Title
Scholarly Communication and Bibliometrics

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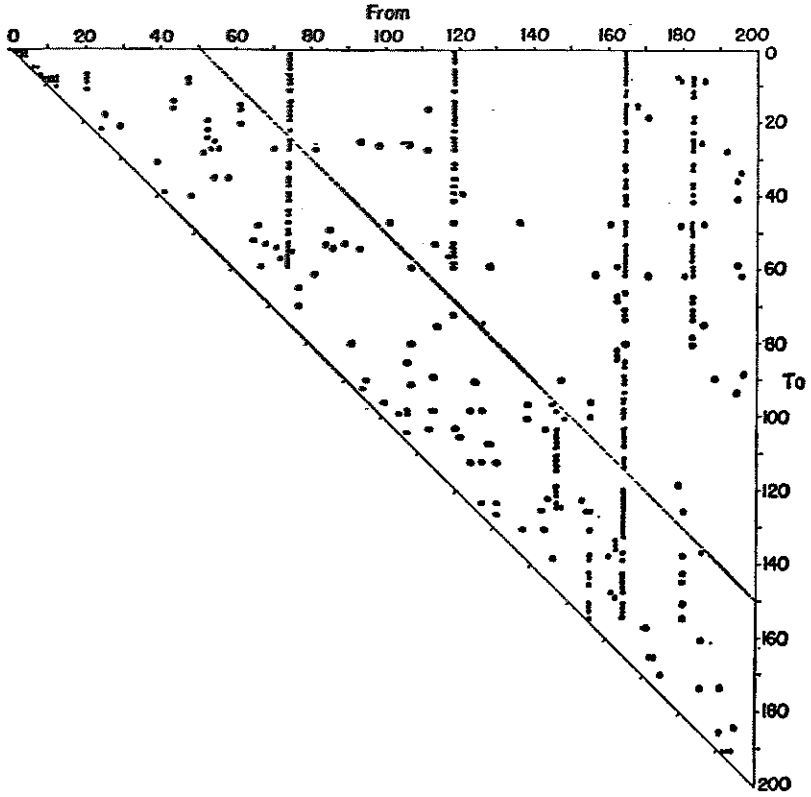
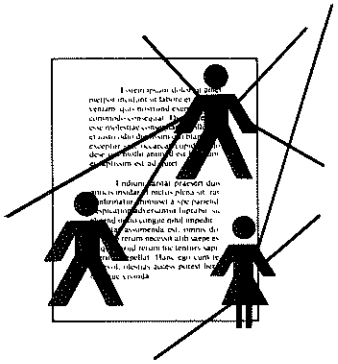


Matrix showing the bibliographical references to each other in 200 papers that constitute the entire field from beginning to end of a peculiarly isolated subject group. The subject investigated was the spurious phenomenon of N-rays, about 1904. The papers are arranged chronologically, and each column of dots represents the references given in the paper of the indicated number rank in the series, these references being necessarily to previous papers in the series. The strong vertical lines therefore correspond to review papers. The dashed line indicates the boundary of a "research front" extending backward in the series about 50 papers behind the citing paper. With the exception of this research front and the review papers, little background noise is indicated in the figure. The tight linkage indicated by the high density of dots for the first dozen papers is typical of the beginning of a new field.

Price, Derek J. deSolla. Figure 6 from: (1965) Networks of scientific papers. Science 149: 514.

SCHOLARLY COMMUNICATION AND BIBLIOMETRICS



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Editor's Introduction

In recent years there has been a resurgence of interest both in scholarly communication as a research area and in the application of bibliometrics as a research method. This volume is a compilation of current theory, method, and empirical studies at the intersection of scholarly communication and bibliometrics. We consider scholarly communication to be the study of how scholars in any field use and disseminate information through formal and informal channels and bibliometrics to be the application of mathematics and statistical methods to books and other media of communication. We propose a matrix for the intersection of these two topics of variables studied (producers, artifacts, and concepts of communication) by research questions asked (characterizing scholarly communities, evolution of scholarly communities, evaluation of scholarly contributions, and the diffusion of ideas). Research in these areas is reviewed, and chapters in this volume are set in the context of the matrix. Reliability and validity issues in the application of bibliometrics are discussed briefly.

