RONALD E. RICE

8. Hierarchies and Clusters Among Communication and Library and Information Science Journals, 1977-1987

Citations among the 77 core communication and library and information science journals, from 1978 through 1987, were network-analyzed to detect structural evidence for a possible increasing interdependence between the two disciplines. Results showed changes in hierarchies and clusters within, but not across, the two disciplines. Results indicate the existence of two distinct subdisciplines in communication research and three in library and information science. Related results indicate increasing cross-disciplinary citations since 1983, especially from communication research journals.

Citation Patterns as Social Networks

This chapter considers bibliometrics as one example of a more general analytical approach—network analysis—and uses one kind of network analysis to identify whether structural changes have occurred in the flow of citations among the journals of two potentially related disciplines—communication research and library and information science.

Network analysis is the study of patterns of relations among a set of nodes. Network analysis has developed from a variety of

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sources, includes sociology, anthropology, small group communication, and network engineering (Burt, 1980; Rice & Richards, 1985). It may be said that network analysis was derived from theoretical and applied interests in forms of social structure such as the allocation of scarce resources (material goods, social status, and so on), formal relations (genealogies, organizational hierarchies, and so on), and informal relations (friendships, political coalitions, and so on).

The basic network dataset consists of measures of the strength (simple presence or absence, frequency, importance, and so on) of links (formal or informal relationships) shared by a set of N nodes either among themselves (thus producing an $N \times N$ matrix) or with respect to a common set of phenomena (thus producing a $N \times K$ matrix). These data may also be represented by a list of pairwise links, especially useful for large and sparse networks (see Small & Greenlee, this volume). Examples include the frequency of communication among friends, the dollar amount of trade flows among nations, the number of executives sitting on common corporate boards, or the number of co-occurrences of word pairs in one or more documents.

It is easy to see that author co-citation data are a special case of an $N \times K$ matrix (all the citations made by N authors in a database to K central authors) converted into a $K \times K$ matrix (where the cell values are the number of times each pair of those K central authors is cited by the N authors). It is also easy to see that citations made among N articles are a special case of the $N \times N$ matrix. Further, aggregating those N articles into their respective N′ journals creates a $N' \times N'$ journal-to-journal citation network matrix (e.g., Price, 1965). Indeed, the citation has been characterized as a particular form of "sociometric choice" (Garfield, Malin, & Small, 1978). Bibliometricians have begun to use formal network analysis concepts and methods in the study of national subfields (Smeenk & Hagendijk, 1989) and changes in co-occurrence of words in key words from articles about a particular subspecialty (Rossum, 1989).

Network analysis can provide descriptive and inferential insights into a wide variety of topics: (a) *roles* such as isolates, members of groupings, or bridges between groupings; (b) the existence and relative positions of those *groupings*; (c) *relationships* such as strength, direction, reciprocation, and stability; and (d) *structure* such as transitivity, hierarchies, and status rankings.

It is easy to see that bibliometric analysis of the flows of citations among journals is a special case of those more general sociological and organizational concerns: (1) Which journals represent various disciplines or provide channels for diffusion of scientific knowledge across the disciplines? (2) Which journals represent subdisciplines and how are those subdisciplines related? (3) Which journals receive proportionately more citations? (4) Do the disciplinary and subdisciplinary structures change over time, particularly in ways that indicate convergence or integration?

Indeed, these questions are particularly relevant to current concerns about scholarly communication within and between the disciplines of communication research and library and information science. The next sections summarize these concerns and apply network-analytic techniques to provide some preliminary answers.

Communication Research and Library and Information Science: Integration or Isolation?

