

Does Citation Reflect Social Structure?

Longitudinal Evidence From the “Globenet” Interdisciplinary Research Group

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Many authors have posited a social component in citation, the consensus being that the citers and citees often have interpersonal as well as intellectual ties. Evidence for this belief has been rather meager, however, in part because social networks researchers have lacked bibliometric data (e.g., pairwise citation counts from online databases), and citation analysts have lacked sociometric data (e.g., pairwise measures of acquaintanceship). In 1997 Nazer extensively measured personal relationships and communication behaviors in what we call “Globenet,” an international group of 16 researchers from seven disciplines that was established in 1993 to study human development. Since Globenet’s membership is known, it was possible during 2002 to obtain citation records for all members in databases of the Institute for Scientific Information. This permitted examination of how members cited each other (intercited) in journal articles over the past three decades and in a 1999 book to which they all contributed. It was also possible to explore links between the intercited data and the social and communication data. Using network-analytic techniques, we look at the growth of intercited data over time, the extent to which it follows disciplinary or interdisciplinary lines, whether it covaries with degrees of acquaintanceship, whether it reflects Globenet’s organizational structure, whether it is associated with particular in-group communication patterns, and whether it is related to the cocitation of Globenet members. Results show cocitation to be a powerful predictor of intercited data in the journal articles, while being an editor or co-

author is an important predictor in the book. Intellectual ties based on shared content did better as predictors than content-neutral social ties like friendship. However, intercited data in Globenet communicated more than did nonintercited data.

Introduction

What drives citation? Is it primarily *who* citers know (social structure) or *what* they know (intellectual structure)? The question still divides analysts. Our entry point into this debate is to study intercited data in a group that has been formally organized for more than a decade. We call the group “Globenet,” a pseudonym for an international network of 16 scholar-authors from seven different academic disciplines. Intercited data occurs when members of this (or any) bounded group cite each other. With our data we can ask, does long-term intercited data vary with degrees of acquaintanceship and communication between Globenetters? Or are intellectual affinities paramount, regardless of social and communication ties? Either alternative, or perhaps some combination of both, has a certain plausibility. The unusual nature of Globenet limits the generalizability of our results, but we believe they illuminate the right problems. Consider these sketches:

Who They Know

A common adage says, “It’s not what you know, it’s who you know” (Nardi, Whittaker, & Schwartz, 2000). Disci-

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plines and specialties find their main institutional purpose in bringing people with like interests together. Scholars and scientists tend to seek out their influences or meet them serendipitously throughout their careers. Among scholars, friends are more apt than strangers to be working in the same research area and to have similar ideas (Feld, 1981; McPherson, Smith-Lovin, & Cook, 2001). So what could be more natural than friends citing each other's work?

When scholars work far apart, the Internet, airplanes, and telephones help them keep in touch (Matzat, 2001). Their geographically dispersed network may crystallize as an invisible college, defined by a shared interest in certain research questions and various levels of interaction (Crane, 1972). According to Gresham (1994, p. 38), such invisible colleges "function as a scholarly in-group within a given specialization," their research "facilitated by informal exchange of information through contacts ..." It thus is likely that citers will be personally acquainted with at least some of their citees, especially those whom they cite recurrently. Social network analysts have been making such arguments for years (e.g., Wellman, 1988; Koku, Nazer, & Wellman, 2001; Matzat, 2002).

What They Know

It may be, however, that the main motivation for citing someone else's work is its perceived relevance and rhetorical usefulness. In that case, the key to scholarly awareness is not who you know but what you and others know in the way of subject matter. As a citer, you mention a work not because of your social ties to its author but because of its authority and relevance for your own new writing.

White (2001a) argued that social ties are neither *necessary* for citation (one may cite authors without knowing them) nor *sufficient* for citation (knowing authors is not reason enough to cite them). Nor is there a clear temporal arrow in the matter: citing may or may not lead to meeting, and meeting may or may not lead to citing. So any attempt to explain citation primarily in terms of acquaintanceship fails. For a better explanation of why people cite, one must look to intellectual factors, such as commonality of discipline, subject matter, research methods, and perspective (e.g., theoretical versus empirical, quantitative versus qualitative). Stewart (1990), Vinkler (1998), Baldi (1998), and Van Dalen and Henkens (2001) present strong empirical evidence for intellectual as opposed to social explanations of citation. Baldi's important article did not rule out the possible importance of social ties in motivating some citers, but he proposed new work "to elaborate the *kinds* of social ties that matter" (p. 844). Our study follows in that vein.

The *social network* hypothesis, then, is that members of an organized group should intercite considerably just because they know each other and that their intercitation should be strongly associated with the closeness of their various social and communication ties, like friendship and frequent conversation. In contrast, the *intellectual network* hypothesis is that intercitation is at most weakly associated

with social ties and more strongly associated with a common discipline and shared subject matter. This latter hypothesis assumes that social ties do not drive citation; they merely affect knowledge of items to be cited.

Both Who and What

Admittedly, intellectual ties and social ties cannot always be neatly separated. If writings are considered relevant to one's work, it would be odd indeed if the people who produced the writings were not considered relevant also. The greatest explanatory power may lie in variables in which acquaintanceship and explicit subject interests are inextricably mixed. Such ties exist when *roles* are used as variables—e.g., when some people in a group have ties as coauthors or departmental colleagues or mentors/students or editors/contributors. For want of a better label, such ties might be called sociocognitive.

The *sociocognitive network* hypothesis is that these mixed ties are most important in driving intercitation. Sociocognitive ties, such as those between collaborators, blend interests and affections in positive feedback duets. Shared interests in a set of problems may lead scholars to become collaborators. Collaborators develop the habit of discussing each other's work, incorporating it into their own intellectual kits, and citing each other's publications. This may in turn strengthen friendships (Garfinkel, 1967). One observer of this dialectic, cosmologist James Hartle (University of California, Santa Barbara), says of his collaboration with Nobel prize winner Stephen Hawking (Cambridge University): "Generally, 'it's the science that drives it' while friendship naturally follows" (quoted in Glanz, 1999, p. D2).

In seeking to explain intercitation, we thus bring several kinds of measures to bear. Those we call *social* require acquaintanceship in some degree but no explicit commonality of subject interests. The contrasting *intellectual* ties require broadly common subject interests but not acquaintanceship. *Sociocognitive* ties mix relations in content-laden roles, such as those of coauthors or editors/contributors. *Communication* ties have to do with whether scholarly and nonscholarly messages are exchanged and with how frequently modes such as e-mail, telephone, and face-to-face conversation are used.

Globenet

Globenet, the formal organization we studied, promotes interdisciplinary research on human development. Its 16 members are dispersed in 13 universities: seven in Canada, five in the United States, and one in Europe. The 13 men and 3 women range in age from mid-40s to mid-60s. All Globenetters are acquainted in varying degrees, and their group exists to breach disciplinary barriers and foster the sharing of ideas. If personal relationships and organizational incentive can induce people to refer to each other's work in print, then they should be especially apt to do so in the

densely knit, frequently interacting scholarly group that we analyze here.

Globenet emerged in the early 1990s out of the intellectual growth and informal discussions of two smaller research networks, a beneficiary of the fashion for governments, corporations, and universities to encourage invisible colleges with funding. It has a definite membership, a budget, a director, some staff time, and a public name. Its shared vision, financial support, formal selection process, and frequent conferences have made it a "visible college," with more formal channels of communication than invisible colleges (Nazer, 2001). At the cost of flexibility, this greater formality provides stability, institutionalized bases for collaboration, and opportunities to receive government and corporate financial support. Nine "senior fellows" receive full salaries from the program, while seven "associates" receive partial funding. This reduces the time they spend teaching and increases the time available for research, collaborating, and networking (Katz & Lazer, 2002).

To join the network, a scholar must be deemed to be doing important research and have a personality that complements those of existing members. Initial members, all well-known scholars, were recruited by the founding director and his advisors. Later, members were invited to join by collective decision after they had passed an informal probationary where they had attended Globenet meetings without having continuing membership—an example of "sponsored mobility" (Turner, 1960). Globenet thus functions as a select club, much like the Knights of the Round Table. It is difficult to be invited in, but once someone becomes a member, there is a norm of mutual respect—an assumption that members are not only experts in their fields but intellectuals with broad purviews who can communicate with members in related fields (Nazer, 2001; Koku, Nazer, & Wellman, 2001).

Globenetters usually work autonomously but are expected to make available to each other their expertise, resources, and research findings. Throughout the period of our observation, they worked together to produce a major book, which was published in 1999. Although the general pattern was for each scholar to contribute a chapter, the members and the editors sought to integrate their findings and analysis into a single, coherent account. Members looked forward to this book's impact on scholarly and public opinion.