Several years after Thomas Kuhn's classic work on the nature of science (Kuhn, 1962) was published, he wrote a postscript to a later edition as a "chance to sketch needed revisions, to comment on some reiterated criticisms, and to suggest directions in which my own thought is presently developing" (Kuhn, 1970, p. 174). In this postscript he reiterates the central importance of the community structure of science and calls for empirical research, noting that "preliminary results, many of them still unpublished, suggest that the empirical techniques required for its exploration are non-trivial, but some are in hand and others are sure to be developed" (Kuhn, 1970, p. 176).

AUTHOR'S NOTE: This introduction and the corresponding article in the *Communication Research* special issue benefited substantially from long discussions with William Paisley, Henry Small, and Leah Lievrouw. I am also thankful for the extensive comments on earlier drafts by Marcia J. Bates, Belver C. Griffith, William Paisley, Sydney J. Pierce, Henry Small, and Linda C. Smith. I retain responsibility for all opinions and errors of fact, of course.

Kuhn cites several studies in support of the latter point (Crane, 1969; Garfield, 1964; Hagstrom, 1965; Kessler, 1965; Mullins, 1966; Price, 1965; Price & Beaver, 1966). Each of these studies relied wholly or in large part on *bibliometrics*, or the application of mathematics and statistical methods to books and other media of communication (Pritchard, 1969), as a research method.

In the 20 years since Kuhn called for empirical research on the processes of communication in science, the research methods have matured, the amount and accessibility of the data have increased, and the research questions to be addressed have become richer and more central to the communication sciences. For all of these reasons, we found it timely to assemble this volume on scholarly communication and bibliometrics.

Bibliometrics

Bibliometric methods have been applied in various forms for a century or more (Pritchard & Wittig, 1981) but, until recently, the data collection was an extremely tedious process and the methods often were lacking in rigor. The last two decades have seen the provision of vast portions of the scholarly record, about both bibliographic and full-text data, in computer-readable form. More than 3,000 publicly available databases already exist on commercial (e.g., Dialog, BRS, Lexis/Nexis) and government (e.g., Medlars) systems. Of particular interest for bibliometrics are the citation databases produced by the Institute for Scientific Information: the *Science Citation Index*, the *Social Sciences Citation Index*, and the *Arts & Humanities Citation Index*. The use of these large datasets makes possible analyses at a scale that cannot be achieved by traditional methods such as surveys and case studies.

As we have gained experience in bibliometrics, the methods have matured significantly, moving from mere counting of citations to an understanding of the content and purposes of citations and the relationships among different methods (Chubin, 1985; Narin & Moll, 1977; White & McCain, 1989). Bibliometrics encompasses a number of empirical indicators that can be found in the formal record of scholarly communication, including authors, citations, and textual content.

Scholarly Communication

Interest in scholarly communication has increased for reasons both external and internal to the communication and information sciences, both of which (as well as others) lay claim to this research area. Among the external reasons are the increasing competition in science for scarce research funds and pressures to show contributions to international competitiveness. Scholars and policymakers alike are concerned about understanding the flow of research findings and improving technology transfer.

Interest internal to these fields is exemplified by their continued introspection about their constituency and viability as disciplines, considering works such as "Ferment in the Field" (1983), Paisley (1984), Delia (1987), and Wiemann, Hawkins, and Pingree (1988) in communication research and Nakayama, Ueda, and Miyamoto (1979), Borgman and Schement (1990), and Prentice (1990) in information science. A field's interest in its own scholarly communication is a sign of its maturity. Fields such as physics, chemistry, and medicine have standing committees and/or publications concerned exclusively with the "fullness of communication" (Kuhn, 1970, p. 177; 1977, p. 461) within the field and with other fields.

Social science researchers have analyzed their own fields as well. Early notable work includes the multiyear "Project on Scientific Information Exchange in Psychology" conducted by the American Psychological Association (Garvey & Griffith, 1964) and the studies of sociology by Crane (1967) and of communication research by Parker and Paisley (1966).