In the mid-1980s, the social science disciplines of communication research and library and information science began to show increased concern with issues of potential convergence and fragmentation both within and between the areas. In communication research, concerns focused on debates between quantitative and qualitative methods and on the relevance of sociological and cognitive theories. See, for example, the special issue of the *Journal of Communication* ("Ferment in the Field," 1983). In information science, concerns focused on cognitive approaches to information retrieval and storage and the relative emphasis of traditional librarianship and newer information science topics. In both disciplines, new media began to provide fertile opportunities to challenge and develop theories of communication and information processing (Rice & Associates, 1984) and scholars became more aware of the interdependence and resonances of the concepts of "information" and "communication" (Beniger, 1988). Finally, several edited handbooks and annual series have attempted to consolidate empirical and theoretical developments across the disciplines and their subdisciplines (Berger & Chaffee, 1987; Dervin & Voigt, annual series; Jablin,

Putnam, Roberts, & Porter, 1987; Ruben, annual series; Williams, annual series).

In spite of these concerns and the potential for integration within and between these two disciplines, there is doubt as to whether the deeper institutional structures of these disciplines (as opposed to side researchers or schools) are responding to, or even acknowledging these challenges. For example, Paisley (1986) and Miyamoto, Midorikawa, and Nakayama (this volume) note that both disciplines are extremely isolated in the wider arena of social science. Rice, Borgman, and Reeves (1988) show a rather stable cleavage between interpersonal and mass media research. Other articles in the special issue of *Human Communication Research* ("Symposium," 1988) suggest continuing cleavages in communication research, and isolation from other social sciences, due to historical origins, research focus, methodological preferences, and so on.

Why Journal-to-Journal Citation Analysis?[1]

One deeper structural indicator of these possible changes, or inertia, is the patterns of citations made *by* articles among communication research and information science journals *to* articles in those journals. Journals are the primary formal channels for communicating theories, methods, and empirical results to the readers of those journals. Thus they may usefully indicate changing research fronts and disciplinary transitions (Brooks, this volume; Price, 1963). Journals are "a central institution of science. . . . [and authors'] public forums" (Doreian, 1985, p. 411). Conducting analyses at the level of the journal presumes that journals focus attention on related materials. This is especially true for "official" journals of associations, for journals that have titles explicitly indicating their content, or for journals that are known for particular emphases. Thus, although authors include citations in an article, and cite specific other articles, aggregating these citations at the journal level should reflect longer-term, more underlying changes or stabilities in the relationships within and between disciplines.

White (this volume) also argues that the large numbers and sources of citations to authors and articles found in datasets typically used in citation analysis should reduce the effect of differing citation motivations by individual authors. Using the journal as the

unit of analysis should further minimize this particular threat to the validity of bibliometric analyses.

Further, journals are one level more general than "invisible colleges," which, although a useful construct (Price, 1963), has questionable empirical validity and requires knowledge of communication processes and content outside of institutional structures (Lievrouw, this volume; Mullins, 1973). As Paisley (1989a, p. 713) notes: "The [co-]citation network extends well beyond any individual researcher's knowledge of who is in the network and what type of research he or she does." Thus formal patterns of communication (citations aggregated at the journal level) are more appropriate for investigating disciplinewide and long-term changes than for studying individual authors or specialties (Lievrouw, this volume).

Finally, analysis of the flow of citations aggregated at the journal level fits into several of the cells suggested by Borgman (this volume) as characterizing bibliometrics. Variables analyzed by such studies include (a) producers, in the form of disciplines and subdisciplines, and (b) artifacts, in the form of citation patterns involving a defined set of academic journals. The research questions posed by such studies include both (a) characterizations of scholarly communication and (b) diffusion of ideas—as identified by roles, groupings, relations, and structure among formal disciplinary channels.

Method

Data

This section summarizes the particular journal-to-journal citation data used to illustrate some bibliometric applications of network analysis. As described elsewhere (see Note 1), the basic data include the asymmetric matrix of citations made to, and received from, all the journals listed as "core journals" in "communication" and in "library and information science" in the Institute for Scientific Information (ISI) *Journal Citation Report* for each year from 1977 to 1987 (then corrected for aberrant and changed journal titles). Table 8.1 lists the full journal titles and the abbreviations used in the figures.

