A Combined Loglinear/MDS Model for Mapping Journals by Citation Analysis

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Loglinear analysis of interjournal citations permits objective evaluation of the network of journals in and around a discipline. Citation frequency is modeled as a probabilistic Poisson process, with its expectation being the product of the "influence" of the cited journal on the citing journal, and of the citing journal's "receptivity." The "influence" is itself modeled as the product of the cited journal's "importance," and of the "similarity" between the two journals. Loglinear analysis is used to extract maximum likelihood estimates of journals' importances and receptivities and a matrix of similarities from their citation matrix. Multidimensional scaling of the derived similarities matrix provides an interpretable map of the journals' relative configuration. As an application of the method, the major marketing journals are mapped relative to journals of related disciplines, showing the influence that the psychology and management disciplines have had upon the marketing literature.

Introduction

The impact of its journals and the dissemination of information is critically relevant to an academic discipline. Exchange of knowledge is essential for both scientific and technical progress. Journals play a vital role in the spread of information within and between disciplines, and published articles form the foundation on which future work is based. Although what is published is influenced by many factors (such as submissions and editorial policy), it is published work that has the greatest impact on the discipline. Publication in a journal not only influences the future progress of the discipline, but is also used as a basis for personnel decisions in selection, promotion and tenure. Few academics have not at one time or another debated the value of a publication in one journal versus another. Research into journals, their publication policies and the nature of their interrelationships is of benefit not only to individual academics but also to the general community. Perception of these benefits is manifested in the increasing amount of research being conducted into journals and their citations since citations counts for journals began to be published (Garfield, 1972). Todorov and Glanzel (1988) discuss the strengths and weaknesses of some of the commonly advocated journal indicators, such as immediacy index and impact factor, that have been based on journal citation rates.

In this article, a loglinear model of citation frequency is proposed such that the expected frequency of citation is proportional to the "receptivity" of the citing journal multiplied by the "importance" of the cited journal and the "similarity" of the two journals. The model is an improvement from the approaches of earlier studies because it includes a consideration of the effect that the similarity between two journals has on their mutual impact. This extension of the model enables us to examine the influence between journals of related disciplines. Loglinear modeling techniques are developed to obtain a maximum likelihood fit of the model to a citation matrix. As an example application of the method, using data from the *Social Sciences Citation Index* (Garfield, 1981–1988), the model is applied to a set of journals in and related to the marketing area, across the period 1981 to 1987, to derive quantitative values for the journals' importances and similarities. The results permit an objective ranking of the journals in importance, and allow trends across time to be investigated. Multidimensional scaling (MDS) of the similarities is used to provide an interpretable map of the journals' relative configuration. The method is applicable to any set of interrelated journals, and can provide information useful to authors submitting papers, to libraries selecting journals, and to reviewing authorities evaluating publication records.

Previous Work

Previous research has in general addressed two interrelated issues, using two generic methodologies. The first issue involves the question of journal quality, impact or importance to the discipline. Researchers addressing

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this issue (Durand, 1974; Hamelman & Mazze, 1973; Jobber & Simpson, 1988; Leong, 1989; Macmillan & Stern, 1987; Vocino & Elliott, 1984) generally derive some kind of rating or ranking of journals to use as an indicator of journal quality. The second question involves the interrelationships among the journals, as in the studies by Coombs (1964, pp. 463–480), Eagly (1975), Goldman (1979), Hamelman and Mazze (1973), Jobber and Simpson (1988), Neeley (1981), and Penava and Pravdic (1989). The issues of journal quality and their interrelationships have in some cases been treated separately, as in particular studies focussing only on the rankings in terms of quality. Studies have tended to concentrate on the flow of information between journals within a supposedly unitary discipline rather than examining the flows between disciplines and subdisciplines. Previous work has not adequately recognized that the impact of one journal upon another is not just a matter of its importance but how similar the two journals are. For example, articles in a journal may be equally likely to refer to a relatively unimportant but closely related journal, or to an extremely important but less closely related journal.

The methodological focus has been either on survey research or on some form of citation analysis. Studies employing the survey methodology usually involve the evaluation of responses from a sample of practitioners and/or academics (sometimes chairpersons of departments or deans) who have been asked to express their perceptions concerning journal quality. Examples of this methodology include Durand (1975), Hawkins, Ritter, and Walter (1973), Mace and Warner (1973), Macmillan and Stern (1987), Vocino and Elliott (1984), and Weber and Stevenson (1981). These studies have been criticized on the grounds that they lack objectivity in surveying subjective opinions which may be only personal views of journal impact and quality (Jobber & Simpson, 1988; Levin & Kratochwill, 1976; Rushton & Roediger, 1978). Such studies have serious problems, beyond sampling bias and nonresponse, and the ratings may simply reflect rater familiarity, perhaps influenced by the respondent's publishing record or other special relationship.

