Multi-university Research Collaborations:
Shifting Geography and Social Stratification in Science

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Supplementary Online Material

Supplementary Materials and Methods:

We downloaded all papers from the Institute of Scientific Information (ISI) database (www.ISIknowledge.com) in the subfields of Science and Engineering, Social Sciences and Arts and Humanities from *1975-2005* where at least one of the participating institutions is located in the USA. Although ISI provides paper records starting from the early 1900's, only entries from 1975 are fully annotated with auxiliary information about the authors and their full addresses. We obtained a total of *3,429,931* papers in Science and Engineering, *632,721* papers in Social Sciences and *173,333* papers in Arts and Humanities. To get an insight into the patterns of collaborations, we utilized a list of 662 universities in the USA that have been supported by grants of the National Science Foundation (NSF) in 2005 (please see SOM Table 1 for a list of these institutions). This sample allows us to focus on a well-defined set of university-to-university collaborations within the United States, as opposed to collaborations with government labs and other national and international research entities that are more difficult to identify and categorize in the data. Filtering all papers that have been published by these institutions only, we obtain *2,107,216* papers in Science and Engineering, *468,200* papers in Social Sciences and *166,595* papers in Arts and Humanities.

Each institution was annotated with its corresponding US-Zip code. We use zip codes for the determination of geographic distance between collaborating schools. In some cases, universities have distributed campuses that have different zip codes. Although we group campuses as a single entity in such a case, authors are assigned the zip code provided in the corresponding paper for any geographic distance calculations.

Supplementary Results:

### Science & Engineering   Social Sciences   Arts & Humanities
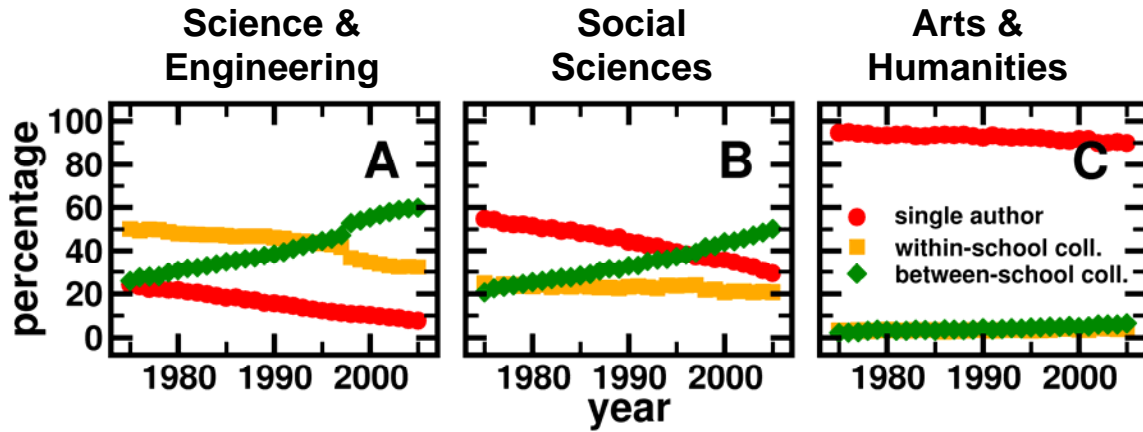
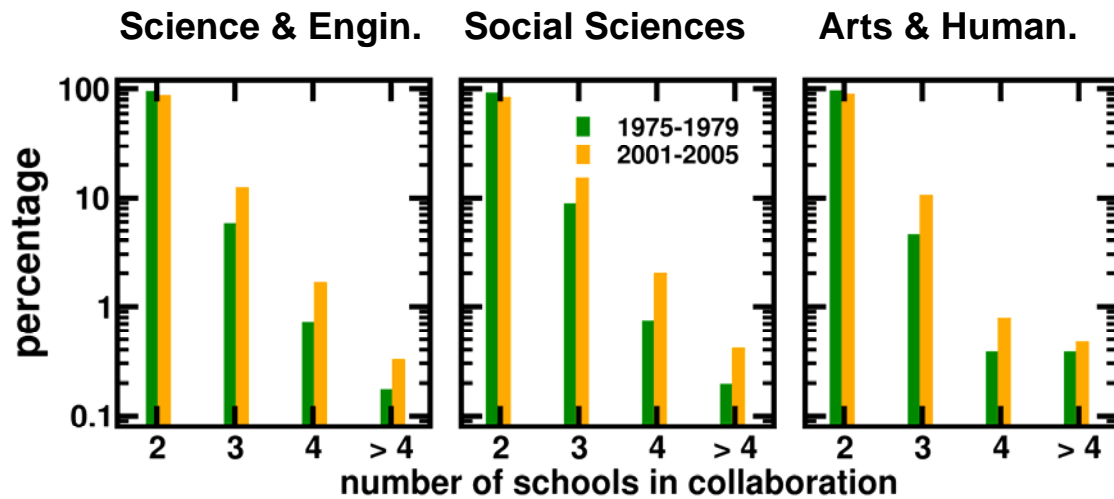**SOM Figure 1: Percentage of collaboration types involving additional institutions.** This figure repeats Fig. 1 in the main paper but with a broader definition of between-school collaboration. Focusing on the same set of 662 US universities, we now additionally include collaborations between authors at these universities with both (a) international collaborators and (b) collaborators at other US institutions (such as government labs and private sector companies). As in Fig. 1 in the main paper, we consider the fractions of papers in the fields of Science and Engineering (**A**), Social Sciences (**B**) and Arts and Humanities (**C**). When including additional types of collaboration partners as in the above figure, we continue to see sharp growth in multi-institutional collaboration. Given its broader definition the level of between-school collaboration appears naturally higher.
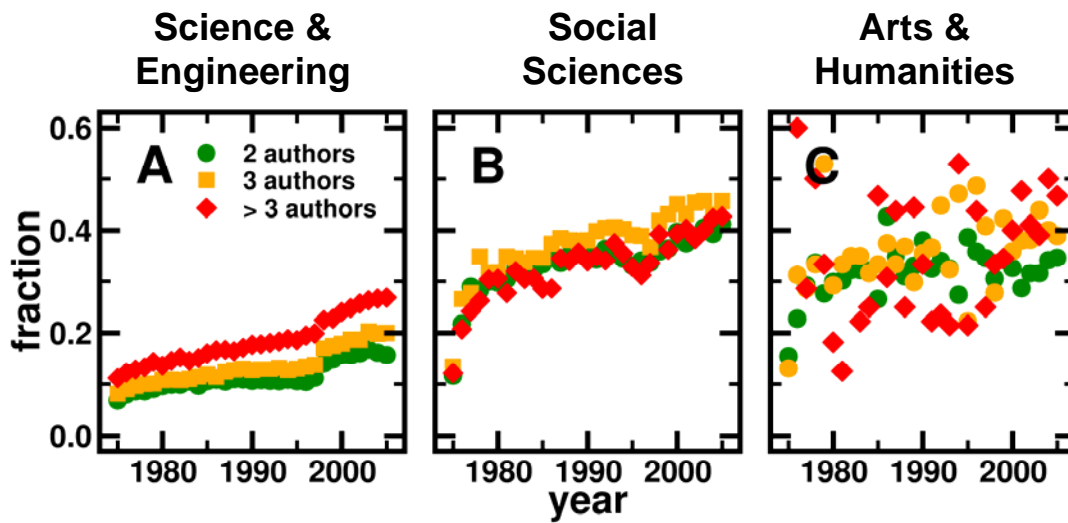
SOM Figure 2: Fractions of papers by team size. This figure shows, by team size, the fraction of papers that are written as multi-university collaborations. We see that the share of multi-university collaborations is rising regardless of team size in both Science and Engineering **(A)** and Social Sciences **(B),** while the pattern is weaker in Arts and Humanities **(C)**. SOM Fig. 4 plots the frequency distribution of number of universities that appear on a given paper.
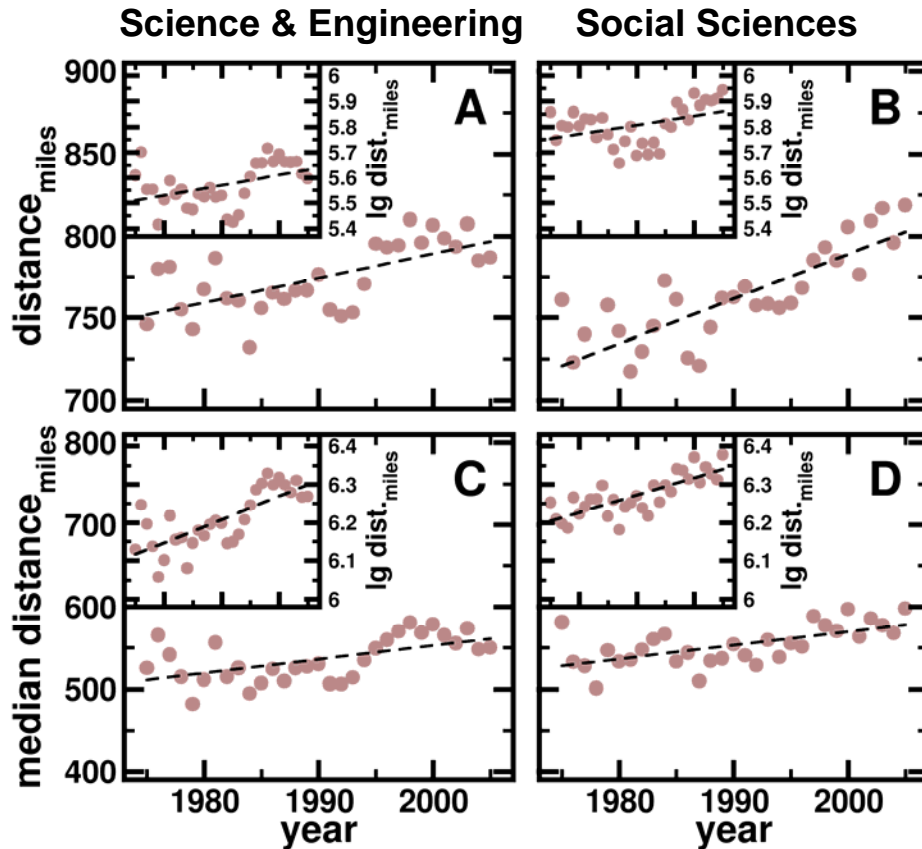
SOM Figure 3: Distances between collaborating schools. Considering papers written by authors at two different institutions in all fields and years we determined the average distance between the collaborating schools. Averages are weighted by the number of papers in each field and year. We observe statistically significant increases for Science and Engineering **(A)** in mean distance (Pearson's $r = 0.66, P < .0001$) and in the mean logarithm of distance (inset, $r = 0.43, P = .013$). **(B)** We observe similar trends in Social Sciences (mean distance: $r = 0.81, P < .0001$; mean lg distance: $r = 0.42, P = .014$). Utilizing the same approach, in **(C)** Science and Engineering we calculate the median distance between collaborating institutions ($r = 0.50, P = .0025$) and the logarithm of median distance (inset, $r = 0.75, P < .0001$). **(D)** We find similar patterns in Social Sciences (median distance $r = 0.61, P < .0001$; lg median distance $r = 0.78, P < .0001$).