Relatively young fields like communication research and information science need to be aware of the strategies by which older fields manage their growth and assert their self-interest vis-à-vis institutional status, access to research support, recognition for their contributions to the whole of science, and so on. These strategies may not be entirely appropriate for all fields at all times but they are a part of the "disciplinary self-awareness" that marks any maturing field.

Bibliometrics and Scholarly Communication: Definitions

Bibliometrics

The most widely accepted definition of *Bibliometrics* is that of Pritchard (1969), which is quite broad in scope:

(1) "to shed light on the processes of written communication and of the nature and course of development of a discipline (in so far as this is displayed through written communication), by means of counting and analyzing the various facets of written communication." (Pritchard, 1968)

(2) "the assembling and interpretation of statistics relating to books and periodicals . . . to demonstrate historical movements, to determine the national or universal research use of books and journals, and to ascertain in many local situations the general use of books and journals." (Raisig, 1962)

Citation analysis is the best-known bibliometric technique, although other analyses of written materials also fall within the scope of bibliometrics. We note that bibliometrics consists of empirical research methods and does not necessarily have any inherent social science content.

Bibliometric methods have been applied not only to the study of scholarly communication but for various other purposes including the evaluation of library collections and as a basis for information retrieval algorithms (Belkin & Croft, 1987; Smith, 1981; White & McCain, 1989). Although these are important applications, they are outside the scope of our current interest.

Scholarly Communication

By *scholarly communication* we mean the study of how scholars in any field (e.g., physical, biological, social, and behavioral sciences, humanities, technology) use and disseminate information through formal and informal channels. The study of scholarly communication includes the growth of scholarly information, the relationships among research areas and disciplines, the information needs and uses of individual user groups, and the relationships among formal

and informal methods of communication (Compton, 1973; Crane, 1971, 1972; Garvey, 1979; Garvey & Griffith, 1964; Meadows, 1974; Paisley, 1968).

Bibliometric methods are applicable only to the study of the *formal* channels of scholarly communication, that is, the written record of scholarship. In combination with data gleaned from other methods, they can provide a large, rich characterization of communication processes not otherwise possible.

A Model for the Intersection of Scholarly Communication and Bibliometrics

The single greatest difficulty in developing this volume, and the *Communication Research* special issue that preceded it, has been reaching a common understanding of the scope of the intersection of scholarly communication and bibliometrics among its editors, advisers, and contributors. Some view the intersection narrowly, constituted only by the use of clustering methods to map relationships among disciplines or to identify scholarly communities. Others view the intersection broadly, considering any bibliometric study necessarily to concern scholarly communication and almost any quantitative analysis of scholarly communication to be bibliometric.

The editors of both the book and the special issue have sought a middle ground. The chapters we considered in scope incorporate quantitative analyses of the written record of communication, either the bibliographic description or the content of the communication artifact, *and* a behavioral interpretation of the communication process under study. We have included theory, method, and empirical studies within these boundaries. Specifically excluded were studies that examine communication *structure* without examining the communication *process*.

We are encouraged to find that a core bibliometrics journal compiled a similar special issue concurrently with our preceding *Communication Research* special issue, suggesting a convergence of interests. The *Scientometrics* issue is titled "The Relationship Between Qualitative Theory and Scientometric Methods in Science and Technology Studies" (Leydesdorff, 1989). The editor's introduction illustrates the common interest in this intersection, although his terminology varies slightly from ours:

> There is growing recognition of the need to integrate qualitative theorizing in the philosophy, sociology and history of science with the quantitative perspectives provided by scientometric studies. . . . Questions are raised such as: can scientometric indicators be used to measure institutional performance, reputational structure or knowledge growth? How do various bibliographic representations ("maps") of science relate to the actual structure of research fields? How do indicators and constructs based on aggregates of citations relate to authors and the "quality" of their publications? Is it possible to bridge the gap between the policy relevance of indicators and the theoretical perspectives of more qualitative S&T [science and technology] studies? (Leydesdorff, 1989, p. 333)

We propose that research applying bibliometrics to scholarly communication can be organized into a two-dimensional matrix with axes of "variables studied" and "research questions asked." The variables chosen largely define the bibliometric techniques applied, while the research questions are driven by the theoretical framework of the studies. Such a matrix is useful for organizing prior bibliometric studies of scholarly communication and for placing the articles in this volume in context.