In an attempt to overcome these defects, other researchers have turned to some form of citation analysis. As an application of nonmetric multidimensional scaling, Coombs (1964, pp. 463–481) evaluated a set of psychology journals by counting their citations to each other in a particular period. From this asymmetric citation matrix he subtracted the column and row main effects (to correct for "bulk" due to a larger number of articles in one journal than in another) to develop a two-dimensional configuration for the journals. Despite problems arising from his use of an asymmetric matrix to generate the map, Coombs' analysis provided an interesting, systematic and relatively objective evaluation and mapping of the psychological journals he analyzed. It is, therefore, surprising that his work has been largely overlooked by other scholars who have attempted citation analysis of journals in their specific disciplines (Durand, 1974; Eagly, 1974; Garfield, 1972; Hamelman & Mazze, 1973, 1976; Jobber & Simpson, 1988; Leong, 1989; Rushton & Roediger, 1978). However, several researchers (Arms & Arms, 1978; Carpenter & Narin, 1973; Doreian, 1988a, b; Narin, Carpenter, & Berlt, 1972, and Slater, 1983) have used citation matrices as the input to cluster analyses, to group journals in related clusters. In addition to Coombs (1964), Gatrell and Smith (1984) and Xhignesse and Osgood (1967) have used multidimensional scaling to generate two or three-dimensional maps of journals from citation matrices. In both clustering and multidimensional scaling, using a citation matrix to generate a similarity matrix has the major problem that the citation matrix is not symmetric, whereas the similarity matrix would be expected to be. The asymmetry in the citation matrix arises from several causes: some journals are more influential (because they publish more influential or more articles, or both); some journals cite more heavily (because they publish more articles, or articles with more references, or both), and finally we are dealing with a random process and can expect some random outcome. Writers who have used cluster or multidimensional scaling techniques have dealt with the asymmetry problem in a variety of empirical ways, such as by averaging the citing and cited counts (Xhignesse & Osgood, 1967), by using only the cited counts (Arms & Arms, 1978), by inputting the asymmetric matrix to the MDS program, or by a process of iterative normalization (Doreian, 1988a; Slater, 1983). Using a loglinear approach, we will show how a maximum likelihood estimate of journal similarities can be extracted from the citation matrix, yielding as by-products, estimates of the journals' "influence" and "receptivity."

The Data Source

Garfield (1972, p. 471) recognized the importance of "citation analysis as a tool in journal evaluation" and bemoaned the fact that "the network of journals that play a paramount role in the exchange of scientific and technical information is little understood." He suggested that one reason for this lack of progress was the "practical difficulty of compiling and manipulating manually the enormous amount of necessary data." A solution to the problem was the appearance of the *Science Citation Index* (SCI)—an international, multidisciplinary data base which includes the world's most important scientific and technical journals. Since 1972 the SCI has been extended and we now have the *Social Sciences Citation Index* (SSCI)—"an international multidisciplinary index to the literature of the social, behavioral and related sciences." The existence of this index provides a ready-made source for the derivation of a matrix to serve as input for an analysis whose objectives are similar to those employed by Coombs.

It is surprising that most researchers following Garfield (1972) have not attempted to use the SSCI for their evaluation of journal citations. Hamelman and Mazze (1973, 1976) in marketing and finance advocate the use of their own computer program for citation analysis but do not attempt anything but the most rudimentary analysis of their data. Eagly (1974) comes very close to Coombs (1974) in evaluating economics journals as a communication network and develops a number of "sending and receiving indices," but rather than using the SSCI he collected his own data from selected journals. Rushton and Roediger (1978) did use the SSCI to evaluate 80 psychology journals but the purpose of their analysis was simply to obtain a unidimensional rank order of the journals based on the SSCI supplied impact factors. A more recent attempt at citation analysis was that of Jobber and Simpson (1988) in marketing. The basis of their analysis was some 375 articles containing over 8,587 references in selected European and American journals. Finally Leong (1989) analyzed the nature of reference sources of articles published in five sample volumes of the *Journal of Consumer Research*. Although the latter analysis revealed trends over time as well as classificatory information concerning cross-disciplinary references by consumer researcher studies, it was only a limited one-way analysis that did not reveal the full interdisciplinary picture. Neither Jobber and Simpson nor Leong used the SSCI and their analyses, although interesting and innovative, did not reveal the fuller picture that could have been provided by an adaptation and development of the work of Coombs (1964).

Marketing researchers may have avoided using the SSCI for citation analysis because it is a somewhat cumbersome data base: extraction of the citation matrix is not straightforward, but requires a search through the journal family tree. A more critical problem is that SSCI does not list all the marketing journals and some have so few cross references that until very recently it was not possible to develop a comprehensive matrix that would do justice to even the major journals. Researchers have therefore had to make a difficult choice between using a relatively incomplete SSCI data base and developing their own citation listing with all its sampling and logistic problems. The picture now is a little better and SSCI provides a reasonable although not entirely complete basis for a citation analysis.

