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Is economics a house divided? Analysis of citation networks

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Is Economics a House Divided? Analysis of Citation Networks

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IS ECONOMICS A HOUSE DIVIDED? ANALYSIS OF CITATION NETWORKS

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Is Economics a House Divided? Analysis of Citation Networks*

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Abstract

We investigate divisions within the citation network in economics using citation data between 1990 and 2010. We consider all partitions of top institutions into two equal-sized clusters, and pick the one that minimizes cross-cluster citations. The strongest division is much stronger than could be expected to be found under idiosyncratic citation patterns, and is consistent with the reputed freshwater/saltwater division in macroeconomics. The division is stable over time, but varies across the fields of economics.

Keywords: citations, clustering, influence, schools of thought

JEL Codes: A11, D85, I23

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1 Introduction

We ask whether the academic discipline of Economics is divided into clusters of universities where authors tend to cite authors from the same cluster more than could be expected under idiosyncratic differences in citation patterns. We use citation data between top economics journals to construct the citation matrix between authors' home institutions. We compare all possible partitions of top universities into two equal-size clusters. We find a very significant division between top universities in this citation network, and it is consistent with what is commonly thought as the divide between "freshwater" and "saltwater" schools.

The likelihood of citing a paper by an author from another university in the same "cluster" is about 16% higher than the likelihood of citing a paper by an author from the other cluster. We assess the statistical significance of this division using simulations. In each simulated citation network, the likelihood of citation propensities is independent across university pairs, while average citation propensities and the distribution of pairwise deviations from average propensities each university match their empirical counterparts. The division is statistically extremely significant, and is robust to considering different extents of "top universities" and across time periods. However, there are significant differences across fields of economics, with macroeconomics and econometrics exhibiting the strongest division and economic theory no division at all.

2 Data

2.1 Data Sources

We use the citation data of articles published in 102 economics journals between 1990 and 2010, where the set of top journals was taken from the classification by Combes and Linnemer (2010).¹ The data was obtained from Thomson Scientific's Web of Science, which is an online database pooling journal articles' data from major databases including Science Citation Index Expanded (SCI-EXPANDED), Social Sciences Citation Index (SSCI), Arts and Humanities Citation Index (A&HCI). Notes, editorials, proceedings, reviews, and discussions were not included. The resulting data cover 97,526 unique articles with 34,431 unique contact authors and 1187 unique affiliations associated with these contact authors.

Our data set contains information on articles cited in the reference sections of these articles. Data on cited articles consist of year of publication, name of journal and name of the contact author.²

¹For the complete list of journals and their summary statistics, see Table A1 in the online appendix.

²Only the name of the contact author is available, even if the cited paper has more than one

2.2 Construction of the Citation Matrix

We use articles published between 1990 and 2010 and articles cited by them to construct a citation matrix between institutions. Data on contact authors of citing articles contain also their affiliation at the time of publication. However, author affiliations for cited articles are not directly observed. Hence we construct a career path for each author from 1977 to 2010 by using affiliation information of citing articles. For this task we also use data on articles published between 1977 and 1989, in order to enlarge the set of cited articles that can be matched with an author affiliation. If an author did not publish in our sample journals in a year then we use his or her next known affiliation; if no affiliation is observed between the cited year and 2010, then we use the last previously observed affiliation. Using this procedure, we are able to identify 36,189 unique authors of a total of 1,662,212 cited articles in the reference sections of 91,635 unique articles written by 32,572 unique authors. Authors of a total of 753,230 cited articles could not be matched with an affiliation. The observed affiliations form a total of 1187 citing and 1192 cited institutions.

We measure citations in units, so that every article conveys one unit of citations, regardless of how many documents it cites. For example, if an article by an author from MIT cites 20 articles, and 4 of them by Harvard authors, then this counts as $4/20 = 0.2$ units of citations from MIT to Harvard.³ Cited publications whose author cannot be matched with an affiliation are treated as authored at an institution called "Unknown".

Citation data is gathered in the aggregate citation matrix, which gives the sum of unit citations from all articles. The element at row i and column j is the sum of unit citations by authors from institution i to articles by authors from institution j . To analyze of subsets of journals and publication years we restrict the summation to subsets of articles, whereas when analyzing subsets of institutions we just keep the relevant submatrix of the aggregate citation matrix.

2.3 Summary Statistics

Figure 1 shows the distribution of articles in our data by publication year. Steady increase in the annual number of articles reflects an increase in the number of journals as well as increase in articles per journal-year. Of the 102 journals in the set 79 were in existence in 1990 and 96 in 2000. The average number of articles published in a journal per year increased from 50 in 1990 to 54 in 2000, and to 73 in 2010.

author.

³It would be ideal to also divide citations for multi-author documents proportionally between the authors, but observing only on the contact author affiliation precludes this.

Figure 1 also shows the distribution of out-citations that are used in the construction of our citation matrix by publication year. The number of out-citations in a given year is the number of articles (in citation units) for which an author affiliation could be identified. Number of in-citations in a given year equals total citation units received by articles published in that year and for which an author affiliation could be identified.

Selected summary statistics of the citation matrix are reported in Table 1. Self-cites, which are dropped from the final analysis, are reported separately. Cites to articles whose contact author could not be matched with an institution are listed as "cites to unknown". All cites are measured in units-per-citing-article, so the sum of outgoing cites, self-cites, and cites to unknown adds up to the total number of articles published by contact authors from each institution.

3 Analysis

There are authors from 1192 institutions in the data. To analyze their possible division we restrict the analysis to a subset of top institutions. We define the "top" by the ranking of institutions by influence in the network of citations, using eigenvalue centrality; for details, see Pinski and Narin (1976).⁴ Self-citations are removed before calculating influence. Table 1 lists the influence measure for the top 50 institutions by influence. Our main specification considers the division between the top 20 academic institutions.

Our goal is to find out whether institutions can be divided into "clusters" within which authors cite each other more than could be expected under idiosyncratic citation patterns. Self-citations are a potential confounding factor, because citations within an institution are necessarily also within-cluster citations. Over 10% of cites in our data are institutional self-cites.⁵ We ignore all self-citations, effectively replacing the diagonal elements of the citation matrix with zeroes.

To measure clustering we use a slightly modified version of Q -modularity of Girvan and Newman (2002).⁶ For a given partition of institutions to clusters, Q measures the difference between the actual and expected proportion of cites between clusters, where the expectation is calculated under independently distributed citation patterns. The strongest division in the network is that which maximizes modularity. Our ad-

⁴Davis and Papanek (1984) provide an early study of department rankings based on citation counts. For rankings of academic journals using network influence, see Liebowitz and Palmer (1984), and *Eigenfactor.org*. Amir and Knauff (2008) and Terviö (2011) apply this method to data on PhD placement / faculty hiring data.

⁵Note that we cannot distinguish between authors citing themselves, and authors citing their peers at the same institution, because we only have data on contact author affiliation.

⁶Newman (2004) shows that this method, although originally defined for binary networks, is also suitable for weighted networks.

ditional normalization takes into account the impact of removing self-citations on expected citation patterns. Without this correction, the expectation benchmark would always predict a significant amount of self-citations. With the correction, expected self-citations are set to zero. Intuitively, the expected citation patterns are calculated under the hypothesis that authors at all institutions distribute their outbound non-self cites at a probability that depends only on target institution, not on sender institution. Analyzing proportions instead of cite counts also serves as a normalization that gives each institution equal weight in defining the strength of deviations from expectation, regardless of its share of all citations.