Variables Studied

Bibliometric studies of scholarly communication use one or more of three theoretical variables: *Producers* of the communication, *artifacts* of communication, and communication *concepts*. Leydesdorff (1989) independently arrived at a similar taxonomy of *scientists*, *texts*, and *cognitions*. Each of these variables may result in multiple operational definitions, resulting in different levels and types of analyses.

PRODUCERS

Producers of written communication may be operationalized as individual authors or as aggregates such as research teams, institutions, fields, or countries. In a communication context, producers

are studied both as senders and as receivers of scholarly communications.

Bibliometric analyses typically represent producers by the embodiment of their ideas in one or more of their published documents. When precision is required in tracing the influence of a communicator's idea, one or a few documents will be used and citation patterns will be obtained. When the study is focused on a producer's overall influence, the unit of analysis will usually be the author's *oeuvre*, or body of work (White & Griffith, 1981a).

ARTIFACTS

Communication artifacts are the formal product, or output, of a sequence of informal communication activities—reading other documents, translating their ideas into their own terms, talking with others (Bazerman, 1988; Callon, Law, & Rip, 1986; Latour & Woolgar, 1979; Small, 1988)—as well as the input to the scholarly communication of others. Artifacts may be studied at the level of the individual article, conference paper, or book. They may also be studied at aggregate levels such as journals or conferences.

Most studies that use the individual article or book as a unit of analysis are considering the artifacts as the message, or the embodiment of an idea. Studies that use the journal as a unit of analysis are likely to view the artifact as the channel through which producers communicate with one another.

CONCEPTS

We combine two somewhat disparate types of research under the label of *communication concepts*: (a) studies that use the authors' own terms (i.e., words in the title or text) or assigned terminology or classification added through the publication process and (b) studies that focus on the purpose or motivation of a citation. Both ascribe meaning to the content of the artifact—one to the substantive content, the other to the links made to other artifacts.

Research on authors' terminology or assigned terminology is most often used to trace the flow of ideas within and across disciplines and is closely related to content analysis (Paisley, this volume). Research on the context of citations includes that on citer motivation (e.g., Kochen, 1989; Moravcsik & Murugesan, 1975) and that which studies the actual content of citations as symbols (Small, 1978).

Research Questions Asked

The range of research questions asked in bibliometric studies of scholarly communication does not fall into categories as neatly as do the variables studied; nor can the list be fully enumerated (as elaborated by Paisley, this volume). Many of the research questions can be addressed at different levels of analysis, using different variables. Other questions are closely linked to a unit of analysis, thus leaving some cells in the matrix empty. Here we discuss four of the major research questions that have been addressed, providing examples from past work. These questions are similar to those stated by Leydesdorff (1989), quoted earlier. A subsequent section places the articles in this volume within the same matrix.

CHARACTERIZING SCHOLARLY COMMUNITIES

The most commonly asked research questions are of the form: "What is the scholarly community of X?" and "Of what types of scholars is the community composed?" Studies asking these questions attempt to characterize a scholarly community as it exists at some moment in time. Longitudinal studies of a scientific community usually ask questions about the growth or evolution of an area and are corollaries of these questions. We treat these separately below.

We are combining studies of invisible colleges and studies of research specialties, which, although theoretically distinct, have much in common methodologically. Invisible colleges comprise social and other links among scholars, although the concept of "invisible college" has never been well explicated (Lievrouw, this volume). Reference specialties, in the sense used by Kuhn (1970), are formed by the focus on a common problem. The cluster of scholars focusing on that problem may or may not have a full complement of social links.

Scholarly communities have been studied through producers, artifacts, and concepts. Most common are artifact studies, counting either individual links among journal articles, as was done by Price (1965; shown as the frontispiece to this volume), or overall counts of

links among journals, as was done by Reeves and Borgman (1983) for journals in the field of communication, later replicated by Rice, Borgman, and Reeves (1988) and So (1988). These journal citation maps reveal distinct clusters of mass and interpersonal communication research with a citation "bridge" between the two communities; the maps are further explicated by Reardon and Rogers (1988) and Wiemann, Hawkins, and Pingree (1988).

