

Heterogeneity in Knowledge Flows of Regions: Impact on Invention Quality

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Outline

Motivation

Literature Review

Theory and Hypotheses

Data and Method

Future Work

Prior art on knowledge flows

Patent citation analysis

Economic Geography Literature

- Knowledge spillovers are localized (Jaffe, Trajtenberg, & Henderson, 1993)
- Innovation is more spatially concentrated than is production (Feldman, 1994)

International Business Literature

- Firms profit from offshoring R&D by leveraging better organizational linkages (Zhao, 2006)
- Subsidiary - MNC parent flows are as strong as MNC parent - Subsidiary knowledge flows (Singh, 2007)

Knowledge flows as outcome of search?

Region and firm boundaries

	Same Region	Different Region
Same Assignee	Independent Research Center	Geographic Diversification
Different Assignee	Cluster	Diffusion

Figure: Categories of knowledge flows

Research Question

*How do the **nature** of knowledge flows in a region affect the **quality** of inventions generated in the region?*

Summary of Preliminary Findings

- Localized knowledge flows do not seem to improve invention quality
- Geographical diversification is seen to improve invention quality
- Results differ between applicant only citations data and applicant and examiner citations dataset echoing concerns raised by Alcácer & Gittelman (2006)
- Much additional research required to distill any stylized facts on the impact of geography and firm boundaries on invention quality

On the Nature of Knowledge Spillovers

- Rent Spillovers vs. Pure Spillovers (Griliches, 1979)
- Knowledge as a private good and a public good (Arrow, 1962)
- Knowledge flows are invisible (Krugman, 1991)
- Knowledge flows sometimes leave a paper trail in the form of patent citations (Jaffe et al., 1993)

On the Localization of Knowledge Spillovers

- Proximity is beneficial due to lower costs of collaboration, opportunities for serendipitous encounters
- Tacit knowledge is not easily transferred across long distances
- Institutions and Regional innovation systems contribute to localization of knowledge flows
- Related variety (Boschma & Iammarino, 2009; Frenken, Oort, & Verburg, 2007; Jacobs, 1969) in urban clusters promotes generation of new ideas

On Knowledge Flows across Countries

- Political borders may constrain flows of knowledge (Singh & Marx, 2013)
- Inventor mobility improves innovation outcomes (Alnuaimi et al., 2012)
- MNC subsidiary location choices influenced by regional innovation systems (Andersen & Christensen, 2005), organizational linkages (Zhao, 2006), and higher independence and ownership (Pearce, 1999)

Invention quality at the independent research center

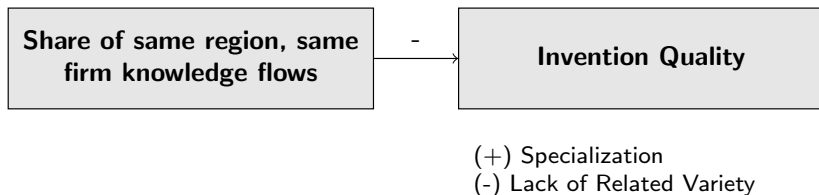


Figure: Hypothesized relationship of knowledge flows within an independent research center on invention quality

Invention quality in a cluster

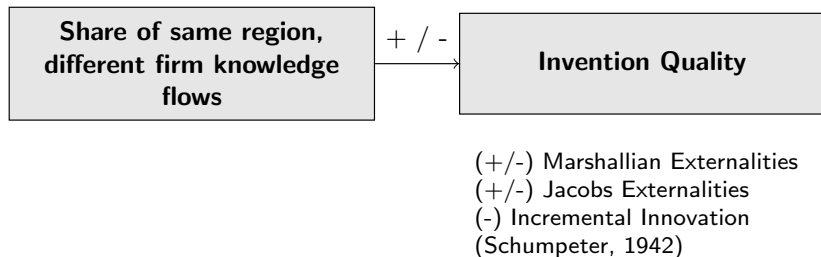


Figure: Hypothesized relationship of knowledge flows within a cluster on invention quality