Denote the aggregate citation matrix for the set of n institutions by M . The normalized citation matrix T has typical elements

$$T_{ij} = M_{ij} / \sum_{i \neq h} M_{ih} \text{ for } i \neq h \quad (1)$$

and $T_{ii} = 0$. Row i measures citations as proportions of outbound non-self cites from institution i . We define its expectation as the average fraction of non-self citations by departments other than i going to department j :

$$E_{ij} = \frac{1}{n-2} \sum_{h \neq i} T_{hj} \text{ for } h \neq j \quad (2)$$

and $E_{ii} = 0$, for $i = 1, \dots, n$. Finally, the citation information that is used in the analysis is contained in the matrix of deviations from expected citation patterns $\Omega = T - E$.

Table 2 shows the unit citations between the top 20 academic institutions, i.e., the matrix M . The background colors of the table represent a heat map of the pairwise deviations from expected citation patterns, i.e., the elements of Ω . If a row department cites a column department more than expected then the corresponding element is red, if citing is less than expected then the element is blue; darkness captures the magnitude of the deviation.

We consider all partitions of the set of n institutions into two equal-sized clusters. The existence of discrete clusters is, of course, an abstraction; the point of this exercise is to uncover a dimension of differentiation in the citation patterns of institutions. Formally, consider any partition of the set of n institutions into subset A and its complement. Our measure for the strength of the division is

$$Q(A|\Omega) = e'_A \Omega e_A + (l - e_A)' \Omega (l - e_A), \quad (3)$$

where e_A is the membership vector for subset A , equal to unity for members and zero for non-members, and l is a vector of ones. This measure gives the sum of total deviations from the expected proportion of normalized citations for within-cluster pairs

of institutions. (Deviations add up to zero, so the amount of deviations for between-cluster pairs of institutions is necessarily just the negative of Q and can be omitted.)

We define the strongest division to be the partition A into two clusters of $n/2$ institutions that maximizes $Q(A|\Omega)$.⁷ Thus, for a set of n institutions, with n even, there are $c_n = \frac{1}{2} \binom{n}{n/2}$ different ways of dividing them into two equal-sized clusters. The problem of finding the optimal partition of a graph is NP-hard, and standard algorithms do not necessarily find the strongest partition. We use the brute force method and select the strongest of all possible partitions.

Clustering results The strongest division is depicted in the last columns of Table 1 for $n = 12, 16, 20, 24$. We call the cluster that includes Harvard "the Saltwater cluster" and the other "the Freshwater cluster."⁸ Most departments always show up in the same cluster. Chicago, Northwestern, Penn, and Rochester are always in the Freshwater cluster; MIT, Stanford, Princeton, Berkeley, and Columbia are always in the Saltwater cluster. The only institutions whose cluster membership varies by specification are Yale and Michigan.

The magnitude of the division can be illustrated by considering the relative propensities to cite within and between clusters. Among the top 20 academic institutions, the average number of unit citations between a pair of institutions in different clusters is 11.76, while the average for institution pairs in the same cluster is 13.67, that is 16% higher. Among the top 16 academic institutions, the average number of unit citations between a pair of institutions in different clusters is 14.91, while the average for institution pairs in the same cluster is 17.32, that is 16% higher.

Strength of attachment The relative strength of attachment to the Salt and Freshwater clusters can be measured for any institution that hosts authors that publish in our sample of journal articles. Table 1 lists the "relative salt" measure for the 50 most influential institutions. It measures the average deviation from the expected share of outgoing citations to Saltwater members in excess of the share going to members of the Freshwater cluster. True to name, the saltiest of saltwater schools appear to be Berkeley and MIT, while Minnesota and Rochester are the freshest of the fresh. Chicago appears surprisingly "neutral" along with Stanford, Yale, and Columbia. Note that, as self-citations were removed and as Chicago is by far the most heavily cited Freshwater department, a disproportionate share of its citations to the Freshwa-

⁷There could, in principle, be several maximizers, but this never occurs in our data.

⁸Stanford economist Robert E. Hall first came up with the freshwater/saltwater term in the 1970s, based on the then workplaces of a group of leading macroeconomists with a distinctive style of research: Robert E. Lucas at Chicago, Thomas Sargent at Minnesota, and Robert Barro at Rochester. See "Fresh Water' Economists Gain," New York Times, July 23, 1988.

ter cluster are ignored in the analysis. Outside academia, the Federal Reserve Bank appears quite "fresh" while World Bank and IMF are somewhat "salty." The joint pattern of attachment to clusters and influence in the citation network and is depicted in Figure 2. The rough pyramid shape of the scatter plot reveals how more influential institutions tend to be less "partisan" in terms of the salt/fresh division.

More precisely, redefine Ω to include all departments and not just the top n . We define the "salt content" of department i as

$$S_i = \frac{e_i' \Omega e_S}{(l - e_i)' e_S} - \frac{e_i' \Omega e_F}{(l - e_i)' e_F}, \quad (4)$$

where e_i is the i th unit vector, and e_S and e_F are the membership vectors of Saltwater and Freshwater clusters. The divisors account for the removal of self-cites: top institutions are themselves members of a cluster, and have one less potential citation partner in their own cluster. Finally, "relative salt" is obtained by subtracting the mean salt content of all departments (0.385).

4 Is the division statistically significant?

Given the large number of possible partitions, it would often be possible to find partitions where the division appears strong even for a random pattern of deviations. To test the statistical significance of the division, we have to take into account that the partition has been selected as the strongest possible from the set of possible partitions, precisely in order to maximize the strength of the apparent division.

We measure the statistical significance of the division by comparing the strength of the strongest division found in the actual sample to its bootstrapped distribution. The bootstrap distribution is obtained by generating random permutations of the deviation matrix Ω and measuring the strength of the strongest division found for each permutation. In these permutations we randomly reorder the off-diagonal elements of Ω , separately for each column, treating all possible permutations as equally likely. These simulated deviation matrices describe a world where the average share of incoming citations is held fixed for each university, but deviations from average non-self citation patterns are idiosyncratic. Furthermore, in the simulation, the distribution of pairwise deviations Ω_{ij} is the same as in actual data, but a tendency to cite a particular institution more does not imply a tendency to cite another particular institution more.

The strongest partition under the random benchmark always appears "statistically significant" to a naive test that treats the strongest partition as given. We conducted 10,000 simulations for each $n = 12, 16, 20$, and 2000 for $n = 24$. In all of these simulations there is only one instance where it is possible to find a division as strong

as we find in the actual data, for $n = 16$. Therefore we conclude that the division is statistically very significant.

5 Subsamples

Time periods We repeat the cluster analysis for a subset of citation years, using a rolling 10-year window starting from 1990-99 and ending in 2001-10, with the set of departments fixed at the top 16 academic departments as calculated for the whole time period. The strongest division is the same throughout the period, but there appears to be a secular trend towards a weaker division.

The time period results are summarized in Figure 3, which plots the strength of attachment to saltwater cluster (as defined in that period) against the last year of the 10-year time window. A noticeable development is the increasing "saltiness" of Chicago. Towards the end of the period, Chicago has a higher relative propensity to cite authors at saltwater schools than the average of all 1187 institutions in the data. Despite this, Chicago shows up in the Freshwater cluster in every time period, because it is so heavily cited by other Freshwater departments. Even though Chicago appears "more salty" than some of the Saltwater departments, an alternative partition where it switches places with a weakly attached Saltwater department would result in more cross-cluster citing and make the division weaker.

Fields We analyze the citations between the subset of 4 most influential field journals for nine fields, with journal fields defined by Combes and Linnemer (2010). Unfortunately we do not have the JEL codes by article, so we do not include articles in general interest journals. The most influential journals are defined using the same influence measure as for institutions in the previous section, calculated from the matrix of unit citations between all 102 journals in our data. See Table A1 in the supplementary appendix for summary statistics by journal.

