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Multivariate Citations Functions and Journal Rankings

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Comprehensive data on citations practices in the social sciences have been available since 1973 in the *Social Sciences Citation Index* (*SSCI*). These data have been used frequently to produce journal rankings. Such rankings have appeared in journals in anthropology [Rounds (1982)], psychology [White and White (1977)] and Rushton and Roediger (1978)], sociology [Roche and Smith (1978)] and economics [Busch, Hamelman and Staaf (1974) and Liebowitz and Palmer (1984)].[1] We will argue that all of these citations-based rankings have serious flaws.

In this paper we focus on the well-known rankings of Liebowitz and Palmer (LP hereafter). The LP ranking has several flaws: (1) LP made no attempt to consider differences between general journals and specialized journals; (2) the rankings are based solely on bivariate analysis, and (3) the rankings are inconsistent in the way citations are weighted. These difficulties, which LP share with other citations-based rankings, follow from the fact that there is no well specified methodological foundation for these rankings. As we explain below, the foundation of any citations-based ranking is a citations function. However, the citations function has never been articulated explicitly.

A METHODOLOGY FOR CITATIONS-BASED RANKINGS

The fundamental relationship which allows understanding of a citations-based ranking is a citations function, for example,

$$C = \alpha + Q + \beta X + \delta Z \tag{1}$$

where C is citations; Q is quality; X is a vector of quantifiable factors which influence citations but are unrelated to Q; Z is a vector of unobservable influences on citations and α, β and δ represent coefficients.[2] Since Q and Z are unobservable we propose that the first step in forming a ranking is to estimate the following equation:

$$C = a + bX + e \tag{2}$$

where a and b are coefficients, and e is a disturbance term. As long as the variables in X are uncorrelated with Q and Z, the estimated coefficients, $\hat{a}$ and $\hat{b}$, will be unbiased estimators of α and β. Under this assumption an estimate of Q can be obtained by using net citations, $NC = C - \hat{C}$, where $\hat{C}$ is the estimated citations level from equation (2). The expected value of NC is $Q + \delta Z$.

A ranking of NC has some drawbacks. Most obviously, the influence of Z is objectionable. There are several examples of variables in Z. Negative citations: some articles are cited because they are low quality not high quality. Self citations: some authors routinely cite their own work. Gratuitous citations: in some cases citations are related to the author's submission strategy. Authors may gratuitously cite the journal or cite articles written by the editor or potential referees. Some articles, review articles in particular, are cited because they provide a short-cut to citing several sources. It is clear that such factors obfuscate the interpretation of a net citations ranking as a quality ranking. One proceeds with a citations-based ranking under the assumption that variations in Q are the dominant source of variation in NC.

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There are two decisions to make before estimating equation (2). First, citations data must be selected; second, the variables in X require identification.

Citations Sources

There are three views on the choice of citations data. At one extreme, Skeels and Taylor restrict the source of citations to a short list which they defend by saying, "The key problem is to find constrained situations where highly qualified economists make decisions about the work of articles" (1972, p. 470). At the other extreme, most citations-based rankings utilize *SSCI* data which include citations from a huge list of publications. The remaining view is a compromise. LP use *SSCI* data on citations, but they weight these data using a procedure they call "impact adjustment" in such a way that citations from highly ranked journals are more heavily weighted than citations from journals with lower ranks.

Restricting the source of citations to a selected list of articles or journals or using a procedure like impact adjustment both have intuitive appeal. However, they can introduce biases, in particular, journals specializing in relatively small fields within a discipline will not be treated equitably.

The Choice of X Variables

The X vector contains variables which, while unrelated to quality, affect citations. Garfield (1972) recognized that a simple ranking of total citations could be dominated by journal size. To correct for this effect, Garfield generated rankings of citations per article.[3] LP found a flaw in citations per article rankings. They point out "... unfortunately the number of articles (taken from the *SSCI* which lists them as 'source items') does not distinguish between full sized articles and comments, replies and short articles" (page 84). This led them to also consider rankings of citations per character.

Their way of adjusting for the effects of journal size provides a good illustration of the value of an explicit citations function. They produced two rankings, one of citations per article and one of citations per character. Both are flawed. A ranking of citations per article ignores the size of the articles. A ranking of citations per character ignores the way in which the characters are arranged, i.e., all in one article or in many small articles. Clearly, there are two size related factors, and two X variables are needed to control for size differences. Using an explicit multivariate citations function we can produce one ranking purged of the effects of both dimensions of size.