Invention quality under geographical diversification

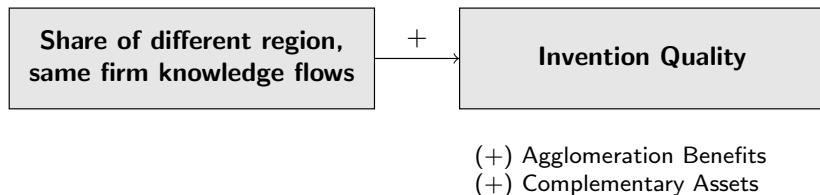


Figure: Hypothesized relationship of knowledge flows under geographical diversification on invention quality

Invention quality under diffusion

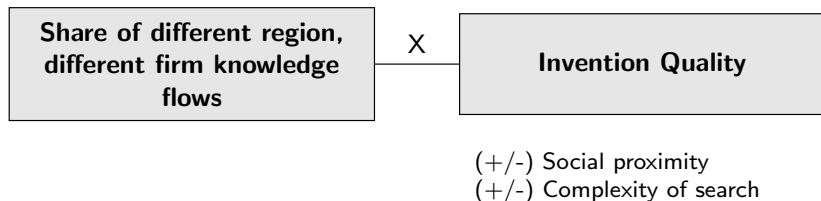


Figure: Hypothesized relationship of knowledge flows under diffusion on invention quality

Geographic Mapping

San Jose

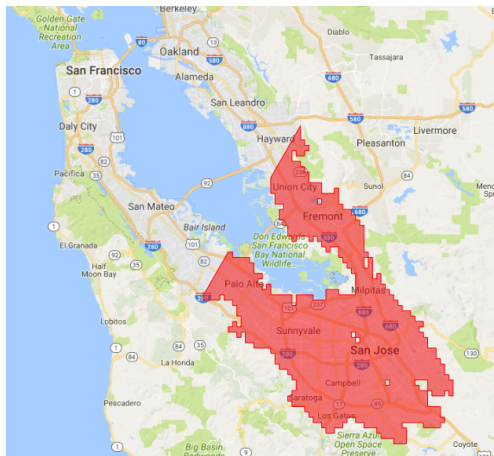


Figure: Geographic Definition of San Jose, CA

Summary Statistics

Applicant only citations

Variable	Mean	Std. Dev.	N
Citations Received	1630.527	8200.133	9358
Non-Self Citations Received	917.342	4958.117	9358
Self Citations Received	248.898	1312.542	9358
Share Citations Made[Same Region, Same Assignee]	0.013	0.034	9358
Share Citations Made[Same Region, Different Assignee]	0.013	0.039	9358
Share Citations Made[Different Region, Same Assignee]	0.038	0.076	9358
Share Citations Made[Different Region, Different Assignee]	0.509	0.2	9358
Share Citations Made[Other]	0.428	0.202	9358
Share Citations Made[Same Region]	0.026	0.054	9358
Share Citations Made[Same Assignee]	0.051	0.087	9358
Log (Total Citations Made)	4.92	2.411	9358
Log (Num Patents)	3.719	1.954	9358
Log (Patent Pool Size)	6.496	2.048	9358

Methodology

- Data Source: Patents from USPTO, source: patentsview.org
- Data Source: Regions using Remote Sensing Data, source: naturalearthdata.com
- Unit of Analysis: Region-Year
- Dependent Variables: Total Citations Received, Non-Self Citations Received
- Independent Variables: Share of citations made within/outside region, within/outside assignee
- Control Variables: Technology subcategories (Hall, Jaffe, & Trajtenberg, 2001), Region fixed effects, Year effects
- Estimation Method: Negative Binomial