It is the purpose of this article to present the results of such an analysis using loglinear modeling, a powerful technique which does not appear to have been previously applied to this problem. Good general descriptions of loglinear modeling techniques can be found in Fienberg (1980), Agresti (1984), Bishop, Fienberg, and Holland (1975), and Knoke and Burke (1980).

The Model

Consider a set of N journals, where F_{ij} represents the number of times in a given period that journal i cites references to journal j. For example, Table 1 shows the frequency with which 18 marketing and related journals cited each other during 1986 and 1987 as reported in the *Social Sciences Citation Index* (1986, 1987). In this table, we see that in 1986 and 1987 the *Journal of Marketing Research* ($i = 14$) contained 54 citations to *Management Science* ($j = 17$), so $F_{14,17} = 54$. On the other hand, Management Science contained 52 citations to the Journal of Marketing Research, so $F_{17,14} = 52$.

Consider journal i, comprising n pages or articles published in the given period. Let there be a probability π that in any one page or article there will be a reference to journal j. On the reasonable assumption

TABLE 1. Citation matrix for 1986–1987.

		Citing Journal (i)																	
Cited Journal (j)		01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18
Admin Sci Quart	01	207	10	46	11	2	0	0	0	36	0	194	0	52	18	0	0	115	0
Adv Consum Res	02	0	363	49	21	0	0	51	11	10	239	0	0	45	43	0	24	0	0
Annu Rev Psych	03	0	11	68	0	0	0	0	0	0	18	0	0	6	0	76	0	0	8
Eur J Marketing	04	0	6	0	43	0	12	0	3	11	0	0	2	29	2	0	0	0	0
Harvard Bus Rev	05	7	31	0	81	165	50	3	11	33	6	61	0	81	8	0	18	65	0
Ind Market Manag	06	0	2	0	33	0	136	0	2	21	0	3	0	43	5	0	5	0	0
J Advertising	07	0	22	0	3	0	9	75	45	0	12	0	0	10	7	0	2	0	0
J Advertising Res	08	0	92	0	28	0	18	88	160	12	59	0	16	26	38	0	12	0	0
J Bus Res	09	0	15	0	6	0	13	0	3	44	13	0	3	7	14	0	3	0	0
J Consumer Res	10	0	514	64	29	0	0	40	32	34	437	0	5	104	131	0	34	0	0
J Manage Stud	11	9	0	0	3	0	0	0	0	4	0	36	0	5	0	0	0	6	0
J Market Res Soc	12	0	1	0	3	0	4	0	4	4	2	0	45	11	5	0	0	0	2
J Marketing	13	0	215	10	157	0	100	31	58	120	117	34	18	322	97	0	67	28	0
J Marketing Res	14	0	299	23	131	0	81	68	95	145	245	0	52	221	417	0	91	52	0
J Pers Soc Psychol	15	21	156	554	6	0	0	26	0	23	141	0	4	57	52	3327	7	0	0
J Retailing	16	0	37	0	30	0	0	0	0	27	14	0	0	41	25	0	116	0	0
Manage Sci	17	6	15	0	21	3	7	0	0	28	18	16	0	21	54	0	0	619	0
Psychometrika	18	0	15	0	0	0	0	0	0	30	7	0	0	0	80	46	0	11	712

that the probability of such a reference is independent from page to page (or at least from article to article), then F_{ij}, the total number of times in the given period that journal i cites references to journal j, will be a random Poisson distributed variable of expectation $E_{ij} = n\pi$. This sampling model is discussed by Fienberg (1980), and was first suggested for contingency tables by Fisher (1950).

Given that the F_{ij} values are Poisson distributed, our model will also use the assumption that they are independently distributed, to form the likelihood function of equation (4) below. That is to say, we shall assume that deviations of F_{ij} from E_{ij} are uncorrelated with deviations of F_{kl} from E_{kl}. This assumption is clearly reasonable if i differs from k, since we would not expect the variations in citations in different journals to be correlated. The assumption is admittedly not quite as clear for the case where i equals k, since an article that happens to quote more than expected from one particular journal may be more likely than expected to quote from another closely related journal, but even in this case we would not expect such dependences to aggregate to produce large correlations between the deviations of F_{ij} and F_{il} from their expectations E_{ij} and E_{il}. This assumption of the independence of the deviations of the frequencies F_{ij} should not be confused with the much stronger (and clearly invalid) assumption that the F_{ij} values themselves are uncorrelated. The weaker assumption that we are making, that the deviations $(F_{ij} - E_{ij})$ are independent, is implicit in all maximum likelihood loglinear modeling, though not always explicitly recognized.