There is a third X variable which is important, specifically field size. Janke (1973) and Bide (1973) have pointed out the inherent bias in citations-based rankings against journals from small disciplines. More recently, because it has been recognized that there are different ciations practices in different disciplines, rankings have been limited to journals in a single discipline. But, as Marton (1983) and Weisheit and Regoli (1984) point out, this does not eliminate the flaw. Journals specializing in small fields within a discipline will still be at a disadvantage in a citations-based ranking. A third X variable is needed to control for the effects of field size differences on citations.

PRODUCING A RANKING OF ECONOMICS JOURNALS

To facilitate comparisons with the Liebowitz-Palmer ranking of economics journals we have used, to the extent possible, the same list of journals and data for characters and articles.[4] Their data were adjusted to exclude citations which were not from journals on our list.[5] This adjustment was made because our measure of field size, discussed below, encapsulates field size within economics.

Our revised equation (2) is:

$$C(t, T) = a + b_1A(T) + b_2CH(T)/A(T) + b_3F(t, T) + e \tag{3}$$

where C(t, T) is citations in year t = 1980 to journal articles appearing in period T = 1975–1979; A(T) is the number of articles published during T; CH(T) is the number of characters published during T, and

F(t, T) is a measure of how the field mix of articles in a journal during T matches with the field mix of citations in t.

Measuring Field Size

Before estimating equation (3), measurements of field size for a journal requires explanation. F(t, T) is based on two matrices of the number of articles listed in the "Subject Index of Articles" in the *Journal of Economic Literature* (*JEL*), L(t) and L(T), which contain counts of listings by field and by journal for t = 1980 and T = 1975–1979. These matrices have j rows and f columns, where j is the number of journals (104) and f is the number of fields (20). First we divide each element by its row sum which provides a typical element which is the percentage of a journal's *JEL* listings in each field.[6]

To account for the number of citations *to* a field, we assume that citations practices vary more across journals than within journals. We gathered information on the number of citations in time t from the *SSCI*. Let CI(t, T) be a 1 × j vector of the number of citations *in* each journal in time t to articles published during time T. Then:

$$CF(t, T) = CI(t, T) \cdot L(t) \tag{4}$$

will be a 1 × f vector which approximates the number of citations to each field. Equation (5) distributes the citations in each journal to a field based upon the field distribution of articles in the journal and then sums the results across journals to estimate the number of citations to each field.

We complete the construction of F(t, T) by multiplying CF(t, T) by L(T); specifically:

$$F(t, T) = CF(t, T) \cdot L(T)', \tag{5}$$

where L(T)′ is the transpose of L(T). F(t, T) is thus a 1 × j vector which yields a field score for each journal. These field scores will be large for journals which, during T = 1975–1979, specialized in fields which were frequently cited in t = 1980.

Estimate of the Citations Function

In estimating equation (3) it was found that a log-linear functional form fit the data best.[7] The result of this estimation is:

$$\begin{aligned} \log C(t, T) = {} & -11.9585 + \underset{(8.94)}{1.8828} \log A(T) + \underset{(2.61)}{.9944} \log [CH(T)/A(t)] \\ & + \underset{(2.80)}{.9793} \log F(t, T) \end{aligned} \tag{6}$$

$$R^2 = .477, N = 104$$

where t statistics are in parentheses below the coefficients.[8]

The results in equation (6) are quite satisfactory in that the coefficients have the expected sign and are statistically significant at the 1% level. The fact that F(t, T) is a significant determinant of citations is crucial for the argument we presented above. *Ceteris paribus*, journals specializing in larger fields will be cited more frequently.

The results for the number of articles and the average size of articles appear to give some support to what we perceive to be typical editorial behavior in economics. Facing constraints on the total number of pages they can publish, editors frequently exhort and occasionally force authors to make their articles shorter. If successful, this generates an increase in the number of articles and a decrease in the number of characters per article. According to our estimated equation this will yield an increase in citations for two reasons: 1.) because the percentage increase in articles will exceed the percentage decrease in characters per article, and 2.) because the effect on citations of a percentage change in articles exceeds the effect on citations of a percentage change in characters per article (1.88 > .99). Viewed another way, our results suggest that if journal editors decide to expand the number of characters they publish, the maximum impact on citations is derived by increasing the number of articles and not by relaxing character constraints placed on authors. This too is consistent with editorial behavior we observe. Frequently, with extra money, editors publish extra issues of their journal or expand the size of each issue but do not appear to relax editorial policies which restrict article size.