Member Pairs

In 1997, one of us (Nazer) visited the offices of each Globenetters, observed them at work, and interviewed them in depth. By matching each member with the other 15, she could study relations among 240 member pairs. Every pair can be examined for ties, i.e., one or more relations such as collaboration or friendship. In asymmetric relations, the definition is directional: an $A \Rightarrow B$ tie is treated separately from a $B \Rightarrow A$ tie. We will frequently use these pairs or

"dyads" rather than individuals as our unit of analysis in portraying Globenet as a network.

Only 10/240 (4%) of the pairs of members work in the same city (6 of the 10 in the same department). To facilitate information-sharing in this far-flung network, Globenet funds all members to attend three face-to-face conferences per year, each lasting 4 days. These conferences are scenes of formal presentations and intense conversations. Although the thrice-yearly conferences are the primary medium through which Globenetters communicate, members sometimes phone or e-mail each other and occasionally make personal visits. Different means of communication supplement each other: Those Globenetters who talk more face-to-face also e-mail and telephone each other more. More than one fifth (22%) of Globenet pairs have collaborated, three fifths (60%) have read each other's work, while nearly two thirds (64%) have discussed each other's research (Koku, Nazer, & Wellman, 2001).

About half of the pairs (52%) have more than one scholarly relationship: collaborating, discussing ideas, or reading each other's work (mean = 1.5). Most Globenet pairs claim good collegiality: Three quarters (74%) consider themselves either friends (25%) or colleagues (49%). Only one fifth (21%) consider themselves mere acquaintances; the remaining 5% have minimal relationships. The stronger the relationship, the more likely are pairs to communicate often and to use multiple means of communication ($r = 0.53$). A Globenet pair's number of scholarly relations is significantly correlated with the frequency of their face-to-face ($r = 0.42$) and e-mail ($r = 0.40$) contacts.

Friends are more apt to engage in more kinds of scholarly relations: collaboration, discussing research, and reading each other's work. Reading each other's work is associated with frequent e-mail contact (Koku, Nazer, & Wellman, 2001; Haythornthwaite & Wellman, 1998). Eighty percent of friends have two or more scholarly relations (mean = 2.2). Fifteen percent engage in all three types of scholarly relations. By contrast, pairs with weak acquaintanceship ties have only 0.5 scholarly relations, while those who have no interpersonal relation have hardly any.

Intercitation

Although members' overall citation counts were included in the original data gathering, intercitation among Globenet pairs is studied here for the first time. We analyze Globenetters' intercitation in journal articles from four discrete periods: pre-1989 (baseline), 1989 to 1992 (the 4 years leading up to formal organization), 1993 to 1996 (the 4 years after), and 1997 to 2000 (the 4 most recent years, as institutionalization set in). We also analyze intercitation in the 1999 book to which all 16 members contributed. Since the book was seen by members as the major culmination of their collective project (Nazer, 2001), it should be well populated with intercitation. For all analyses we can compare intercitation in articles (our main focal variable) with intercitation in the book.

Note, however, that this is a study of how social relationships and intellectual affinities are related to intercitation *within* a densely knit and mutually aware in-group. Although our study provides suggestive evidence, we do not know the processes by which Globenetters cite scholars outside their group. Nor do we directly address the broader question of how social relationships and intellectual affinities are related to intercitation among scholars in the wider, less bounded scholarly world.

Methods

Most analysts would agree that the citation networks and the social networks of scholars often overlap. But while people can give examples from personal experience (e.g., White & McCain, 2000; Cronin & Shaw, 2002), relatively few empirical studies exploit this belief about overlap to learn more about scientific communication. (Among them are Mullins, Hargens, Hecht, and Kick, 1977; Murray & Poolman, 1982; Lievrouw, Rogers, Lowe, and Nadel, 1987; Leydesdorff & Amsterdamska, 1990; Perry & Rice, 1998, 1999; Rowlands, 1999; Sandstrom, 2001; Zuccala, 2001.) The scarcity of systematic research is probably attributable to a disciplinary divide: Social networks analysts from sociology, such as Wellman and Nazer, have lacked citation counts for multiple author-pairs from online databases, while citation network analysts from information science, such as White, have lacked measures of scholarly acquaintanceship and communication. The present article marks a new collaborative beginning by pooling the different kinds of data that each discipline usually holds separately. As advocated by Lievrouw et al. (1987), it employs both sociometric and bibliometric techniques, rather than one or the other.

Social and Communication Ties

Nazer measured social relationships and communication behaviors in Globenet and gathered background information, such as members' opinions on the value of interdisciplinarity. The data were obtained through questionnaires in which all Globenet members self-assessed their levels of acquaintanceship and interaction on two ordinal scales:

- Perceived closeness to other members (no relation, acquaintance, colleague, and friend)
- Type of interaction with other members (no affiliation, read the other's work, discuss research, collaborate)

The two scales also exist as eight binary variables, as used below (colleague/other, friend/other, read work/do not read work, and so on). Two other social variables are:

- Which other members do you seek advice from?
- Which Globenetters did you know before joining?

Nazer's survey questions tap many aspects of communication in Globenet. They inquire about the settings in which both scholarly and nonscholarly communication occurs (only in formal meetings or informally as well) and the use of specific modes (face-to-face, telephone, paper/post, e-mail, fax). Answers on communication modes were obtained both in binary form (use/not use) and as estimated frequencies and percentages of use per year. The counts were both logged and recoded into ordinal categories (no contact, infrequent, somewhat infrequent, somewhat frequent, and frequent contact). Measures of physical separation include whether members work at the same university or in the same city; if not, the airline miles between them.

Citation Records

Scholars are second only to athletes in having measures of their productivity (articles published) publicly available. They surpass athletes in public measures of their (intellectual) connectivity. In the citation indexes of the Institute for Scientific Information (ISI), those who study scholars have abundant reliable information about who cites whom and in what article.

Since the Globenetters' real names are known to us (though given Nazer's pseudonyms here), it was possible for White in 2002 to obtain citation records for all of them. Using Dialog's OneSearch capability, he combined Scisearch with Social Scisearch (that is, the online *Science Citation Index* with the online *Social Sciences Citation Index* or Dialog files 7, 34, and 434) to encompass the full range of research in human development. These records provide various kinds of citation counts for the Globenetters over the decades covered by ISI files. Intercitation counts in Dialog were drawn from each member's "citation identity," i.e., the set of an author's citees ranked by how frequently that author has cited them (White, 2000, 2001a,b).

While ISI covers citations *to* documents of any sort, it only covers citations *from* documents in serial publications (mainly journals). Therefore, we gathered intercitation data from the 1999 Globenet book by hand. Every cited member received an increment of one for every publication cited in another member's chapter (although not for additional mentions of the same work in the same chapter). This was done even if the cited member was not the first author in a multiple-author piece. This liberal kind of scoring is not feasible with data gathered from ISI online, because the counts in Dialog add an increment of only one to the cited author's count no matter how many of his or her different works are cited in a single article. In addition, if the citation refers to a piece with multiple authors, only the first author's count is credited. This is a limitation because Globenetters function in scientific disciplines where multiple authorships are the norm, and they are not always the first author in the bylines of author teams. Consequently, our Dialog-ISI counts may understate article intercitation by Globenetters during 1972–2000.

Cocitation Counts

The Dialog-ISI records were also tapped for data on the *cocitation* of Globenettters—that is, counts of their joint appearances in the reference lists of anyone’s later articles. Cocitation analysts in Small’s (1973) tradition work with cocitation of particular *papers* by, e.g., Smith or Brown. In contrast, we here use cocitations of *authors* (White, 1990)—that is, mention of *any* work by Smith with *any* work by Brown in the references of a later work. Every later work that cites the Smith-Brown pair increments their cocitation count by one.

Cocitation data capture perceptions of any two members’ scholarly relatedness in a global way, possibly across disciplinary lines. Only *recurrent* cocitation of pairs matters much in establishing intellectual relationships. Frequently cocited author-pairs often have social relationships as persons, but such ties are not necessary (e.g., Stephen Hawking can be cited with Copernicus) and are not presumed (cf. White, 1990). Because scholars are cited together for many reasons, cocitation data can be noisy, but in the aggregate they are a robust measure of how citers view the intellectual linkages in a research domain.