TABLE 8.1
"Core" Communication and Library and Information Science Journals Included in the Journal Citation Report, with Abbreviations Used in Present Analysis

Abbreviation	*Full Journal Title*
Cen1	*Central States Speech Journal*
Col2	*Columbia Journalism Review*
Com3	*Communication*
Com4	*Communication Education*
Com5	*Communication Monographs*
Com6	*Communication Research*
ECT7	*Educational Communication and Technology Research*
Hum8	*Human Communication Research*
JBr9	*Journal of Broadcasting and Electronic Media*
JC10	*Journal of Communication*
JT11	*Journal of Technical Writing and Communication*
JQ12	*Journalism Quarterly*
La13	*Language and Communication*
Me14	*Media, Culture and Society*
Pu15	*Public Opinion Quarterly*
Pu16	*Public Relations Review*
QJ17	*Quarterly Journal of Speech*
Sp18	*Speech Communication*
Te19	*Telecommunications Policy*
Wr20	*Written Communication*
Am21	*American Archivist*
AR22	*Annual Review of Information Science and Technology*
AS23	*ASLIB Proceedings*
Be24	*Behavioral and Social Sciences Librarian*
BM25	*Bulletin of the Medical Library Association*
Ca26	*Canadian Journal of Information Science*
Ca27	*Canadian Library Journal*
CR28	*College Research Libraries*
Db29	*Database*
Dr30	*Drexel Library Quarterly*
Ed31	*Education for Information*
El32	*Electronic Library*
Go33	*Government Information Quarterly*
Go34	*Government Publications Review*
IF35	*IFLA Journal*
In36	*Information Age*
In37	*Information Processing and Management*
In38	*Information Technology and Libraries*
In39	*Information Technology—Research Development Applications*
In40	*Interlending and Document Supply*
In41	*International Classification*
In42	*International Forum on Information and Documentation*
In43	*International Library Review*

(continued)

TABLE 8.1 continued

Abbreviation	*Full Journal Title*
JA44	*Journal of Academic Librarianship*
JD45	*Journal of Documentation*
JE46	*Journal of Education for Library and Information Science*
Jo47	*Journal of Information Science*
JL48	*Journal of Librarianship*
JL49	*Journal of Library History Philosophy and Comparative Librarianship*
JA50	*Journal of the American Society for Information Science*
La51	*Law Library Journal*
L&52	*Library and Information Science Research*
Li53	*Library Acquisitions—Practice and Theory*
L&54	*Library and Information Science*
Li55	*Library Journal*
Li56	*Library Quarterly*
Li57	*Library Resources and Technical Services*
Li58	*Library Trends*
Li59	*Libri*
Na60	*Nachrichten fur Dokumentation*
Na61	*Nauchno-Tekhnicheskaya Informatsiya Seriya 1*
Na62	*Nauchno-Tekhnicheskaya Informatsiya Seriya 2*
On63	*Online*
On64	*Online Review*
Pr65	*Proceedings, American Society for Information Science*
Pr66	*Program-Automated Library and Information Systems*
Re67	*Review of Public Data Use*
RQ68	*RQ*
Sc69	*Scholarly Publishing*
Sc70	*Scientometrics*
Se71	*Serials Librarian*
So72	*Social Science Information*
So73	*Social Science Information Studies*
Sp74	*Special Libraries*
Wi75	*Wilson Library Bulletin*
Ze76	*Zeitschrift für Bibliothkswesen und Bibliographie*
Ze77	*Zentralblatt für Bibliothekswesen*

Analysis

In order to portray information about roles, groupings, relationships, and structure in a parsimonious way, the matrices were analyzed by the HRCHY network analysis program (Reitz, 1988). The program defines groups on the basis of both hierarchy and closeness.

Hierarchical relationships are determined by ranking the journals according to the total number of citations they receive; ties are broken by determining the total number of citations received by the journals that cite the tied journals. A journal that is "close" to a particular highly ranked journal will most likely be a member of the same grouping as the highly ranked journal. The symmetric measure of closeness is computed by first dropping any journal that does not cite, or is not cited by, at least two journals (including itself), then doubly normalizing the asymmetric citation matrix, resulting in each row and column summing to the number of journals in the remaining network. In effect, this controls for the obvious fact that some journals make or receive more citations in a given year simply because they have more issues and/or more articles (Doreian, 1985). Thus the sum of the final values in matrix cells (i, j) and (j, i) represents the closeness, or proportional degree of citation, between any two journals i and j, controlling for differences in total citations both made to and received for each journal. It is a measure of "pure" structure.