A COMPARISON OF JOURNAL RANKINGS

Table 1 presents rankings based on equation (6). For comparison, we also include two of the LP rankings, rankings based on citations per character and impact-adjusted citations per character and the "mean" and "prestige" rankings from the survey results of Hawkins, Ritter and Walter (1973) (HRW hereafter). The HRW mean rank refers to the average response to their survey which asked respondents to rank journals on a 0 to 20 scale. The prestige rank was formed by multiplying the average score by the percentage of respondents giving a score to a journal. In each case, the ranks have been recomputed to reflect a common set of journals. There were 104 journals ranked in our study and in LP, and 54 of these same journals were ranked by HRW.

We include the HRW rankings in the discussion because they represent the best example of an alternative to basing a ranking on citations. Also, it is interesting to note that the HRW prestige rank shares a problem with citations-based journal rankings. The prestige rank gives an advantage to journals with which the survey respondents are familiar. These journals would be the older, general journals and the journals in the respondent's field. Presuming the respondents were chosen randomly, this gives an advantage to field journals from large fields.

Concerning the LP rankings, it is interesting to consider the group of journals which changed rank dramatically as a result of employing our procedure. The 14 journals improving at least 20 positions, comparing our rankings with the LP impact adjusted rankings, are dominated by field journals from relatively small fields. This list contained five journals with "History" in the title. The group of journals which fell at least 20 positions in the same comparison includes fifteen journals. This group is split almost evenly between field journals from relatively large fields and general journals which had been ranked in the second thirty or below by LP.

It is important to recognize that there is relatively little disagreement about the top of the rankings. LP's top ten journals in the impact adjusted rankings are included in our top twelve journals. Our top ten journals are included in LP's top sixteen. There is slightly less congruence at the top of the rankings between ours and those of HRW. Using the prestige ranks from HRW, their top ten are included in our top twenty-four and our top ten are included in their top eighteen.

CONCLUSIONS

Our conclusions can be organized under two headings. First, previous citations-based rankings of journals suffer from the lack of a well specified methodological base. We argue that an explicit citations function should be estimated as the basis for a ranking. Using this methodology, a single ranking can be produced which controls simultaneously for several factors which influence citations but are unrelated to quality of the research.

Second we produce a ranking of economics journals as an example of our methodology. One important difference of our ranking from its predecessors is that it controls for the effects of differences in field size of journals on citations. This type of correction is very important since rankings of journals are frequently used to aid the evaluation of individual economist's research. We demonstrate that previous rankings have been biased in favor of journals from larger fields.

TABLE 1
Net Citations Rankings of Journals Based on Equation (6)

		LP Ranks		HRW Ranks		
Net Citations Rank	NC	Citations Per Character	Impact Adjusted Citations Per Character	Mean	Prestige	*
1. J. Polit. Econ.	648.5	1	1	3	2	(1)
2. Amer. Econ. Rev.	492.5	2	3	1	1	(2)
3. Econometrica	302.6	8	7	2	3	(3)
4. Bell J. Econ.	204.9	10	8	24	18	(4)
5. J. Financ. Econ.	196.1	4	2	—	—	
6. J. Monet. Econ.	188.6	9	4	—	—	
7. Brookings Pap. Econ. Act.	183.2	12	9	—	—	
8. J. Econ. Lit.	166.2	3	6	11	8	(5)
9. Rev. Econ. Statist.	164.5	5	16	5	6	(6)
10. Rev. Econ. Stud.	145.8	17	10	6	9	(7)
11. J. Econometrics	122.8	23	17	—	—	
12. J. Finance	113.8	6	5	14	11	(8)
13. Econ. J.	110.3	13	23	7	5	(9)
14. Quart. J. Econ.	108.9	16	13	4	4	(10)
15. Int. Econ. Rev.	102.7	24	19	13	15	(11)
16. J. Law Econ.	101.4	18	26	15	14	(12)
17. J. Urban Econ.	90.5	15	33	—	—	
18. J. Cons. Res.	78.5	14	55	—	—	
19. J. Public Econ.	68.1	30	22	—	—	
20. J. Int. Econ.	68.1	32	18	18	32	(13)
21. J. Math. Econ.	67.1	22	12	—	—	
22. Econ. Inquiry	64.2	28	24	30	24	(14)
23. Economica	63.3	27	11	9	7	(15)
24. J. Human Res.	58.9	21	20	29	29	(16)
25. J. Money, Credit, Banking	47.4	31	21	19	22	(17)
26. J. Business	39.6	35	27	21	21	(18)
27. J. Econ. Hist.	35.1	57	66	16	16	(19)
28. Nat. Tax J.	34.8	40	34	32	25	(20)
29. Oxford Econ. Pap.	32.8	44	41	12	12	(21)
30. Population Stud.	31.0	50	93	—	—	
31. J. Acc. Res.	30.0	53	35	—	—	
32. Demography	29.7	19	97	—	—	
33. J. Environ. Econ. Manage.	29.2	56	49	—	—	
34. Ind. Lab. Relat. Rev.	29.1	26	28	37	26	(22)
35. J. Royal Statist. Assoc. A	25.6	63	48	—	—	
36. Econ. Develop. Cult. Change	25.2	60	67	26	23	(23)
37. J. Amer. Statist. Assoc.	24.4	11	38	10	9	(24)
38. Manchester Sch. Econ. Soc. Stud.	22.3	61	37	31	27	(25)
39. J. Ind. Econ.	21.2	59	31	35	36	(26)
40. Urban Stud.	20.3	42	59	—	—	
41. Econ. Hist. Rev. 2nd Ser.	20.2	66	87	—	—	
42. J. Econ. Theory	19.5	25	14	8	19	(27)
43. J. Devel. Econ.	18.6	71	46	—	—	
44. Explorations Econ. Hist.	18.0	73	65	—	—	
45. Amer. Econ. Rev. P. and P.	14.4	20	15	—	—	
46. Labor Hist.	14.2	58	85	—	—	