Hundreds of citers in the journal literature supplied our cocitation data. Unless the data are adjusted, however, these citers can include Globenet members themselves. If so, cocitation of Globenet pairs may be conflated with their intercitation. For example, if Smith cites both himself and fellow Globenetter Brown, it will increment the Smith-to-Brown intercitation count by one and the Smith-Brown cocitation count by one. (If Smith does not self-cite, only the intercitation count will be incremented.) Because we wished to use cocitation as a predictive measure for intercitation, we blocked Globenettters who intercite from contributing to their own cocitation counts. This is done online in Dialog by systematically removing from the set of items *cociting* a pair of authors any items *by* either member of the pair. (The removal occurs even when someone is not first in the byline of a piece with more than one author.) Thus, the intercitation counts and the cocitation counts used below do not overlap.

Both intercitation and cocitation data are inherently dyadic and can be readily matched with social and communication data for each author pair. There are two main differences. First, cocitation counts are symmetric (the number of times A is cited with B is the same for B with A); intercitation counts are asymmetric (A does not necessarily cite B as B cites A). Second, cocitation records are for the most part out of Globenetter’s hands, while intercitation is an act they control directly. In this second regard, intercitation lines up nicely with our measures of Globenettters as social actors (e.g., ties of friendship or collaboration; frequency of scholarly contacts).

Intellectual Ties

We have three crude measures of intellectual ties that do not depend on being acquainted:

- Members’ cocitation counts (which range from 0 to 78)
- Whether members belong to the same academic discipline (also called “disciplinary homogeneity”)
- Whether a member reads another member’s work

The first is from White’s literature searches as just described; the other two are from Nazer’s survey.

Using Matrices for Analysis

This study’s data are cast as matrices for network analysis. The 16 Globenettters’ names are placed in identical order on the matrices’ rows and columns. As noted, cocitation relations between them are symmetric and make for a term-term co-occurrence matrix, a structure long familiar in information science. The other matrices are asymmetric, each describing intercitation or specific types of social and intellectual relations.

In asymmetric matrices, the matrix consists of sender-receiver intersections. Row names are the senders and column names are the receivers of the relation—for example, the person in row *i* cites or has discussions with the person in column *j*. With intercitation data, counts in the off-diagonal cells reflect the sender’s *outcitations*, which are the receiver’s *incitations*—a sociometric choice measure. (Self-citation counts are omitted here as not relevant to studying interpersonal relationships. If included, they would go on the diagonal, where senders and receivers are the same persons.)

Row marginals are totals of the outcitations an author has sent; column marginals are totals of the incitations he or she has received. For example, in Table 1, Oldfield has cited others a total of 16 times and has received a total of 9 citations. The cells show him citing Martins in 12 publications and Martins citing him in 6. Martins and Oldfield are each others’ highest citers, suggesting an active regard for each other’s work. By contrast, although Oldfield cites Hart twice and Hopkins once, neither Hart nor Hopkins cites Oldfield.

Matrix Types

If counts are in the cells, the matrix is called “valued.” The counts can be stepped down to reflect simply whether intercitation is present (1) or absent (0); in that case, the matrix is called “binary.” Non-zero values of intercitation can be graphed as directed lines, showing relationships between the authors (“nodes” in social network analysis). Incitations and outcitations can be counted as “indegrees” and “outdegrees” of the nodes, the basis of standard degree measures of centrality in network analysis.

For example, in a binary matrix, Oldfield’s indegree of 4 shows that four other Globenettters cite him (it is Martins’s multiple citations of him that make for the total of nine citations to his work in Table 1). Oldfield’s outdegree of 4 shows that he cites four other Globenettters (and gives them the total of 16 citations seen in Table 1).

TABLE 1. Aggregated intercitation counts from articles through 2000 (Matrix I_{av}).

	Mn	Ap	Gr	Mr	Jo	Wo	Sm	St	Ha	Co	Ho	Sc	De	OI	Br	Gr	Total
Mann	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2
Applebaum	2	0	0	3	0	0	0	6	1	0	0	0	0	1	0	0	13
Green	0	0	0	0	0	0	0	2	0	0	0	0	9	0	0	0	11
Martins	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	6
Jones	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wood	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Smith	1	0	3	2	1	0	0	0	2	0	9	0	0	1	2	1	22
Stone	0	0	2	1	1	0	1	0	1	0	1	1	1	1	1	1	12
Hart	1	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	8
Cook	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hopkins	0	0	1	0	1	0	3	1	1	0	0	0	0	0	1	0	8
Scott	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Demore	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Oldfield	0	0	0	12	0	0	0	0	2	0	1	0	0	0	1	0	16
Brown	1	5	0	0	0	0	0	0	8	0	3	0	0	0	0	0	17
Grey	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	5	5	10	18	3	0	4	9	15	0	16	1	10	9	12	2	

In what follows, two of the intercitation matrices are drawn from the articles data as cumulated through 2000, and two from the 1999 book data. In each case, one matrix is valued and the other is binary. For the articles, the binary matrix has 46 intercinging author-pairs, and the valued matrix has the number of times that these 46 pairs interceded—119 in all. The book’s binary matrix shows 62 intercinging pairs; its valued matrix has 85 interceditions. The four matrices are labeled I_{ab} , I_{av} , I_{bb} , and I_{bv} , where I = intercedition, ab = articles binary, av = articles valued, bb = book binary, and bv = book valued.

Sociocognitive Ties

We have three sociocognitive measures, all roles

- Being a collaborator with another member, as self-identified on Nazer’s questionnaire
- Being a coauthor, which designates members who jointly wrote chapters in the book (the same pairs also coauthored articles, but we did not create a separate variable for this)
- Being an editor of the book, as opposed to a contributor

The binary variable *Editors* was created especially for the present study. It represents the fact that two of Globenet’s formal leaders, here called *Stone* and *Smith*, had the additional task of editing the 1999 book that presented the group’s research. Stone is Globenet’s director and heads one of its main research programs; Smith heads the other research program. In Nazer (2001), Stone and Smith ranked first and second, respectively, on *Prominence*, a variable created by combining members’ scores on measures of collaboration, communication, and advice giving. The Editors variable singles out the special role of Stone and Smith as proponents and synthesizers of interdisciplinary work, on the assumption that this special role is associated with liberal intercedition. In the Editors matrix (not shown here),

Stone’s and Smith’s “sender” interceditions with other members (and each other) contain ones in the cells, while the interceditions of the rest contain zeroes, representing the complementary role of contributors.

Statistics

In the next section we will compare the quadratic assignment procedure (QAP) Pearson correlations of various ties with Globenet intercedition. We will also show how these ties perform when intercedition is regressed on them and they yield beta weights (partial standardized regression coefficients). Beta weights show the unique effect of each input variable when the effects of all other input variables have been controlled (in this case, algorithmically removed). In addition, we will present QAP *t*-tests of whether means of communication behaviors differ significantly for interceditors and noninterceditors. QAP statistics are annotated in the documentation of UCINET, a software package for network analysis (Borgatti, Everett, & Freeman, 2002).

QAP correlation is appropriate for network data like ours. It presumes neither random sampling of cases from a population (Globenet is the population) nor independence of observations (dyadic observations are not independent). The algorithm calculates an initial Pearson *r* from the input matrices and then compares that with the 2,500 Pearson *r*s obtained when the rows and columns of one of the matrices are randomly permuted 2,500 times. The *p* values for QAP correlations are the proportion of times that the initial *r* is equaled or exceeded by the *r*s from the permutations. As is conventional in other significance tests, a proportion of .05 or less is taken to suggest a nonchance relationship.

Statistical significance in our *t*-tests is computed by UCINET using permutation trials (10,000 per run). Like the tests for the QAP correlations, they do not assume random sampling or independent observations.

In the regressions we use UCINET's QAP matrix regression module, whose tests of significance involve 2,000 permutations. The procedure is slightly sensitive to the order in which variables are entered, and significance values fluctuate somewhat when permutation tests are repeated. Nevertheless, the results displayed below are reasonably representative of what various runs showed.

Results

Articles and Book Interrelated

The intercitation matrices for the articles and the book are positively associated. The QAP Pearson correlation between I_{ab} and I_{bb} is .27 ($p = .006$). Between I_{av} and I_{bv} , it is .23 ($p = .007$). This suggests some tendency for those who cite each other in articles to cite each other in the book as well. Although not surprising, the association is rather weak, suggesting somewhat different dynamics in the intercitation patterns of Globenetters when they were writing book chapters as opposed to articles—a point to which we will return.