Table 3 shows the strongest division by field. The analysis is in each case conducted for the 16 most influential academic departments as measured for the relevant citation network. We define the p -value as the fraction of simulations where the strongest division into two clusters is as strong or stronger as the one found in actual data. With all journals included this p -value is therefore 0.0001. Among the individual fields, macroeconomics and econometrics show the strongest division, at $p = 0.0000$. By contrast, microeconomic theory appears to show no clustering at all, with $p = 0.973$. Public economics (0.027) and Growth/Development (0.054) also exhibit a clear division, while the remaining fields show only weak evidence for a division, with p -values between 0.1 and 0.2. Table A2 in the supplementary appendix provides more details by field.

6 Conclusion

The network of citations in economics between authors' exhibits a division where authors from certain institutions are significantly less likely to cite across cluster lines. The division is the same as was found in hiring/placement data in Terviö (2011), and adheres to the common notions of “Freshwater” and “Saltwater” schools.⁹ Same factors are likely to be behind it. It is plausible that some of it is explained by tendency to cite their former colleagues and mentors. Of course, citation data alone cannot tell whether the division is more based on methodological or ideological differences. The division is strongest when restricting the set of journals to only macroeconomics, whereas restricting to economic theory takes away the division, with other fields in between in the strength of the division.

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⁹The set of top PhD programs is slightly different from the set of top universities by citations. Using the same set of top 16 US departments as Terviö (2011) results in exactly the same division in citation patterns as was found in the PhD hiring/placement patterns.

TERVIÖ, MARKO: “Divisions within Academia: Evidence from Hiring and Placement.”
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Table 1. Summary Statistics and Main Results for Top 50 Institutions

Institution	Cites in	Cites out	Self-cites	Cites to Unknown	Unique Authors	Influence	Relative Salt	Strongest division for			
								Top 24	Top 20	Top 16	Top 12
1 Harvard	2 482.93	888.20	224.62	601.18	583	5.126	0.651	S	S	S	S
2 Chicago	2 042.52	582.97	135.78	349.25	368	4.292	-0.221	F	F	F	F
3 MIT	1 941.23	570.79	127.81	360.39	295	4.005	1.042	S	S	S	S
4 Stanford	1 652.42	609.57	123.34	414.09	441	3.516	0.126	S	S	S	S
5 Princeton	1 512.75	434.00	68.98	230.03	224	3.030	0.851	S	S	S	S
6 Northwestern	1 303.40	570.31	105.09	259.60	321	2.752	-1.147	F	F	F	F
7 Berkeley	1 248.10	662.44	120.08	454.49	480	2.501	1.352	S	S	S	S
8 Pennsylvania	1 126.74	588.49	90.16	295.35	343	2.340	-1.555	F	F	F	F
9 Yale	1 072.01	393.06	80.00	251.94	277	2.225	0.059	S	S	S	F
10 <i>Federal Reserve</i>	1 093.26	1 053.16	234.83	393.01	677	1.965	-1.508				
11 Columbia	867.85	492.04	67.13	269.83	338	1.729	0.196	S	S	S	S
12 Rochester	852.98	268.14	44.17	126.69	169	1.703	-1.982	F	F	F	F
13 Michigan	805.30	481.96	64.46	277.58	366	1.613	-0.538	S	S	F	F
14 NYU	821.24	566.06	72.70	232.24	293	1.547	-1.419	F	F	F	
15 UCLA	730.26	426.52	64.43	256.05	284	1.527	-0.986	F	F	F	
16 Wisconsin	732.28	522.95	67.82	318.22	352	1.393	-0.481	F	F	F	
17 LSE	753.41	450.93	65.38	240.68	305	1.283	0.625	S	S	S	
18 UCSD	694.68	256.96	40.56	127.47	135	1.246	-0.239	S	S		
19 Carnegie Mellon	567.71	200.28	26.16	123.56	165	1.150	-1.347	F	F		
20 Minnesota	545.43	303.93	44.38	216.68	249	1.084	-2.107	F	F		
21 Cornell	562.31	434.20	64.89	310.91	337	1.059	-0.586	F	F		
22 <i>World Bank</i>	545.06	469.50	120.39	346.12	407	0.963	0.932				
23 Illinois	489.97	464.64	63.36	308.01	326	0.940	-1.048	F			
24 Duke	417.44	385.02	47.53	212.45	263	0.854	-1.271	F			
25 Maryland	477.03	417.22	57.42	252.35	251	0.832	-0.020	S			
26 UBC	496.13	370.38	48.97	203.64	217	0.826	0.414	S			
27 Hebrew	395.34	201.61	43.34	144.05	135	0.782	-0.084				
28 Oxford	437.86	329.36	46.90	181.75	268	0.731	1.548				
29 Tel Aviv	365.07	215.30	31.53	103.17	108	0.705	-0.775				
30 Boston	322.11	239.46	24.87	113.67	149	0.642	0.147				
31 Toronto	338.08	345.74	35.95	175.31	223	0.637	-0.619				
32 UC Davis	335.19	319.12	46.27	218.62	214	0.609	-0.039				
33 Ohio State	332.69	339.89	35.45	186.66	230	0.603	-1.035				
34 Texas-Austin	339.10	382.01	37.85	224.14	276	0.576	-1.168				
35 USC	294.50	254.58	25.37	139.05	164	0.571	-1.175				
36 Washington	304.01	230.31	24.12	129.58	174	0.562	-0.789				
37 Virginia	298.93	195.71	19.38	108.90	144	0.543	-0.530				
38 Penn State	300.33	304.04	30.63	170.33	209	0.542	-1.565				
39 <i>IMF</i>	304.92	353.73	45.87	143.39	291	0.512	0.760				
40 Michigan State	301.68	294.24	35.04	175.72	201	0.508	0.009				
41 Caltech	238.43	129.08	22.22	71.71	73	0.501	-1.439				
42 Indiana	280.42	244.60	23.71	135.69	173	0.480	-1.157				
43 Iowa	245.24	178.83	16.01	89.16	129	0.478	-2.399				
44 ANU	267.16	205.56	25.26	133.18	151	0.442	0.125				
45 UNC	236.50	291.13	31.72	180.15	245	0.436	-1.195				
46 Brown	226.44	205.73	23.66	99.61	91	0.428	-0.626				
47 Florida	242.49	196.30	21.05	117.65	155	0.424	-1.417				
48 UCL	234.70	213.26	22.93	82.82	114	0.421	0.683				
49 Arizona	239.10	217.00	34.02	155.98	192	0.412	-0.977				
50 Cambridge	246.18	190.01	28.51	113.48	173	0.406	1.265				
<i>Others (1142 institutions)</i>	21 747.74	35 768.34	3 128.56	19 970.10	29934	35.546	0.020				
<i>All</i>	54 708.65	54 708.65	6 130.65	30 795.70	42682	100	0.000				

Articles from all sample journals from 1990 to 2010. *Non-academic institutions in italics.*

Influence in the network of citations is calculated after dropping self-citations by institutions from the data.

"Relative salt" measures the propensity to cite members of Saltwater cluster relative to Freshwater cluster (with clusters defined for Top 20).