TABLE 1 (Continued)

Net Citations Rank	NC	LP Ranks: Citations Per Character	LP Ranks: Impact Adjusted Citations Per Character	HRW Ranks: Mean	HRW Ranks: Prestige	*
47. Reg. Sci. Urban Econ.	14.1	65	56	—	—	
48. Land Econ.	11.7	54	48	39	27	(28)
49. Can. J. Econ.	10.9	52	29	17	17	(29)
50. Scand. J. Econ.	10.6	29	25	—	—	
51. Reg. Stud.	10.4	37	80	—	—	
52. Lloyds Bank Rev.	10.3	64	54	48	36	(30)
53. Scot. J. Polit. Econ.	7.6	62	57	40	37	(31)
54. Europ. Econ. Rev.	7.3	67	40	46	51	(32)
55. J. Reg. Sci.	7.3	41	44	27	31	(33)
56. Hist. Polit. Econ.	6.7	92	74	—	—	
57. Sloan Manage. Rev.	3.0	51	71	44	46	(34)
58. Rev. Soc. Econ.	3.0	95	72	54	54	(35)
59. Kyklos	2.2	43	36	23	20	(36)
60. Int. J. Soc. Econ.	1.6	89	78	—	—	
61. Ind. Relat.	1.1	34	47	43	53	(37)
62. J. Econ. Educ.	.9	85	49	51	44	(38)
63. Public Choice	−.2	47	42	28	4	(39)
64. Bus. Hist. Rev.	−1.2	98	96	—	—	
65. Public Finance	−2.4	90	39	33	37	(40)
66. J. Devel. Stud.	−2.6	75	77	45	48	(41)
67. Public Finance Quart.	−2.9	78	43	—	—	
68. Weltwirsch. Arch.	−3.7	69	52	36	43	(42)
69. Oxford Bull. Econ. Statist.	−3.8	84	63	25	35	(43)
70. Econ. Geogr.	−5.3	39	82	49	47	(44)
71. J. Devel. Areas	−5.6	94	68	52	49	(45)
72. Nebr. J. Econ. Bus.	−6.1	99	70	—	—	
73. J. Common Mkt. Stud.	−7.1	96	99	—	—	
74. Public Policy	−9.1	38	81	38	45	(46)
75. Amer. J. Econ. Soc.	−9.2	83	88	50	32	(47)
76. J. Econ. Stud.	−9.3	102	104	—	—	
77. Sci. Soc.	−9.8	77	100	53	49	(48)
78. Malayan Econ. Rev.	−10.3	101	83	—	—	
79. Matekon	−10.7	103	102	—	—	
80. Applied Econ.	−11.0	76	45	42	52	(49)
81. J. Trans. Econ. Policy	−12.7	91	79	—	—	
82. Australian J. Agr. Econ.	−14.9	104	94	—	—	
83. Econ. Rec.	−16.7	74	64	34	30	(50)
84. Brit. J. Ind. Relat.	−18.7	49	51	—	—	
85. J. Econ. Bus.	−21.0	87	60	—	—	
86. J. Int. Bus. Stud.	−22.6	101	84	—	—	
87. Policy Analysis	−28.2	46	95	—	—	
88. J. Econ. Issues	−28.7	79	62	47	41	(51)
89. J. World Trade Law	−32.1	68	98	—	—	
90. Quart. Rev. Econ. Bus.	−36.4	88	63	41	37	(52)
91. Natural Res. J.	−40.0	70	91	—	—	
92. Calif. Manage. Rev.	−45.6	81	92	—	—	