Growth of Intercitation

Table 2 reveals the effects of Globenet's promotion of interconnected research over the years. Is the Zen cup of citation half empty or half full? On the one hand, nearly three quarters of the Globenet pairs do not cite each other. (This would disarm suspicions that members are systematically inflating each other's counts.) On the other hand, from a modest base, the percentage of intercitation *has* grown markedly over the four periods studied.

Table 2 shows the cumulative counts from Dialog (recall that the true numbers may well be higher). Interciting articles rose almost sixfold, from 21 in the pre-1989 baseline period to 119 in 2000. Among the 16 members, citers grew from a minority of 6 in the baseline period to a majority of 11. Citees almost tripled, from 5 to 14.

There has also been a growth of interdisciplinarity, which members claim in their survey responses to support strongly. As of 2000, members representing all seven dis-

TABLE 2. Cumulative intercitation in articles and book by Globenetters through 2000.

Period	Articles	Citers	Citees	Interdisciplinary count
Pre-1989	21	6	5	3 disciplines citing 2
1989-1992	37	8	7	4 disciplines citing 3
1993-1996	68	10	11	4 disciplines citing 4
1997-2000	119	11	14	4 disciplines citing 7

Year	Book chapters	Citers	Citees	Interdisciplinary count
1999	18	15	16	7 disciplines citing 7

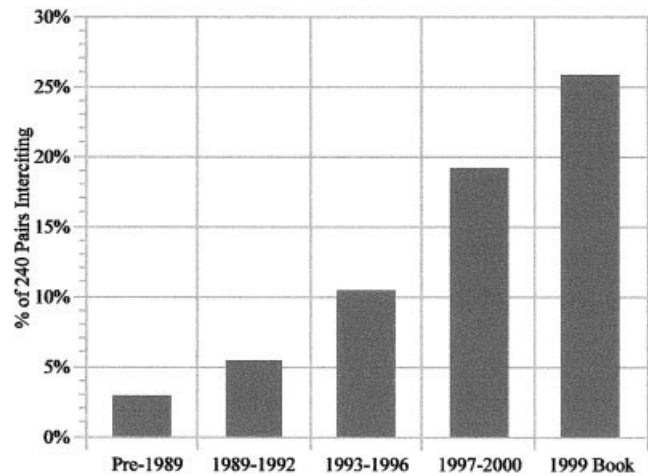


FIG. 1. Globenet intercitation in articles (four periods) and book: Cumulative network density.

ciplines had been cited, although citers' disciplines numbered only four.

The network density measure gives the fraction of the 240 pairs of Globenet authors who have actually intercited in articles. It is graphed in Figure 1. The cumulated total of pairs more than sextupled, from 7/240 (or less than 3%) in the earliest period to 46/240 (or more than 19%) in the latest. In each of the three periods after the pre-1989 base, intercitation roughly doubled, approximating exponential growth.

Of the 46 pairs with at least one intercitation, 12 cite reciprocally; 34, nonreciprocally. As usual in bibliometrics, the data form a highly skewed, "core-and-scatter" distribution. In general, a "core" is made up of the relatively few cases that produce a disproportionate amount of some output, and a "scatter" comprises the many cases that produce lesser amounts, down to one unit of output each. Here, although the 12 reciprocating pairs are only 26% of all intercing pairs, they authored more than half of the articles with inter citations (64/119) and thus are a major part of the core. At the other end of the long tail of "scatter" are 23 pairs (50%) in which one member cites the other once without reciprocation.

Table 3 adds some details for the reciprocal citers. It shows how the first member of each pair categorized relations with the second member on Nazer's questionnaire (e.g., Oldfield, who cited Martins 12 times, characterized him as a friend and as a collaborator). Note that pairwise agreement on both the closeness of acquaintanceship and the level of interaction is quite high (e.g., Martins said the same about Oldfield that Oldfield said about him). Moreover, the reciprocating pairs are alike in many respects. This suggests that homogeneity of background may have a place in explaining intercitation.

The intercitation patterns of the Globenetters' book also appear in Table 2 and Figure 1. Given the book's purpose and lengthy gestation, it is not surprising that all Globenetters are cited by others in their book chapters, and that all

TABLE 3. Twelve pairs of reciprocal intercitters in Globenet.

Names	Intercitations	Closeness of acquaintance	Level of interaction	Knew before Globenet?	Discipline
Oldfield-Martins	12	Friend	Collaborator	Yes	Same
Martins-Oldfield	6	Friend	Collaborator	Yes	Same
Green-Demore	9	Friend	No affiliation	Yes	Same
Demore-Green	4	Friend	No affiliation	Yes	Same
Smith-Hopkins	9	Friend	Collaborator	Yes	Same
Hopkins-Smith	3	Friend	Collaborator	Yes	Same
Brown-Hart	8	Colleague	Collaborator	Yes	Different
Hart-Brown	7	Colleague	Collaborator	Yes	Different
Brown-Hopkins	3	Colleague	Discuss research	No	Different
Hopkins-Brown	1	Colleague	Read work	No	Different
Stone-Green	2	Friend	Collaborator	No	Same
Green-Stone	2	Friend	Collaborator	No	Same

but one member (15/16; 94%) cite other members. Hence, all the disciplines of members are connected through intercitation. About one quarter of the possible interciting pairs have some sort of citation relationship, in one or both directions (network density = 0.258). These results are contemporary with and about twice the density of intercitation in articles in the final period of the articles data, 1997–2000 (network density for this period alone is 0.125). It is probable that the joint exercise of producing an integrative book during the years 1997 through 2000 focused Globenetters' minds on each other's work. The quarter of interciting pairs in the book probably approaches the upper limit of intercitation among Globenetters.

The Editorial Role

Intercitation data for both the articles and the book clearly show the book's editors, Stone and Smith, as central to the group. This confirms their leadership roles independent of their formal titles or social prominence (measured by indegree). It answers the question "Does citation reflect social structure?" with an unambiguous yes. Figure 2 exhibits the effect for the articles data.

What causes that placement is not mysterious. There are two kinds of degree centrality: indegree and outdegree.

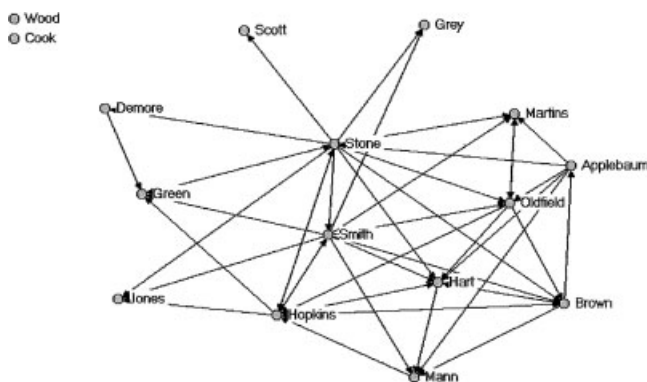


FIG. 2. Cumulative Globenet intercitation in articles through 2000.

They are exemplified here as the number of citations a Globenet author receives from members (incitations) and gives to members (outcitations), as shown by the direction of the arrows (two-headed arrows show reciprocal intercitation). The two counts can be tallied separately or together when degree centrality is computed. Both Stone and Smith receive some incitations, but what really sets them apart is their high number of outcitations (cf. Table 1). These latter are a predictable, though probably unplanned, behavior in organizational leaders: What better way to show the coherence of Globenet than by citing members across disciplinary lines? Stone leads in members cited, and Smith leads in number of citations given. When incitation and outcitation counts are combined, the two editors have more connections to other Globenetters than anyone else. Hence, they appear at the center of the sociogram.

Incitation counts—citations received—mark intellectual usefulness within the group. When these are considered separately, we see quite different results. Rather than Smith and Stone dominating, several other members have roughly equal scores. Thus, Hopkins, Brown, and Hart lead in the articles data of Figure 1, while Hopkins, Smith, and Jones lead in the book data. (Two other members, Cook and Wood, appear in the matrices and graphs as isolates, neither citing nor cited within Globenet.)

The difference between incitation and outcitation can be seen in network centralization measures for the matrices. The outcitation centralization score for the article matrix (I_{ab}) is a high 57.8. The outcitation centralization score for the book matrix (I_{bb}) is an even higher 64.9, because Stone and Smith are even more central outcitters in the book than in the articles. Incitation centralization in the same matrices is much lower: 22.2 for both. The similarity of both sets of results implies that *two* citation environments—articles and book—reflect only *one* Globenet leadership structure.

The importance of the editorial role in outcitation is also demonstrated by correlating the editors' matrix with the outcitation matrices for articles (I_{ab}) and books (I_{bb}). The respective QAP correlations are .46 ($p = .010$) and .47 ($p = .006$). This finding is, to be sure, quite specialized: Few

TABLE 4. QAP Pearson correlations of intercitation counts with predictor ties in Globenet articles and book.