	Minnesota	Rochester	Penn	NYU	Carnegie Mellon	Northwestern	UCLA	Cornell	Wisconsin	Chicago	Michigan	UCSD	Yale	Stanford	Columbia	LSE	Harvard	Princeton	MIT	UC Berkeley
Minnesota	44.4	5.3	8.9	5.7	5.3	9.9	6.4	4.3	5.6	15.1	3.4	2.8	6.0	11.2	4.9	2.8	14.0	6.9	11.4	7.1
Rochester	4.6	44.2	7.9	5.4	5.6	11.7	4.8	2.5	2.7	16.7	6.1	4.1	8.3	11.0	3.6	3.0	12.8	6.9	8.7	4.6
Penn	9.6	13.4	90.2	12.7	9.4	22.2	10.4	6.7	10.5	40.5	9.8	4.8	15.0	23.3	14.1	5.9	36.0	19.9	26.2	13.7
NYU	7.9	15.2	18.5	72.7	8.1	20.6	12.3	6.7	8.4	34.8	8.1	7.4	11.5	22.3	16.0	7.3	32.5	19.5	24.0	13.4
Carnegie Mellon	2.6	3.6	5.8	4.1	26.2	5.9	3.8	4.1	2.5	12.2	3.7	1.7	5.9	11.3	3.9	1.5	10.0	5.1	7.3	4.2
Northwestern	8.3	15.3	20.7	10.5	9.7	105.1	11.3	7.0	10.4	36.5	9.6	8.3	14.4	29.8	10.6	7.1	32.0	20.7	29.5	15.2
UCLA	6.9	8.7	13.6	9.1	5.8	15.2	64.4	5.0	6.7	28.1	7.4	5.6	10.1	21.9	9.5	3.5	27.6	13.5	19.3	13.2
Cornell	6.4	6.4	9.4	7.0	4.8	11.0	7.8	64.9	8.2	18.8	8.5	5.8	10.6	14.9	6.4	5.8	18.8	13.3	15.4	11.6
Wisconsin	5.3	7.2	13.0	7.4	6.7	14.3	8.3	6.0	67.8	21.0	9.7	7.3	9.9	16.7	7.7	5.5	21.4	15.2	18.0	17.3
Chicago	6.2	12.7	18.2	11.1	9.3	24.3	14.0	7.9	9.8	135.8	11.7	8.9	18.5	26.1	10.7	5.8	46.8	22.7	35.0	15.3
Michigan	4.7	11.0	14.4	7.7	3.7	12.8	8.6	5.6	9.0	25.5	64.5	6.6	10.5	18.6	8.6	4.5	34.0	16.4	17.8	11.4
UCSD	2.3	6.4	6.3	3.3	3.3	8.5	4.3	2.0	4.8	11.4	4.9	40.6	8.2	9.9	3.3	3.0	13.9	10.1	9.9	7.5
Yale	5.6	5.6	11.5	5.7	4.3	12.9	7.5	3.5	6.2	18.0	6.5	5.2	80.0	17.4	8.4	7.0	22.6	13.6	16.8	10.9
Stanford	7.1	12.2	16.8	9.1	10.2	24.9	12.9	6.3	7.1	32.0	11.3	8.2	17.4	123.3	13.8	5.8	41.8	19.9	31.6	24.5
Columbia	4.8	10.0	13.9	9.3	6.7	14.8	8.2	4.5	7.0	29.2	8.9	5.8	13.5	24.1	67.1	5.0	36.3	22.0	24.5	13.3
LSE	3.9	6.8	9.6	7.7	4.2	10.7	4.6	3.9	6.3	18.0	4.9	7.1	11.4	15.0	6.3	65.4	24.3	16.8	23.5	10.8
Harvard	8.2	17.2	24.4	15.5	9.2	25.5	17.2	8.8	10.2	55.2	18.3	9.9	24.0	38.4	19.8	10.9	224.6	35.5	59.6	30.0
Princeton	4.4	8.8	9.2	6.1	5.4	15.3	5.3	5.7	7.1	22.9	6.6	6.6	13.6	21.8	9.9	7.4	30.3	69.0	27.0	11.5
MIT	5.4	10.6	17.8	7.4	5.0	16.2	9.7	6.3	7.5	35.8	11.1	8.4	16.3	25.9	12.1	8.4	50.5	27.6	127.8	18.5
UC Berkeley	6.4	7.0	16.0	9.7	6.5	17.7	9.8	5.9	7.5	27.1	10.8	7.1	18.1	34.7	11.7	5.3	45.1	24.0	36.4	120.1

Table 2. Unit citations from row to column department for the top 20 academic departments. Colors depict deviations from expected citations patterns in the absence of clustering (excluding self-citations). Red depicts citations above and blue below expected intensity, darker shades depict stronger deviations. Institutions are ordered by the strength of their connection to the saltwater cluster.

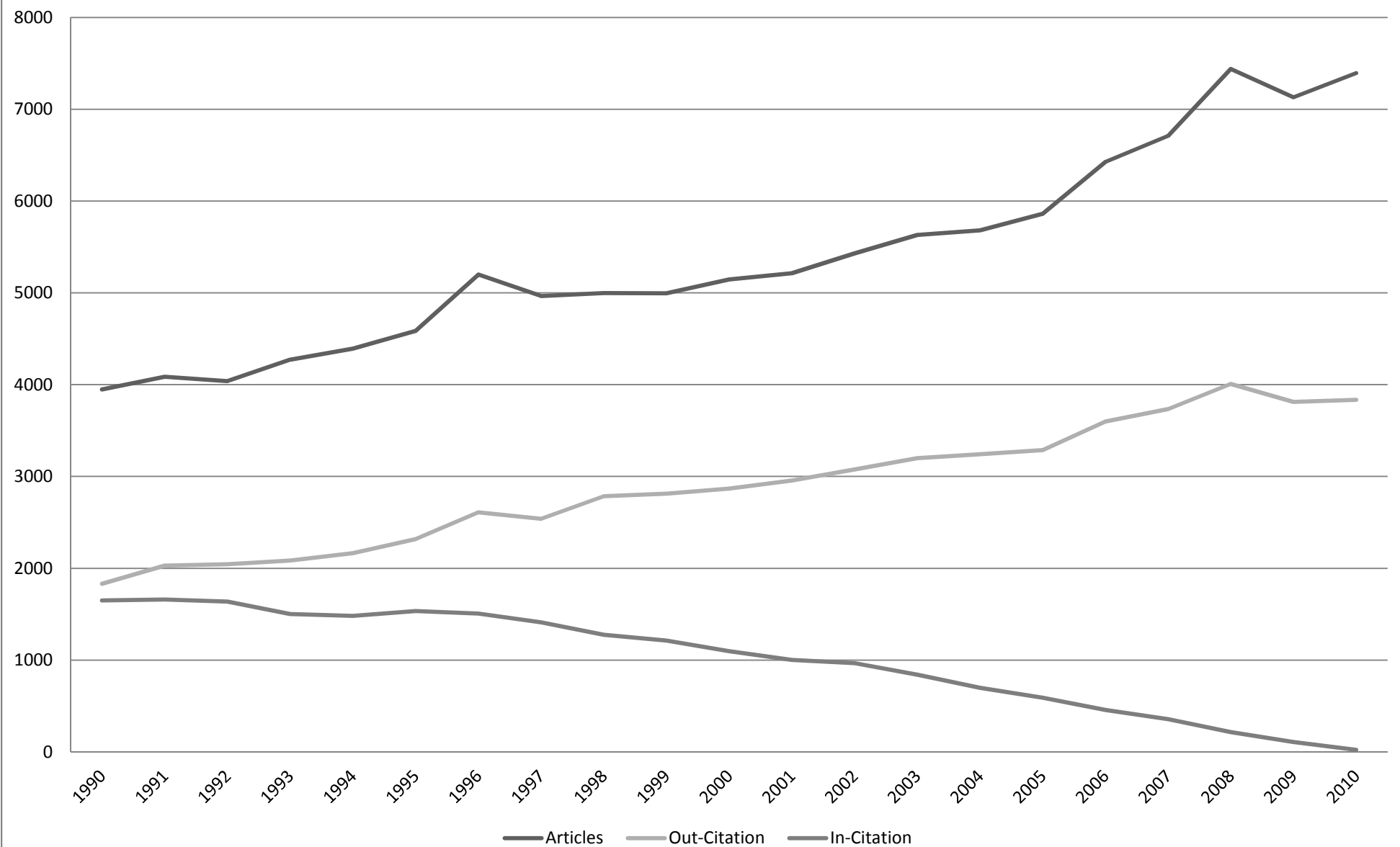
Table 3. Significance of Division by Field

<i>Field</i>	<i>p-value</i>
Macroeconomics/Monetary	0.0000
Microeconomic theory	0.9734
Industrial Organization	0.1515
Econometrics	0.0000
Labor	0.1113
Growth/Development	0.0535
Finance	0.1911
Public	0.0270
International	0.1829
All	0.0001

Includes top 16 most influential departments by field, and 10,000 simulations for the 4 most influential field journals.