TABLE 1 (Continued)

Net Citations Rank	NC	LP Ranks: Citations Per Character	LP Ranks: Impact Adjusted Citations Per Character	HRW Ranks: Mean	HRW Ranks: Prestige	*
93. Soc. Res.	−55.2	82	101	—	—	
94. J. Financial Quant. Anal.	−79.9	55	30	22	34	(53)
95. Mich. Law Rev.	−81.4	36	89	—	—	
96. J. Risk Ins.	−81.9	79	75	—	—	
97. Soc. Sci. Quart.	−92.7	97	90	—	—	
98. Yale Law J.	−101.9	98	69	—	—	
99. Int. Soc. Sci. J.	−104.1	100	103	—	—	
100. Southern Econ. J.	−108.7	48	32	20	13	(54)
101. Int. Lab. Rev.	−127.5	93	77	—	—	
102. Amer. J. Agr. Econ.	−130.2	33	53	—	—	
103. World Devel.	−172.1	72	86	—	—	
104. Mon. Lab. Rev.	−3038.5	86	73	—	—	

*The numbers in parentheses are our net citations ranks of the 54 journals common to our study and HRW.

NOTES

1. Citations-based journal rankings which do not use *SSCI* data can also be found in economics, see Coats (1971), Billings and Viksnins (1972), Skeels and Taylor (1972), and Michael Lovell (1973).
2. We have presented equation 1 as linear solely to simplify the analysis, and we have assumed that Q can be expressed in units consistent with a unitary coefficient. Given the emphasis we are placing on grouping economics into different fields, it is important to recognize that we are assuming that Q is invariant across fields within journals. This assumption may not be reasonable for some journals. Some journals may publish very good articles in some fields and ones which are not as good in others.
3. In addition to Garfield (1972), rankings based on citations per article, which Garfield termed "journal impact" can be found in Rounds (1982), Rushton and Roediger (1978) and White and White (1977).
4. We thank Stan Liebowitz and John Palmer for providing the raw data required to translate the indexes in LP to data on citations, characters and articles. Unfortunately, in matching our data on *JEL* listings with the LP data, we had to drop four journals. Articles from the *Journal of Legal Studies* and the *Journal of the Royal Statistical Association B, Economic Letters,* and *Inquiry* were not classified by the *JEL* for a sufficient number of years to be included in our rankings.
5. This same adjustment was made by LP as part of their impact adjustment. For the two journals, *Journal of Mathematical Economics* and *Journal of Econometrics* for which LP approximated citations, we had to approximate the percentage of listings which were not from journals on the list. This approximation was accomplished by assuming that this percentage was equal for *Econometrica* and the *Journal of Econometrics* and that it was equal for the *Journal of Economic Theory* and the *Journal of Mathematical Economics.*
6. The *JEL* listing practices allow an article to be listed in several of the three-digit codes. The authors will provide a list of field definitions. Since our fields in most cases combine several three digit codes, there is a possibility of an article being listed twice in one field as well as its being listed in more than one field. These multiple listings may generate errors in our measures of the percentage of a journal's articles in each field. Ideally we would like each article to have the same weight in such a measure. That is, if an article deserves to be listed twice, it should enter each time with a weight of ½. As long as *JEL* multiple listing practices are consistent within journals, this will be accomplished. For example, if each *American Economic Review* article is listed 4 times and each *Journal of Human Resources* article is listed 2 times, multiple listings will not affect our results. Undoubtedly this is not the case, so our measures of percentage of articles in each field will be slightly off; they will likely overstate the relative size of fields composed of many three digit-codes.
7. The log-linear functional form yielded the best fit as measured by the R^2 and F statistics. Other functional forms yielded journal rankings which were quite close to those presented below. For example, the rank order correlation between the ranking we present and one derived from a linear specification of equation (3) is .91 (with a probability value of .0001).

8. In generating $\hat{C}(t, T)$ from equation (6) we must recognize that the exponential of estimated log C(t, T) will be biased. Since exp (·) is a convex function, an unbiased estimator of log C(t, T) when exponentiated will underestimate C(t, T). To account for this bias, we use a correction factor suggested by Eddy and Kadane (1982). This correction factor is equal to the ratio of the sum of C(t, T) and the sum of the exponential of the estimated log C(t, T). Our $\hat{C}(t, T)$ series has been adjusted by this correction factor which equaled 1.05530 for our data. The use of this correction has a minor effect on our rankings. The rank order correlation between these rankings and ones produced without the correction is .99 (probability value = .0001).

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