Social ties	Intercitation in articles, I_{av}	QAP significance	Intercitation in book, I_{bv}	QAP significance
Knew person before Globenet	0.402	.000	0.144	.043
Friend	0.231	.001	0.215	.018
Sought advice	0.130	.054	0.207	.005
Sociocognitive ties				
Collaborator	0.270	.002	0.237	.002
Editor	0.156	.029	0.443	.008
Coauthored chapter in book	0.174	.078	0.423	.000
Intellectual ties				
Cocitation count	0.717	.000	-0.010	.508
Same discipline	0.380	.001	0.140	.035
Have read his/her work	0.148	.015	0.163	.078

citers are both leaders and editors in small, formally organized groups. But it points to the desirability of knowing the motivational contexts of citation. Although an interdisciplinary style of citing may arise from personal catholicity of interests, it may also be influenced by the norms of sociocognitive roles, such as when academics edit a book or write a literature review article.

Three Kinds of Ties

We shift now from binary to valued matrices for intercitation in the articles and the book. The valued data reveal not only the presence of citation but also how many citations occurred for each of the 240 Globenet pairs. We ran QAP correlations of both I_{av} and I_{bv} with about 15 variables. Interestingly, all three of our main categories of ties—social, intellectual, and sociocognitive—produced statistically significant zero-order correlations (i.e., correlations with no other variables controlled). Some are significant with both the articles and book citation matrices. These duplications of significance hint at similar causes of citation for both data sets, although the correlations in the two differ notably in their pattern of highs and lows. The relatively strong r s are presented in Table 4, sorted on the correlations in the articles data. (Correlations with logged versions of I_{av} and I_{bv} were computed but have been left out to simplify the table; they would rarely change substantive interpretation.)

Individual zero-order correlations like those in Table 4 do not finally explain what drives intercitation. Later, we will test the explanatory power of all variables simultaneously by combining them in regression analyses of the articles and book data.

Two of Nazer's social scales—closeness of acquaintanceship and type of interaction—both correlate significantly with the intercitation matrices I_{av} and I_{ab} in the 0.15 to 0.25 range. But both also exist as eight binary variables (friend/other, etc.). By allowing us to treat each relation

individually, these binary variables provide a clearer account of what is actually going on.

It is being a collaborator, and, to a lesser extent, being a friend or reading the other person's work, that correlates significantly with both articles and book intercitation. The other five binary variables, such as being a mere acquaintance or colleague, or merely discussing research together, do not make the cut; neither does working in the same university or any other measure of physical distance between respondents.

The highest correlations in the book data associate intercitation with sociocognitive roles specific to the book: being an editor and/or coauthoring a book chapter. The latter two roles carry over faintly into the articles data. Advice seeking, a social tie, is weakly correlated with intercitation in both columns: It may be that some of the advice sought related specifically to the book, which was in preparation when the Globenetters were surveyed.

The top-ranked variable under social ties shows that, in Globenet, intercitation is more likely if the citer knew the citee before joining the group. We found that nearly half (47%) of the pairs who knew each other before Globenet was organized cite each other in articles. This compares with the significantly lower 14% intercitation rate of those who did not know each other before joining. These results closely resemble those obtained with another of the variables correlated with intercitation in Table 4: whether citer and citee belong to the same discipline (disciplinary homogeneity). Of those who belong to the same discipline, 46% interceded in articles, versus only 15% of those who do not.

A Qualification

In a side study of the effects of the two predictor variables just mentioned, we discovered an interesting complication. After finding that pre-Globenet acquaintanceship affects intercitation, we controlled on disciplinary homoge-

neity as a temporally prior independent variable. It turns out that the original relationship holds only for *cross-disciplinary* citation. That is, when members who knew each other before joining Globenet are in the *same* discipline, they are not significantly more likely to intercite than those who did not know each other (47% vs. 44%; Pearson's $r = .027$). However, when they are in *different* disciplines, they are much more likely to intercite than those who did not know each other (53% vs. 12%; Pearson's $r = .295$). Their social ties compensate for absence of disciplinary ties.

Unpacking Some Differences

The relationship of disciplinary homogeneity with intercitation is much stronger in the articles data than the book data. Cocitation, the other intellectual tie appearing in Table 4, performs similarly. It is strongly correlated with intercitation in the articles ($r = 0.72, p < .000$), yet not at all correlated with intercitation in the book ($r = -.01, p = .508$). Why these striking differences? We will try to unpack them over the rest of this section.

We gathered the book data as a check on the articles data, thinking that the former might replicate the effects seen in the latter. Table 4 in fact shows some faint similarities, but it appears that we have tapped into two fairly different sets of behavior. The Globenetters' book is a distinctive project that breaks with what they did in their various articles over the years. Although members intercite quite extensively in their chapters, the Globenet pairs with the highest cocitation counts mostly fail to intercite in the book at all, and almost everyone cites in ways quite different from what their cocitation records from the 1970s on would predict. In particular, many cite other members not along but across disciplinary lines, often making wholly new connections—exactly what Globenet was organized to promote.

In contrast, members' long-term intercitation in journal articles runs more along disciplinary lines. The intellectual ties hypothesis says that intercitation grows out of commonality of subject matter. If we assume that belonging to the same discipline implies common subject matter, then disciplinary homogeneity should be associated with intercitation, and in Table 4 we see that it is. If we assume that cocitation is another measure of common subject matter, then it and disciplinary homogeneity should be associated, and in our data they are ($r = .45, p < .001$). For the same reason, cocitation should be associated with intercitation, and, again, that is what we see in Table 4.

Recall that, in our data, authors not in Globenet were responsible for the cocitation, and Globenet members were responsible for the intercitation. But the two variables came to be correlated as part of the natural evolution of ideas in various disciplines. The best single explanation of their correlation is that both members of Globenet and all other writers are responding to similarity of content in Globenetters' publications.

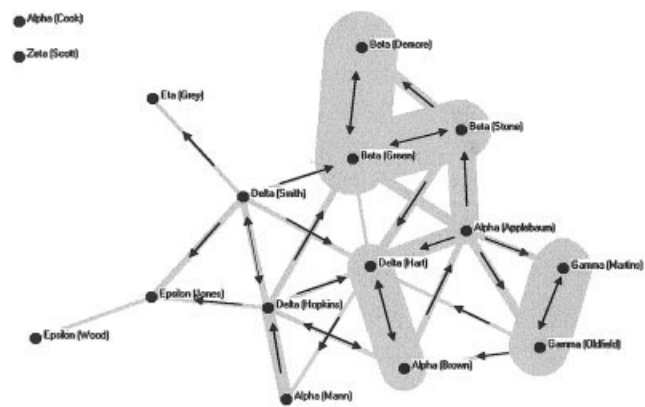


FIG. 3. Strongest cocitation and intercitation links of Globenet disciplines and authors in articles through 2000.

Intercitation and Cocitation

By superimposing intercitation ties on cocitation ties and labeling disciplinary affiliations, we can show the mutually reinforcing nature of these variables. Figure 3 is a simplification of the more complex cocitation patterns that exist in the data (129 of the 240 pairs have nonzero cocitation counts). It shows the Globenet pairs linked by cocitation counts of *three or higher*. Nodes are labeled with Greek letters standing for members' disciplines followed by their pseudonyms. The light gray lines connecting paired author-nodes have been made proportional to their cocitation counts in size, which fattens some lines into "areas." The narrowest lines reflect counts of three; the broadest reflects Demore-Green's count of 78—a range suggesting that citers find some ties much plainer than others. (Cook, who has a count of one with nine other members, and Scott, who has a count of one with one other member, show as isolates.)

What emerges is the tendency of cocitation to register *disciplinary* ties—i.e., broad commonality of subject matter, a key to the correlation of .72 between cocitation and I_{av} . At top, cocitation unites the three betas; at right, the two gammas; at center-left, the three deltas; at lower left, the two epsilons. (The remaining disciplines, eta and zeta, have only one representative each.) Several figures (e.g., Applebaum, Green, and Hart) emerge as interdisciplinary linchpins. The cross-disciplinary linkages of the Alphas with the Deltas (e.g., of Applebaum or Brown with Hart) may be explained by their common interest in topics related to a particular *stage* of human development (for example, despite their different disciplines, Brown and Hart have engaged in a series of collaborations).