Much of the mapping of communication artifacts relies on clustering of documents. Bibliographic coupling (Kessler, 1965) and document co-citation analysis (Griffith & Mullins, 1972; Small, 1973; Small & Griffith, 1974) both involve the distance between authors in an intellectual space on the basis of citations they give to or receive from other authors.

Authors may be studied directly to characterize scholarly communities. These studies usually begin with a list of authors that was generated from one or more sources. The authors are then mapped directly, as in sociometric maps, or clustered using author co-citation analysis (White, this volume; White & Griffith, 1981a).

Concepts, in either of the senses used above, may be applied to define scholarly communities. Lievrouw, Rogers, Lowe, and Nadel (1987) identified invisible colleges among lipid metabolism researchers through the use of co-word analysis of document texts combined with co-citation, sociometric, and qualitative analyses and interviews. Small and Greenlee (1980) mapped the community of researchers studying recombinant DNA by combining context analysis of citations with document co-citation analysis.

EVOLUTION OF SCHOLARLY COMMUNITIES

Most of the work that has followed scientific communities over time has relied on citation analysis of artifacts, especially document co-citation analysis. By comparing the rate at which clusters of co-cited documents change in composition, it is possible to identify both the rate and the direction of change in research topics. Garfield, Malin, and Small (1978) report on four years of data (1970-1973) for 31 specialties, finding an average 55% change in the constituency of the clusters over that period, with about one-third experiencing major shifts in research direction, with an almost entirely new set of documents appearing. The quantitative record of such shifts may be compared with results of interviews with scholars about trends

in their research areas, as was done by Small (1973). Changes over time in the composition and relationships among entire disciplines can be mapped also, as demonstrated visually in a videotape produced by Small (1988).

EVALUATING SCHOLARLY CONTRIBUTIONS

Bibliometric techniques have been used widely to evaluate the contributions of producers and of artifacts. Most studies of producers' influence appear to rely on citations received by particular pieces they have written, although direct studies of an author's body of work are possible (White, this volume). An example is Garfield (1985), who analyzed Derek J. deSolla Price's influence through a citation analysis of *Little Science, Big Science* (1963).

The "importance" of an idea is measured by the number of citations received by the document(s) in which it is embodied. In this way a reference to an artifact is viewed as a sociometric choice (Garfield, Malin, & Small, 1978). Garfield systematically reports on highly cited documents, or "citation classics," in his regular column in *Current Contents*. The reports are complemented by comments from their authors about the origin of the article and their views of its subsequent impact (e.g., Crane, 1989, commenting on her 1972 book, *Invisible Colleges*).

Bibliometric analyses are particularly useful when compared with influence measures obtained from other methods, as was done by Latour and Woolgar (1979) in conducting an anthropological study of scientists in a laboratory. Among the bibliometric dimensions they used to measure the scientists' productivity were the proportion of literature in the specialty being produced by the laboratory, the channels through which papers were disseminated, the audience to which they were directed, and computations of the production cost per article as a portion of the total laboratory budget.

Other research evaluates artifacts, principally scholarly journals, as channels of communication. Rather than producing maps most of these measures are applied to journals individually, assessing their influence relative to other journals. Todorov and Glanzel (1988) review the many measures of journal impact that have been applied, such as "impact factors," "immediacy index," and "half-life."

DIFFUSION STUDIES

Bibliometrics may be used to trace the evolution of an idea within and across disciplines. At the earliest stages of diffusion, the idea is linked with the document in which it was first presented, thus allowing tracing through citations. As an idea diffuses further, it may become dissociated from its bibliographic origins, thus requiring tracing through terminology.

Among the ideas traced through citations are the "double helix" (Winstanley, 1976), Shannon's information theory (Dahling, 1962), and topics relevant to psychiatry originating in related fields (Davis, 1970).

