.035)
City-field FE	Y	Y	Y
Field-year FE	Y	Y	Y
Inventor FE		Y	Y
Firm FE			Y
N	834183	829439	826087
Adj. R^2	0.089	0.249	0.252
Mean of y Variable	0.025		

Note: Star inventors are inventors who are at or above the ninetieth percentile in the total number of patents

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Innovation spillovers within firms and within cities

Dependent variable: Adjusted citations

	(1)	(2)	(3)
Ln(Firm_ FieldInv)	0.050***	0.062***	0.062***
	(0.006)	(0.004)	(0.004)
Ln(Firm_ OtherInv)	-0.005	-0.009**	0.000
	(0.007)	(0.004)	(0.006)
Ln(Firm_ NonInv)	-0.055***	-0.048***	-0.019*
	(0.006)	(0.004)	(0.010)
Ln(City_ FieldInv)	0.147**	0.041*	0.002
	(0.066)	(0.023)	(0.023)
Ln(City_ OtherInv)	-0.037	0.002	-0.028
	(0.052)	(0.029)	(0.028)
City-field FE	Y	Y	Y
Field-year FE	Y	Y	Y
Inventor FE		Y	Y
Firm FE			Y
N	5624014	5608106	5607070
Adj. R^2	0.056	0.272	0.278
Mean of y Variable	0.347		

Note: The number of inventors in the same city *excludes* those in the same firm

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Innovation spillovers within firm and within cities: Active inventor-firm pairs

	(1)	(2)	(3)
Ln(Firm_ FieldInv)	0.047***	0.060***	0.067***
	(0.008)	(0.005)	(0.006)
Ln(Firm_ OtherInv)	-0.006	-0.010**	0.005
	(0.008)	(0.005)	(0.008)
Ln(Firm_ NonInv)	-0.063***	-0.045***	-0.008
	(0.007)	(0.006)	(0.014)
Ln(City_ FieldInv)	0.187**	0.040	0.001
	(0.085)	(0.028)	(0.028)
Ln(City_ OtherInv)	-0.054	-0.025	-0.048
	(0.063)	(0.035)	(0.034)
City-field FE	Y	Y	Y
Field-year FE	Y	Y	Y
Inventor FE		Y	Y
Firm FE			Y
N	4624143	4609390	4608386
Adj. R^2	0.056	0.282	0.290
Mean of y Variable	0.433		

Note: The number of inventors in the same city *excludes* those in the same firm

Innovation spillovers within firm and within cities: Star inventors

Dependent variable: log(Adjusted citations)

	(1)	(2)	(3)
Ln(Firm_ FieldInv)	0.023***	0.025***	0.032***
	(0.008)	(0.004)	(0.006)
Ln(Firm_ OtherInv)	-0.021	-0.007	0.007
	(0.013)	(0.006)	(0.011)
Ln(Firm_ NonInv)	-0.044***	-0.037***	-0.098***
	(0.009)	(0.007)	(0.016)
Ln(City_ FieldInv)	0.085	-0.094**	-0.126***
	(0.095)	(0.038)	(0.041)
Ln(City_ OtherInv)	-0.090	-0.114**	-0.133***
	(0.076)	(0.049)	(0.047)
City-field FE	Y	Y	Y
Field-year FE	Y	Y	Y
Inventor FE		Y	Y
Firm FE			Y
N	632930	624777	622884
Adj. R^2	0.059	0.263	0.269
Mean of y Variable	-0.178		

Note: Star inventors are inventors who are at or above the ninetieth percentile in the total number of patents

