

# Distance matters: The causal effect of coauthor mobility on scientific collaboration

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**Abstract** This study examines the impact of geographic distance on scientific collaboration, with a focus on the mobility of coauthors as a proxy for changes in distance. While advancements in information, communication, and transportation technologies have facilitated collaboration across distances, the extent to which these means of communication compensate for the lack of face-to-face interaction remains a subject of ongoing debate. By utilizing a matching method to construct two groups of scientist pairs and comparing the changes in their collaboration performance before and after mobility, the causal effect of geographic change on collaboration is estimated. The findings indicate that when collaborators who previously resided in the same city relocate to different cities, the productivity and citation impact of their co-publications are significantly reduced. These results suggest that physical proximity still plays a crucial role in scientific collaboration despite the availability of technological means for remote collaboration.

## 1. Introduction

Scientific collaboration has emerged as the dominant approach to knowledge production in both the natural and social sciences (Wuchty et al., 2007). The escalation of complexity and magnitude of scientific problems (Milojević, 2014), the narrowness of expertise due to the burden of knowledge (Jones, 2009), and the dependence on equipment, facilities, and other resources (Catalini et al., 2020) have necessitated collaborative research. By engaging in joint problem-solving, learning, and resource sharing, scientists are better able to address complex issues. Numerous studies have demonstrated that scientific collaboration stimulates innovation and enhances impact (Wuchty et al., 2007; Ding, 2011).

Several factors may hinder the realization of the benefits of scientific collaboration. One of the main hindrances is geographical distance, which can lead to communication difficulties and increased travel expenses. However, the development of information and communication technologies (ICTs) and transportation has made remote collaboration more accessible and cost-effective. As a result, scientific collaboration is increasingly transcending geographical boundaries (Jones et al., 2008). In fact, research indicates that scientific teams are becoming more dispersed (Adams et al., 2005; Hoekman et al., 2010). Some scholars have even proposed the "death of distance" hypothesis (Cairncross et al., 1997), which suggests that distance no longer has a

significant impact on long-distance collaboration.

However, some scholars have questioned the validity of the "death of distance" hypothesis. Although ICTs can mitigate the inconvenience associated with distance and facilitate communication to some extent, the benefits of in-person, offline interaction cannot be entirely replaced by virtual, remote interaction. Face-to-face interactions foster a more flexible environment that encompasses not only language but also behavior, which can better facilitate the transfer of tacit knowledge (Olson & Olson, 2000; Werker & Ooms, 2020).

Despite the advancement of information and communication technologies (ICTs) and transportation, it remains inclusive whether geographic distance still affects scientific collaboration. This study aims to explore the causal effect of geographic change on collaboration. Changes in the geographic proximity of collaborators due to scientific mobility, such as cross-country or cross-region mobility, can impact the original collaborative relationship by introducing new collaborators and increasing the cost of work with original collaborators (Jonkers & Tijssen, 2008). We used the mobility of a collaborator from the same city to another as a proxy for geographic change and examined its effect on the collaboration productivity and quality of scientist pairs.

## **2 Literature review**

### *2.1. Spatial characteristics of collaboration*

The development of (ICTs) and transportation results in improved cost and convenience of travel within and between cities and nations (Catalini et al., 2020). Additionally, instant messaging tools have made long-distance collaboration more accessible, allowing scientists to work together online without face-to-face meetings. Technological advances have transformed the spatial characteristics of scientific collaboration in two main ways. First, globalization has led to an increase in the average distance between collaborators in recent decades (Hoekman et al., 2010; Waltman et al., 2011). However, longer distances have been observed to decrease collaboration between scientists (Hoekman et al., 2010; Luo et al., 2018).

### *2.2. Geographic distance and collaboration*

The impact of geographic distance on collaboration has been discussed for years (Katz, 1994). Studies have found that geographic distance can hinder collaboration and negatively affect knowledge spillovers (Fernández et al., 2016; van der Wouden & Youn, 2023). Geographic proximity is particularly important for collaborations between institutions with diverse backgrounds (Ponds et al., 2007). Offline meetings serve as a starting point for most collaborations (Freeman et al., 2014). Face-to-face interactions are crucial for establishing new partnerships or maintaining long-distance collaborations. The impact of geographic distance on collaboration is primarily attributed to the friction of distance, which results in higher communication and search costs when there is a lack of face-to-face interaction between collaborators (Hoekman

et al., 2010). To meet, collaborators have to bear the time, financial, and energy costs. Several studies have estimated the effect of travel costs on scientific collaboration through special event shocks. For instance, Catalini et al. (2018) conducted a quasi-experiment and found that the introduction of low-cost airlines increased the quantity and quality of collaboration. Similarly, Hu et al. (2022) examined the impact of direct flights between China and the United States on scientific collaboration and found that it boosted influential papers in China.