Superimposed on the grayed links are arrows reflecting intercitation flows—two-headed arrows if citation is reciprocal, one-headed if not. The six two-headed arrows connect authors who, as reciprocal interciters in Table 3, accounted for 55% (66/119) of all article inter citations. An additional 29% (34/119) flow along other cocitation links explicit in the map. Thus, 84% of article intercitation ties match cocitation ties shown in Figure 3, and another 15% (18/119) flow along lesser cocitation links not shown. Only one

Globenet pair has an intercitation tie without being cocited. Obviously, the two kinds of citation data here jibe very well.

The “thick” intercitation structures on the right side of Figure 3 were already in place years before Globenet officially began; in a sense they presage it. (The “thin” structures to the left of Demore, Green, and Hopkins are newer.) The original interciters in the pre-1989 period were the three betas plus Hopkins and, separately, the two gammas. During 1989 through 1992, the betas and gammas were connected when an alpha, Applebaum, cited authors from both disciplines. Brown and Hart’s alpha-delta tie started in the same period. Citers outside Globenet also saw these authors as related and connected them through heavy cocitation, as Figure 3 makes clear.

The strong intellectual ties may also be social. As seen in Table 4, knowing a member before Globenet began and being friends with a member are significantly correlated with intercitation in articles. “Knew before Globenet” is also significantly correlated with sameness of discipline ($r = .560, p < .000$) and cocitation ($r = .404, p < .000$). Friendship is likewise, if less strongly, correlated with sameness of discipline ($r = .270, p = .001$) and cocitation ($r = .305, p = .001$).

Cocitation and the Book

However, when the intercitation ties from the book are overlaid on the cocitation linkages in Figure 3, the picture changes greatly. (We will state the differences rather than add another figure.) Fully 98% (45/46) of intercinging pairs in the articles data had also been cocited. This compares to only 66% (41/62) of intercinging pairs in the book. In contrast to the 84% of article inter citations that can be mapped onto the cocitation ties of three or more in Figure 3, only 41% of the 85 inter citations in the book can be mapped in this way. Moreover, of those who can, the largest reciprocal flows occur among authors at lower left (Smith, Hopkins, Jones, and Wood), who have relatively low cocitation counts and who did not intercite before Globenet was formed. Another 23% of the 85 can be mapped onto “minor” cocitation ties of one or two, but this still leaves 36% of inter citations in the book that cannot be mapped onto any cocitation ties. As noted earlier, solid disciplinary pairs like the Oldfield and Martins fail to intercite in the book at all, while bursts of interdisciplinary citation bring together authors never before linked. The cocitation map clearly fits intercitation in the articles much better than intercitation in the book.

A Longitudinal View

To shed more light on what is going on, counts of intercitation in the articles were disaggregated over the four periods and then correlated with the overall record of cocitation and the intercitation counts from the book. (The analytical period 1997–2000 corresponds roughly to the period in which the book was produced.) Table 5 presents the results. For the disaggregated cocitation data, correlation

TABLE 5. Periodized correlations of intercitation in articles with cocitation and intercitation in book.

Uncumulated periods	Cocitation	QAP significance	Iintercitation in book	QAP significance
Pre-1989	0.750	.000	−0.060	.209
1989–1992	0.482	.000	−0.025	.479
1993–1996	0.456	.000	0.123	.064
1997–2000	0.297	.006	0.437	.000

is highest in the pre-1989 period (well before Globenet started) and falls off as the years go by. In this case, cocitation best matches the intercitation linkages of the pre-Globenet years, and it is that earlier strength that most affects the strong correlation of .72 for the aggregate data of I_{av} . The right side of Figure 3 is essentially a picture of linkages that were already strong when Globenet was formed.

For I_{bv} , the book data, correlation is negligible or low until 1997–2000, when intercitation patterns in the articles and the contemporaneous book grow more alike ($r = .44, p < .000$). (The abovementioned r of .23 for *cumulated* intercitation in book and articles reflects the strong relation of 1997–2000 attenuated by the weak relations of earlier periods.) We would explain the much higher r of the last period as the effect of several years of Globenet socialization on members. Old citation patterns are breaking down, and new ones are emerging in both their journal articles and their book chapters.

The correlation of certain other variables with the book data in Table 4 fits with this account. Friendship correlates with intercitation at about the same level in both book and articles. However, the relation of pre-Globenet acquaintance to intercitation in the book, while significant, is much weaker. So is the relation of disciplinary homogeneity. These two ties loom large in Figure 3, which is strongly influenced by patterns antedating Globenet. In contrast, having sought advice from a member is *more* significant for the book data than for the articles data, and we think that advice seeking may go with the emergent citation patterns of 1997–2000. Dimly, we are picking up social and intellectual change.

Communication Ties

We look on communication behaviors as parallels to intercitation, not as causing it. However, it would be of great interest if intercitation were stably associated with one or more of these behaviors. The correlations between intercitation and some communication variables appear in Table 6, sorted high to low in roughly thematic groups. Only correlations that are significant for both articles and book intercitation are reported. Most of the correlations are below .25, and none exceeds in strength the highest correlations in Table 4. They thus add little in the way of explanatory power.

TABLE 6. QAP Pearson correlations of communication ties with intercitation counts in Globenet articles and book.

Scholarly communication ties	Intercitation in articles, I_{av}	QAP significance	Intercitation in book, I_{bv}	QAP significance
Frequency per year (ordinal)	0.298	.000	0.161	.013
Ties outside of meetings	0.194	.004	0.292	.000
Percent face-to-face	-0.206	.001	-0.231	.000
By e-mail (logged)	0.211	.001	0.170	.008
Frequency per year, e-mail (ordinal)	0.184	.004	0.161	.013
By e-mail (binary)	0.160	.013	0.128	.048
Percent by e-mail	0.132	.042	0.189	.003
Frequency per year paper/post (ordinal)	0.254	.001	0.149	.043
By paper/post (logged)	0.245	.001	0.128	.048
By paper/post (binary)	0.222	.001	0.141	.029
Percent by paper/post	0.139	.032	0.121	.061
By fax (binary)	0.256	.000	0.113	.041
Nonscholarly communication ties				
Percent face-to-face	0.318	.001	0.317	.000
Frequency per year	0.169	.009	0.183	.004

Intercitation rises with overall frequency of scholarly communication and with communication outside of meetings. As an adjunct to writing, intercitation is fittingly associated with *written* communications, whether sent by paper/post, e-mail, or fax. It does not correlate significantly with any measures of telephone use.

The most intriguing finding is the correlation of intercitation with face-to-face communication. The correlation is negative when face-to-face communication is scholarly and positive when nonscholarly. Although face-to-face scholarly communication is nearly universal in Globenet, much of it happens at the thrice yearly formal meetings. These meetings bring together members who may never think of citing each other, with the effect that the correlation is negative.

The contrasting positive correlation, which tops .30 for both articles and book data, reflects the relatively special cases in which nonscholarly communication exists at all. While only 18% of the Globenet pairs are friendships with frequent nonscholarly communication (Koku, Nazer, & Wellman, 2001), it is this minority who also tend to have longstanding ties *and* who intercite. All but two of them reported “100%” when asked to estimate the percentage of their nonscholarly communication that is face-to-face. They apparently meant that their nonscholarly communication occurs *only* face-to-face and not through other modes such as the telephone. (The many Globenetters who do not engage in nonscholarly face-to-face communication did not give a percentage and have zeroes in the matrix.)

Our data leave little doubt that the Globenet pairs who intercite use more modes of communication—and use them more actively—than pairs who do not intercite. We ran one-tailed QAP *t*-tests across the 30 usable communication variables. The split on interciting versus noninterciting pairs is 46/194 for the articles data and 62/178 for the book data. The research hypothesis was always that those who intercite

will have significantly higher means on communication behaviors than those who do not.

Interciters proved to have higher mean communication behaviors than noninterciters on 29 out of the 30 variables. The one exception was on percentage of face-to-face scholarly communication, where, for reasons already explained, the noninterciters have the higher mean. On all 30 variables in both data sets the differences in means are identical in direction. In the articles data, the differences are significant or nearly significant at $p \leq .05$ in all but one case. In the book data, they are significant 11 times at the same level.

Since many of the 30 variables are simply variants on the same measures of communication modes (raw frequencies vs. percentages vs. ordinal, binary, and logged versions), we report only the selections seen in Table 7, to give the flavor.

The test variable, presence or absence of intercitation, was added years after the measurement of communication

TABLE 7. Interciters versus noninterciters: Selected significance values of permutation *t*-tests on mean communication behaviors.