The expected value E_{ij} will be a function of the receptivity of journal i to cite references (which we shall refer to as R_i) and the influence of the cited journal j on journal i. The influence need not be symmetric, being dependent both on how important the cited journal is, and on how distant the two journals are from each other. This asymmetry can be modeled by considering the influence as being the product of the cited journal's global importance (which we shall call I_j), and the symmetric similarity (S_{ij}) between the two journals. A pair of lighthouses of unequal brightness provide an illuminating physical analogy: the light received by one lighthouse is proportional to the brightness of the other, multiplied by a symmetric measure of similarity (the inverse square of the distance between them, in this physical analogy). If we postulate a multiplicative (or loglinear) Citation model, it will be of the form:

$$E_{ij} = \text{Expected}(F_{ij}) = R_i \cdot I_j \cdot S_{ij} \qquad (1)$$

Different journals will have differing receptivities. For example, during 1987 the *Harvard Business Review* cited a total of only 194 references (to all journals), while in the same year the *Journal of Personal and Social Psychology* cited 9216 references. Similarly, journals may differ in their importances. There is therefore no reason to expect the F_{ij} matrix to be symmetric. However the matrix of similarities, S_{ij}, can reasonably be required to be symmetric. Without imposing any further constraints on the model, R_i and I_j can be scaled so that S_{ij} equals unity when i equals j. For i and j not equal, we would then expect S_{ij} to be less than or equal to unity.

Following the notation used by Fienberg (1980, p. 40), the maximum likelihood fit to the model of equation (1) can be found by minimizing:

$$G^2 = 2\Sigma_{ij} F_{ij} \cdot \log(F_{ij}/E_{ij}) \qquad (2)$$

It can be shown that G^2 has asymptotically a chi-squared distribution with the number of degrees of freedom appropriate to the particular model being considered. Depending on the constraints applied to the similarities, S_{ij}, a sequence of hierarchical models of the form of equation (1) can be fitted.

Model	Constraints	Degrees of Freedom	Chi-Sq
1. Full Independence	S_{ij} = constant, for all i, j	$(N-1)^2$	G^2_{Independ}
2. Off-Diagonal Independence (Baseline Model)	S_{ij} = constant, for all $i \neq j$	$(N-1).(N-2)$	G^2_{Baseline}
3. Citation Model	$S_{ij} = S_{ji}$	$(N-1).(N-2)/2$	G^2_{Citation}
4. Saturated	None	Zero	Zero

The full independence model allows no interactions. The second model relaxes this condition, allowing a perfect fit on the diagonal, but retaining independence for the off-diagonal cross-references. This off-diagonal independence model will be used as a baseline model to assess the proportion of variation explained by the citation model. The citation model corresponds to the model we have specified above, with the similarities between journals being symmetric. The condition that S_{ii} be unity does not absorb any degrees of freedom since it can be achieved by a suitable scaling of the importances or receptivities. Finally, the saturated model, allowing asymmetric S_{ij} values, will give a perfect fit but have no degrees of freedom. In each model, except the full independence model, the fit along the diagonal will be perfect.

As we go from the first to the second, third, and fourth models we can conclude that the elaboration of the model is justified if the reduction in G^2 is significant, as a chi-squared with degrees of freedom equal to the difference in degrees of freedom between the two subsequent models being compared. However, as Agresti (1984, p. 64) and Knoke and Burke (1980, pp. 40–41) point out, large sample sizes can be expected to lead to situations where G^2 is significantly large for all except the saturated model, since G^2 is proportionate to the sample size. Accordingly, as Knoke and Burke (1980) suggest, significance tests can usefully supplemented by a measure of variation explained, equivalent to R^2 in regression analysis. The R^2 analogue that we shall use is

$$R^2 = (G^2_{\text{Baseline}} - G^2_{\text{Citation}})/G^2_{\text{Baseline}} \quad (3)$$

Whereas the full independence and the saturated models can be fitted using standard loglinear modeling techniques, the intermediate citation and baseline models cannot be fitted using the commonly available loglinear computer programs. The maximum likelihood estimation technique (Agresti, 1984, pp. 235–237) can be extended to fit the citation and baseline models, as we shall outline below.