However, counterarguments suggest that long-distance collaboration may lead to improved academic outcomes. Long-distance collaboration enables the combination of diverse skills and resources, which can foster innovation (Fleming, 2001). Furthermore, providing dissemination opportunities to remote research centers can improve the citation impact of research papers (Abramo et al., 2020). Nomaler et al. (2013) examined international co-authored papers in Europe and found that citation impact of papers was positively correlated with geographic distance between collaborating countries.

### *2.3. Scientific mobility and collaboration*

Scientific mobility has been demonstrated to have an impact on both the productivity and collaboration of scientists, partly due to changes in geographic distance. Following relocation to a new institution, the lack of frequent communication and face-to-face interaction due to the extended distance renders it arduous to uphold connections and other social capital established at the initially affiliated institution (Groysberg et al., 2008; Jaffe et al., 1993). However, evidence from several studies suggests that scientists can not only form new collaborations after mobility but also sustain previous collaborations (Liu & Hu, 2022; Zhao et al., 2022). This phenomenon is attributed to the advancements in information and communication technologies (ICTs) that have facilitated communication and coordination (Frenken et al., 2009).

## **3. Data and methodology**

### *3.1. Data collection*

To track the mobility of scientists, we used the ORCID snapshot of February 10<sup>th</sup> 2022. The ORCID platform provides CVs and unique identifiers of researchers, effectively addressing the issue of name disambiguation among them. We extracted the education and employment records of individual researchers. Records lacking affiliation or with missing starting and ending times were excluded, culminating in a total of 13,971,340 records for 4,344,940 scientists. We utilized co-authored papers to capture collaboration between scientists. The ORCID identifiers of scientists were used for matching articles. The core Web of Science dataset was used for obtaining articles from January 2008 to December 2021 since the ORCID identifiers date back to 2008 in the database.

### *3.2. Research design*

In this study, we focused on a set of scientist pairs consisting of scientists who have not

moved for a long time and their collaborators who have moved during the collaboration. We estimated the impact of geographic change on scientific collaboration by comparing the variations in the collaborative performance of these pairs before and after the collaborator's mobility. We used whether the collaborators moved to other cities as a proxy for geographic change. Since there are variations in geographical distance, administrative systems, transportation facilities, and other factors, the cost of traveling between different cities is often higher than traveling within the same city (Tang et al., 2022). The sample of scientists and their collaborators encompassed in the study were required to satisfy the following three criteria:

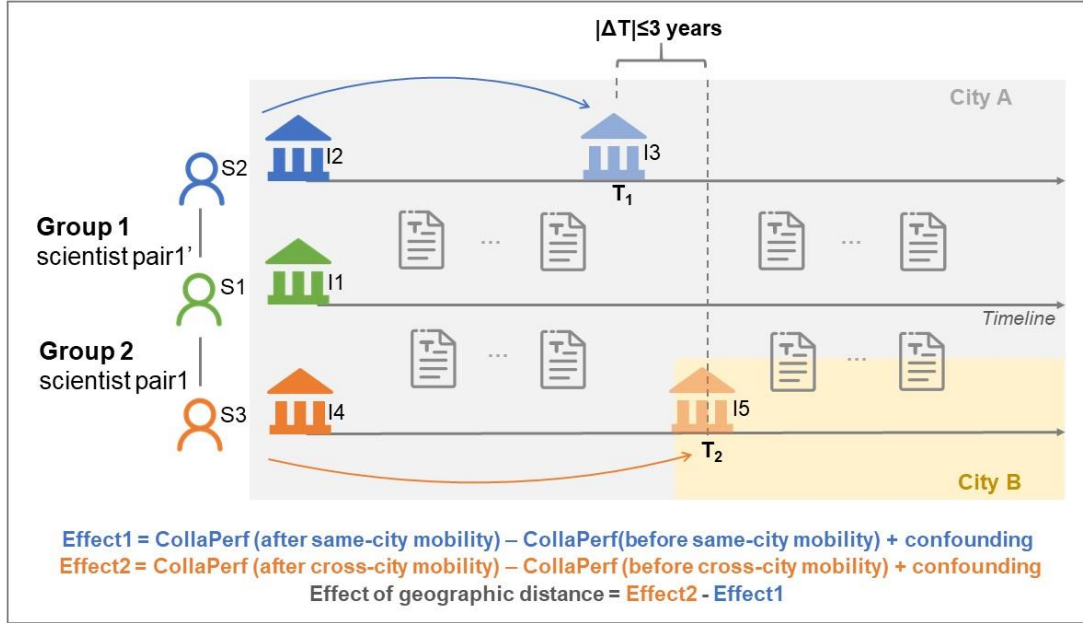
- (1) The scientists have not moved to other institutions for a specified period.
- (2) The scientist had a collaborator in a different institution in the same city, who has moved to another institution in the same city during this period. The pairs have collaborated on publishing papers prior to the mobility.
- (3) The scientist had a collaborator in a different institution in the same city, who has moved to other cities during the period. The pairs have collaborated on publishing papers prior to the mobility.