Scholarly communication	Articles data $p =$	Book data $p =$
Frequency per year	0.00	0.16
Ties outside of meetings	0.00	0.00
Percent face-to-face*	0.00	0.00
Percent by phone	0.07	0.02
Percent by e-mail	0.03	0.02
Percent by paper/post	0.03	0.21
Percent by fax	0.00	0.05
Nonscholarly communication		
Percent face-to-face	0.00	0.02
Frequency per year	0.01	0.19

* For this p value, the mean is significantly higher for those who do not intercite. For all other p values shown, the means are higher for those who do.

TABLE 8. Results of regressing intercitation in articles and book on 11 predictor ties.

Predictor ties	Beta weights, intercitation in articles, I_{av}	QAP signif.	Beta weights, intercitation in book, I_{bv}	QAP signif.
Social ties				
Knew before joining Globenet	0.14	.082	0.04	.338
Friend	-0.08	.189	0.04	.296
Sought advice	-0.12	.095	-0.04	.331
Sociocognitive ties				
Editor of book	0.11	.088	0.39	.007
Coauthor of chapter	0.13	.096	0.23	.015
Collaborator	0.05	.317	0.06	.279
Intellectual ties				
Cocitation count	0.66	.000	-0.20	.006
Have read his/her work	0.03	.367	0.01	.471
Same discipline	0.00	.430	0.04	.283
Communication ties				
% Nonscholarly face-to-face	0.05	.260	0.28	.008
Scholarly outside of meetings	0.04	.322	0.02	.442

ties. These results therefore seem quite hardy. If level of communication activity stratifies Globenet, then citation reflects that aspect of social structure.

Regression Analyses

Despite the evidence already presented on the interplay between intercitation and other ties, most of the variables in Tables 4 and 6 have little power to predict intercitation when they are entered simultaneously in QAP regression analyses and partialled as beta weights (Table 8). I_{av} and I_{bv} were regressed on 11 social, intellectual, and communication ties selected from Tables 4 and 6 on the basis of relatively high zero-order correlations. The nine from Table 4 were augmented with two from Table 6: percentage of nonscholarly face-to-face communication and presence of scholarly communication outside of meetings, both of which are relatively strongly associated with intercitation in both articles and book.

As it turns out, the strongest predictors differ for the articles data and the book data, and so the latter do not provide a ringing replication of outcomes from the former. Out of 22 possible relationships, only one variable out of the 11 is significant for the articles data; only four of the 11 are significant for the book data.

When all other variables are controlled, the only statistically significant predictor of intercitation for the articles data is the cocitation record of Globeneters. It has a strong and highly significant beta weight of 0.66 ($p < .000$). Four other variables are suggestive, although not statistically significant: coauthoring a book chapter, editing the book, seeking advice from another member, and knowing each other before joining Globenet. The adjusted R^2 value for the articles data is .56 ($p < .001$). When used alone as a predictor, cocitation produces an adjusted R^2 of .52.

As we have noted, cocitation counts evolved over the same span of years as the intercitation counts in the articles data (roughly from the mid-1970s on) and prove to have a

similar pattern. The main reason is that both cocitation and intercitation involve similarities of subject matter. But also, cocitation in Globenet is not solely an intellectual tie, despite our classification of it. The highest cocitation counts in our study belong to pairs of members who are known to have had longstanding personal ties. The upshot is that cocitation swamps the social variables in the articles data set, just as it swamps disciplinary homogeneity and whether members read each other's work.

Reinterpreting cocitation as a "mixed" variable is not unreasonable, because almost all of our variables can be interpreted that way. We implied earlier, for example, that social ties among researchers might incorporate common subject interests even if they do not require them, and this means that social ties can have an intellectual side. So it is quite conceivable that a social variable such as friends or a sociocognitive variable such as collaborators could have outperformed cocitation as a predictor. But none did.

When we move to the book, cocitation is weakly and negatively related to intercitation (beta = -0.20, $p = .006$). We have argued that the book represents a break with the past and has its own logic of construction. Intercitation in it stems from relatively recent developments, while intercitation in the articles has a much greater time depth, as does cocitation.

Two variables that vary positively with intercitation in the book are being an editor (beta = 0.39, $p = .007$) and being the coauthor of a chapter (beta = 0.23, $p = .015$). However, they resemble cocitation in that they, too, reflect ties that are mixed in nature, having intellectual as well as social components (we called the mix "sociocognitive"). The only other significant predictor for the book data is percentage of nonscholarly communication that is face-to-face (beta = 0.28, $p = .008$). Ten intercitation flows in the book coincide with these face-to-face ties, and most of them differ from the article intercitation patterns seen in Figure 3. However, this association is probably peculiar to Globenet.

The editorial and coauthorship relations seem more likely to be replicable in other studies.

The adjusted R^2 value for the book data is .36 (considerably less than the R^2 for the articles data). Most of this correlation is attributable to the editors and coauthors variables, the two easiest to interpret. If only they are retained as predictors, the adjusted R^2 is .315.

The regressions suggest that, whatever causes intercitation to take place in a scholarly group, content-free social and communication ties are far from the whole story. Neither regression corroborates a theory of citation that puts social ties (“who they know”) ahead of sociocognitive or intellectual ties (“what they know”). Our evidence is thus consistent with the findings of Baldi, Stewart, Van Dalen, & Henkens, and Vinkler on the primacy of intellectual ties.

Discussion

Perhaps the strongest finding here, one we did not anticipate, is the power of cocitation to predict intercitation when data are drawn from ISI files. In a nutshell, *You tend to cite those with whom you are cocited*. We think that this finding may be replicable with other groups and that cocitation ties may generally be more powerful predictors than overtly social ties. At the same time, the failure of cocitation data to predict intercitation in the Globenetters’ book shows that citers can break with established patterns if they wish. Citers’ behavior does not run in iron grooves; for example, they can assimilate work from other disciplines in innovative ways. Nevertheless, it may be that the failure of cocitation to predict intercitation in the book is simply the result of our focusing exclusively on intercitation among the 16 Globenetters. Were the scope of inquiry extended beyond Globenet to each member’s total range of citees, who generally run to many hundreds, cocitation might reassert itself as a strong predictor.

Beyond this summation, we offer a series of observations that other researchers may wish to explore with other groups.

Who They Know

When scholars and scientists discuss their research, they almost always say, “Of course, people cite their friends, acquaintances, and colleagues. We do, and we notice that others do!” Our data show why they believe this to be so.

1. As Globenetters became more acquainted with each other, they cited each other much more in their articles.
2. The common focus of the collaborative book was the occasion for even more intercitation. To be sure, this was self-conscious on the part of the authors and fostered by the editors, but it did lead the Globenetters to demonstrate more awareness of each other’s work. These included the two editors of the book, who cited the other Globenetters integratively.

3. All of these inter citations knit Globenet much more densely in 2000 than it had been a decade before.
4. Interciters were not distributed randomly. Despite the egalitarian within-club ethos of Globenet, some members were cited much more than others. For example, a core group of 12 pairs predominated in the articles data.
5. Citations across disciplines grew over time, which is what one would expect as the members of an interdisciplinary group came to know each other and each other’s work.
6. Collegial ties matter. Interciters tend to be working on a joint project or reading each other’s work or coauthoring something. The dynamics may go in both directions: While work colleagues may come to cite each other more, it is possible that those who have cited each other in the past will come to work together out of common interest and mutual admiration.
7. Friendship matters. Friends cite each other more than acquaintances. The association here is not quite as strong as it is for collegial ties.
8. The age of the tie matters, but only when the tie is interdisciplinary: Globenetters from different disciplines who knew each other before they joined cite each other more.
9. The Globenet members who communicated more, on average, cited each other more than members who communicated less.

What They Know

Our intercitation story does not end with friendship and collegiality. Indeed, it starts with intellectual affinity—two scholars working in the same discipline or specialty area.

10. The intellectual affinities of some Globenetters are strongly associated with how often they cite each other. We used third-party reports of intellectual affinities: when a scholar not in Globenet cites both members of a Globenet pair. Many of these cocitations occurred before Globenet properly began.
11. The association of intellectual affinity (cocitation) on the likelihood of two Globenetters citing each other is independent of their friendship or even their collegial working relationship.
12. Not only is there an independent effect of intellectual affinity, when it is present there is no effect of social or collegial ties. Although cocitation may well have led to social or collegial relationships in the past—as cocited scholars notice each other and develop contact through conferences and correspondence—it is the intellectual affinity reflected in cocitation that the regressions point to, and not the social ties. As a direct effect, it is intellectual affinity, *what they know*, that matters and not social ties, *who they know*.

Does Citation Reflect Social Structure?