F_{ij} and E_{ij} ($= R_i \cdot I_j \cdot S_{ij}$) are the observed and expected citation frequencies. On our model, developed above, the observed frequencies F_{ij} can be considered to be sampled from independent Poisson distributions. It must be emphasized that the independence assumption here is that the deviations ($F_{ij} - E_{ij}$) are uncorrelated, not that the F_{ij} values themselves are uncorrelated. The likelihood function for the joint probability of the independently Poisson distributed frequencies F_{ij} is given by the product of their individual probabilities:

$$L = \Pi_{ij}[\exp(-E_{ij})] \cdot (E_{ij})F_{ij}/F_{ij}!$$
$$= \Pi_{ij}[\exp(-R_i \cdot I_j \cdot S_{ij})] \cdot (R_i \cdot I_j \cdot S_{ij})^{F_{ij}}/F_{ij}! \quad (4)$$
$$\therefore \log L = Fn(F_{ij}) + \Sigma_{ij}(F_{ij} \cdot \log(R_i \cdot I_j \cdot S_{ij}) - R_i \cdot I_j \cdot S_{ij}) \quad (5)$$

The maximum likelihood estimate must satisfy the set of conditions

$$\partial(\log L)/\partial R_i = 0 \quad (6)$$
$$\partial(\log L)/\partial I_j = 0 \quad (7)$$
$$\partial(\log L)/\partial S_{ij} = 0 \quad (8)$$

The Baseline model (which can be expressed as $E_{ij} = R_i \cdot I_j, i \neq j; E_{ii} = F_{ii}$), therefore requires

$$R_i = (\Sigma_{j\neq i}F_{ij})/(\Sigma_{j\neq i}I_j) \quad (9)$$
$$I_j = (\Sigma_{i\neq j}F_{ij})/(\Sigma_{i\neq j}R_i) \quad (10)$$

For the Citation model, with $S_{ij} = S_{ji}$, the conditions (6) to (8) can be satisfied by iteratively solving

$$R_i = (\Sigma_j F_{ij})/(\Sigma_j(I_j \cdot S_{ij})) \quad (11)$$
$$I_j = (\Sigma_i F_{ij} \cdot)/(\Sigma_i(R_i \cdot S_{ij})) \quad (12)$$
$$S_{ij} = S_{ji} = (F_{ij} + F_{ji})/(R_i \cdot I_j + R_j \cdot I_i), i \neq j \quad (13)$$
$$S_{ii} = 1 \quad (14)$$

It is of interest to note that the maximum likelihood procedure of equations (11) to (14) is similar to, but is not identical to, the empirical double normalization procedure advocated by Slater (1983) and by Doreian (1988a). The major differences lie in our constraints that the diagonal be composed of equal unitary similarities, and that the off-diagonal similarities be symmetric, as determined by equations (13) and (14).

For each model, all the R_i values could be multiplied by an arbitrary factor, and the I_j values divided by the same factor, without changing the expected cell frequencies E_{ij}. Since we are more interested in comparing the importances (I) of journals than their receptivities (R) the results are scaled so that the geometric mean of the importances is unity.

In applying the models developed above, the problems of sample size and of sampling zeros need to be considered. Fienberg (1980, pp. 172–176) discusses evidence from which he concludes that the asymptotic chi-squared properties are reasonably well satisfied if the average cell count exceeds four or five. For the examples we shall be considering, the average cell count is in excess of 20. Structural zeros and sampling zeros need to be distinguished from one another. Structural zeros exist when the expectation of a cell count is zero (such as, for example, the incidence of pregnant men). There are no structural zeros in our postulated models, since any journal within a related set could conceivably refer to any other, though the expected frequency will in many cases be less than one. Consequently, many of the cells will have zero sampling frequencies. Although the iterative fitting procedure will generate nonzero expected frequencies, problems will arise in the iteration if any row or column of sampled frequencies has only zeros except on the diagonal. This situation will arise if an included journal is either not referred to by any other journal in the set, or does not itself refer to any of the others. In this case, while the E_{ij} values will remain small but nonzero, the relevant S_{ij} values will become vanishingly small, while the journal's importance (I) or receptivity (R) will become large without limit. This result is equivalent, for example, to saying that a journal which is referred to by others, but does not refer to them, is of very large importance and of very small similarity to them. To avoid this situation, 0.5 is added to all the observed frequencies before analysis, in accord with the procedure advocated by Goodman (1970). Although, as Knoke and Burke (1980) point out, this procedure will tend to underestimate the contrast between parameters, we find that it does not affect the rank ordering of the results and it does considerably speed the iteration process.

A computer program to fit the baseline and citation models for a matrix of journal references was written in Pascal on a Macintosh SE computer. Run time to convergence was about 10 minutes for an 18 by 18 matrix. The output consists of vectors giving for each journal its importance and receptivity, plus a matrix of similarities between the journals, with values of one on the diagonal. The similarity matrix provides an ideal input to a multidimensional scaling procedure, allowing the computation of a two-dimensional (or higher dimensional) map of the relative configuration of the journals.