Grouping journals into local clusters is performed by following the path of strongest closeness for each journal that has the locally highest status. Then two such local clusters are combined if the average tie between the two clusters is (a) greater than one and (b) the largest average involving each of the clusters. This continues until no more clusters appear.

The results from this method (a) take into account both status and closeness, (b) are not dependent on the overall network density (of journal-to-journal citation flows divided by the possible number of citation flows, which is $N \times [N - 1]$), (c) are not dependent on the overall size of the network, and (d) provide clusters that contain hierarchic groupings of ranked journals that are closer to each other than expected and than to journals in other clusters.

Results

Due to space limitations, Figures 8.1 through 8.4 portray the hierarchies and clusters only for 1978, 1981, 1984, and 1987 (see Note 1). The vertical axis shows the ranking of journals based on citations received; the horizontal axis is arbitrary.

(text continues on page 150)

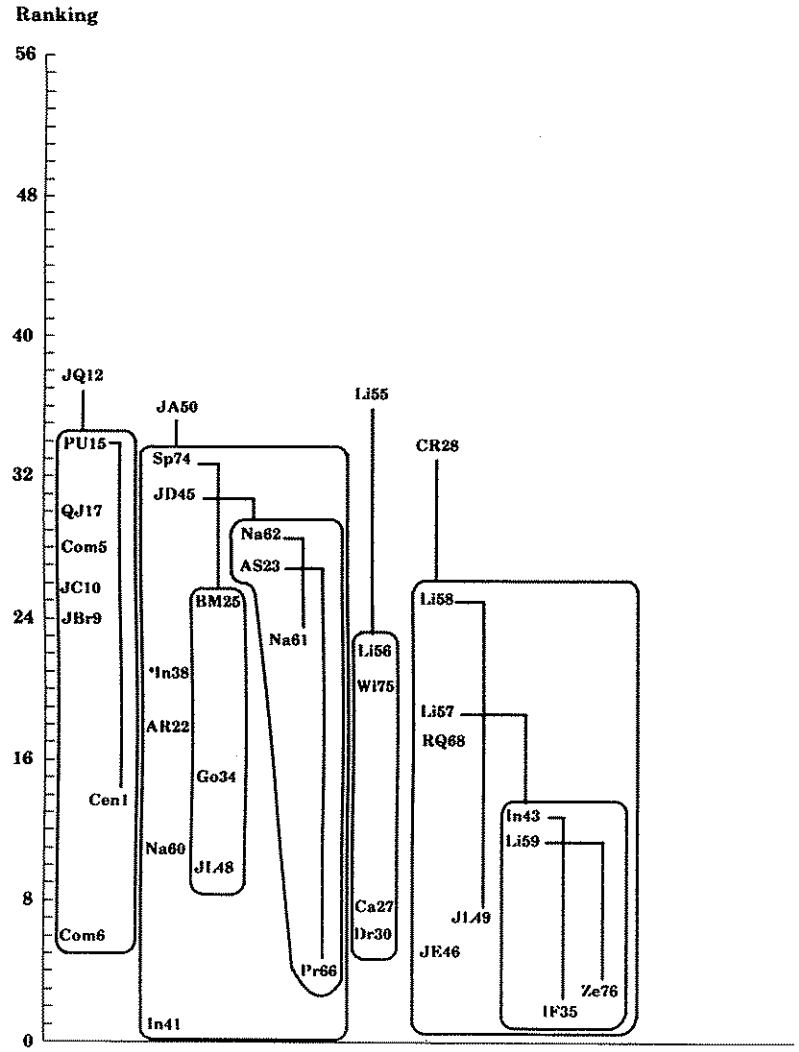

Figure 8.1. Journals Ranked by Citations Received and Clustered by Double-Normalized Citation Closeness, 1977