Science & Engin. **Social Sciences** **Arts & Human.**

SOM Figure 4: Percentage of the number of collaborating schools. For multi-university papers, we investigate the percentage of the number of schools involved in collaborations in Science and Engineering, Social Sciences and Arts and Humanities in the periods of 1975-1979 and 2001-2005. Generally, we not only find a trend toward collaborations with an increasing number of schools but also that the vast majority of collaborations involve two schools.
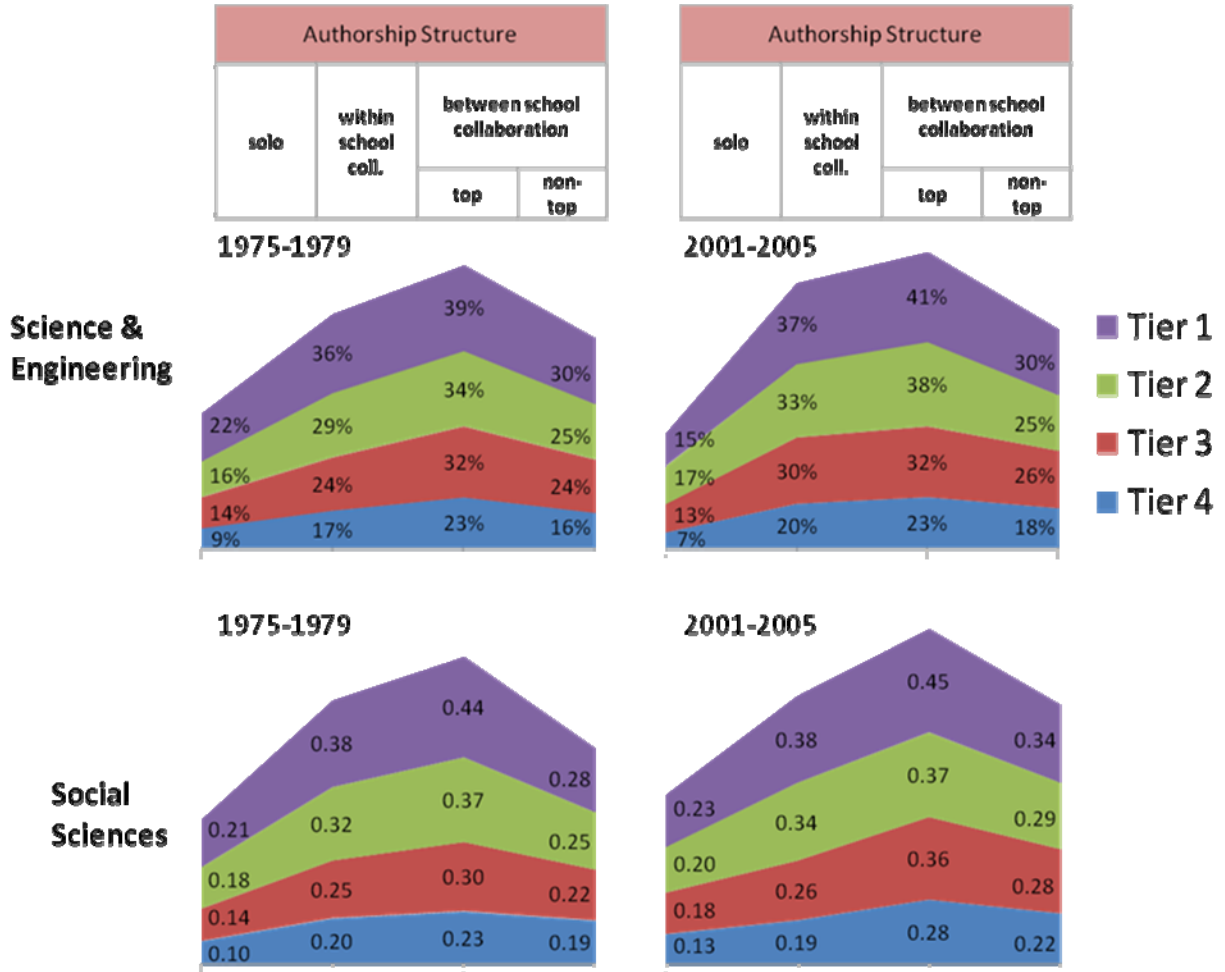
SOM Figure 5: Impact of collaborations with schools of different Tiers. We calculate the probability that a publication earns more than the average number of citations in the indicated time frame and field. We determine these probabilities for different authorship structures (solo, within-school collaborations, and between-school collaborations). For collaborations between schools, we further investigate the dependence on the type of collaboration partner. In particular, we rank schools according to the total number of citations each school receives in the corresponding years. Tier I schools were in the top 5% of the distribution, Tier II schools are in the 6-10%, Tier III schools are in the 11-20%, and Tier IV schools are the remainder. We define "top" schools as being either tier *1* and *2*.
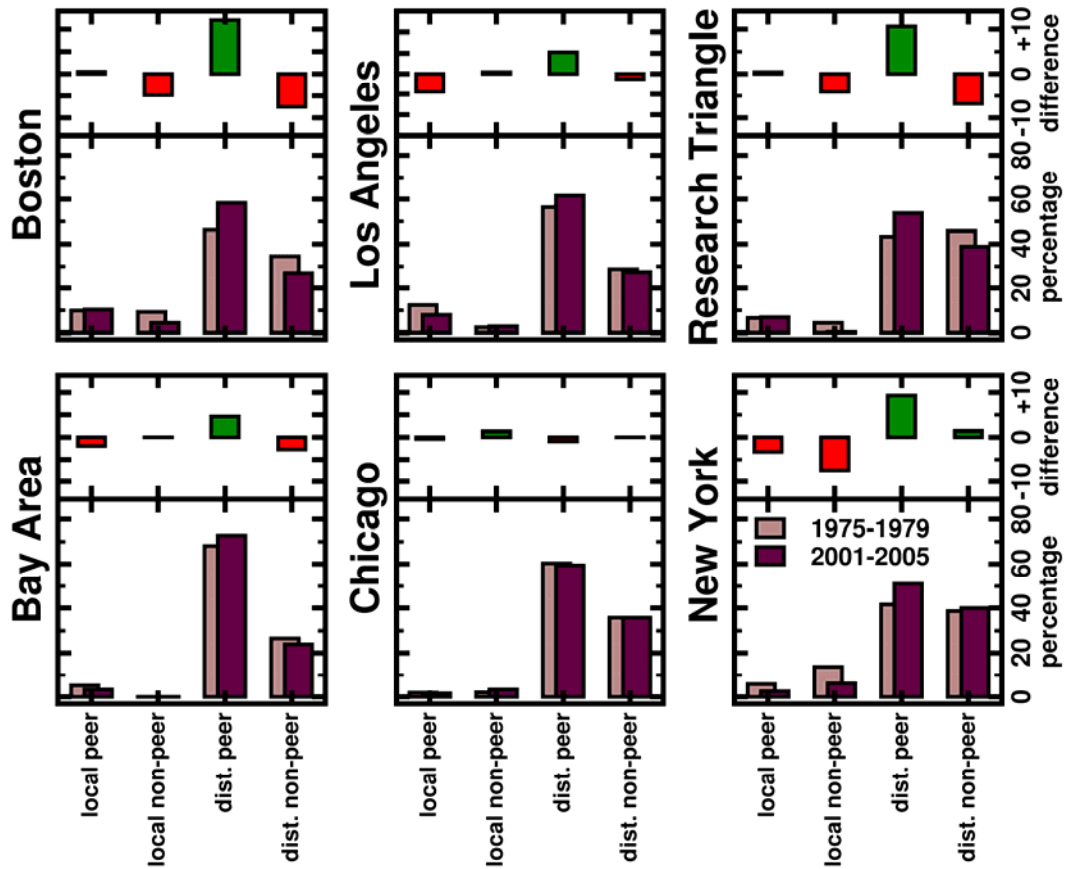
SOM Figure 6: Geographical patterns of collaborations in Science & Engineering I.
For Science and Engineering, we examine collaboration patterns for schools located in
the San Francisco Bay area, Boston, Chicago, Los Angeles, New York and the research
triangle in North Carolina. We define a (non-)peer school as an institution that is among
(outside) the top *10%* of ranked institutions. Similarly, we define local (distant) schools
as institutions that are less (more) than *20* miles away from the geographic center. The
geographic center is chosen as the zip code that allows us to encompass within *20* miles