Based on the established criteria, the pairs of scientists were found and divided into two groups. Figure 1 provides a schematic illustration of our identification and matching process. Specifically,  $S1$  (scientists without mobility),  $S2$  (collaborator of  $S1$  with same-city mobility), and  $S3$  (collaborator of  $S1$  with cross-city mobility) were originally affiliated with different institutions located in *City A*.  $S2$  moved to another institution within *City A* at the time  $T_0$ , while  $S3$  moved to an institution situated *City B* at time  $T_1$ . To eliminate the potential influence of time-varying factors, we restricted the time difference between the mobility of  $S1$  and  $S2$  to a maximum of three years. The  $S1$ - $S2$  pairs were classified as Group 1, which is used to evaluate the effect of same-city mobility of collaborators by calculating the difference in collaboration performance before and after the mobility. The  $S1$ - $S3$  pairs are classified into Group 2, which we utilized to evaluate the impact of cross-city mobility. The effect of the geographic change is captured by the difference between the two effects.

After matching, our dataset includes 832 pairs of scientists, including 416  $S1$ - $S2$  pairs and 416  $S1$ - $S3$  pairs.

Figure 1: Illustration of sample identification and matching process.  $S1$  (in green) refers to the scientist who stays in institution  $I1$  (in green) for a long period of time.  $S2$  (in blue) is a collaborator of  $S1$ , who moves from institution  $I2$  (in blue) in *City A* (light gray rectangle) to institution  $I3$  (in light blue) in the same city at  $T_1$  time.  $S3$  (in orange) is another collaborator of  $S1$ , who moves from institution  $I4$  (in orange) in *City A* to institution  $I5$  (in light orange) in the *City B* (yellow rectangle) at  $T_2$  time.

Both the pairs  $S1$ - $S2$  and  $S1$ - $S3$  published co-publications before the mobility.



### 3.3. Variables

#### Dependent variables

We used collaboration performance as the dependent variable and quantified them in two aspects: productivity and citation impact. Productivity was measured by the number of publications published by the collaborators with mobility three years before or after the mobility (*# Publication*), and the impact was measured by the average citations of co-publications three years before or after the mobility. The citation window is limited to three years ( $C_3$ ) and five years ( $C_5$ ).

#### Independent variables

The primary independent variable is whether the pairs collaborate after the geographic change (*AfterMoveFar*). It is a dichotomous variable, taking a value of one when the collaboration took place subsequent to the collaborator's cross-city mobility and zero otherwise. Additionally, there exist two other independent variables, one serving to differentiate whether the pair have undergone a geographic change (*MoveFar*), and the other refers to whether the collaboration conducts prior to or post the mobility (*After*).

#### Control variables

To mitigate the influence of factors that could potentially impact collaboration performance amongst scientists, a set of control variables is incorporated. These control variables comprise of (1) the number of publications published before the scientist-pairs collaborate by the collaborators who have moved to other institutions (*CollaboratorProductivity*), to control for the collaborators' past productivity (Fernandez-Zubieta et al., 2013); (2) the average number of authors for the papers the collaborators who have moved to other institutions published (*AvgTeamsize*) to control the collaboration propensity (Lariviere et al., 2014; Abramo et al., 2014).