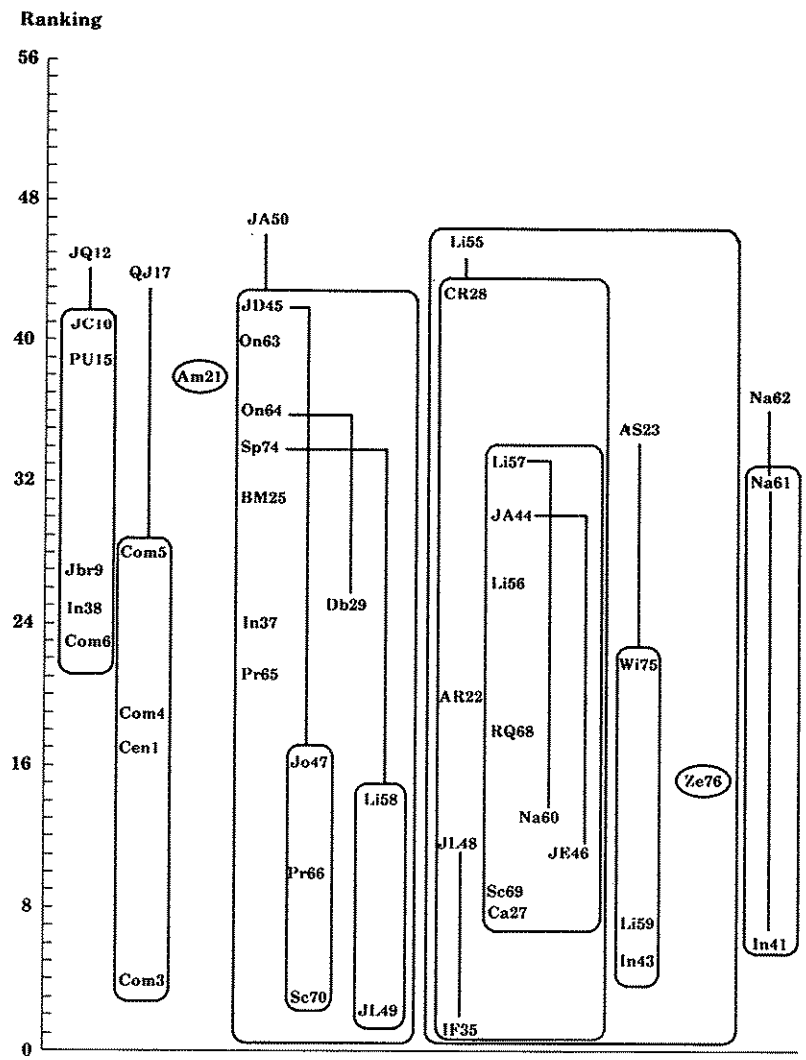

Figure 8.2. Journals Ranked by Citations Received and Clustered by Double-Normalized Citation Closeness, 1981