the obvious eminent universities in each area (e.g. Harvard and MIT in Boston, Stanford
and UC Berkeley in the Bay Area, etc). Calculating the incidence of different types of
collaborations and changes in incidence between 1975-1979 and 2001-2005, we find that
the peer schools in the underlying areas are shifting toward distant collaborations with
other peer schools (χ^2-test, *p < .001*).
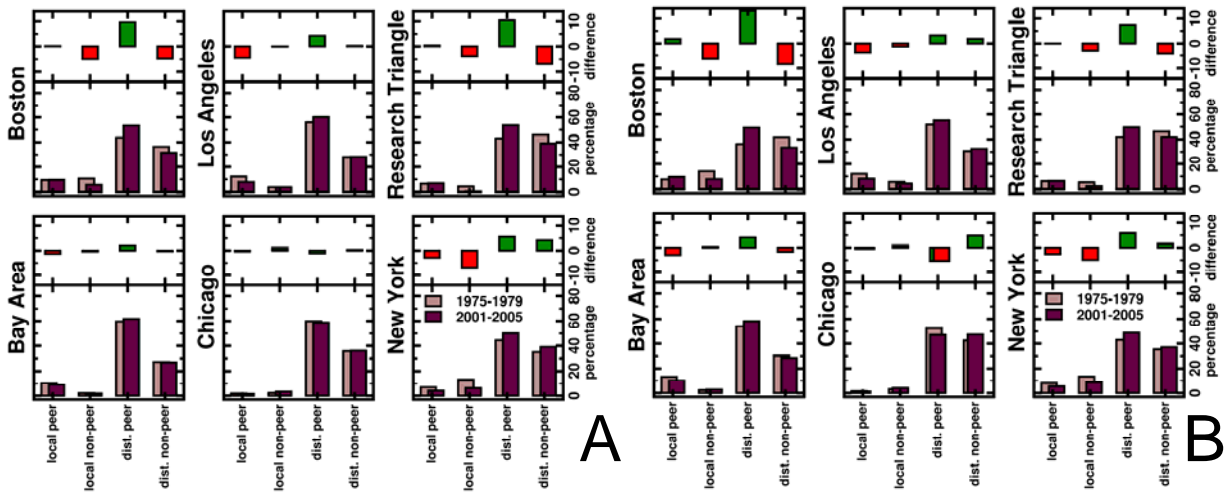
SOM Figure 7: Geographical patterns of collaborations in Science & Engineering II. We repeat SOM Figure 6 but with a larger geographic radius in defining local collaborators. Here we consider cutoffs based on *50* **(A)** and *100* **(B)** miles from the geographic center. The results are similar to those based on the shorter cutoff. In all areas, we find that the peer schools in the underlying areas shift toward distant collaborations with other peer schools, a statistically significant shift (χ^2-test, *p < .001*).
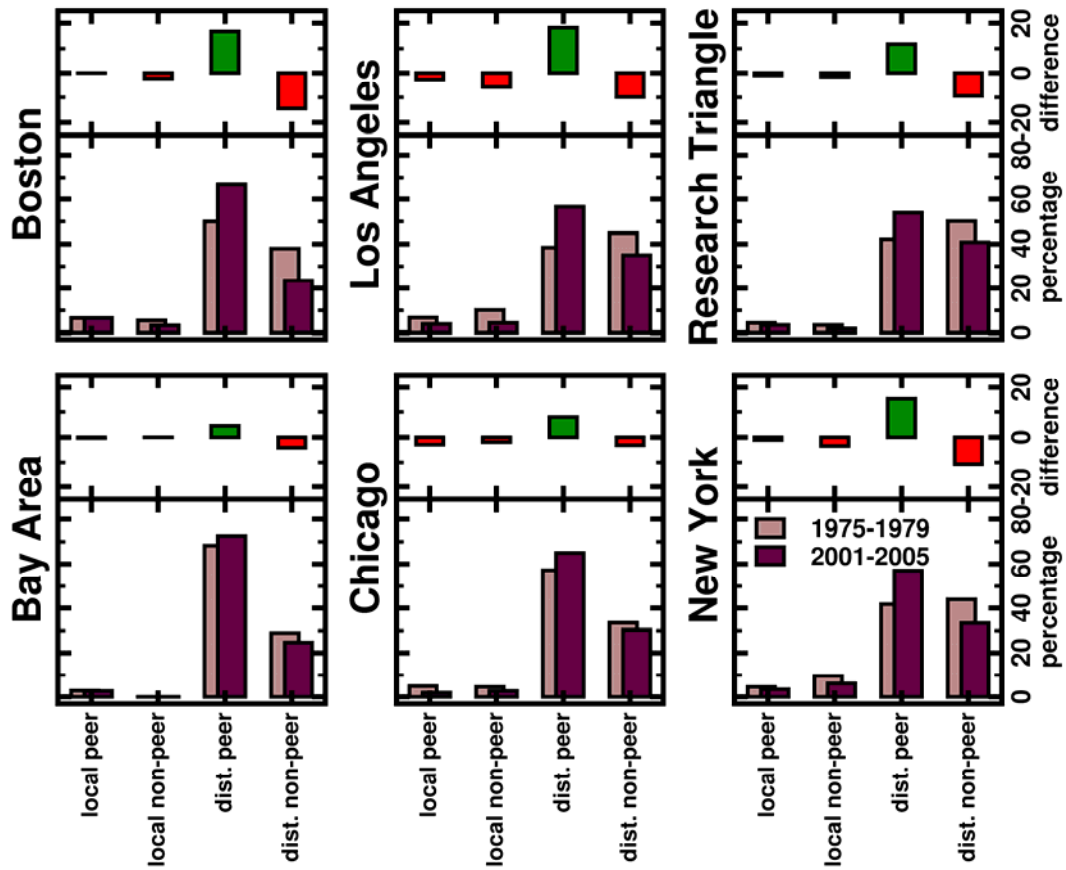
SOM Figure 8: Geographical patterns of collaborations in Social Sciences I. We repeat SOM Figure 6 but examine Social Science instead of Science and Engineering utilizing a *20* miles threshold. In all areas, we find that the peer schools in the underlying areas shift toward distant collaborations with other peer schools, a statistically significant shift applying a χ^2-test (*P < .001*).
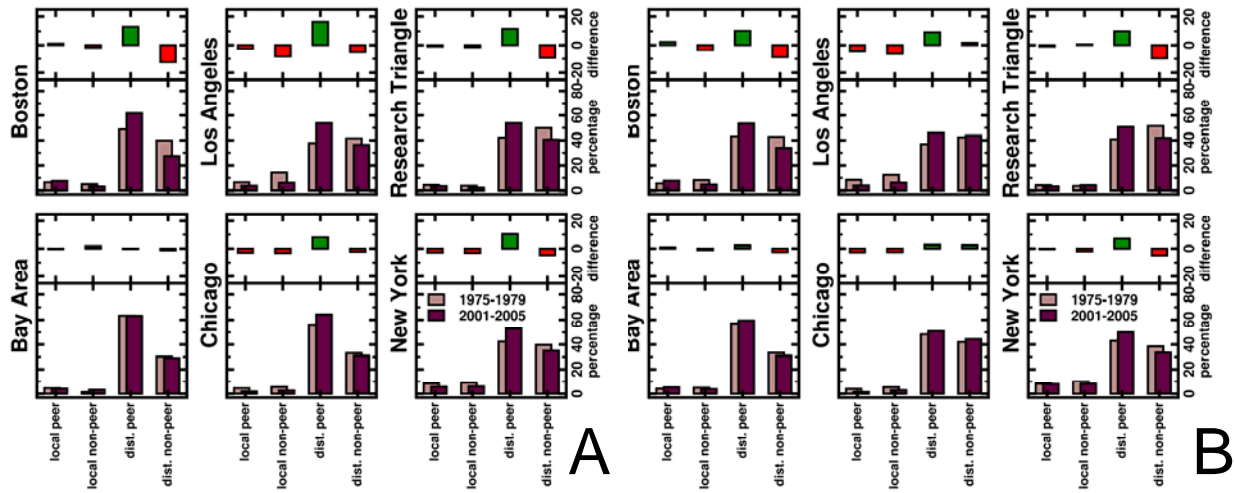
SOM Figure 9: Geographical patterns of collaborations in Social Sciences II. We repeat SOM Figure 8 for Social Sciences but with a larger geographic radius in defining local collaborators. Here we consider cutoffs based on *50 (A)* and *100 (B)* miles from the geographic center. The results are similar to those based on the shorter cutoff. In all areas, we find that the peer schools in the underlying areas shift toward distant collaborations with other peer schools, a statistically significant shift applying χ^2-test ($P < .001$).