### 3.4. Estimation strategy

We estimate the effect using OLS linear model including the *SI*-fixed effect:

$$\text{CollaborationPerformance} = \alpha + \beta_0 \text{AfterMoveFar} + \beta_1 \text{MoveFar} + \beta_2 \text{After} + \beta_3 \text{Controls} + \gamma + \varepsilon, \quad (1)$$

where *AfterMoveFar* is an indicator variable that takes the value of one after the collaborators move cross-city; *MoveFar* refers to whether the mobility is cross-city or in the same city; *After* refers to whether the collaboration is conducted after the collaborators' mobility;  $\gamma$  is an *SI*-fixed effect to control unobservable, time-invariant differences of scientists who do not move to other cities (*SI* in Figure 1); and  $\varepsilon$  is an error term.

## 4. Results

Table 1 displays the descriptive statistics for the variables. The dependent variables are *#publication*,  $C_3$ , and  $C_5$ , respectively. The *#publication* ranges from 0 to 247, with a mean of 3 and a standard deviation of 13. The average values of  $C_3$  and  $C_5$  are 25 and 55, respectively. The geographical distance of 45.9% of the scientists changed while 54.1% of scientist pairs remains in the same cities.

Table 1. Descriptive statistics of the variables.

	Variable	Obs.	Mean	Std. Dev.	Min	Max
Dependent variables	#publication	1,718	3	13	0	247
	$C_3$	1,718	25	131	0	1,811
	$C_5$	1,718	55	301	0	4,007
Independent variables	AfterMoveFar	1,718	0.234	0.423	0	1
	MoveFar	1,718	0.459	0.498	0	1
	After	1,718	0.510	0.500	0	1
Control variables	AvgTeamsize	1,718	21	150	1	3,172
	Collaborator Productivity	1,718	3	10	0	111

Table 2 presents the estimated effects of geographic change on collaboration performance. Column 1 shows the results when only the independent variables were included in the model. The coefficient for the variable *AfterMoveFar* is negative and statistically significant. We sequentially added all the control variables and the *SI*-fixed effect in Column 2 and Column 3, respectively. The coefficient for the variable *AfterMoveFar* is -0.290 ( $p < 0.01$ ) in Column 3, suggesting that the geographic change leads to a 29% decrease in the number of co-publications by the pairs. Columns 4 and 5 provide the regression results using  $C_3$  and  $C_5$  as the dependent variables, respectively. Both coefficients for *AfterMoveFar* are negative and significant at 0.01 level, indicating that the geographic change results in a decrease of 35.4% and 47.2% in the three-year and five-year citations of the co-publications by the pairs.

Table 2. The effect of geographical distance changes on collaboration performance.

	(1)	(2)	(3)	(4)	(5)
	<b>ln(#publication+1)</b>			<b>ln(C<sub>3</sub>+1)</b>	<b>ln(C<sub>5</sub>+1)</b>
AfterMoveFar	-0.290***	- 0.291***	-0.290***	-0.354***	-0.472***
	(0.062)	(0.063)	(0.049)	(0.116)	(0.133)
MoveFar	-0.002	-0.003	-0.022	-0.111	-0.075
	(0.041)	(0.045)	(0.034)	(0.080)	(0.091)
After	-0.515***	- 0.514***	-0.512***	-1.406***	-1.848***
	(0.046)	(0.043)	(0.033)	(0.081)	(0.095)
AvgTeamsize		-0.000*	-0.000**	-0.000	-0.001
		(0.000)	(0.000)	(0.000)	(0.000)
CollaboratorProductivity		-0.003*	-0.005**	-0.004	-0.005
		(0.002)	(0.002)	(0.005)	(0.006)
Control variables	NO	YES	YES	YES	YES
SI fixed effect	NO	NO	YES	YES	YES
N	1,718	1,718	1,718	1,718	1,718
adj. R <sup>2</sup>	0.214	0.216	0.531	0.356	0.397

Standard errors in parentheses

\*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

To test the robustness of the results, we restricted the time difference between the mobility of *S2* and *S3* to one year and two years and re-ran the benchmark model. The results shown in Table 3 are consistent with the benchmark model. The coefficients of *AfterMoveFar* are negative and statistically significant at 0.01 level, and the magnitude of this coefficient does not change significantly.

Table 3. Model estimation results with a more strict time difference of collaborators' moving year.