Several studies of the diffusion of ideas have been done within the field of communication. Paisley (1984) traced the concepts "information society," "uses and gratifications," and "knowledge gap" from their origins in communication research through their appearance in the publications of other disciplines. Beniger (1988) recently traced the concept of "information" across a wide range of disciplines using citation indexes and then analyzed the context in which the terminology was applied.

Chapters in This Volume

The goal for the composition of this volume was to compile a complementary set of theoretical essays, methodological discussions, and empirical studies distributed across this matrix of variables and research questions.

The 15 chapters forming the body of this volume are organized into the three parts noted below, bracketed by this editorial introduction and a closing synthesis by the coeditor of the special issue, William Paisley. The chapters are fairly evenly distributed across the matrix shown in Table I.1 and are discussed in sequence below.

Part I: Theory and Perspective

We first present three essays, by Griffith, Pierce, and Lievrouw, that provide historical perspective, explicate concepts, and lay the theoretical framework for the later chapters addressing methods and results.

TABLE I.1
Scholarly Communication and Bibliometrics: Matrix of Variables Studied and Research Questions Asked by Chapters in this Volume

	Variables		
Research Questions	*Producers: Authors, Institutions, Nations, and so on*	*Artifacts: Articles, Journals, Books, and so on*	*Concepts: Words, Meanings, and so on*
Scholarly communities and networks	Griffith Lievrouw White Rogers & Cottrill Moed & de Bruin	Pierce Swanson Rice	Beniger
Growth and evolution	Griffith White Rosengren McCain Moed & de Bruin	Swanson Small & Greenlee Brooks	Brooks Beniger
Influence and importance	Griffith Rosengren Zsindely & Schubert		Beniger
Diffusion and gatekeeping	Griffith		Beniger

NOTE: Miyamoto, Midorikawa, and Nakayama and Paisley chapters omitted from matrix, as they are reviews that cover topics in most of these cells.

We open the volume with the essay by Belver Griffith, who sets bibliometrics in the context of the sociology of science by tracing the influence of three central figures: Robert K. Merton, Thomas S. Kuhn and Derek J. deSolla Price. Griffith's chapter is placed in all cells of the "Producers" column, as he addresses all of these research questions (and more) in the context of the communication behavior of individual scholars (Table I.1).

Next is Sydney Pierce's chapter. A sociologist by training, she asks what a contemporary sociology of science might contribute to bibliometrics. Among her proposals are that bibliometrics can benefit from the sociological research that characterizes the nature of scholarly disciplines and particularly from the renewed interest in the scientific paper as the embodiment of the scientific process. She suggests that the "new seriousness" afforded the scientific paper will lead to a new seriousness for bibliometrics in the sociology of science.

The chapter by Leah Lievrouw focuses on the intersection of four fields concerned with the sociology of science by examining their treatment of the concept of "invisible college." She attempts to reconcile research on the structure of the invisible college (using bibliometrics) and research on the informal communication process underlying that structure.

Part II: Bibliometric Research Methods

All five of the chapters in this section provide both methodological discussions and empirical results and are placed in this section because each is more heavily weighted toward explaining the method than toward explaining the results.

We open Part II with a chapter by Sadaaki Miyamoto, Nobuyuki Midorikawa, and Kazuhiko Nakayama covering bibliometric research in Japan published both in Japanese and in English. Theirs is a comprehensive review of several dozen papers, organized by application and by research method. They close with data of their own, mapping the field of library and information science within the behavioral sciences. Because they touch on almost every cell in the matrix, we have not placed them explicitly in Table I.1.

Howard White, among the developers of the author co-citation method, discusses the method and reviews the research in which it has been applied. In doing so he presents a rich discussion of the validity issues in citation analysis, responding to those who have attempted to discredit the method. We place his chapter at the intersections of the "Producers" column in both of the "Scholarly Communities" and "Growth and Evolution" rows, as most of the research applying the author co-citation method attempts to characterize a community of scholars in some way, either statically or over time.

White, among others, acknowledges Karl Erik Rosengren, a Swedish sociologist, as the first to invent the author co-citation method, which he calls "co-mentions" (Rosengren, 1968). Rosengren's chapter, which reviews his work on the co-mentions technique, follows the chapter by White. His chapter appears in the second and third cells of the "Producers" column, as he is more interested in identifying changes in scholarly communities over time than in characterizing existing communities and is perhaps most interested in identifying the influence of earlier scholars on current writing.