Results

Applicant only citations

	(1)	(2)	(3)	(4)	(5)	(6)
	Total Citations Received	Total Citations Received	Total Citations Received	Non-Self Citations Received	Non-Self Citations Received	Non-Self Citations Received
Share Citations Made[Same Region, Same Assignee]	-0.125 (0.372)	-0.156 (0.468)	-0.0437 (0.809)	-0.0698 (0.613)	-0.0575 (0.782)	-0.113 (0.560)
Share Citations Made[Same Region, Different Assignee]	-0.0501 (0.677)	-0.250 (0.305)	0.0494 (0.704)	0.214 (0.052)	0.0341 (0.889)	0.267 (0.035)
Share Citations Made[Different Region, Same Assignee]	0.260 (0.002)	0.316 (0.015)	0.326 (0.003)	0.215 (0.013)	0.209 (0.105)	0.247 (0.040)
Share Citations Made[Different Region, Different Assignee]	0.00251 (0.933)	0.0382 (0.383)	0.0123 (0.760)	0.0426 (0.160)	0.0336 (0.447)	0.0615 (0.143)
Log (Total Citations Made)	0.0194 (0.000)	0.0126 (0.031)	0.0220 (0.000)	0.0131 (0.002)	0.00662 (0.258)	0.0152 (0.012)
Log (Num Patents)	0.788 (0.000)	0.860 (0.000)	0.830 (0.000)	0.799 (0.000)	0.826 (0.000)	0.849 (0.000)
Log (Patent Pool Size)	-0.124 (0.000)	-0.303 (0.000)	-0.110 (0.000)	-0.0871 (0.000)	-0.157 (0.000)	-0.108 (0.000)
Constant	-0.911 (0.000)	0.510 (0.002)	-1.368 (0.000)	-1.296 (0.000)	-0.557 (0.002)	-1.677 (0.000)
Observations	9358	3974	5384	9037	3868	5169
Groups	1359	539	820	1255	503	752
Sample	All Locations	U.S. Locations	Non-U.S. Locations	All Locations	U.S. Locations	Non-U.S. Locations

p-values in parentheses

All models include region fixed effects, year dummies and technology subcategory controls

Addressing Potential Issues

Applicant and Examiner Citations

	(1) Total Citations Received	(2) Total Citations Received	(3) Total Citations Received	(4) Non-Self Citations Received	(5) Non-Self Citations Received	(6) Non-Self Citations Received
Share Citations Made[Same Region, Same Assignee]	0.818 (0.000)	0.463 (0.126)	1.258 (0.000)	1.403 (0.000)	1.294 (0.000)	1.641 (0.000)
Share Citations Made[Same Region, Different Assignee]	-0.846 (0.004)	-1.158 (0.006)	-0.444 (0.268)	0.0468 (0.885)	-0.433 (0.374)	0.227 (0.606)
Share Citations Made[Different Region, Same Assignee]	0.652 (0.000)	0.365 (0.055)	0.843 (0.000)	1.139 (0.000)	0.792 (0.001)	1.192 (0.000)
Share Citations Made[Different Region, Different Assignee]	0.0517 (0.195)	0.230 (0.000)	0.109 (0.037)	0.994 (0.000)	1.354 (0.000)	0.920 (0.000)
Log (Total Citations Made)	0.0656 (0.000)	0.0290 (0.031)	0.0858 (0.000)	-0.0349 (0.000)	-0.0813 (0.000)	0.0387 (0.005)
Log (Num Patents)	0.730 (0.000)	0.820 (0.000)	0.755 (0.000)	0.845 (0.000)	0.919 (0.000)	0.805 (0.000)
Log (Patent Pool Size)	-0.0982 (0.000)	-0.273 (0.000)	-0.102 (0.000)	-0.0571 (0.000)	-0.145 (0.000)	-0.0743 (0.000)
Constant	-0.185 (0.000)	1.003 (0.000)	-0.547 (0.000)	-1.000 (0.000)	-0.390 (0.000)	-1.312 (0.000)
Observations	18102	6850	11252	17730	6749	10981
Groups	2006	631	1375	1896	610	1286
Sample	All Locations	U.S. Locations	Non-U.S. Locations	All Locations	U.S. Locations	Non-U.S. Locations

p-values in parentheses

All models include region fixed effects, year dummies and technology subcategory controls