	<b>The difference of the moving year ≤ 1 year</b>		<b>The difference of the moving year ≤ 2 years</b>	
	<b>ln(#publication+1)</b>	<b>ln(C<sub>3</sub>+1)</b>	<b>ln(#publication+1)</b>	<b>ln(C<sub>3</sub>+1)</b>
AfterMoveFar	-0.302***	-0.441***	-0.316***	-0.470***
	(0.0613)	(0.149)	(0.0538)	(0.122)
MoveFar	0.0372	-0.0476	-0.0304	-0.108
	(0.0428)	(0.103)	(0.0376)	(0.0853)
After	-0.557***	-1.386***	-0.529***	-1.351***
	(0.0432)	(0.105)	(0.0364)	(0.0878)
Control variables	YES	YES	YES	YES
SI fixed effect	YES	YES	YES	YES
N	972	972	1414	1414

adj. $R^2$	0.577	0.367	0.557	0.383
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Standard errors in parentheses

\*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Further, we calculated the number of co-publications and the citations per article in the four and five years before and after the mobility of collaborators and re-ran the model by replacing the dependent variables. The results shown in Table 4 are still consistent with those of the benchmark model.

Table 4. Model estimation results with collaboration performance in different time windows.

	Four-years co-publications		Five-years co-publications	
	$\ln(\#publication+1)$	$\ln(C_3+1)$	$\ln(\#publication+1)$	$\ln(C_3+1)$
AfterMoveFar	-0.343***	- 0.527***	-0.372***	- 0.555***
	(0.048)	(0.108)	(0.048)	(0.105)
MoveFar	-0.028	-0.090	-0.007	-0.051
	(0.034)	(0.073)	(0.033)	(0.069)
After	-0.513***	- 1.360***	-0.509***	- 1.394***
	(0.034)	(0.078)	(0.034)	(0.077)
Control variables	YES	YES	YES	YES
SI fixed effect	YES	YES	YES	YES
$N$	1868	1868	1968	1968
adj. $R^2$	0.523	0.390	0.514	0.409

Standard errors in parentheses

\*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

## 5. Discussion and Conclusions

This study examines the influence of geographic change on scientific collaboration due to the mobility of scientist collaborators. We focused on pairs of scientists, where one scientist has not relocated for a prolonged period, and their collaborator has either relocated within or across cities. For each immobile scientist, a collaborator with cross-city mobility is matched with another collaborator with same-city mobility. By comparing the changes in collaboration performance before and after the mobility, we estimated the causal effect of geographic change on collaboration. The results indicate that geographic change has a negative effect on scientific collaboration. Specifically, the numbers and citation impact of co-publications by scientist pairs decreased after collaborators moved to other cities.

The geographic mobility of collaborators has a significant impact on scientific collaboration in two distinct ways. First, collaboration productivity decreases after the cross-city mobility of collaborators. Geographic proximity is associated with



collaboration opportunities (Freeman et al., 2014). Long-distance collaboration brings high communication and travel costs, which significantly reduces collaboration productivity. Second, long-distance collaboration lowers the quality of collaboration. Transmission of tacit knowledge, in contrast to codified knowledge, heavily relies on face-to-face interaction, making it challenging to disseminate effectively through digital means (Hu et al., 2022). Despite advancements in virtual communication, face-to-face collaboration is difficult to replicate, which hinders mutual learning among scientists (van der Wouden & Youn, 2023) and the generation of creative ideas (Brucks & Levav, 2022; Horvát & Uzzi, 2022). In contrast, increasing offline meetings can lead to an improvement in the citation impact of co-publications papers (Catalini et al., 2020; Hu et al., 2022).

The contribution of this study exists in evidencing the argument that distance plays a crucial role in collaboration from a perspective of causal inference. The implications of this study are substantial for scientific collaboration, as it raises awareness among scientists regarding the significance of geographical proximity.

The study has several limitations. First, the ORCID data used in this study has inherent defects. The registered ORCID users are typically younger, and the distribution of countries is uneven (Bohannon, 2017), which may introduce some biases in our findings. Second, we used whether scientists move to a different city as a proxy for geographic change. However, different cities cover different geographic areas. In future work, we will utilize geographic coordinates to calculate the average geographic distance. Third, we overlooked the flow direction of collaboration, which may have varying impacts on collaboration performance due to changes in the research environment and institutional reputation (Deville et al., 2014).