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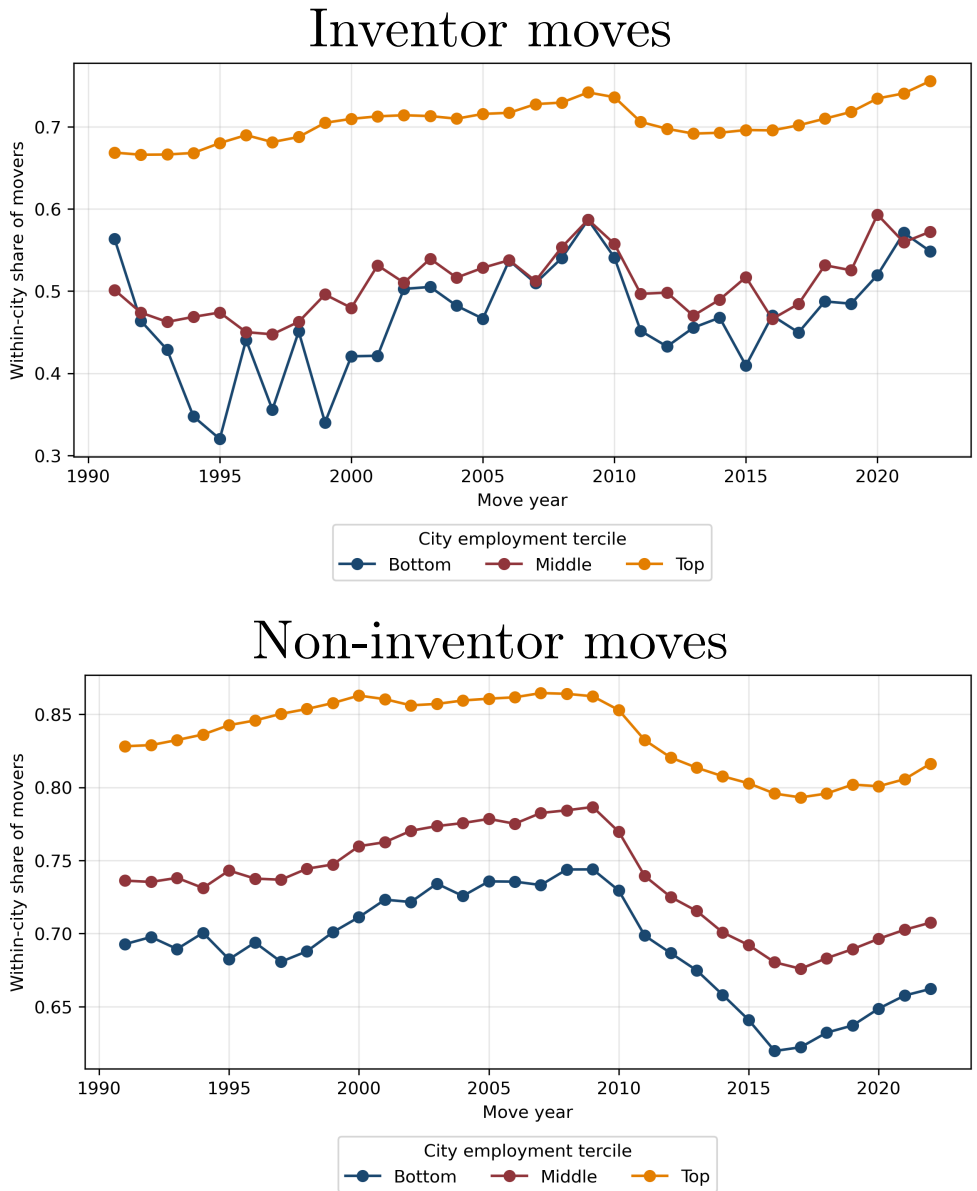
Moves within city by city size