For details by field, see Table A2 in the appendix.

Figure 1. Publications and Unit Citations by Publication Year, 1990-2010



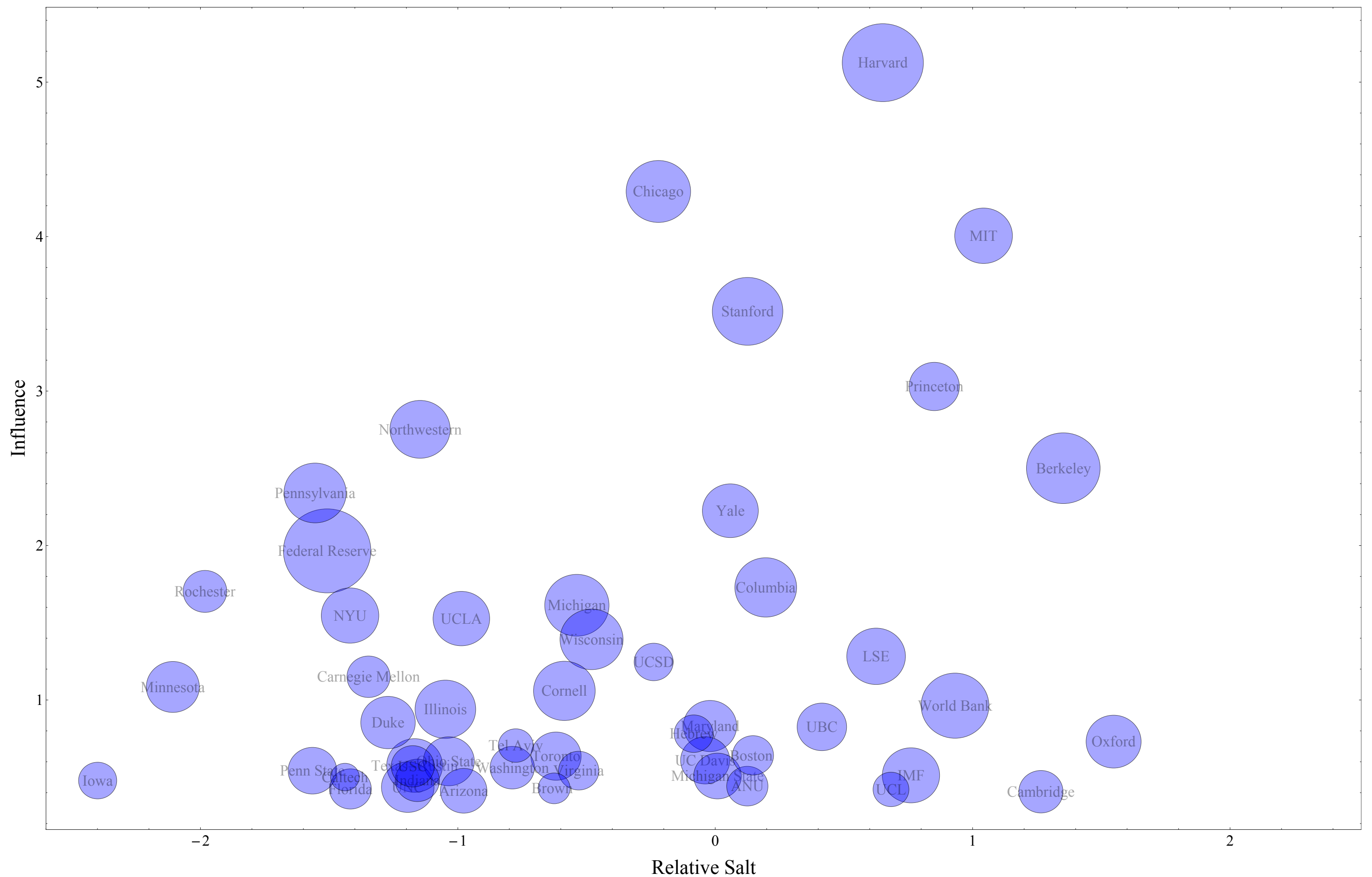


Figure 2. Relative strength of attachment to the clusters (more positive = more Saltwater than Freshwater) and influence in the citation network, for the 50 most influential institutions. Bubble size is proportional to the number of unique authors.

Figure 3. Time series of the strength of attachment and cluster membership for academic institutions that form the top 16 for the whole period 1990-2010 (Last year of the 10-year moving window shown)

