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ABSTRACT

Anthony Biglan (1973) proposed a typology of academic disciplines that identified three dimensions of academics' perceptions of the similarity of fields of scholarship: (1) "hard-soft", (2) "pure-applied", and (3) "life-non-life". Derek Price (1965) suggested that bibliographic data could be used to provide an assessment of whether hard and soft fields vary as suggested by Biglan's interpretation. Using reference network graphs of publication patterns of citation patterns, Price argued that in research areas exhibiting high levels of consensus, scholars tend to cite recently published documents but in fields with low levels of consensus, there is no disproportional citation of recent work. To assess Price's argument, this study collected data in nine research areas in disciplines spanning Biglan's hard-soft dimension. Using published reviews in each area and indices, publication lists were created of cited works. The results are generally consistent with Biglan's interpretation of the hard-soft dimension as reflecting disciplinary differences in consensus. Four physical science specialties showed over-citation of recent papers while the four social and behavioral science areas showed under-citation of recent papers. One area, in mathematics, did not show the predicted results. The consistency between the results found and Biglan's interpretation of the nature of the "hard-soft" dimension, provides a measure of support for Biglan's interpretation. (Contains 16 references.) (JLS)

Interpreting Biglan's "Hard-Soft" Dimension of Disciplinary Variation

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Interpreting Biglan's "Hard-Soft" Dimension of Disciplinary Variation

In two papers published almost a quarter of a century ago, Anthony Biglan (1973a, 1973b) presented a typology of academic disciplines that greatly influenced subsequent research on higher education (Bayer, 1987). Reporting the results of a multidimensional scaling analysis of academics' perceptions of the similarity of fields of scholarship, Biglan identified three dimensions: (1) a "hard-soft" dimension, (2) a "pure-applied" dimension and (3) a "life-non life" dimension. In a series of papers inaugurated in 1975, John Smart and his collaborators popularized the "Biglan model" as a means of exploring disciplinary variation in faculty behaviors, and many subsequent studies have extended and updated their work (for a review of Smart's papers and subsequent work, see Braxton and Hargens, 1996). For the most part, subsequent research has found that the first of these dimensions--the hard-soft dimension--captures the greatest amount of variation in college and university faculty members' attitudes and behaviors. This dimension distinguishes between fields such as chemistry, physics and the biological sciences on the one hand, and fields such as English, psychology and educational administration on the other. In his original paper, Biglan speculated that the source of variation between these two groups of fields was variation in overall levels of consensus on such issues as appropriate research problems, techniques and solutions. Specifically, the former fields (the "hard" fields) allegedly enjoy higher levels of consensus than the latter fields (the "soft" fields). Subsequent studies have virtually always used Biglan's interpretation of this dimension to interpret their results.

Beginning in the late 1970s, however, some researchers began to question whether scholarly fields differ in their overall levels of consensus. For example, social constructivists portrayed scientific research as a process of negotiated reality construction, and argued that because all fields exhibit the same basic social negotiation patterns, it is incorrect to claim that fields differ in overall levels of consensus (Knorr Cetina, 1982; Collins, 1985). Constructivists usually attribute disciplinary differences in scholars' attitudes and behaviors to differential levels of social and financial support rather than to varying levels of agreement over research priorities and techniques. Recently, some non-constructivist scholars have also suggested that, at least at the research front, consensus is low in all fields (Cole, 1993).

Those questioning whether the hard-soft dimension should be interpreted as reflecting disciplinary variation in consensus have used indirect evidence as the basis of their claims. Knorr-Cetina, for example, used ethnographic data from one research laboratory as the basis for her argument that all fields of scholarship show the same processes of "consensus construction," and Cole based his claims on evidence such as the lack of disciplinary variation in correlations between citation counts and peer-recognition measures (for a review and analysis of claims that fields do not vary in consensus, see Braxton and Hargens, 1996).

In this paper I use an analytic tool originally suggested by Derek Price (1965) to provide a more direct, but still indirect, assessment of whether hard and soft fields vary in a manner consistent with Biglan's interpretation of this dimension. In his discussion of the potential uses of bibliographic data to provide information on the scale and pattern scientific research, Price suggested that research areas varying in overall levels of consensus should have reference network graphs with different structures.