### **Open science practices**

ORCID (Open Researcher and Contributor ID) is an open science data source that provides researchers with a unique identifier to distinguish them from other researchers. The ORCID platform provides a snapshot of all publish data in the Registry each year. The 2022 ORCID dataset we used was downloaded from [https://orcid.figshare.com/articles/dataset/ORCID\\_Public\\_Data\\_File\\_2022/21220892/6](https://orcid.figshare.com/articles/dataset/ORCID_Public_Data_File_2022/21220892/6).

### **Author contributions**

Xin Liu: Conceptualization, Methodology, Software, Data curation, Writing - original draft. Dan Tian: Data curation, Methodology, Writing - original draft. Jiang Li: Supervision, Conceptualization, Methodology, Writing - review & editing.

### **Reference**

Abramo, G., D'Angelo, C. A., & Di Costa, F. (2020). The role of geographical

- proximity in knowledge diffusion, measured by citations to scientific literature. *Journal of Informetrics*, 14(1), 101010. <https://doi.org/10.1016/j.joi.2020.101010>
- Abramo, G., D'Angelo, C. A., & Murgia, G. (2014). Variation in research collaboration patterns across academic ranks. *Scientometrics*, 98(3), 2275–2294. <https://doi.org/10.1007/s11192-013-1185-3>
- Bohannon, J., & Doran, K. (2017). Introducing ORCID. *Science*, 356(6339), 691–692. <https://doi.org/10.1126/science.356.6339.691>
- Brucks, M. S., & Levav, J. (2022). Virtual communication curbs creative idea generation. *Nature*, 605(7908), Article 7908. <https://doi.org/10.1038/s41586-022-04643-y>
- Cairncross, F. (2001). *The Death of Distance: How the Communications Revolution is Changing Our Lives*. Harvard Business School Press. [https://books.google.com.sg/books?id=6W\\\_-8GvYgD0C](https://books.google.com.sg/books?id=6W\_-8GvYgD0C)
- Catalini, C., Fons-Rosen, C., & Gaulé, P. (2020). How Do Travel Costs Shape Collaboration? *Management Science*, 66(8), 3340–3360. <https://doi.org/10.1287/mnsc.2019.3381>
- Deville, P., Wang, D., Sinatra, R., Song, C., Blondel, V. D., & Barabási, A.-L. (2014). Career on the Move: Geography, Stratification and Scientific Impact. *Scientific Reports*, 4(1), Article 1. <https://doi.org/10.1038/srep04770>
- Ding, Y. (2011). Scientific collaboration and endorsement: Network analysis of coauthorship and citation networks. *Journal of Informetrics*, 5(1), 187–203. <https://doi.org/10.1016/j.joi.2010.10.008>
- Fernández, A., Ferrándiz, E., & León, M. D. (2016). Proximity dimensions and scientific collaboration among academic institutions in Europe: The closer, the better? *Scientometrics*, 106(3), 1073–1092. <https://doi.org/10.1007/s11192-015-1819-8>
- Fernandez-Zubieta, A., Geuna, A., & Lawson, C. (2013). Researchers' Mobility and its Impact on Scientific Productivity. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.2244760>
- Fleming, L. (2001). Recombinant Uncertainty in Technological Search. *Management Science*, 47(1), 117–132. <https://doi.org/10.1287/mnsc.47.1.117.10671>
- Freeman, R. B., Ganguli, I., & Murciano-Goroff, R. (2014). Why and Wherefore of