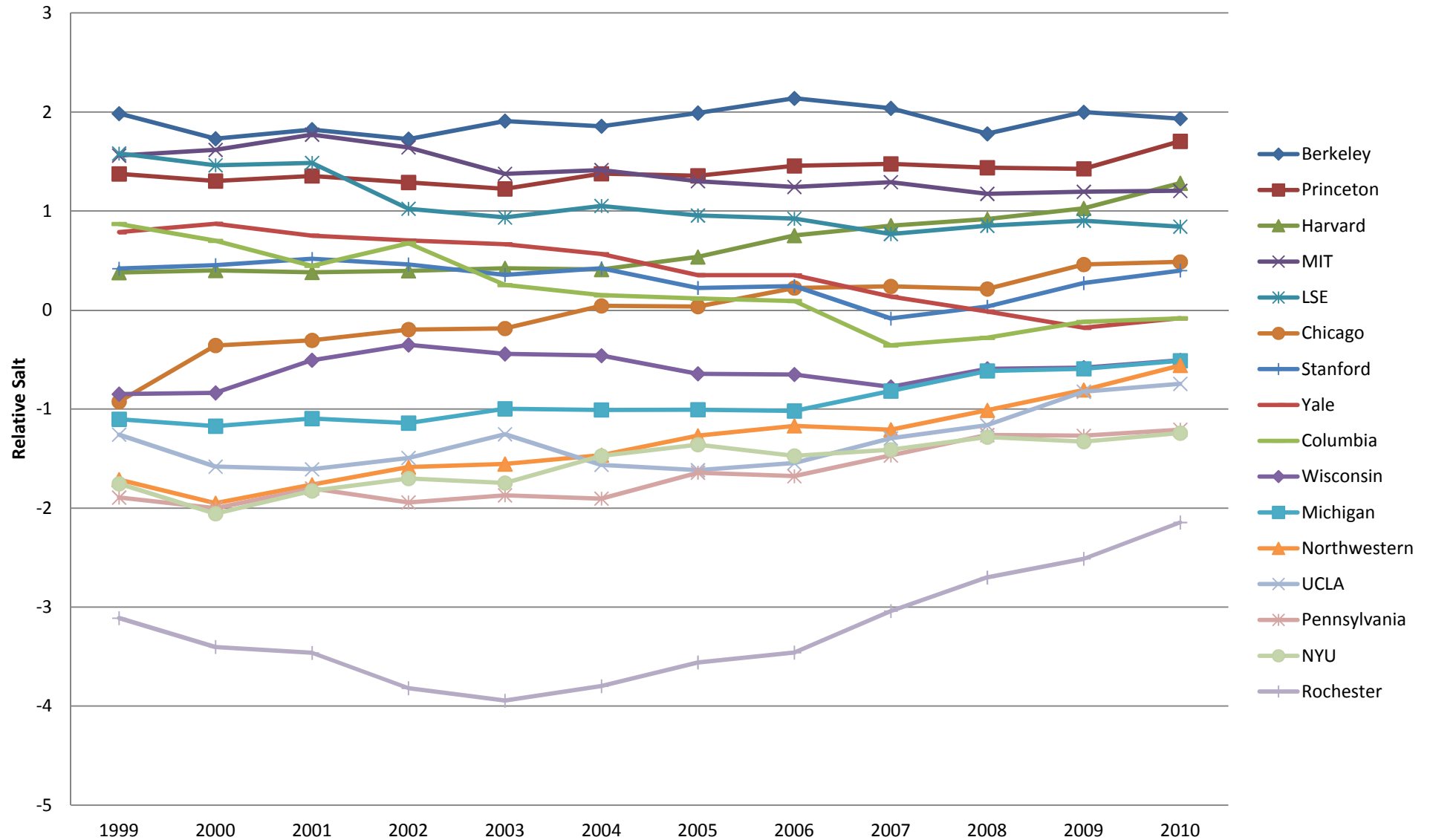


Table A1. Summary Statistics and Influence by Journal

<i>Rank</i>	<i>Journal Title</i>	<i>Articles</i>	<i>Cites In</i>	<i>Cites Out</i>	<i>Self Cites</i>	<i>Cites to Other</i>	<i>Influence</i>	<i>Top Field</i>
1	<i>Econometrica</i>	995	3071.69	297.64	150.66	541.71	11.137	
2	<i>American Economic Review</i>	3222	2751.80	959.97	244.78	1748.25	9.668	
3	<i>Journal of Political Economy</i>	857	1895.59	305.10	63.24	481.66	7.635	
4	<i>Quarterly Journal of Economics</i>	783	1476.68	258.37	50.08	471.55	5.923	
5	<i>Review of Economic Studies</i>	778	1036.27	348.94	46.79	379.27	4.734	
6	<i>Journal of Finance</i>	1373	1245.49	538.25	255.60	576.15	4.708	<i>Finance</i>
7	<i>Journal of Economic Theory</i>	1764	981.51	671.10	209.00	875.90	4.503	<i>Theory</i>
8	<i>Journal of Financial Economics</i>	1018	867.63	426.41	163.89	427.71	3.712	<i>Finance</i>
9	<i>Journal of Econometrics</i>	1721	781.87	586.13	153.10	956.77	2.770	<i>Econometrics</i>
10	<i>Journal of Monetary Economics</i>	1130	748.34	462.90	103.98	555.12	2.606	<i>Macro/Money</i>
11	<i>Rand Journal of Economics</i>	766	536.83	323.02	66.45	376.53	1.904	<i>IO</i>
12	<i>Review of Economics and Statistics</i>	1195	646.46	458.65	38.82	689.53	1.846	
13	<i>Journal of Public Economics</i>	1500	598.69	536.08	124.04	833.89	1.764	<i>Public</i>
14	<i>Journal of Economic Perspectives</i>	753	418.99	161.28	16.32	516.40	1.621	
15	<i>Review of Financial Studies</i>	762	340.58	400.31	49.37	312.32	1.607	<i>Finance</i>
16	<i>International Economic Review</i>	964	431.28	448.29	31.67	482.04	1.592	
17	<i>Economic Journal</i>	1449	608.13	526.92	51.66	824.42	1.591	
18	<i>Journal of Economic Literature</i>	75	440.67	17.58	1.10	53.32	1.529	
19	<i>Games and Economic Behavior</i>	1291	270.67	494.48	94.43	674.09	1.349	<i>Theory</i>
20	<i>Journal of the American Statistical Assoc.</i>	2231	321.31	80.22	232.33	1631.45	1.289	<i>Econometrics</i>
21	<i>Economics Letters</i>	4261	389.55	1926.21	157.95	2001.84	1.210	
22	<i>European Economic Review</i>	1504	417.39	572.00	44.11	801.89	1.147	
23	<i>Journal of Labor Economics</i>	555	286.83	222.88	33.30	294.82	1.089	<i>Labor</i>
24	<i>Journal of International Economics</i>	989	400.76	375.90	90.94	517.17	1.063	<i>International</i>
25	<i>Journal of Business & Economic Statistics</i>	786	291.34	323.55	33.50	414.95	0.998	<i>Econometrics</i>
26	<i>Journal of Business</i>	481	241.70	238.15	18.98	220.87	0.946	
27	<i>Journal of Human Resources</i>	609	261.85	182.79	32.70	380.51	0.915	<i>Labor</i>
28	<i>Econometric Theory</i>	789	128.46	253.62	57.48	455.91	0.778	<i>Econometrics</i>
29	<i>Journal of Law & Economics</i>	449	193.87	123.18	19.26	289.56	0.756	
30	<i>Journal of Money Credit and Banking</i>	956	262.49	406.03	46.13	487.84	0.751	<i>Macro/Money</i>
31	<i>Journal of Mathematical Economics</i>	888	154.60	267.44	65.13	530.44	0.733	<i>Theory</i>
32	<i>Journal of Ec. Dynamics & Control</i>	1485	223.62	596.44	62.11	790.46	0.717	<i>Macro/Money</i>
33	<i>Journal of Financial and Quant. Analysis</i>	648	171.71	360.01	27.26	259.73	0.685	<i>Finance</i>

Table A1 (continued)

<i>Rank</i>	<i>Journal Title</i>	<i>Articles</i>	<i>Cites In</i>	<i>Cites Out</i>	<i>Self Cites</i>	<i>Cites to Other</i>	<i>Influence</i>	<i>Top Field</i>
34	<i>Economic Inquiry</i>	951	180.50	306.32	13.15	587.53	0.588	
35	<i>American Political Science Review</i>	598	134.05	39.34	44.58	419.08	0.567	<i>Public</i>
36	<i>Public Choice</i>	1535	141.09	373.79	132.74	961.47	0.535	<i>Public</i>
37	<i>Journal of Econ. Behavior & Organization</i>	1512	156.23	535.27	57.43	869.31	0.519	<i>Theory</i>
38	<i>Journal of Development Economics</i>	1059	197.26	356.39	47.37	621.24	0.493	<i>Growth/Dev</i>
39	<i>Industrial & Labor Relations Review</i>	605	126.36	148.42	40.73	393.85	0.480	<i>Labor</i>
40	<i>Journal of Applied Econometrics</i>	688	149.65	305.67	17.05	363.28	0.466	
41	<i>Journal of Law Economics & Organization</i>	412	96.07	125.92	17.47	261.60	0.452	
42	<i>Brookings Papers on Economic Activity</i>	193	78.60	45.50	2.79	136.71	0.438	<i>Macro/Money</i>
43	<i>International Journal of Game Theory</i>	593	99.02	164.08	44.83	330.09	0.429	
44	<i>Journal of Urban Economics</i>	935	180.10	282.70	104.14	534.16	0.420	
45	<i>Journal of Accounting & Economics</i>	475	76.78	97.14	67.28	299.58	0.416	
46	<i>Journal of Industrial Economics</i>	495	151.06	205.38	22.68	260.94	0.400	<i>IO</i>
47	<i>Canadian Journal of Economics</i>	1109	157.26	463.04	35.67	586.29	0.398	
48	<i>Economica</i>	631	134.75	270.08	13.23	342.69	0.358	
49	<i>Social Choice and Welfare</i>	849	78.83	246.92	66.52	508.56	0.342	
50	<i>Journal of Banking & Finance</i>	1849	112.01	732.80	125.43	959.77	0.339	
51	<i>Journal of Environ. Ec. and Management</i>	844	273.22	254.19	83.08	497.73	0.325	
52	<i>Journal of Risk and Uncertainty</i>	451	94.33	132.35	40.57	265.08	0.318	
53	<i>Oxford Economic Papers</i>	691	140.15	266.95	18.05	398.01	0.313	
54	<i>National Tax Journal</i>	732	93.68	139.45	59.95	468.60	0.309	<i>Public</i>
55	<i>Scandinavian Journal of Economics</i>	641	118.45	266.88	16.34	347.79	0.304	
56	<i>International Journal of Industrial Org.</i>	953	120.04	429.75	40.86	475.40	0.302	<i>IO</i>
57	<i>Journal of Economic History</i>	435	63.50	52.33	21.63	328.04	0.286	
58	<i>Review of Economic Dynamics</i>	351	59.82	170.70	8.14	170.16	0.283	
59	<i>Journal of Health Economics</i>	853	119.46	188.51	63.63	566.86	0.267	
60	<i>Oxford Bulletin of Economics and Statistics</i>	652	135.50	265.42	18.32	359.26	0.267	
61	<i>Amer. Journal of Agricultural Economics</i>	2140	195.83	421.21	244.94	1295.85	0.260	
62	<i>Journal of Econ. & Management Strategy</i>	394	66.08	178.08	11.40	202.52	0.241	<i>IO</i>
63	<i>Journal of International Money and Fin.</i>	962	104.85	412.23	51.59	490.19	0.227	<i>International</i>
64	<i>Regional Science and Urban Economics</i>	645	89.16	229.29	34.90	363.81	0.208	
65	<i>Journal of Economic Growth</i>	126	62.77	54.32	5.41	66.27	0.202	<i>Growth/Dev</i>
66	<i>Economic Theory</i>	1303	42.13	547.12	9.71	701.17	0.191	
67	<i>Econometric Reviews</i>	117	51.00	49.96	3.13	62.91	0.190	
68	<i>Review of Income and Wealth</i>	434	41.43	95.62	16.79	293.59	0.150	