Application of the Model

The model developed above was applied to a set of journals relating to the marketing area, using citation counts as reported in the *Social Sciences Citation Index* annual reports for 1981 through 1987. These annual reports tabulate for each journal the number of times in the year it has cited each other journal, and the number of times it has been cited by each other journal. The set of journals to be included was defined first by identifying three journals that were hypothesized as being preeminent within the field. These were the *Journal of Marketing Research,* the *Journal of Consumer Research* and the *Journal of Marketing.* Referring to the 1986 and 1987 SSCI reports, 15 further journals were selected, being those journals which had most heavily cited or been cited by the first three. Of the 18 journals thus selected, 15 had their citations reported for each of the 1981 to 1987 SSCI reports. *Advances in Consumer Research* and *Industrial Marketing Management* are reported from 1984 onwards, while the *Journal of Advertising* is reported only for 1986 and 1987. The *Journal of Management Studies* was included because of its high citation rate of the other journals, apart from the core three. The citation matrix for 1986 and 1987 appears in Table 1.

It is noteworthy that, of the 18 journals selected, three are hard core psychology journals (*Journal of Personality and Social Psychology, Annual Review of Psychology* and *Psychometrika*); four are what may be regarded as general management journals (*Harvard Business Review, Administrative Science Quarterly, Journal of Management Studies* and the *Journal of Business Research*); one is a quantitative general management journal (*Management Science*), and the remaining 10 are marketing journals. While the particular set of journals selected is, to a certain extent, a function of the SSCI citation journal pool, it is nonetheless important to note that the marketing literature is strongly linked to the psychology and general management disciplines. This is hardly unexpected. However, the total absence of an economics journal is surprising, particularly since marketing has traditionally been referred to as applied economics and indeed had its origins as an academic discipline in the schools of agricultural economics (Bartels, 1976).

A full analysis of all 18 journals was undertaken for the combined 1986 and 1987 data. A longitudinal analysis was also carried out for each year from 1981 to 1987 for the 15 journals whose data spanned the whole period. The loglinear model developed in the preceding section was applied to each citation matrix. The statistics for fitting the combined 1986 and 1987 data were as follows

Model	Degrees of Freedom	Chi-Sq
1. Full independence	289	41,337
2. Off-diagonal independence (Baseline model)	272	7,706
3. Citation model	136	583
4. Saturated	Zero	Zero

The decrease in the chi-square statistic was thus very highly significant in going from the first to the second to the third model. However, even the citation model is not a perfect fit, since the remaining chi-square of 583 with 136 degrees of freedom is highly significant. But, as we have seen above, a perfect fit is not to be expected with such a large sample size (the matrix contained a total of 14,802 citations). A more appropriate test is the proportion of variation explained, as defined in equation (3) (Knoke & Burke, 1980, p. 41). The citation model explains 98.6% of the variation in the full independence model, and 92.4% of the variation in the off-diagonal independence baseline model. Similar proportions of variation explained were obtained for analyses of each year's citation matrix, from 1981 to 1987, from which we conclude that the citation model gives an adequate fit to the data.

As we have seen, fitting the citation model to a matrix assigns an "importance" and a "receptivity" to each journal, and generates a matrix of interjournal similarities. The importances have been scaled to a geometric mean of one. The similarity matrix has a diagonal comprised of ones. Figure 1 shows the importances for each of the 15 journals analyzed for the period 1981 to 1987. These importances can be interpreted as the relative tendency for a journal to be cited: for a given citing journal, the expected number of times it cites another journal will be proportional to the importance of the cited journal, multiplied by its similarity to that journal.

The journals are rank ordered in accord with their importances in 1987, but the order has remained remarkably stable throughout the period. It is of interest that the three marketing journals with which we started lie halfway down. Above them are five feeder journals, from the psychology and management areas, which are strong sources of material to the marketing literature. These sources are varied and provide a mixture of the highly quantitative (*Psychometrika* and *Management Science*), the theoretical and empirical (*Journal of Personality and Social Psychology* and *Administrative Science Quarterly*) and the applied (*Harvard Business Review*). Of particular interest is the *Harvard Business Review:* despite its practitioner emphasis (explaining its low receptivity) it is of very high importance to the other journals. Below the three top marketing journals lie the less academic and less important journals which refer frequently to the higher ranking journals.

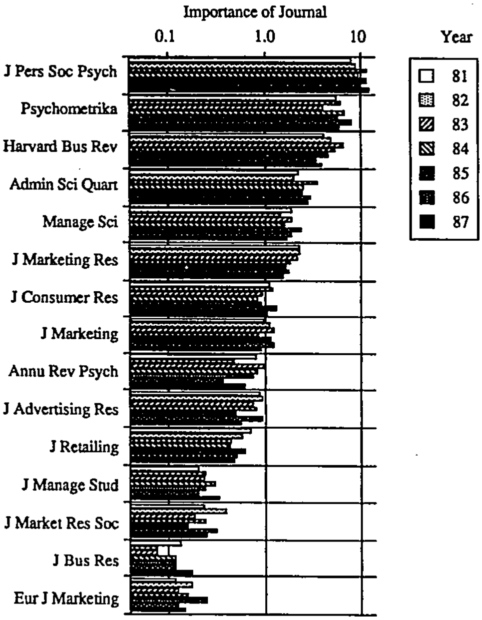

FIG. 1. Journal importances, 1981 to 1987.