SOM Table 1: List of Universities

1	A.T. Still University of Health Sciences	40	Bethune-Cookman College
2	Abilene Christian University	41	Biola University
3	Adelphi University	42	Black Hills State University
4	Air Force Institute of Technology	43	Bloomsburg University of Pennsylvania
5	Alabama Agricultural and Mechanical University	44	Bluefield State College
6	Alabama State University	45	Boise State University
7	Alaska Pacific University	46	Boston College
8	Albany College of Pharmacy	47	Boston University
9	Albany Medical College	48	Bowdoin College
10	Albany State University	49	Bowie State University
11	Alcorn State University	50	Bowling Green State University
12	Alfred University	51	Bradley University
13	Allegheny College	52	Brandeis University
14	Alliant International University	53	Bridgewater State College
15	American University	54	Brigham Young University
16	Amherst College	55	Brown University
17	Andrews University	56	Bryn Mawr College
18	Angelo State University	57	Bucknell University
19	Antioch University	58	Butler University
20	Appalachian State University	59	California Institute of Technology
21	Arizona State University	60	California State Polytechnic University San Luis Obispo
22	Arkansas State University	61	California State Polytechnic University Pomona
23	Arkansas Tech University	62	California State University Bakersfield
24	Assumption College	63	California State University Channel Islands
25	Auburn University	64	California State University Chico
26	Augsburg College	65	California State University Dominguez Hills
27	Augustana College	66	California State University East Bay
28	Austin Peay State University	67	California State University Fresno
29	Azusa Pacific University	68	California State University Fullerton
30	Babson College	69	Humboldt State University
31	Ball State University	70	California State University Long Beach
32	Barnard College	71	California State University Los Angeles
33	Barry University	72	California Maritime Academy
34	Bates College	73	California State University Monterey Bay
35	Baylor College of Medicine	74	California State University Northridge
36	Baylor University	75	California State University Sacramento
37	Bemidji State University	76	California State University San Bernardino
38	Benedict College	77	San Diego State University
39	Bennett College	78	San Francisco State University

79	San Jose State University	122	Coppin State University
80	California State University San Marcos	123	Cornell University
81	Sonoma State University	124	Creighton University
82	California State University Stanislaus	125	CUNY Baruch College
83	California University of Pennsylvania	126	CUNY Brooklyn College
84	Calvin College	127	CUNY College of Staten Island
85	Cameron University	128	CUNY Graduate Center
86	Carleton College	129	CUNY Herbert H. Lehman College
87	Carlos Albizu University	130	CUNY Hunter College
88	Carnegie Mellon University	131	CUNY John Jay College of Criminal Justice
89	Case Western Reserve University	132	CUNY Medgar Evers College
90	Catholic University of America	133	CUNY Queens College
91	Central Connecticut State University	134	CUNY The City College
92	Central Michigan University	135	CUNY York College
93	Central Missouri State University	136	Dartmouth College
94	Central State University	137	Delaware State University
95	Central Washington University	138	Denison University
96	Chapman University	139	DePaul University
97	Charles R. Drew University of Medicine and Sci	140	DePauw University
98	Chicago State University	141	Desert Research Institute
99	Claflin University	142	Dickinson College
100	Claremont Graduate University	143	Dillard University
101	Clarion University of Pennsylvania	144	Dominican University of California
102	Clark Atlanta University	145	Drake University
103	Clark University	146	Drexel University
104	Clarkson University	147	Duke University
105	Clemson University	148	Duquesne University
106	Cleveland State University	149	East Carolina University
107	Colby College	150	East Central University
108	Colgate University	151	East Stroudsburg University of Pennsylvania
109	College of Charleston	152	East Tennessee State University
110	College of New Jersey	153	Eastern Illinois University
111	College of New Rochelle	154	Eastern Kentucky University
112	College of St. Rose	155	Eastern Michigan University
113	College of the Holy Cross	156	Eastern New Mexico University
114	College of William and Mary	157	Eastern Oregon University
115	College of Wooster	158	Eastern Virginia Medical School
116	Colorado College	159	Eastern Washington University
117	Colorado School of Mines	160	Eckerd College
118	Colorado State University	161	Edinboro University of Pennsylvania
119	Columbia University	162	Elizabeth City State University
120	Connecticut College	163	Embry-Riddle Aeronautical University
121	Cooper Union	164	Emory University