Table A1 (continued)

<i>Rank</i>	<i>Journal Title</i>	<i>Articles</i>	<i>Cites In</i>	<i>Cites Out</i>	<i>Self Cites</i>	<i>Cites to Other</i>	<i>Influence</i>	<i>Top Field</i>
69	<i>World Development</i>	1655	84.01	183.20	65.26	1132.54	0.150	<i>Growth/Dev</i>
70	<i>Land Economics</i>	628	131.39	161.31	39.99	409.70	0.146	
71	<i>Applied Economics</i>	3195	79.76	1079.06	109.70	1932.24	0.139	
72	<i>Journal of Comparative Economics</i>	593	41.07	155.98	31.60	388.42	0.136	
73	<i>Explorations In Economic History</i>	325	27.86	58.49	9.29	248.22	0.123	
74	<i>Economics of Education Review</i>	661	35.76	165.33	40.50	430.18	0.112	<i>Growth/Dev</i>
75	<i>Econ. Development and Cultural Change</i>	536	59.15	121.14	15.44	369.43	0.111	
76	<i>Journal of Financial Intermediation</i>	235	29.57	122.93	5.71	106.36	0.110	
77	<i>Mathematical Finance</i>	273	37.21	47.15	15.46	183.39	0.108	
78	<i>Macroeconomic Dynamics</i>	347	29.21	172.18	4.43	165.40	0.102	
79	<i>Labour Economics</i>	432	39.73	188.20	7.44	236.36	0.092	<i>Labor</i>
80	<i>Journal of Population Economics</i>	525	34.71	188.07	15.70	316.23	0.091	
81	<i>Journal of Risk and Insurance</i>	513	42.88	139.60	55.45	306.95	0.090	
82	<i>Journal of the European Economic Assoc.</i>	323	19.28	134.57	1.94	174.49	0.088	
83	<i>International Tax and Public Finance</i>	379	40.66	157.94	12.40	205.66	0.083	
84	<i>Journal of Regulatory Economics</i>	456	30.34	143.91	23.63	275.46	0.069	<i>International</i>
85	<i>World Economy</i>	830	26.36	128.73	25.56	518.71	0.068	
86	<i>Journal of Real Estate Finance and Econ.</i>	547	25.53	158.90	35.79	336.31	0.067	
87	<i>Energy Journal</i>	402	29.66	78.14	21.43	263.43	0.065	
88	<i>Environmental & Resource Economics</i>	726	57.81	246.94	26.31	439.75	0.062	
89	<i>Journal of Productivity Analysis</i>	375	32.13	100.89	22.58	246.53	0.055	<i>International</i>
90	<i>Water Resources Research</i>	4928	29.26	52.15	885.94	3556.91	0.054	
91	<i>Journal of Economic Psychology</i>	604	19.94	109.03	24.27	392.70	0.052	
92	<i>Health Economics</i>	868	30.69	175.07	47.98	590.95	0.044	
93	<i>Economic History Review</i>	259	11.08	15.64	13.45	191.90	0.042	
94	<i>Experimental Economics</i>	138	12.29	66.63	2.78	68.59	0.033	<i>International</i>
95	<i>Resource and Energy Economics</i>	302	23.76	103.10	4.50	185.40	0.028	
96	<i>Ecological Economics</i>	1429	31.96	193.34	68.89	990.77	0.028	
97	<i>Southern Economic Journal</i>	1164	11.00	350.01	2.13	705.86	0.026	
98	<i>Insurance Mathematics & Economics</i>	900	14.48	77.02	124.96	586.02	0.022	
99	<i>Journal of Economic Geography</i>	119	8.56	32.42	3.20	74.38	0.019	<i>International</i>
100	<i>Industrial and Corporate Change</i>	188	6.01	29.17	5.52	130.31	0.013	
101	<i>Journal of Common Market Studies</i>	294	5.89	13.68	9.78	171.55	0.009	
102	<i>Economy and Society</i>	246	1.10	2.96	5.59	106.45	0.001	
Total			28155.80	28155.80	6222.29	53080.91	100.000	

Table A2. Influence and Division of Field Journals

<i>Macroeconomics/Monetary Economics</i>				<i>Microeconomic Theory</i>				<i>Industrial Organization</i>			
<i>Rank</i>	<i>Institution</i>	<i>Influence</i>	<i>Cluster</i>	<i>Rank</i>	<i>Institution</i>	<i>Influence</i>	<i>Cluster</i>	<i>Rank</i>	<i>Institution</i>	<i>Influence</i>	<i>Cluster</i>
1	Fed Reserve Bank	6.748		1	Northwestern Univ	5.6225	F	1	Stanford Univ	5.5790	F
2	Univ Chicago	5.404	F	2	Stanford Univ	4.9160	S	2	Harvard Univ	5.5658	S
3	Harvard Univ	5.001	S	3	Harvard Univ	4.5609	S	3	MIT	5.0191	S
4	Princeton Univ	4.409	S	4	MIT	3.0671	S	4	Univ Calif Berkeley	3.8157	S
5	MIT	4.280	S	5	Univ Chicago	2.6729	F	5	Northwestern Univ	3.8119	F
6	Northwestern Univ	3.215	F	6	Univ Penn	2.6345	F	6	Univ Chicago	3.4647	S
7	Stanford Univ	3.184	S	7	Univ Calif Berkeley	2.6283	S	7	Princeton Univ	3.0156	F
8	Columbia Univ	3.165	S	8	Hebrew Univ Jerusalem	2.3405	S	8	Yale Univ	2.7202	S
9	Univ Rochester	2.898	F	9	Princeton Univ	2.2235	S	9	Univ Penn	1.7994	S
10	Univ Penn	2.895	F	10	Yale Univ	1.9789	F	10	Univ Michigan	1.6604	F
11	Carnegie Mellon Univ	2.298	F	11	Univ Rochester	1.6796	F	11	London Sch Econ	1.6439	S
12	New York Univ	2.249	F	12	Caltech	1.6352	F	12	Univ Calif Los Angeles	1.4305	S
13	Univ Calif Berkeley	1.961	S	13	Columbia Univ	1.2958	F	13	Columbia Univ	1.3893	F
14	Yale Univ	1.797	S	14	Univ Calif San Diego	1.2892	S	14	Univ Oxford	1.3638	F
15	Univ Minnesota	1.705	F	15	Univ Minnesota	1.2812	F	15	New York Univ	1.3060	F
16	Univ Calif Los Angeles	1.221	F	16	New York Univ	1.2608	S	16	Univ Wisconsin	1.1362	F
17	Univ Michigan	1.206	S	17	Carnegie Mellon Univ	1.2550		17	Univ British Columbia	1.0537	
18	Univ Calif San Diego	1.200		18	Univ Calif Los Angeles	1.2513		18	Carnegie Mellon Univ	1.0098	
19	Int Monetary Fund	1.104		19	Tel Aviv Univ	1.2202		19	Boston Univ	0.8990	
20	Univ Virginia	1.035		20	London Sch Econ	1.1743		20	Univ Toulouse 1	0.8909	
<i>Significance of division: $p = 0$</i>				<i>Significance of division: $p = 0.9734$</i>				<i>Significance of division: $p = 0.1515$</i>			