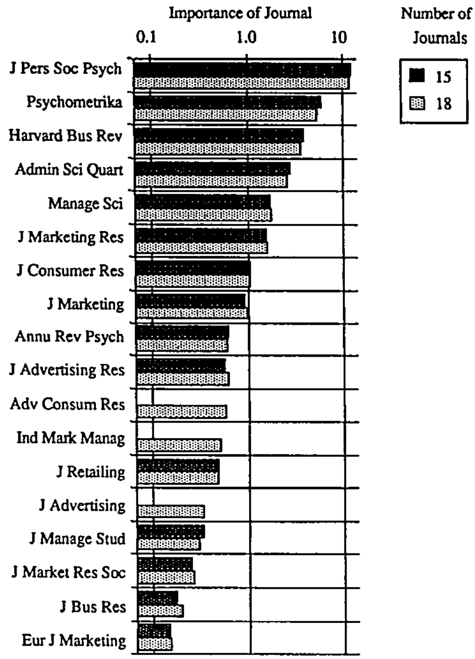

FIG. 2. Effect of changing number of journals.

For each journal, there are moderate variations in the yearly importances. Fitting exponential trend models to each set of seven values, none of the trends were found to be significant at the 5% level. However, given a longer period of available data, the method could be used to track secular changes in the journals' importances.

Figure 2 shows the importances obtained for analyses of the combined 1986 and 1987 data for all 18 journals, compared with the results for the analysis of the combined 1986 and 1987 data for the 15 journals considered in Figure 1. Both results have been standardized so that the geometric means of importance are unity for the 15 journals common to both analyses. It is clear that adding the three extra journals to the analysis does not appreciably alter the relative importances.

The similarity matrix obtained from the combined 1986 and 1987 data for all 18 journals was subjected to multidimensional scaling to minimize Kruskal's (1964) stress. Fitting the similarities successively to one, two, three, four, and five dimensions gave minimum stress values of 0.396, 0.182, 0.118, 0.086, and 0.063. Accordingly, since adding more dimensions did not greatly reduce the stress, the two-dimensional fit was used (with stress of 0.182). The resulting configuration is mapped in Figure 3.

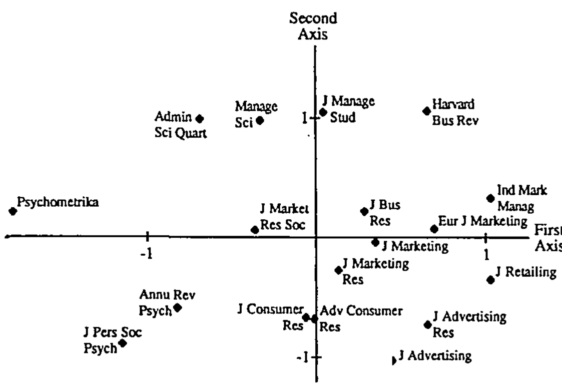

FIG. 3. MDS map of journals, based on 1986–1987 references

The map of the 18 journals gives them relative positions that make sense. The marketing journals are closely grouped, with the advertising, retailing, and consumer journals lying below them. At the top of the map lie the general management journals, while the psychology journals lie to the lower left, with *Psychometrika* somewhat distant from the other two psychology journals. The axes may also be tentatively interpreted. The horizontal axis ranges from the highly quantitative and theoretical journals on the left (such as *Psychometrika* and the *Journal of Personality and Social Psychology*) to the more applied journals on the right (for example, *Industrial Marketing Management* and the *Harvard Business Review*). The vertical axis is a little more difficult to interpret, but appears to vary from general management at the top (as exemplified by the *Journal of Management Studies* and the *Administrative Science Quarterly*) through general marketing (for example, the *Journal of Marketing*) to more specific and perhaps behavioral areas (such as the *Journal of Advertising*).

Criticisms of the Model

The model for citation analysis advanced in this article differs from previous work in considering the influence of one journal upon another as being the product of (asymmetric) importance and (symmetric) similarity. Because the distance between journals is now being considered, it is not surprising that the results do not accord with those of earlier writers, such as Jobber and Simpson (1988), who equated influence with importance, ignoring relative distance. The difference in models explains why we have identified psychology and general management journals as being of greater relative importance: their influence is detected even across some distance. We also expand on the work of Leong (1989) by providing a truly cross-disciplinary analysis based on an asymmetric matrix of within and between journal citations. Further, the context of our model is broadened by the explicit inclusion of relevant nonmarketing journals in the analysis.