165	Emporia State University	208	Haverford College
166	Evergreen State College	209	Hendrix College
167	Fairfield University	210	Hofstra University
168	Fairleigh Dickinson University	211	Hood College
169	Fayetteville State University	212	Hope College
170	Ferris State University	213	Howard University
171	Fisk University	214	Humboldt State University
172	Fitchburg State College	215	Idaho State University
173	Florida Agricultural and Mechanical University	216	Illinois Institute of Technology
174	Florida Atlantic University	217	Illinois State University
175	Florida Gulf Coast University	218	Indiana State University
176	Florida Institute of Technology	219	Indiana University Bloomington
177	Florida International University	220	Indiana University South Bend
178	Florida State University	221	Indiana University Kokomo
179	Fordham University	222	Indiana University East
180	Fort Hays State University	223	Indiana University Indianapolis
181	Fort Lewis College	224	Indiana University Northwest
182	Fort Valley State University	225	Indiana University Southeast
183	Franklin & Marshall College	226	Indiana University Northwest
184	Frostburg State University	227	Indiana University Southeast
185	Fuller Theological Seminary in California	228	Indiana University Fort Wayne
186	Furman University	229	Indiana University of Pennsylvania
187	Gallaudet University	230	Indiana Wesleyan University
188	Gannon University	231	Institute of Paper Science and Technology
189	George Mason University	232	Institute of Textile Technology
190	George Washington University	233	Iona College
191	Georgetown University	234	Iowa State University
192	Georgia College and State University	235	Ithaca College
193	Georgia Institute of Technology	236	Jackson State University
194	Georgia Southern University	237	Jacksonville State University
195	Georgia State University	238	James Madison University
196	Goucher College	239	Jarvis Christian College
197	Governors State University	240	John Carroll University
198	Grambling State University	241	Jarvis Christian College
199	Grand Valley State University	242	John Carroll University
200	Grinnell College	243	Johns Hopkins University, The
201	Gustavus Adolphus College	244	Juniata College
202	Hamilton College	245	Kalamazoo College
203	Hampshire College	246	Kansas City University of Med and Biosciences
204	Hampton University	247	Kansas State University
205	Hartwick College	248	Kean University
206	Harvard University	249	Kennesaw State University
207	Harvey Mudd College	250	Kent State University

251	Kentucky State University	294	Middle Tennessee State University
252	Kettering University	295	Middlebury College
253	Knox College	296	Midwestern State University
254	Kutztown University of Pennsylvania	297	Midwestern University
255	La Salle University	298	Miles College
256	Lafayette College	299	Millersville University of Pennsylvania
257	Lake Forest College	300	Milwaukee School of Engineering
258	Lamar University	301	Minnesota State University
259	Langston University	302	Mississippi State University
260	Lawrence Technological University	303	Mississippi University for Women
261	Lehigh University	304	Mississippi Valley State University
262	Lewis and Clark College	305	Monmouth University
263	Lincoln University	306	Montana State University
264	Loma Linda University	307	Montana Tech Univ
265	Long Island University	308	Montclair State University
266	Loras College	309	Morehead State University
267	Louisiana State University	310	Morehouse College
268	Louisiana Tech University	311	Morehouse School of Medicine
269	Loyola College	312	Morgan State University
270	Loyola Marymount University	313	Morris Brown College
271	Loyola University	314	Mount Holyoke College
272	Macalester College	315	Mount Sinai School of Medicine
273	Maharishi University of Management	316	Mount St. Mary's College
274	Manhattan College	317	Murray State University
275	Marist College	318	Naval Postgraduate School
276	Marquette University	319	New England College of Optometry
277	Marshall University	320	New Jersey City University
278	Marymount University	321	New Jersey Institute of Technology
279	Marywood University	322	New Mexico Highlands University
280	Massachusetts College	323	New Mexico Institute of Mining and Technology
281	Massachusetts Institute of Technology	324	New Mexico State University
282	McNeese State University	325	New School, The
283	MCP Hahnemann University	326	New York Institute of Technology
284	Medical College of Georgia	327	New York Medical College
285	Medical College of Wisconsin	328	New York University
286	Medical University of Ohio	329	Niagara University
287	Medical University of South Carolina	330	Nicholls State University
288	Meharry Medical College	331	Norfolk State University
289	Mercer University	332	North Carolina Agricultural University
290	MGH Institute of Health Professions	333	North Carolina Central University
291	Miami University	334	North Carolina State University
292	Michigan State University	335	North Central College
293	Michigan Technological University	336	North Dakota State University

337	Northeastern Illinois University	380	Purdue University
338	Northeastern Ohio Universities	381	Quinnipiac University
339	Northeastern State University	382	Radford University
340	Northeastern University	383	Reed College
341	Northern Arizona University	384	Regis University
342	Northern Illinois University	385	Rensselaer Polytechnic Institute
343	Northern Kentucky University	386	Rhode Island College
344	Northern Michigan University	387	Rice University
345	Northwest Missouri State University	388	Rider University
346	Northwestern State University	389	Rivier College
347	Northwestern University	390	Roanoke College
348	Nova Southeastern University	391	Rochester Institute of Technology
349	Oakland University	392	Rockefeller University
350	Oakwood College	393	Roosevelt University
351	Oberlin College	394	Rosalind Franklin University
352	Occidental College	395	Rose-Hulman Institute of Technology
353	Ohio State University	396	Rowan University
354	Ohio University	397	Rush University
355	Ohio Wesleyan University	398	Russell Sage College
356	Oklahoma State University	399	Rutgers University
357	Old Dominion University	400	Sacred Heart University
358	Oregon Health & Science University	401	Saginaw Valley State University
359	Oregon Institute of Technology	402	Sam Houston State University
360	Oregon State University	403	San Diego State University
361	Pace University	404	San Francisco State University
362	Pacific Lutheran University	405	San Jose State University
363	Pacific University	406	Santa Clara University
364	Pennsylvania College	407	Sarah Lawrence College
365	Pennsylvania State University	408	Savannah State University
366	Pepperdine University	409	Seattle University
367	Philadelphia College of Osteopathic Medicine	410	Seton Hall University
368	Pittsburg State University	411	Shaw University
369	Pitzer College	412	Shippensburg University of Pennsylvania
370	Point Loma Nazarene College	413	Simmons College
371	Polytechnic University	414	Skidmore College
372	Pomona College	415	Slippery Rock University of Pennsylvania
373	Ponce School of Medicine	416	Smith College
374	Pontifical Catholic University of Puerto Rico	417	Sonoma State University
375	Portland State University	418	South Carolina State University
376	Prairie View A&M University	419	South Dakota School of Mines and Technology
377	Prescott College	420	South Dakota State University
378	Princeton University	421	Southeast Missouri State University
379	Providence College	422	Southeastern Louisiana University

423	Southeastern Oklahoma State University	466	Swarthmore College
424	Southern Connecticut State University	467	Syracuse University
425	Southern Illinois University	468	Talladega College
426	Southern Methodist University	469	Tarleton State University
427	Southern Oregon University	470	Teachers College Columbia University
428	Southern University and A&M College	471	Temple University
429	Southwest Missouri State University	472	Tennessee State University
430	Spalding University	473	Tennessee Technological University
431	Spelman College	474	Texas A&M University
432	St. Cloud State University	475	Texas Christian University
433	St. John's University	476	Texas Southern University
434	St. Joseph College	477	Texas State University
435	St. Joseph's University	478	Texas Tech University
436	St. Louis University	479	Texas Woman's University
437	St. Mary's College of Maryland	480	Thomas Jefferson University
438	St. Mary's College	481	Tougaloo College
439	St. Mary's University	482	Towson University
440	St. Mary's University of Minnesota	483	Trinity College (Hartford, CT)
441	St. Olaf College	484	Trinity University
442	Stanford University	485	Truman State University
443	Stephen F. Austin State University	486	Tufts University
444	Stevens Institute of Technology	487	Tulane University
445	Sul Ross State University	488	Tuskegee University
446	SUNY Albany	489	Uniformed Services University
447	SUNY Binghamton	490	Union College
448	SUNY Buffalo	491	University of Akron
449	SUNY College Brockport	492	University of Alabama
450	SUNY College Buffalo	493	University of Alaska
451	SUNY College Cortland	494	University of Arizona
452	SUNY College Geneseo	495	University of Arkansas
453	SUNY College Environmental Science and Forestry	496	University of Baltimore
454	SUNY College of Optometry	497	University of California Berkeley
455	SUNY College Old Westbury	498	University of California Davis
456	SUNY College Oneonta	499	University of California Irvine
457	SUNY College Oswego	500	University of California Los Angeles
458	SUNY College Plattsburgh	501	University of California Riverside
459	SUNY College Potsdam	502	University of California San Diego
460	SUNY Fredonia	503	University of California San Francisco
461	SUNY Health Science Center Brooklyn	504	University of California Santa Barbara
462	SUNY New Paltz	505	University of California Santa Cruz
463	SUNY Purchase College	506	University of Central Arkansas
464	SUNY Stony Brook	507	University of Central Florida
465	SUNY Upstate Medical University	508	University of Central Oklahoma