Note: Cluster column denotes members of the strongest division between freshwater (F) and saltwater (S) clusters.

Table A2 (continued)

<i>Econometrics</i>				<i>Labor Economics</i>				<i>Growth and Development</i>			
<i>Rank</i>	<i>Institution</i>	<i>Influence</i>	<i>Cluster</i>	<i>Rank</i>	<i>Institution</i>	<i>Influence</i>	<i>Cluster</i>	<i>Rank</i>	<i>Institution</i>	<i>Influence</i>	<i>Cluster</i>
1	Harvard Univ	4.0812	S	1	Univ Chicago	6.0248	F	1	World Bank	6.6918	
2	Yale Univ	4.0494	F	2	Harvard Univ	5.7762	S	2	Harvard Univ	5.2555	S
3	Univ Chicago	3.2981	F	3	MIT	3.9138	S	3	MIT	3.2398	S
4	Stanford Univ	3.0671	S	4	Princeton Univ	3.7586	S	4	Univ Chicago	2.8572	F
5	Univ Wisconsin	2.7577	S	5	Univ Michigan	2.8488	F	5	Princeton Univ	2.8380	F
6	Univ Calif San Diego	2.5052	F	6	Cornell Univ	2.6335	S	6	Stanford Univ	2.2975	F
7	Univ Calif Berkeley	2.4271	S	7	Northwestern Univ	2.2136	F	7	Univ Calif Berkeley	2.1822	F
8	MIT	2.4249	F	8	Stanford Univ	2.1601	F	8	Univ Penn	2.1374	F
9	Princeton Univ	2.0573	F	9	Columbia Univ	2.0402	S	9	Yale Univ	1.8715	F
10	Univ Minnesota	1.8980	S	10	Univ Calif Berkeley	1.9212	S	10	Univ Oxford	1.7516	S
11	London Sch Econ	1.7210	F	11	Univ Wisconsin	1.7542	F	11	Int Monetary Fund	1.6168	
12	Australian Natl Univ	1.4065	F	12	Univ Penn	1.6850	S	12	Columbia Univ	1.6053	F
13	Univ Calif Los Angeles	1.3731	S	13	Univ Illinois	1.3616	F	13	Univ Calif Los Angeles	1.4137	S
14	Northwestern Univ	1.2735	F	14	Yale Univ	1.3361	F	14	London Sch Econ	1.2300	S
15	Carnegie Mellon Univ	1.2575	S	15	Univ Calif Los Angeles	1.3359	F	15	Univ Sussex	1.1414	S
16	Univ Washington	1.1755	S	16	Michigan State Univ	1.1199	S	16	New York Univ	1.0910	S
17	Univ Rochester	1.1570		17	Rand	1.0766		17	Cornell Univ	1.0385	S
18	N Carolina State Univ	1.1018		18	London Sch Econ	1.0264		18	Univ Michigan	1.0201	F
19	Univ Penn	1.0981		19	Fed Reserve Bank	0.9765		19	Univ Maryland	1.0175	
20	Fed Reserve Bank	1.0876		20	Univ Rochester	0.9166		20	Northwestern Univ	0.9900	
<i>Significance of division: $p = 0$</i>				<i>Significance of division: $p = 0.1113$</i>				<i>Significance of division: $p = 0.0535$</i>			

Note: Cluster column denotes members of the strongest division between freshwater (F) and saltwater (S) clusters.

Table A2 (continued)

<i>Finance</i>				<i>Public Economics</i>				<i>International Economics</i>			
<i>Rank</i>	<i>Institution</i>	<i>Influence</i>	<i>Cluster</i>	<i>Rank</i>	<i>Institution</i>	<i>Influence</i>	<i>Cluster</i>	<i>Rank</i>	<i>Institution</i>	<i>Influence</i>	<i>Cluster</i>
1	Univ Chicago	7.8673	S	1	Harvard Univ	6.1096	S	1	Harvard Univ	4.7528	S
2	Harvard Univ	5.1636	S	2	Stanford Univ	3.6090	F	2	MIT	4.1995	S
3	MIT	4.1508	S	3	Univ Chicago	3.1788	S	3	Columbia Univ	3.6099	S
4	Univ Penn	3.7895	F	4	Princeton Univ	3.0292	F	4	Princeton Univ	3.5515	S
5	New York Univ	3.6090	F	5	MIT	2.9096	S	5	Univ Chicago	3.2578	F
6	Stanford Univ	3.4444	S	6	Univ Michigan	2.6438	S	6	Univ Calif Berkeley	3.1833	F
7	Univ Rochester	3.1435	F	7	Northwestern Univ	1.8147	F	7	Fed Reserve Bank	3.1302	
8	Univ Calif Los Angeles	3.0611	F	8	Univ Rochester	1.7341	F	8	Int Monetary Fund	2.9166	
9	Northwestern Univ	2.8458	S	9	Yale Univ	1.7076	F	9	Stanford Univ	2.4534	F
10	Princeton Univ	2.2709	S	10	Univ Calif Berkeley	1.6974	S	10	World Bank	2.2068	
11	Columbia Univ	2.0991	F	11	Carnegie Mellon Univ	1.6327	F	11	Univ Penn	2.0556	F
12	Univ Michigan	1.9926	F	12	Univ Penn	1.6069	S	12	Northwestern Univ	1.8857	S
13	Univ Calif Berkeley	1.9176	S	13	Univ Wisconsin	1.5837	S	13	Yale Univ	1.8760	S
14	Yale Univ	1.6008	S	14	Univ Calif Los Angeles	1.5698	F	14	New York Univ	1.6134	F
15	Fed Reserve Bank	1.5739		15	Univ Calif San Diego	1.5403	F	15	Univ Michigan	1.5766	S
16	Cornell Univ	1.4666	F	16	London Sch Econ	1.3275	S	16	Univ Calif Los Angeles	1.4886	S
17	Duke Univ	1.4440	F	17	Univ Maryland	1.2446		17	Univ Calif San Diego	1.4779	F
18	Univ Illinois	1.4170		18	Columbia Univ	1.1431		18	Univ Rochester	1.3049	F
19	Univ So Calif	1.3899		19	Fed Reserve Bank	1.1407		19	Univ British Columbia	1.0187	F
20	Ohio State Univ	1.2346		20	Caltech	1.1369		20	Tel Aviv Univ	1.0149	
<i>Significance of division: p = 0.1911</i>				<i>Significance of division: p = 0.027</i>				<i>Significance of division: p = 0.1829</i>			

Note: Cluster column denotes members of the strongest division between freshwater (F) and saltwater (S) clusters.

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