A reference network graph arrays the documents (articles, books, etc.) in a research area chronologically on two dimensions, and then, by placing dots in the appropriate rows and columns of the graph, shows the other documents that each document cited (see Figure 1, which shows Price's original graph). By convention, reference network graphs show citing papers in their columns and cited papers in their rows. Thus, for example, a dot in the fourth column and the second row of such a graph indicates that the fourth paper in the field cited the second paper. Long columns of dots in these graphs represent review papers, and pronounced rows of dots indicate highly cited or "classic" documents.

Price argued that in research areas exhibiting high levels of consensus, scholars tend to cite recently published documents whereas in fields with low levels of consensus there is no tendency of disproportionately cite recent work. The basis for Price's conjecture is that when consensus is high, scholars compete for priority in publishing research results. As a consequence, scholars in such areas are likely to closely monitor and build upon recently published work. Price used the research literature in a turn-of-the-century physics specialty, N-rays, to exemplify the reference network structure he claimed to be characteristic of high consensus (hard science) fields. Figure 1 clearly shows this structure; the dots (references) tend to be clustered close to the diagonal of the graph, indicating that the N-rays papers tended to cite relatively recent work. The emphasis on recent work shown by this pattern is consistent with Alfred North Whitehead's famous dictum that "A science which hesitates to forget its founders is lost" (Whitehead, 1917:115).

Price contrasted the pattern shown by the N-rays reference network with a pattern where papers in a research literature are just as likely to cite old papers in that literature as they are to cite recent papers. Price claimed that this kind of pattern typifies fields in which there is little consensus, and wrote that it reflects "humanistic type of metabolism in which the scholar has to digest all that has gone before, let it mature gently in the cellar of his wisdom, and then distill forth new words of wisdom about the same sorts of questions" (Price, 1970: 15).

Curiously, neither Price nor subsequent researchers have constructed reference network graphs for other research areas. Thus, although Price's general argument about how reference network graphs should vary across the hard-soft dimension seems eminently reasonable, we have no evidence about its validity. By constructing such graphs for research areas in both "hard" and "soft" disciplines it is possible to assess, in at least a preliminary way, both the validity of Price's argument and also Biglan's claim that the hard-soft dimension reflects disciplinary variation in consensus.

To assess Price's argument (and Biglan's claim) I collected data on nine research areas in disciplines spanning Biglan's hard-soft dimension. Table 1 lists these research areas and their parent disciplines. I chose these areas after consulting with members of each field in order to identify research areas that have purportedly exhibited significant intellectual progress. For example, the "organizational population ecology" research area in sociology was identified by an NAS report on the state of the social and behavioral sciences as one of the most important scholarly developments to occur within the last 50 years (Smelser and Gerstein, 1986). Similarly, the "rational expectations" area in economics is frequently identified as constituting a "paradigm shift" in economics, and one of its founders received the most recent economics Nobel Prize. All of the research areas in my study would be classified as focusing on "pure" as opposed to "applied" topics; I chose to restrict my study to the one category of Biglan's second dimension to reduce the number of possible interpretations of results.

To construct the reference network graph for a given research area, I began by making a list of documents included in the literature of that area. I used published reviews as sources for an initial list for most of the areas, and I also consulted topical indexes of publications when these were available (for example, listings of papers on celestial masers in the yearly indexes of astronomy journals, or listings of papers on rational expectations in the Journal of Economic Literature). After examining the reference lists of the papers in the initial list for a given field, I added other papers to the list that were frequently cited by the initial papers. Scholarly literatures are not neatly divided into clearly demarcated groups, and in cases where whether a paper belonged on a final list was ambiguous, I consulted knowledgeable informants. By choosing relatively clearly defined research areas, clearly specifying what they include (for example, the area labeled "separation of chiral molecules" is a short label for "direct resolution of enantiomers by liquid chromatography"), and specifying that I would include only published research reports (as opposed to, for example, unpublished papers and articles in popular sources such as Scientific American), I minimized ambiguities about whether a given document should be included in a given literature. I believe that the errors yielded by the procedures I followed are likely to be errors of omission, and that omitted documents are likely to be those that have had little impact on the subsequent development of a given research area.

Most of the nine research areas I studied have a clear beginning, but few have endings. I therefore used calendar years as a means of specifying the end points for my analysis; at the end of the year that a literature had grown to about 350 documents I ended my data collection for it, or, for those areas that haven't yet grown to that size, I ended my data collection with the end of a recent calendar year. Table 1 shows the years for which I collected data on each of the nine research areas. After arriving at a final list of the documents to be included in a research area's literature, I constructed the reference network for that research area by determining what other documents in the literature each document cited.