Don Swanson's brief chapter discusses the extensive research he has done in identifying literatures that are logically but not yet bibliometrically related, thus predicting future document co-citation. His work is among the rare predictive research in bibliometrics.

Ronald Rice discusses the use of network analysis on journal-to-journal citation maps to elicit the deep structure of journal relationships, a method not otherwise covered in this volume. The method is illustrated with data from the intersection of the fields of communication research and information science.

Part III: Empirical Studies

As with the above section, all seven of these chapters provide both methodological discussions and empirical results. These are more heavily weighted toward explaining the results of the research than toward providing examples of the method. Each quantitative analysis is complemented by one or more analyses of the underlying communication processes.

We open this section with a brief chapter by Everett Rogers and Charlotte Cottrill that compares the scholarly communities of "diffusion of innovation" and "technology transfer," which were found to be almost unrelated bibliometrically. Rogers, a central figure in diffusion of innovations research, and his coauthor provide an insightful explanation of this result. This is the only one of the empirical chapters that falls in the "Scholarly Communities and Networks" row.

In the "Growth and Evolution" row is the chapter by Henry Small and Edwin Greenlee, who have performed a comprehensive study of AIDS research using the document co-citation technique first developed by Small (1973) and others (Griffith & Mullins, 1972; Small & Griffith, 1974). They document the evolution of AIDS research from its first identification as a clinical disease in 1981 through its state as a full-blown research area in 1987. This is a massive study, providing maps of the emergence of this important new research area at multiple levels of detail. The structural analyses are complemented by contextual analyses of the references, thus showing the intellectual content of each shift in research direction. The Small and Greenlee article in the *Communication Research* special issue

is the first publication (to our knowledge) of a bibliometric analysis of AIDS research; this is a revision and extension of that article.

Complementing Small and Greenlee's document co-citation study, we have Katherine McCain's author co-citation study of population genetics researchers. She attempts both to validate research trends identified by other means and to validate a developmental model of the growth of science, comparing the structural maps produced by bibliometrics with prior sources and with results of interviews with authors studied.

Henk Moed and Renger de Bruin of the Netherlands provide their first report on a large study of scholarly communication in the field of agriculture, done for the Commission of European Communities. They focused on the awareness of European Community (EC) scholars of work done in other EC countries and collaborations across international boundaries, both within EC nations and in links outside the EC. These are analyses over time, assessing the impact of EC funding to encourage cooperative research.

Terrence Brooks bounds an active research area, superconductivity, by articles indexed under that terminology in a major indexing and abstracting source. He then analyzes the distribution of journals in which they appeared, comparing the results with an established empirical law of bibliometrics (Bradford's law), thus assessing the influence of these journals as communication channels. Because he used both concepts in the journals and the journals themselves in his analyses, we place his chapter in two cells in the "Growth and Evolution" row.

We close the empirical results section with two chapters looking at the influence of individual scholars. The chapter by Sándor Zsindely and András Schubert, two Hungarian bibliometricians, assesses the role of editors of medical journals or gatekeepers. They are clearly authorities, by nature of their positions, but are they also experts? Are they now or were they ever highly cited scholars in their fields?

The last empirical chapter is one by a communication scholar, James Beniger, that analyzes the roles of individual scholars and the influences of multiple disciplines on the field of communication. He does so via a content analysis of the new and comprehensive *International Encyclopedia of Communications*. His use of content analysis and his multiple research questions place him in all cells of the "Concepts" column. Beniger's is the only chapter in the volume that relies on a content analysis of a single text, providing a suitable bridge to Paisley's proposals for the direction of future research.

William Paisley, who has studied scholarly communication and bibliometrics for 25 years (Paisley, 1965), reflects on the history of each of these areas. He finds that the rapidly increasing availability of electronic texts and analytical tools will lead to burgeoning interest in the use of bibliometric techniques to study scholarly communication. He compares bibliometrics with complementary research methods, including content analysis, indicators research, sociometrics, and unobtrusive measures, showing what might be learned from each. Paisley closes with his reflections on the model presented in this chapter, suggesting how the model might evolve in the future.