Limitations

- The use of patent citations as a measure of knowledge flows may be subject to error (Arora et al., 2017)
- Any systematic biases in our definition of regions (Urban Centers from Natural Earth Data) can create biases in measures of knowledge flows

Future Work

- Examine the effects of search on technology domain (Rosenkopf & Nerkar, 2001)
- Investigate the effect on alternate outcomes, e.g., breakthrough inventions
- Identify the mechanisms underlying the impact of knowledge flows on invention quality

- Alcácer, J., & Gittelman, M. 2006. Patent citations as a measure of knowledge flows: The influence of examiner citations. **Review of Economics and Statistics**, 88(4): 774–779.
- Alnuaimi, T., Singh, J., & George, G. 2012. Not with my own: Long-term effects of cross-country collaboration on subsidiary innovation in emerging economies versus advanced economies. **Journal of Economic Geography**, 12(5): 943–968.
- Andersen, P. H., & Christensen, P. R. 2005. **From localized to corporate excellence: How do MNCs extract, combine and disseminate sticky knowledge from regional innovation systems**. DRUID Working Paper 16, Danish Research Unit on Industrial Dynamics.
- Arora, A., Belenzon, S., & Lee, H. 2017. **Reversed citations and the localization of knowledge spillovers**. Working Paper 23036, National Bureau of Economic Research.
- Arrow, K. J. 1962. The economic implications of learning by doing. **The Review of Economic Studies**, 29(3): 155–173.
- Boschma, R., & Iammarino, S. 2009. Related variety, trade

linkages, and regional growth in Italy. **Economic Geography**, 85(3): 289–311.

Feldman, M. P. 1994. **The geography of innovation**. Boston: Kluwer Academic Publishers.

Frenken, K., Oort, F. V., & Verburg, T. 2007. Related variety, unrelated variety and regional economic growth. **Regional Studies**, 41(5): 685–697.

Griliches, Z. 1979. Issues in assessing the contribution of research and development to productivity growth. **The Bell Journal of Economics**, 10(1): 92–116.

Hall, B. H., Jaffe, A. B., & Trajtenberg, M. 2001. **The NBER patent citation data file: Lessons, insights and methodological tools**. Working Paper 8498, National Bureau of Economic Research.

Jacobs, J. 1969. **The economy of cities**. New York: Random House.

Jaffe, A. B., Trajtenberg, M., & Henderson, R. 1993. Geographic localization of knowledge spillovers as evidenced by patent

citations. **The Quarterly Journal of Economics**, 108(3): 577–598.

Krugman, P. R. 1991. **Geography and trade**. The MIT press.

Pearce, R. D. 1999. Decentralised R&D and strategic competitiveness: Globalised approaches to generation and use of technology in multinational enterprises (mnes). **Research Policy**, 28(2–3): 157 – 178.

Rosenkopf, L., & Nerkar, A. 2001. Beyond local search: Boundary-spanning, exploration, and impact in the optical disk industry. **Strategic Management Journal**, 22(4): 287–306.

Schumpeter, J. A. 1942. **Capitalism, socialism and democracy**. New York, NY: Harper.

Singh, J. 2007. Asymmetry of knowledge spillovers between mncs and host country firms. **Journal of International Business Studies**, 38(5): 764–786.

Singh, J., & Marx, M. 2013. Geographic constraints on knowledge spillovers: Political borders vs. spatial proximity. **Management Science**, 59(9): 2056–2078.

Zhao, M. 2006. Conducting R&D in countries with weak intellectual property rights protection. **Management Science**, 52(8): 1185–1199.