509	University of Chicago	552	University of North Carolina
510	University of Cincinnati	553	University of North Dakota
511	University of Colorado	554	University of North Florida
512	University of Connecticut	555	University of North Texas
513	University of Dayton	556	University of Northern Colorado
514	University of Delaware	557	University of Northern Iowa
515	University of Denver	558	University of Notre Dame
516	University of Detroit Mercy	559	University of Oklahoma
517	University of Evansville	560	University of Oregon
518	University of Findlay	561	University of Pennsylvania
519	University of Florida	562	University of Pittsburgh
520	University of Georgia	563	University of Portland
521	University of Guam	564	University of Puerto Rico
522	University of Hartford	565	University of Puget Sound
523	University of Hawaii Hilo	566	University of Redlands
524	University of Houston	567	University of Rhode Island
525	University of Idaho	568	University of Richmond
526	University of Illinois	569	University of Rochester
527	University of Iowa	570	University of San Diego
528	University of Kansas	571	University of San Francisco
529	University of Kentucky	572	University of Scranton
530	University of La Verne	573	University of South Alabama
531	University of Louisiana	574	University of South Carolina
532	University of Louisville	575	University of South Dakota
533	University of Maine	576	University of South Florida
534	University of Maryland	577	University of Southern California
535	University of Maryland Baltimore County	578	University of Southern Maine
536	University of Maryland Eastern Shore	579	University of Southern Mississippi
537	University of Massachusetts	580	University of St. Francis
538	University of Medicine and Dentistry of NJ	581	University of St. Thomas
539	University of Memphis	582	University of Tennessee
540	University of Miami	583	University of Texas Arlington
541	University of Michigan	584	University of Texas Austin
542	University of Minnesota	585	University of Texas Brownsville
543	University of Mississippi	586	University of Texas Dallas
544	University of Missouri	587	University of Texas El Paso
545	University of Montana-Missoula	588	University of Texas San Antonio
546	University of Montana	589	University of Texas Tyler
547	University of Nebraska	590	University of Texas Health Science Center
548	University of Nevada	591	University of Texas M. D. Anderson Cancer Center
549	University of New Hampshire	592	University of Texas Medical Branch
550	University of New Haven	593	University of Texas of the Permian Basin
551	University of New Mexico	594	University of Texas Southwestern Medical Center

595	University of Texas-Pan American	630	Wesleyan University
596	University of the District of Columbia	631	West Chester University of Pennsylvania
597	University of the Incarnate Word	632	West Texas A&M University
598	University of the Pacific	633	West Virginia State University
599	University of the Sciences in Philadelphia	634	West Virginia University
600	University of the Virgin Islands	635	West Virginia University Institute of Tech.
601	University of Toledo	636	Western Carolina University
602	University of Tulsa	637	Western Connecticut State University
603	University of Utah	638	Western Illinois University
604	University of Vermont	639	Western Kentucky University
605	University of Virginia	640	Western Michigan University
606	University of Washington	641	Western New England College
607	University of West Florida	642	Western University of Health Sciences
608	University of West Georgia	643	Western Washington University
609	University of Wisconsin	644	Whitman College
610	University of Wyoming	645	Wichita State University
611	Utah State University	646	Widener University
612	Valdosta State University	647	Wilberforce University
613	Valparaiso University	648	Wiley College
614	Vanderbilt University	649	Wilkes University
615	Vassar College	650	Willamette University
616	Villanova University	651	William Paterson University of New Jersey
617	Virginia Commonwealth University	652	Williams College
618	Virginia Military Institute	653	Winston-Salem State University
619	Virginia Polytechnic Institute	654	Winthrop University
620	Virginia State University	655	Woods Hole Oceanographic Institution
621	Virginia Union University	656	Worcester Polytechnic Institute
622	Wabash College	657	Wright State University
623	Wagner College	658	Xavier University
624	Wake Forest University	659	Xavier University of Louisiana
625	Washington College	660	Yale University
626	Washington State University	661	Yeshiva University
627	Washington University in St. Louis	662	Youngstown State University
628	Wayne State University		
629	Wellesley College		

SOM Table 2: The Impact Advantage of Between-School Collaborations. The impact measure is the probability a given paper receives above average citations. Following our ranking procedure in the main text, top-tiers are defined as schools from Tier I and II, while non-top tier schools are in Tier III and IV. Marginal advantages of between-school collaborations are calculated from regressions (by tier) that include field, team size, and year fixed effects. Arrows mark direction of change. Marginal advantages are significant with *p*<.0001 unless noted by a "*" indicating *p*≤.1. Insignificant results appear in grey. Standard errors are clustered by subfield. Data cover the 1995-2005 period.

Percentage of papers receiving > mean citations

Science and Engineering

School Tiers	Within-School Collaboration Baseline	Between-School Collaboration Marginal Advantage Over Within-School Baseline		
Panel A: All Schools				
All	32.7%	↑ 2.89%		
Panel B: Schools separated by Tier				
		All Tiers	Top Tier	Non-Top Tier
Tier I	37.2%	↑ 1.82%	↑ 4.66%	↓ 2.26%
Tier II	32.7%	↑ 3.48%	↑ 7.15%	↓ 1.58%
Tier III	29.5%	↑ 3.66%	↑ 6.43%	↓ 1.72%
Tier IV	23.5%	↑ 4.54%	↑ 7.23%	↑ 1.05%*

Social Sciences

School Tiers	Within-School Collaboration Baseline	Between-School Collaboration Marginal Advantage Over Within-School Baseline		
Panel A: All Schools				
All	34.1%	↑ 5.71%		
Panel B: Schools separated by Tier				
		All Tiers	Top Tier	Non-Top Tier
Tier I	40.6%	↑ 4.78%	↑ 9.91%	↔ -1.66%
Tier II	36.6%	↑ 5.57%	↑ 12.0%	↓ 1.76%*
Tier III	30.3%	↑ 5.36%	↑ 10.2%	↔ -0.10%
Tier IV	22.9%	↑ 7.50%	↑ 12.1%	↑ 2.82%

SOM Table 3: The Impact Advantage of Between-School Collaborations in SE – Alternative Ranking Methods: This table repeats SOM Table 2 but uses alternative ranking methods. In the upper panel, Tiers I – IV are determined using the university Hirsch index. In the lower panel, Tiers I – IV are determined using a university's mean citations per paper.

Percentage of papers receiving > mean citations

Science and Engineering

School Tiers	Within-School Collaboration Baseline	Between-School Collaboration Marginal Advantage Over Within-School Baseline		
Panel: Schools separated by Tier(Hirsch)				
		All Tiers	Top Tier	Non-Top Tier
Tier I	37.9%	↑ 1.56%	↑ 4.47%	↓ 2.83%
Tier II	32.8%	↑ 3.43%	↑ 6.85%	↓ 1.05%*
Tier III	29.3%	↑ 3.82%	↑ 7.25%	↓ 1.88%
Tier IV	23.4%	↑ 4.51%	↑ 7.65%	↑ 1.17%

School Tiers		All Tiers	Top Tier	Non-Top Tier
Panel: Schools separated by Tier(Citations per Paper)				
Tier I	39.6%	↑ 1.27%	↑ 4.90%	↓ 2.49%
Tier II	35.1%	↑ 3.26%	↑ 7.43%	↔ -0.22%
Tier III	31.3%	↑ 3.64%	↑ 8.19%	↓ 0.81%*
Tier IV	26.0%	↑ 4.37%	↑ 8.90%	↑ 1.53%

SOM Table 4: The Impact Advantage of Between-School Collaborations in SS:.
This table repeats SOM Table 2 but uses alternative ranking methods. In the upper panel, Tiers I – IV are determined using the university Hirsch index. In the lower panel, Tiers I – IV are determined using a university's mean citations per paper.