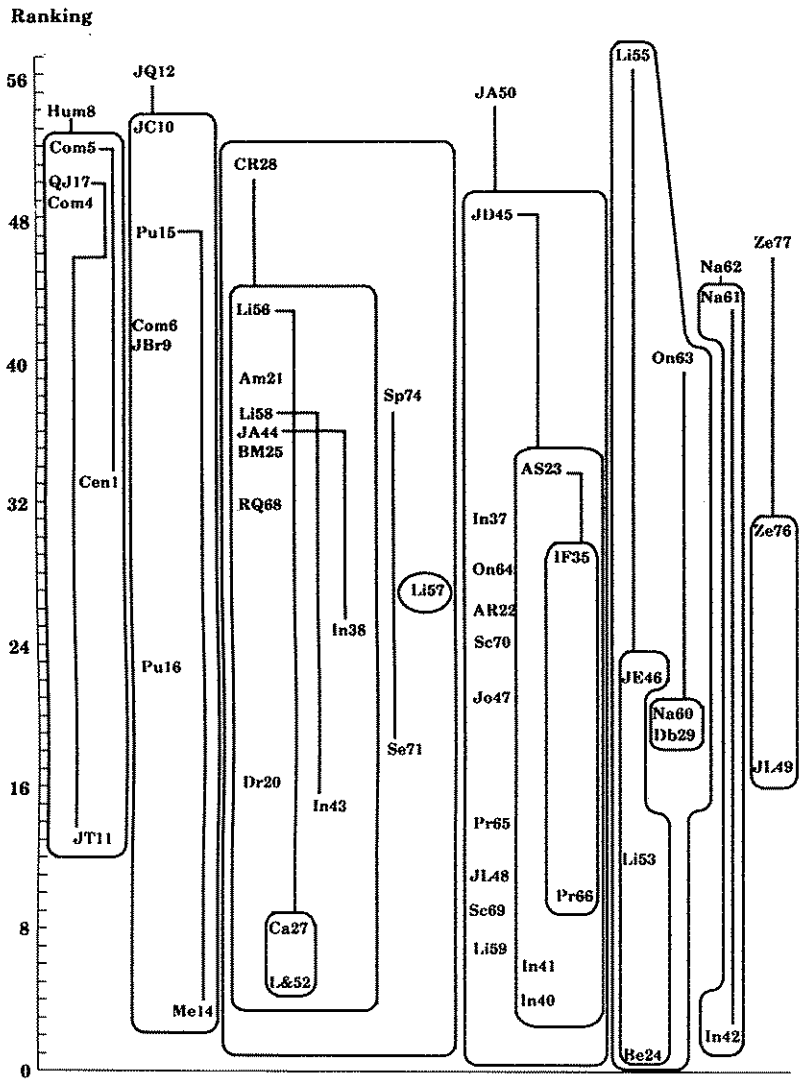

Figure 8.3. Journals Ranked by Citations Received and Clustered by Double-Normalized Citation Closeness, 1984