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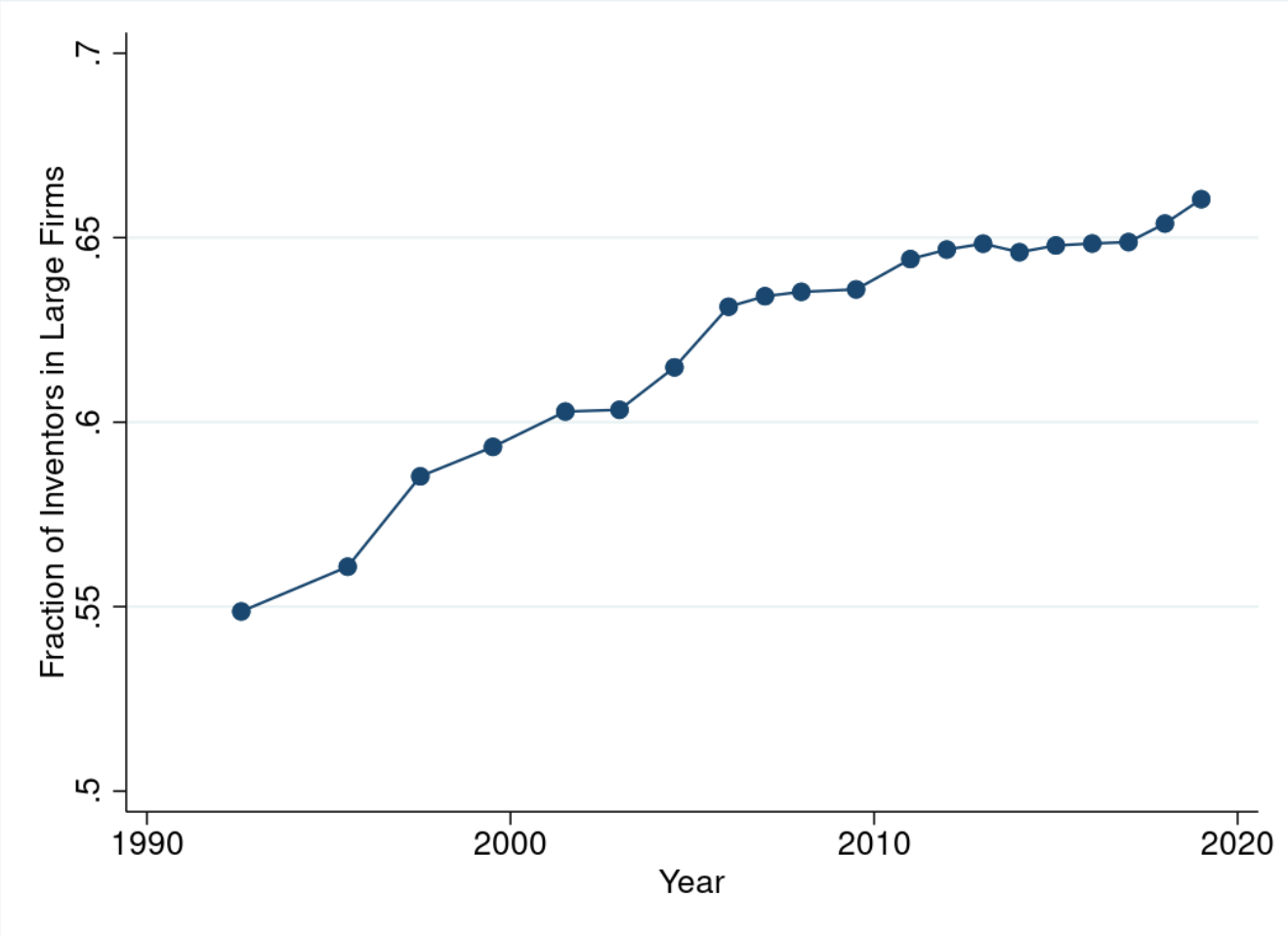
Innovation spillovers interacting citation sources



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Inventor-led firm performance

	$Patent_{[t,t+5]}$	$Ln(Emp_{t+3})$	$Funded_{[t,t+3]}$	$Ln(1+Raised_{[t,t+3]})$	$Acq_{[t,t+5]}$	$IPO_{[t,t+10]}$
	(1)	(2)	(3)	(4)	(5)	(6)
Inventor_Spinoff	0.205***	0.226***	0.180***	0.782***	0.035***	0.017***
	(0.009)	(0.023)	(0.009)	(0.034)	(0.005)	(0.003)
Controls	Y	Y	Y	Y	Y	Y
Industry × Est. Year FE	Y	Y	Y	Y	Y	Y
State FE	Y	Y	Y	Y	Y	Y
Team Size FE	Y	Y	Y	Y	Y	Y
N	66253	66253	66253	66253	66253	66253
Adj. R^2	0.139	0.074	0.187	0.201	0.026	0.047
Mean of y Variable	0.061	1.547	0.227	0.527	0.036	0.009

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