Percentage of papers receiving > mean citations

Social Sciences

School Tiers	Within-School Collaboration Baseline	Between-School Collaboration Marginal Advantage Over Within-School Baseline		
Panel: Schools separated by Tier(Hirsch)				
		All Tiers	Top Tier	Non-Top Tier
Tier I	41.3%	↑ 4.58%	↑ 9.62%	↓ 2.01%*
Tier II	36.6%	↑ 5.34%	↑ 11.6%	↓ 1.29%*
Tier III	31.1%	↑ 5.78%	↑ 11.2%	↓ 1.21%*
Tier IV	21.8%	↑ 7.84%	↑ 12.5%	↑ 3.37%

School Tiers				
Panel: Schools separated by Tier(Citations per Paper)				
		All Tiers	Top Tier	Non-Top Tier
Tier I	43.6%	↑ 5.19%	↑ 10.3%	↔ +1.24%
Tier II	39.3%	↑ 5.26%	↑ 12.4%	↑ 1.23%*
Tier III	35.7%	↑ 5.18%	↑ 13.2%	↔ -0.34%
Tier IV	24.4%	↑ 7.75%	↑ 13.9%	↑ 4.88%

SOM Table 5: Who Collaborates with Whom?

For teams that span two different institutions, we calculate the percentages of papers published by pairs of schools in different tiers. Schools are ranked according to the main paper. Tier I schools are those ranked in the top 5%, Tier II (6-10%), Tier III (11-20%), and Tier IV (remainder). In the left panel, we show the percentage of two-school collaborations written by the corresponding tiers in 2001-2005. The right panel (upper rows, above diagonal) presents the ratio of this frequency to the expected frequency under random matching, given the propensity for schools in each tier to write papers. The right panel (lower rows, below diagonal) shows the change in this ratio between the 1975-1979 and 2001-2005 periods. All quantities in the right panel are statistically significant with p<.001 unless marked by a "†". Statistical significance is determined by bootstrapping.

Science and Engineering

Collaboration Frequency

Tier	1	2	3	4
1	16.6%	17.8%	15.5%	9.8%
2		4.9%	9.9%	7.1%
3			5.6%	8.4%
4				4.4%

Relative Risk Ratio

Tier	1	2	3	4
1	1.14 / +.05	0.98 / +.01	0.91 / -.04	0.81 / -.02
2		0.90 / +.09	0.94 / +.02	0.97 / -.07
3			1.03 / +.10	1.19 / -.05
4				1.89 / -.00†

Social Sciences

Collaboration Frequency

Tier	1	2	3	4
1	16.2%	15.0%	13.7%	11.2%
2		4.1%	9.2%	7.9%
3			5.1%	10.9%
4				6.7%

Relative Risk Ratio

Tier	1	2	3	4
1	1.27 / +.25	1.10 / +.17	0.86 / -.01	0.68 / -.07
2		0.97 / -.06	1.05 / -.08	0.91 / -.19
3			0.95 / -.14	1.14 / -.03
4				1.35 / -.02

SOM Table 6: Stratification of collaborations, SE and SS: Hirsch Index ranking method. This table repeats SOM Table 5 (see notes above) but uses the university Hirsch index to rank schools. This ranking approach produces similar stratification results.

Science and Engineering

Collaboration Frequency

Tier	1	2	3	4
1	16.2%	17.6%	15.0%	8.0%
2		5.4%	11.2%	7.5%
3			6.0%	8.6%
4				4.4%

Relative Risk Ratio

Tier	1	2	3	4
1	1.27 / +.12	0.99 / -.08	0.88 / -.02	0.73 / -.05
2		0.84 / +.02	0.93 / +.04	0.99 / +.01
3			1.04 / +.16	1.18 / -.05
4				1.86 / +.04

Social Sciences

Collaboration Frequency

Tier	1	2	3	4
1	15.4%	16.0%	12.6%	11.2%
2		4.3%	8.9%	8.7%
3			4.1%	11.0%
4				7.8%

Relative Risk Ratio

Tier	1	2	3	4
1	1.27 / +.21	1.12 / +.16	0.88 / +.03	0.66 / -.08
2		0.95 / -.03	1.07 / +.02	0.89 / -.19
3			0.98[†] / -.24	1.13 / -.10
4				1.33 / -.00

SOM Table 7: Stratification of collaborations, SE and SS: Mean Citations Per Paper Ranking Method. This table repeats SOM Table 5 (see notes above) but uses the university mean citations per paper to rank schools. This ranking approach produces similar stratification results.

Science and Engineering

Collaboration Frequency

Tier	1	2	3	4
1	13.5%	15.9%	11.5%	9.5%
2		3.9%	7.9%	8.0%
3			4.4%	13.8%
4				11.6%

Relative Risk Ratio

Tier	1	2	3	4
1	1.72 / +.20	1.54 / +.02	0.89 / +.01	0.56 / -.25
2		1.16 / +.17	0.92 / -.09	0.72 / -.19
3			0.82 / +.00	0.98 / +.05
4				1.26 / +.07

Social Sciences

Collaboration Frequency

Tier	1	2	3	4
1	2.5%	6.8%	8.6%	4.9%
2		3.8%	13.0%	9.1%
3			11.1%	23.0%
4				17.1%

Relative Risk Ratio

Tier	1	2	3	4
1	2.14 / +.68	1.78 / +.61	1.18 / +.25	0.60 / -.05
2		1.22 / +.38	1.10 / +.14	0.68 / -.13
3			0.98 / -.12	0.90 / -.22
4				1.19 / -.03

SOM Table 8: Ranking results with different methods. As a check on the face validity of ranking procedures, we provide a list of the top 50 schools in Science & Engineering according to the indicated rankings. Rankings based on citations per paper or citations per faculty member appear to have lower face validity, largely because they elevate to the upper ranks many schools that publish very rarely but happen to have one or more highly cited papers. Note that the main results for impact and stratification that are emphasized in the paper are substantially robust to the ranking method, as detailed in SOM Tables 2-7. This robustness follows largely because, although the rank ordering changes, many elite universities (Harvard, Stanford, MIT, etc) are still assigned to the top tier, and these universities dominate the tier compared to the small universities that publish very little.

Rank	Total Citations	Hirsch Index
1	HARVARD UNIVERSITY	HARVARD UNIVERSITY
2	STANFORD UNIVERSITY	STANFORD UNIVERSITY
3	UNIVERSITY OF CALIFORNIA BERKELEY	MASSACHUSETTS INSTITUTE OF TECHNOLOGY
4	UNIVERSITY OF MICHIGAN	YALE UNIVERSITY
5	UNIVERSITY OF CALIFORNIA LOS ANGELES	UNIVERSITY OF CALIFORNIA BERKELEY
6	UNIVERSITY OF WASHINGTON	UNIVERSITY OF PENNSYLVANIA
7	UNIVERSITY OF PENNSYLVANIA	UNIVERSITY OF CALIFORNIA SAN FRANCISCO
8	YALE UNIVERSITY	UNIVERSITY OF WASHINGTON
9	UNIVERSITY OF WISCONSIN	JOHNS HOPKINS UNIVERSITY, THE
10	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	UNIVERSITY OF CALIFORNIA LOS ANGELES
11	UNIVERSITY OF CALIFORNIA SAN FRANCISCO	UNIVERSITY OF CALIFORNIA SAN DIEGO
12	UNIVERSITY OF ILLINOIS	UNIVERSITY OF MICHIGAN
13	JOHNS HOPKINS UNIVERSITY, THE	WASHINGTON UNIVERSITY IN ST. LOUIS
14	UNIVERSITY OF CALIFORNIA SAN DIEGO	DUKE UNIVERSITY
15	WASHINGTON UNIVERSITY IN ST. LOUIS	ROCKEFELLER UNIVERSITY
16	UNIVERSITY OF MINNESOTA	UNIVERSITY OF TEXAS SOUTHWESTERN MEDICAL CENTER
17	DUKE UNIVERSITY	CALIFORNIA INSTITUTE OF TECHNOLOGY
18	CORNELL UNIVERSITY	UNIVERSITY OF WISCONSIN
19	UNIVERSITY OF NORTH CAROLINA	CORNELL UNIVERSITY
20	NORTHWESTERN UNIVERSITY	UNIVERSITY OF NORTH CAROLINA
21	UNIVERSITY OF CALIFORNIA DAVIS	NORTHWESTERN UNIVERSITY
22	PENNSYLVANIA STATE UNIVERSITY	BAYLOR COLLEGE OF MEDICINE
23	CALIFORNIA INSTITUTE OF TECHNOLOGY	UNIVERSITY OF CHICAGO
24	UNIVERSITY OF PITTSBURGH	COLUMBIA UNIVERSITY
25	UNIVERSITY OF COLORADO	NEW YORK UNIVERSITY
26	UNIVERSITY OF CHICAGO	UNIVERSITY OF MINNESOTA
27	UNIVERSITY OF FLORIDA	UNIVERSITY OF TEXAS M. D. ANDERSON CANCER CENTER
28	UNIVERSITY OF MARYLAND	UNIVERSITY OF MASSACHUSETTS
29	UNIVERSITY OF TEXAS M. D. ANDERSON CANCER CENTER	UNIVERSITY OF ILLINOIS
30	COLUMBIA UNIVERSITY	EMORY UNIVERSITY
31	UNIVERSITY OF MASSACHUSETTS	PRINCETON UNIVERSITY
32	BAYLOR COLLEGE OF MEDICINE	VANDERBILT UNIVERSITY
33	OHIO STATE UNIVERSITY	PENNSYLVANIA STATE UNIVERSITY
34	UNIVERSITY OF TEXAS SOUTHWESTERN MEDICAL CENTER	UNIVERSITY OF SOUTHERN CALIFORNIA
35	EMORY UNIVERSITY	UNIVERSITY OF PITTSBURGH