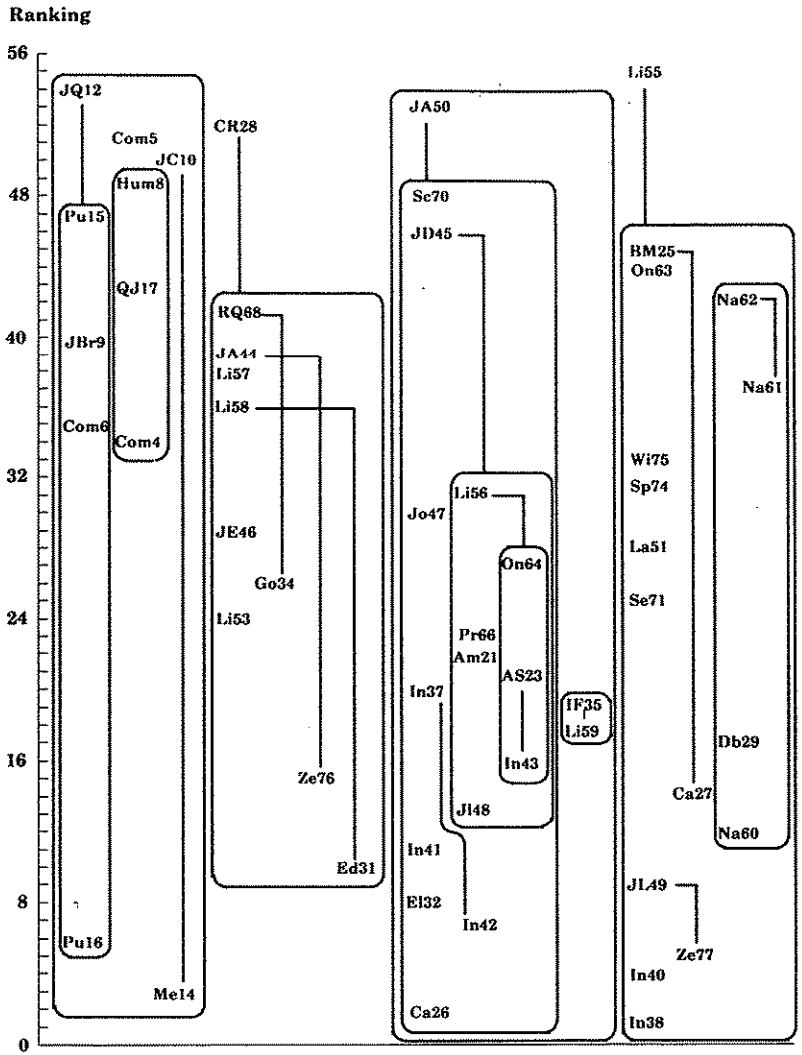

Figure 8.4. Journals Ranked by Citations Received and Clustered by Double-Normalized Citation Closeness, 1987

Over the four periods, the number of journals making citations to or receiving citations from at least two journals generally increased (38, 47, 57, and 55, respectively; also see point e in Note 1) as did the number of inclusive clusters (4, 8, 10, and 7). (Both measures declined slightly in 1987 due to the use of 1985 as our base year; see point b in Note 1.)

In 1978, "communication" was represented by a single cluster with a mixture of interpersonal and mass media journals, indicating a fairly simple and unified discipline, relative to the complete two-discipline network. *Journalism Quarterly* was the highest ranked of all the journals in the two-discipline network.

"Library and information science" was represented by three clusters, indicating multiple subdisciplines. The most numerous and complex cluster was headed by the *Journal of the American Society for Information Science*, commonly referred to as *JASIS* (JA50). The two other clusters were led by *Library Journal* (Li55) and *College and Research Libraries* (CR28), respectively. Throughout all the time periods, the *Journal of Documentation* (JD45) led its own subcluster but was slightly secondary to *JASIS*.

By 1981, communication had split into two subdisciplines, mass media (led by *Journalism Quarterly*) and interpersonal communication (led by the *Quarterly Journal of Speech*).

In library and information science, a number of new journals entered the ranks. Three major subdisciplines remained but within two clusters. *JASIS* (JA50) and *Library Journal* (Li55) continued their high rankings, with *College and Research Libraries* (CR28) increasing its ranking but this time placed within the *Library Journal* (Li55) cluster. A small third cluster was led by *Nauchno-Tekhnicheskaya Informatsiya Seriya 2* (Na62).

By 1984, the overall network had become more elaborate. The interpersonal (led by *Human Communication Research*, Hum8) and mass media (again led by *Journalism Quarterly*, JQ12) subdisciplines remained in communication. After 1981, *Quarterly Journal of Speech* (QJ17) lost its relationship of the interpersonal subdiscipline.

In library and information science, the overall structure continued to become more complex, with five distinct clusters or subdisciplines, three led by the major journals *College Research Libraries* (CR28), *JASIS* (JA50), and *Library Journal* (Li55) and two small clusters led by *Zentralblatt für Bibliothekswesen* (Ze77) and the Na62 subcluster.

By 1987, communication was clustered as one overall discipline, but the two major subdisciplines remained, led by *Journalism Quarterly* (JQ12) and *Communication Monographs* (Com5), along with a third subdisciplinary clustering led by *Journal of Communication* (JC10), which reported a wide diversity of research topics.

In library and information science, three disciplines have quite clearly emerged. *College and Research Libraries* (CR28) leads what might be called "library science," which includes scientific studies of practice and policy in academic and research libraries and some new trends in systems. Higher-status journals in this subdiscipline include *RQ* (RQ68), *Journal of Academic Librarianship* (JA44), *Library Resources and Technical Services* (LI57), *Library Trends* (Li58), and *Journal of Education, Library and Information Science* (JE46).

JASIS (JA50) leads what might be called "information science," which includes bibliometrics, information retrieval, and some historical interests. Higher-status journals in this subdiscipline include *Scientometrics* (Sc70), *Journal of Documentation* (JD45), *Library Quarterly* (Li56), *Journal of Information Science* (Jo47), and *Online Review* (On64).