- Increased Scientific Collaboration. In *The Changing Frontier: Rethinking Science and Innovation Policy* (pp. 17–48). University of Chicago Press. <https://doi.org/10.7208/chicago/9780226286860.003.0002>
- Frenken, K., Hardeman, S., & Hoekman, J. (2009). Spatial scientometrics: Towards a cumulative research program. *Journal of Informetrics*, 3(3), 222–232. <https://doi.org/10.1016/j.joi.2009.03.005>
- Groysberg, B., Lee, L.-E., & Nanda, A. (2008). Can They Take It With Them? The Portability of Star Knowledge Workers' Performance. *Management Science*, 54(7), 1213–1230. <https://doi.org/10.1287/mnsc.1070.0809>
- Horvát, E.-Á., & Uzzi, B. (2022). Virtual collaboration hinders a key component of creativity. *Nature*, 605(7908), 38–39. <https://doi.org/10.1038/d41586-022-00126-2>
- Hu, G., Ni, R., & Tang, L. (2022). Do international nonstop flights foster influential research? Evidence from Sino-US scientific collaboration. *Journal of Informetrics*, 16(4), 101348. <https://doi.org/10.1016/j.joi.2022.101348>
- 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. <https://doi.org/10.2307/2118401>
- Jones, B. F. (2009). The Burden of Knowledge and the “Death of the Renaissance Man” : Is Innovation Getting Harder? *The Review of Economic Studies*, 76(1), 283–317.
- Jones, B. F., Wuchty, S., & Uzzi, B. (2008). Multi-University Research Teams: Shifting Impact, Geography, and Stratification in Science. *Science*, 322(5905), 1259–1262. <https://doi.org/10.1126/science.1158357>
- Jonkers, K., & Tijssen, R. (2008). Chinese researchers returning home: Impacts of international mobility on research collaboration and scientific productivity. *Scientometrics*, 77(2), 309–333. <https://doi.org/10.1007/s11192-007-1971-x>
- Larivière, V., Gingras, Y., Sugimoto, C. R., & Tsou, A. (2015). Team size matters: Collaboration and scientific impact since 1900. *Journal of the Association for Information Science and Technology*, 66(7), 1323–1332. <https://doi.org/10.1002/asi.23266>
- Liu, M., & Hu, X. (2022). Movers' advantages: The effect of mobility on scientists' productivity and collaboration. *Journal of Informetrics*, 16(3), 101311. <https://doi.org/10.1016/j.joi.2022.101311>

- Luo, Q., Xia, J. C., Haddow, G., Willson, M., & Yang, J. (2018). Does distance hinder the collaboration between Australian universities in the humanities, arts and social sciences? *Scientometrics*, 115(2), 695–715. <https://doi.org/10.1007/s11192-018-2686-x>
- Milojević, S. (2014). Principles of scientific research team formation and evolution. *Proceedings of the National Academy of Sciences*, 111(11), 3984–3989. <https://doi.org/10.1073/pnas.1309723111>
- Nomaler, Ö., Frenken, K., & Heimeriks, G. (2013). Do more distant collaborations have more citation impact? *Journal of Informetrics*, 7(4), 966–971. <https://doi.org/10.1016/j.joi.2013.10.001>
- Olson, G. M., & Olson, J. S. (2000). Distance Matters. *Human–Computer Interaction*, 15(2–3), 139–178. [https://doi.org/10.1207/S15327051HCI1523\\_4](https://doi.org/10.1207/S15327051HCI1523_4)
- Ponds, R., Van Oort, F., & Frenken, K. (2007). The geographical and institutional proximity of research collaboration\*. *Papers in Regional Science*, 86(3), 423–443. <https://doi.org/10.1111/j.1435-5957.2007.00126.x>
- Tang, C., Qiu, P., & Dou, J. (2022). The impact of borders and distance on knowledge spillovers—Evidence from cross-regional scientific and technological collaboration. *Technology in Society*, 70, 102014. <https://doi.org/10.1016/j.techsoc.2022.102014>
- van der Wouden, F., & Youn, H. (2023). The impact of geographical distance on learning through collaboration. *Research Policy*, 52(2), 104698. <https://doi.org/10.1016/j.respol.2022.104698>
- Waltman, L., Tijssen, R. J. W., & Eck, N. J. van. (2011). Globalisation of science in kilometres. *Journal of Informetrics*, 5(4), 574–582. <https://doi.org/10.1016/j.joi.2011.05.003>
- Werker, C., & Ooms, W. (2020). Substituting face-to-face contacts in academics' collaborations: Modern communication tools, proximity, and brokerage. *Studies in Higher Education*, 45(7), 1431–1447. <https://doi.org/10.1080/03075079.2019.1655723>
- Wuchty, S., Jones, B. F., & Uzzi, B. (2007). The Increasing Dominance of Teams in Production of Knowledge. *Science*, 316(5827), 1036–1039. <https://doi.org/10.1126/science.1136099>
- Yao, X., Zhang, C., Qu, Z., & Tan, B. C. Y. (2020). Global village or virtual balkans?

Evolution and performance of scientific collaboration in the information age. *Journal of the Association for Information Science and Technology*, 71(4), 395–408. <https://doi.org/10.1002/asi.24251>

Zhao, Z., Bu, Y., & Li, J. (2022). Does the mobility of scientists disrupt their collaboration stability? *Journal of Information Science*, 48(2), 199–209. <https://doi.org/10.1177/0165551520948744>