36	VANDERBILT UNIVERSITY	UNIVERSITY OF VIRGINIA
37	UNIVERSITY OF TEXAS AUSTIN	UNIVERSITY OF COLORADO
38	NEW YORK UNIVERSITY	BOSTON UNIVERSITY
39	TEXAS A&M UNIVERSITY	UNIVERSITY OF CALIFORNIA IRVINE
40	UNIVERSITY OF SOUTHERN CALIFORNIA	UNIVERSITY OF CALIFORNIA SANTA BARBARA
41	PRINCETON UNIVERSITY	UNIVERSITY OF CALIFORNIA DAVIS
42	UNIVERSITY OF ALABAMA	UNIVERSITY OF ALABAMA
43	UNIVERSITY OF VIRGINIA	UNIVERSITY OF UTAH
44	UNIVERSITY OF ARIZONA	UNIVERSITY OF ARIZONA
45	UNIVERSITY OF UTAH	UNIVERSITY OF FLORIDA
46	UNIVERSITY OF CALIFORNIA IRVINE	RICE UNIVERSITY
47	PURDUE UNIVERSITY	UNIVERSITY OF TEXAS AUSTIN
48	BOSTON UNIVERSITY	UNIVERSITY OF MARYLAND
49	UNIVERSITY OF IOWA	GEORGIA INSTITUTE OF TECHNOLOGY
50	ROCKEFELLER UNIVERSITY	UNIVERSITY OF IOWA

Rank	Ciations/Paper	Citations/Faculty member
1	ROCKEFELLER UNIVERSITY	BARNARD COLLEGE
2	HARVARD UNIVERSITY	ROCKEFELLER UNIVERSITY
3	PONCE SCHOOL OF MEDICINE	MGH INSTITUTE OF HEALTH PROFESSIONS
4	MGH INSTITUTE OF HEALTH PROFESSIONS	CUNY GRADUATE CENTER
5	UNIVERSITY OF TEXAS SOUTHWESTERN MEDICAL CENTER	LINCOLN UNIVERSITY
6	BRANDEIS UNIVERSITY	SARAH LAWRENCE COLLEGE
7	YALE UNIVERSITY	HAVERFORD COLLEGE
8	STANFORD UNIVERSITY	IONA COLLEGE
9	UNIVERSITY OF CALIFORNIA SAN FRANCISCO	ROOSEVELT UNIVERSITY
10	BAYLOR COLLEGE OF MEDICINE	BRANDEIS UNIVERSITY
11	RICE UNIVERSITY	HARVARD UNIVERSITY
12	WASHINGTON UNIVERSITY IN ST. LOUIS	RICE UNIVERSITY
13	MASSACHUSETTS INSTITUTE OF TECHNOLOGY	STANFORD UNIVERSITY
14	JOHNS HOPKINS UNIVERSITY, THE	PONCE SCHOOL OF MEDICINE
15	UNIVERSITY OF PENNSYLVANIA	HAMILTON COLLEGE
16	CALIFORNIA INSTITUTE OF TECHNOLOGY	YALE UNIVERSITY
17	EMORY UNIVERSITY	UNIVERSITY OF TEXAS SOUTHWESTERN MEDICAL CENTER
18	NEW YORK UNIVERSITY	CALIFORNIA INSTITUTE OF TECHNOLOGY
19	MOUNT SINAI SCHOOL OF MEDICINE	PRINCETON UNIVERSITY
20	UNIVERSITY OF TEXAS M. D. ANDERSON CANCER CENTER	HARTWICK COLLEGE
21	UNIVERSITY OF CHICAGO	PEPPERDINE UNIVERSITY
22	UNIVERSITY OF CALIFORNIA BERKELEY	BAYLOR COLLEGE OF MEDICINE
23	DUKE UNIVERSITY	MASSACHUSETTS INSTITUTE OF TECHNOLOGY
24	HAMILTON COLLEGE	WOODS HOLE OCEANOGRAPHIC INSTITUTION
25	HAVERFORD COLLEGE	UNIVERSITY OF CALIFORNIA SAN FRANCISCO
26	BOSTON COLLEGE	UNIVERSITY OF CALIFORNIA BERKELEY
27	UNIVERSITY OF CALIFORNIA SAN DIEGO	UNIVERSITY OF CALIFORNIA SANTA CRUZ
28	HENDRIX COLLEGE	UNIVERSITY OF TEXAS M. D. ANDERSON CANCER CENTER
29	PRINCETON UNIVERSITY	WASHINGTON UNIVERSITY IN ST. LOUIS
30	THOMAS JEFFERSON UNIVERSITY	UNIVERSITY OF CHICAGO
31	PEPPERDINE UNIVERSITY	UNIVERSITY OF CALIFORNIA SANTA BARBARA

32	UNIVERSITY OF CALIFORNIA LOS ANGELES	DUKE UNIVERSITY
33	NORTHWESTERN UNIVERSITY	BOSTON COLLEGE
34	VANDERBILT UNIVERSITY	EMORY UNIVERSITY
35	UNIVERSITY OF WASHINGTON	UNIVERSITY OF PENNSYLVANIA
36	COLUMBIA UNIVERSITY	UNIVERSITY OF CALIFORNIA SAN DIEGO
37	UNIVERSITY OF MASSACHUSETTS	SUNY COLLEGE ONEONTA
38	UNIVERSITY OF NORTH CAROLINA	JOHNS HOPKINS UNIVERSITY, THE
39	TUFTS UNIVERSITY	NORTHWESTERN UNIVERSITY
40	UNIVERSITY OF CALIFORNIA SANTA BARBARA	SKIDMORE COLLEGE
41	UNIVERSITY OF CALIFORNIA SANTA CRUZ	CUNY HUNTER COLLEGE
42	INDIANA UNIVERSITY NORTHWEST	UNIVERSITY OF CALIFORNIA LOS ANGELES
43	GEORGETOWN UNIVERSITY	VANDERBILT UNIVERSITY
44	BOSTON UNIVERSITY	UNIVERSITY OF OREGON
45	UNIVERSITY OF VIRGINIA	UNIVERSITY OF WASHINGTON
46	OREGON HEALTH & SCIENCE UNIVERSITY	NEW YORK UNIVERSITY
47	ALBANY MEDICAL COLLEGE	UNIVERSITY OF NORTH CAROLINA
48	UNIVERSITY OF CALIFORNIA IRVINE	UNIVERSITY OF MASSACHUSETTS
49	UNIVERSITY OF ROCHESTER	PRESCOTT COLLEGE
50	UNIVERSITY OF MICHIGAN	HAMPTON UNIVERSITY