Our results permit both “Yes” and “No” answers to our title question. Surely *yes* in the increase over time in the number and percentage of inter citations among

Globenettters. Surely *yes*, as one further token of the heightened communication found in editor-contributor networks and coauthor networks. Surely *yes*, in the sense that organizational leaders are distinctively high in their citation of members when promoting an image of interconnected work.

But apparently *no*, if one means that citation will vary strongly and reliably with social ties such as collegiality or advice seeking or friendship. An even stronger *no*, if one means that members of an organization will cite each other at fulsome levels to boost each other's reputations. If we were witnessing an orgy of backscratching, the Globenet intercitation matrices would be much more densely filled than they are.

None of the predictors of this study is powerful across the board. Most of their significant zero-order correlations are quite low, and even those fade out when their covariance with other predictors is controlled. That is disappointing in a way. But, again, note the implicit message: The variables that did moderately well in the regressions have a common thread. Being a book editor or a chapter coauthor mixes both collegial ties and intellectual affinities. Being repeatedly cocited reflects intellectual affinities. None of these three variables is exclusively social; all imply perceptions of common content.

We can put the matter as a rhetorical question. If frequent cocitees also cite each other, why would they do it unless they see their content as mutually relevant? The same logic holds if they are creating a book together or if they are coauthors. Were the explanation simply social, then ties that are content neutral, like friendship or long acquaintance, would have greater explanatory power than they do. The evidence points instead toward intellectual networks—content-laden networks—as the real origin of intercitation. Who you know pays off only if the people you know have something worth knowing—something plainly relevant to your own claims.

We daresay that this finding may be true for more than scholars. Groups like Globenet are harbingers of the turn away from tightly bounded, highly structured bureaucracies to networks that span space, disciplines, and institutions. Knowledge workers of all kinds are acting like scholars, searching for information across amorphous boundaries and in shifting sets of work relationships, inside and outside of organizations. Thus, Globenet may be a window into the ways in which information flows in virtual and networked organizations. In such networked systems, information, prominence, and esteem flow along relatively unbounded nets as well as within discrete, bounded organizational units and hierarchies. Our findings suggest that both prior reputation (here measured by early cocitation) and facilitative social venues (the Globenettters' frequent conferences) can lead individuals to meet, communicate, socialize, and exchange information and knowledge, one mark of which is intercitation.

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References

- Baldi, S. (1998). Normative versus social constructivist processes in the allocation of citations: A network-analytic model. *American Sociological Review*, 63, 829–846.
- Borgatti, S.P., Everett, M.G., & Freeman, L.C. (2002). UCINET 6 for Windows: Software for social network analysis. Harvard, MA: Analytic Technologies.
- Crane, D. (1972). *Invisible colleges: Diffusion of knowledge in scientific communities*. Chicago, IL: University of Chicago Press.
- Cronin, B., & Shaw, D. (2002). Identity creators and image makers: Using citation analysis and thick description to put authors in their place. *Scientometrics*, 54, 31–49.
- Feld, S. (1981). The focused organization of social ties. *American Journal of Sociology*, 86, 1015–1035.
- Garfinkel, H. (1967). *Studies in ethnomethodology*. Englewood Cliffs, NJ: Prentice Hall.
- Glanz, J. (1999, September 14). What fuels progress in science? Sometimes, a feud. *New York Times*, pp. D1–D2.
- Gresham, J.J. (1994). From invisible college to cyberspace college: Computer conferencing and the transformation of informal scholarly communication networks. *Interpersonal Computing and Technology*, 2, 37–52.
- Haythornthwaite, C., & Wellman, B. (1998). Work, friendship and media use for information exchange in a networked organization. *Journal of the American Society for Information Science*, 49, 1101–1114.
- Katz, N., & Lazer, D. (2002, September). Building effective intra-organizational networks: The role of teams. Working Papers, Center for Public Leadership, Kennedy School of Government, Harvard University, Cambridge, MA (pp. 83–107).
- Koku, E., Nazer, N., & Wellman, B. (2001). Netting scholars: Online and offline. *American Behavioral Scientist*, 44, 1750–1772.
- Leydesdorff, L., & Amsterdamska, O. (1990). Dimensions of citation analysis. *Science, Technology and Human Values*, 15, 305–335.
- Lievrouw, L.A., Rogers, E.M., Lowe, C.U., & Nadel, E. (1987). Triangulation as a research strategy for identifying invisible colleges among biomedical scientists. *Social Networks*, 9, 217–248.
- Matzat, U. (2001). *Social networks and cooperation in electronic communities*. Groningen, Netherlands: Interuniversity Center for Social Science Theory and Methodology.
- Matzat, U. (2002, October). Social network incentives or hope for reciprocity as stimuli for the transfer of information in electronic groups. Paper presented at the Internet Research 3.0 Conference, Maastricht, Netherlands.
- McPherson, M., Smith-Lovin, L., & Cook, J.M. (2001). Birds of a feather: Homophily in social networks. *Annual Review of Sociology*, 27, 415–444.

- Mullins, N.C., Hargens, L.L., Hecht, P.K., & Kick, E.L. (1977). Group structure of co-citation clusters—comparative study. *American Sociological Review*, 42, 552–562.
- Murray, S.O., & Poolman, R.C. (1982). Strong ties and scientific literature. *Social Networks*, 4, 225–232.
- Nardi, B.A., Whittaker, S., & Schwartz, H. (2000). It's not what you know, it's who you know: Work in the information age [Online]. *First Monday*, 5(5). Available: http://www.firstmonday.org/issues/issue5_5/nardi/index.html
- Nazer, N. (2001). Operating virtually within a hierarchical framework: How a virtual organization really works. Unpublished doctoral dissertation. Department of Sociology, University of Toronto.
- Perry, C.A., & Rice, R.E. (1998). Scholarly communication in developmental dyslexia: Influence of network structure on change in a hybrid problem area. *Journal of the American Society for Information Science*, 49, 151–168.
- Perry, C.A., & Rice, R.E. (1999). Network influences on involvement in the hybrid problem area of developmental dyslexia. *Science Communication*, 21, 38–74.
- Rowlands, I. (1999). Patterns of author co-citation in information policy: Evidence of social, collaborative and cognitive structure. *Scientometrics*, 44, 533–546.
- Sandstrom, P.E. (2001). Scholarly communication as a socioecological system. *Scientometrics*, 51, 573–605.
- Small, H. (1973). Co-citation in the scientific literature: A new measure of the relationship between two documents. *Journal of the American Society for Information Science*, 24, 265–269.
- Stewart, J.A. (1990). Drifting continents and colliding paradigms: Perspectives on the geoscience revolution (pp. 216–238). Bloomington, IN: Indiana University Press.
- Turner, R. (1960). Sponsored and contest mobility and the school system. *American Sociological Review*, 25, 855–867.
- Van Dalen, H.P., & Henkens, K. (2001). What makes a scientific article influential? The case of demographers. *Scientometrics*, 50, 455–482.
- Vinkler, P. (1998). Comparative investigation of frequency and strength of motives toward referencing: The reference threshold model. *Scientometrics*, 43, 107–127.
- Wellman, B. (1988). Structural analysis: From method and metaphor to theory and substance. In B. Wellman & S.D. Berkowitz (Eds.), *Social structures: A network approach* (pp. 19–61). Cambridge, England: Cambridge University Press.
- White, H.D. (1990). Author co-citation analysis: Overview and defense. In C.L. Borgman (Ed.), *Scholarly communication and bibliometrics* (pp. 84–106). Newbury Park, CA: Sage.
- White, H.D. (2000). Toward ego-centered citation analysis. In B. Cronin & H.B. Atkins (Eds.), *The web of knowledge: A festschrift in honor of Eugene Garfield* (pp. 475–496). Medford, NJ: Information Today (ASIS Monograph Series).
- White, H.D. (2001a). Authors as citers over time. *Journal of the American Society for Information Science and Technology*, 52, 87–108.
- White, H.D. (2001b). Author-centered bibliometrics through CAMEOs: Characterizations automatically made and edited online. *Scientometrics*, 51, 607–637.
- White, H.D., & McCain, K.W. (2000). In memory of Belver C. Griffith. *Journal of the American Society for Information Science*, 51, 959–962.
- Zuccala, A. (2001). Revisiting the invisible college: A case study of the intellectual structure and social process of singularity theory research in mathematics. In M. Davis & C.S. Wilson (Eds.), *Proceedings of the 8th International Conference on Scientometrics & Informetrics* (pp. 897–899). Sydney: Bibliometric and Informetric Research Group, University of New South Wales.