Library Journal (Li55) leads what might be called "librarianship," which includes practice, training, news, and current topics. Higher-status journals in this subdiscipline include the *Bulletin of the Medical Library Association* (BM25), *Online* (On63), *Wilson Library Bulletin* (Wi75), *Special Libraries* (Sp74), *Law Library Journal* (La51), and several German documentation journals.

Generally, the journal-to-journal structure increased in complexity over the four cross-sectional mappings; not only the size but also the topography of intellectual space in the two disciplines changed. However, the portrayal of this space in 1987 shows that a fairly explicit hierarchic and clustered structure had emerged. The overall communication discipline consisted of the two traditional subdisciplines with *Journal of Communication* emerging as a possible bridge both between these and two other disciplines (see Rice, Borgman, & Reeves, 1988). The overall library and information science discipline consisted of three, rather than two, subdisciplines: library science, information science, and library practice.

Discussion

In the context of this volume, this chapter is reflective; it uses bibliometric methods to study the disciplines most concerned with scholarly communication. It applied a general methodological approach (network analysis) to issues of interest to the audiences of this volume (potentially changing structures of scholarly communication) by inspecting formal relationships (indicated by journal-to-journal citation patterns) within and between the two primary audiences (information science and communication research).

The particular network analysis method used here is just one of many that analysts of scholarly communication might consider (see Rice & Richards, 1985). It has a variety of advantages, as noted earlier. However, it does seem to allow the variability in journal rankings (due to the addition of numerous new journals to the overall network year and to the naturally changing levels of citations within and among journals) to influence the results—see, for example, the shifting cluster membership of the lower-ranked library and information science journals. Finally, this method does not show whether the clusters are coming closer together in intellectual space. However, multidimensional scaling of the covariance matrix derived from the citation relationships within and among the primary aggregated clusters could be used to complement the present analyses (see Rice, Borgman, & Reeves, 1988). But results did show an increasing complexity in the hierarchic clustering of journal rankings in the four one-year periods of 1978, 1981, 1984, and 1987. Further, the top-ranked journals were consistent throughout, and the clusterings seem to be evolving into identifiable subdisciplines.

Indeed, we must conclude from these results that, although there *is* movement and change *within* disciplines, there is no significant change in cross-disciplinary clustering, based upon citations exchanged among the primary formal communication channel, the academic journal (but see point e, Note 1; there cross-citation has occurred since 1983, proportionately much more of it involving communication journals). As Pierce (this volume) notes: "If the separate bodies of knowledge of different disciplines provide strength, they are also a weakness." In this case, the structure of citation flows among journals has yet to change in ways that reflect some of the growing concerns both within and across the two disciplines of communication research and information science.

Note

1. The extreme page limitations for this chapter prevent any discussion of the following important topics:

(a) the larger study (see Rice, Borgman, & Reeves, 1988);

(b) strengths, weaknesses, and assumptions in the use of citation data in general, and our particular solutions to various problems with the source journal citation data (obtained from the ISI *Journal Citation Report*; see Edge, 1979; Pierce, this volume; Rice, Borgman, Bednarski, & Hart, 1989; White, this volume);

(c) the need to combine analysis of citations with analysis of other aspects of scholarly communication such as cognitive maps of a discipline, actual lab and writing processes, informal use of multiple channels (such as telephone, electronic mail, and conferences), and experts' nominations (see Borgman, Lievrouw, McCain, Pierce, White—all this volume);

(d) detailed analyses of the relationships among the communication research journals (see Rice, Borgman, & Reeves, 1988);

(e) more detailed analyses of the trends in the overall journal-to-journal citation network and changes between the two disciplines (Borgman & Rice, in preparation);

(f) a wider discussion of network analysis methods, concepts, and issues in general (Rice & Richards, 1985) and specific advantages and techniques of network analysis for bibliometrics (Rice, Borgman, & Reeves, 1988); and

(g) prior research on journal-to-journal citation networks (Doreian, 1985; Rice, Borgman, & Reeves, 1988).

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