The number of zero cell entries, as seen for example in Table 1, could pose a problem for the loglinear modeling. However, the average cell count in Table 1 is 46, and exceeds 20 for each single year citation table. Fienberg (1980, Appendix IV) discusses the asymptotics of large sparse multinomials, and concludes from simulation studies that the asymptotic chi-square properties are reasonably well satisfied for average cell sizes exceeding 4 or 5; our data comfortably satisfy that condition, since the average cell counts for Table 1 is 46. Fienberg acknowledges that exceptions could occur if most of the sample size is concentrated in a few cells with relatively large cell counts. In Table 1, even though 49% of the citations lie in the 6% of cells that lie along the diagonal (self-citations), and 46% of the cells are empty, the average off-diagonal cell size still exceeds 24, well above Feinberg's safety limit of 4 or 5. The asymptotic behavior of large sparse multinomial tables is further discussed by Koehler (1977) and by Haberman (1977). The latter author shows that the usual chi-squared tests are still valid in comparing hierarchical loglinear models for such tables.

Given that 46% of the cells of Table 1 are empty, it could be feared that some instability in the results might occur: if expectations of less than 1 applied to a cell, then the presence or absence by chance of an item in the cell might be suspected to cause large changes in the results. As we have seen, the published evidence, as discussed above, is reassuring on this point. However, further reassurance can be obtained by examining the stability of our results. The importances reported in Figure 2 are based on seven totally independent citation matrices, for the 15 journals whose data span the entire seven-year period. There are 225 cells in each matrix. The seven matrices have respectively 58%, 52%, 55%, 58%, 52%, 57%, and 53% of empty cells, but only 32% of the cells are empty for all seven years. If the large (and varying) proportion of empty cells were a significant problem, it would be expected that the results derived independently from these seven matrices would show signs of instability. An examination of Figure 1 shows, on the contrary, that the importances computed from these seven independent matrices are remarkably stable. It should be added that the stability of the method is helped by the procedure of adding 0.5 to all the observed frequencies before analysis, as advocated by Goodman (1970).

It could be feared that the results might be sensitive to the number of journals included in the analysis. This fear can be allayed by reference to Figure 2: almost identical results are obtained whether the analysis be of all 18 journals, or is restricted to 15 journals by leaving out the three most recent journals. Reanalysis omitting the *Journal of Management Studies* made no appreciable difference to the results. This insensitivity to the choice of included journals shows that the model is robust, and the conclusions are not likely to be greatly altered if we could include journals, such as *Marketing Science,* that are not listed in the *Social Sciences Citation Index* (1981–1987). Similarly, the inclusion of border line journals such as the *Annual Review of Psychology* and *Advances in Consumer Research* does not significantly alter the results.

Conclusions

In this article we have addressed the critical issue of journal evaluation, as well as the network of interrelationships among journals within the marketing discipline. Few would disagree that the journals play a vital role in the development of theory and practice and that therefore journal output contributes not only to the progress of the discipline as a science but to the wider community as well. The research reported here was designed to provide some relatively objective information concerning these issues, by analysis of the asymmetric matrix of citations developed from the SSCI.

We have developed a loglinear model able to fit citation frequencies as the product of the citing journal's "receptivity" and the cited journal's "influence," which is in turn the product of its "importance," and the symmetric "similarity" between the journals. In applying the model to a set of marketing and related journals, we have found that it explains over 90% of the variation in the cross-references, and produces results which are readily interpretable and not counter-intuitive. The results of the analysis indicate that there exist a number of very important psychology and management journals which strongly influence published research in the marketing discipline. Some of the influential journals are highly quantitative and/or theoretical, but the application-oriented *Harvard Business Review* also figures prominently among this group. It is interesting that all of these important journals appear to be "feeder" journals, as they make few citations from the marketing journals. The surprising finding is the absence of any economics, accounting, or finance journals in the list. It may therefore be concluded that the disciplines having most influence on marketing are psychology and general management. This finding provides an interesting point of departure for debate concerning the direction and future of research in marketing. Have the hard core disciplines such as economics, accounting, and finance really lost their influence as reference points for research in marketing, as our study indicates? Have they anything to offer? Should this apparent direction be altered? The methodology described in this article will provide a means of tracking the evolution of the changing relationships between disciplines: Figure 1 shows that, over the seven-year period studied, the relationships between the journals have been remarkably consistent.

The method we have described provides a convenient objective means of evaluating and mapping journals in any discipline. The method is quite general and clearly not restricted to the marketing area, but can be applied to any defined set of journals. It could be used by writers in selecting journals to submit articles to, by libraries in selecting journals to stock, and for review bodies in evaluating journals and authors. One proviso in applying the results of the analysis relates to the meaning of the "importance" measure. It is a measure of the overall importance of a journal, not of a single paper in the journal. Since some journals publish much more material than others, the importances would need to be standardized in inverse proportion to the publication quantities, before being used to evaluate the average article in each journal. The method applied here to mapping the relationships and importances of journals is extendible to the analysis of a range of situations involving the dissemination of information or other quantities across a network of nodes.

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