Reliability and Validity Issues

Bibliometrics has been heralded as providing invaluable insights into the scholarly communication process that could not be obtained by any other method. At the same time the methods have been criticized as being overly rationalized and promoting a positivist, realist view of science (Edge, 1979) and as being both unreliable and invalid (e.g., MacRoberts & MacRoberts, 1987b, 1989).

Reliability, or the amount of error in measurement, and validity, or the degree to which we are measuring what we think we are measuring, are an inseparable pair of issues in assessing the value of bibliometrics or any other research method.

Reliability

One of the major strengths of bibliometrics is its high reliability. Bibliometric methods rely on unobtrusive measurement of readily accessible data, and results can be replicated easily. Although reliability problems do exist in individual data sources (e.g., Moed & Vriens, 1989; Rice, Borgman, Bednarski, & Hart, 1989), they generally can be identified and corrected by the careful researcher.

Validity

Critiques of the validity of bibliometrics have focused on the assumptions underlying citation analysis. Although citation analysis

assumes *some relation* between a citing and a cited document, it does not assume that all citations are made for the same purpose or that all citations are thus equal (Cole, 1970; Smith, 1981; White, this volume). Although critiques of citation analysis have attributed such assumptions to citation researchers (notably Edge, 1979; MacRoberts & MacRoberts, 1989), a close analysis of citation studies rarely reveals such assumptions, as White discusses at length.

Citation analysis is most useful for achieving a macro perspective on scholarly communication processes through the use of voluminous datasets. In doing so we are seeking the aggregate of links among authors, or their writings, that emerges. Citation analysis assumes that authors or documents that are frequently cited have some importance, even if the reasons for the citations vary. Study of the individual links between authors or documents is better pursued by methods that provide more behavioral insights.

On one central point both citation researchers and their detractors agree: Citation data are most useful when they are supported by other evidence (Edge, 1979; White, this volume). As reviewed earlier, the results of bibliometric analyses have been compared with sociometric data, survey data, case studies, usage statistics, and various other indicators, often with very strong results.

Reviews of correlations among bibliometric and other measures include Narin and Moll (1977), Todorov and Glanzel (1988), O'Connor and Voos (1981), Chubin (1987), Garfield, Malin, and Small (1978), Porter, Chubin, and Jin (1988), and Pritchard (1980). As most of these authors note, any comparison between citation measures and subjective measures must also compare the objectives of study. Differing results can often be explained by differing research motives. Pritchard (1980) uses the example of comparisons between bibliometric and journal usage studies on factors such as ranking of journals and obsolescence rates. Although the variables appear similar, the citation studies are measuring formal communication (documents publicly cited as a source of information) while the journal usage studies are measuring informal communication (browsing documents for various purposes). The existence of lack of correlation between these measures is meaningful in and of itself and may be used to address such questions as the degree to which scanned journals are actually cited later.

Because bibliometrics captures data on a scale larger than that of other social science methods, full validation of bibliometric results

by other methods is virtually impossible. Conversely, however, we can use bibliometric data to validate other measures, such as sociometrics, because they use a subset of the respondents provided by bibliometrics.

In selecting chapters for this volume, we have carefully chosen work that reflects a sensitivity to reliability and validity issues and that provides support from other data sources and interprets the communication processes studied. Each chapter addresses the validity of its method in some way; White provides the most extensive discussion. Other useful reviews of these issues can be found in Smith (1981) and a recent issue of *Scientometrics* (1987, Volume 12, numbers 5-6) that contains a critique of one aspect of citation analysis (MacRoberts & MacRoberts, 1987b) and 16 responses to the critique.

Conclusions

This introduction has attempted to provide an overview of the substance of bibliometrics and of the ways in which it may be applied to the study of scholarly communication. The large volume of work published in this area has given us many insights into the nature of the scholarly communication process and of the community structure of science. At the same time past research has generated an ever-larger number of research questions of increasing urgency. The rapidly increasing data sources, improved tools, and increased understanding of the research questions involved offer exciting and challenging directions for the communication and information sciences.