In sum, my analysis is based on data for nine research areas in disciplines spanning Biglan's hard-soft continuum. If Biglan's interpretation of that dimension, and Price's speculation about the structure of reference network graphs are both correct, one would expect greater concentrations of dots close to the diagonals of reference network graphs in the research areas from "hard" disciplines than in the graphs from research areas in the "soft" disciplines.

Figures 2 and 3 give the resulting reference network graphs for two of the research areas in my analysis: celestial masers (astronomy) and rational expectations (economics). These two areas, and all of the other research areas in my study, show much higher citation densities than Price's N-rays network (Figure 1), indicating that documents in the research areas in my study are much more likely to cite each other than was true for the N-rays literature. The higher network densities make it difficult to determine visually the extent to which recent publications are overcited, so I defined a quantitative measure of this feature of a reference network graph. The measure compares the observed number of references that are close to the diagonal of the graph (operationally defined as the most recent 40 papers before any given paper[1]) with the number that one would find in this region if references were randomly distributed throughout the graph. Forming the ratio of the former number to the latter gives a quantity which is larger than unity when recent papers are more likely to be cited than older papers, unity when there is no overcitation of recent papers, and less than unity when recent papers are less likely to be cited than one would expect by chance. In all of the analyses reported below, I excluded literature review papers and books. Such documents play a different role than papers reporting original research results, and it is the latter that should show the overcitation of recent previous work when a field is showing cumulative development.

Column (1) of Table 1 gives the values of this ratio for the nine research areas in my analysis. These results are generally consistent with Biglan's interpretation of the hard-soft dimension as reflecting disciplinary differences in consensus. The first four areas, all physical science specialties, show varying degrees of overcitation of recently published papers while the last four, all social and behavioral science areas, show varying degrees of undercitation of recent papers. The only exception to the results that one would expect under Biglan's interpretation is the result for matroid theory, which given Biglan's claim that mathematics is a "hard" field, should overcite recently published work instead of underciting it.

Table 1: Results for the Nine Research Areas Included in The Analysis

Research Area	Parent Discipline	Years Studied	(1) Obs./Exp	(2) χ^2
Light Front Physics	Nuclear Physics	1949-91	1.15	12.9
Special Relativity	Theoretical Physics	1905-15	1.65	100.7
Celestial Masers	Astronomy	1965-80	1.37	85.0
Separation of Chiral Molecules	Chemistry	1971-88	1.29	30.6
Matroid Theory	Mathematics	1935-75	.89	3.7
Stroop Effect	Psychology	1935-90	.90	5.8
Rational Expectations	Economics	1961-84	.64	60.6
Organizational Population Ecology	Sociology	1977-93	.89	10.3
Role Algebra Analysis	Psychology and Sociology	1971-88	.82	28.0

Are the differences in Column (1) of Table 1 statistically reliable? Since the ratio in Column (1) compares observed and expected frequencies, one can use its components to form the Pearsonian chi-squared statistic and to test the null hypothesis that the number of citations in a field that go to recent papers is not significantly different than the number one would expect if there were no over- or undercitation of recent papers.[2] Column (2) presents the values of this statistic for each of the nine fields in my analysis. In each case the chi-squared statistic has one degree of freedom, and using $\alpha = .05$ implies rejecting the null hypothesis if the statistic's value is greater than 3.84.

The results in Column (2) show that one would reject the null hypothesis of no over- or under-citation of recent work for all of the research areas in my analysis except for matroid theory. All of the physical science areas significantly overcite recent work and all of the behavioral science areas significantly undercite it. Although the matroid theory literature shows a tendency to undercite recent work, the tendency is too weak to allow the statistical rejection of the null hypothesis that there is neither over- nor undercitation of recent work in that area.[3]

With the possible exception of matroid theory, then, the results presented above are consistent with (1) Biglan's interpretation of the hard-soft dimension as capturing interdisciplinary differences in overall consensus and (2) Price's claim that reference network graphs show different levels of overcitation of recently published work in high-consensus compared to low-consensus fields. Although generally supporting Biglan's interpretation, however, these results obviously do not provide definitive evidence for it. The nine research areas in my analysis constitute a very small subset of all of the research areas that might be examined by a study such this one, and it is certainly possible that if one could select a random sample of such areas, rather than focusing on those that observers identify as having made significant scholarly progress, one might obtain different results. In addition, high concentrations of points close to the diagonal of a reference network graph may be produced by other processes beside the cumulative building on recent work that Price saw as <u>the</u> cause of such a reference network structure.[4] Nevertheless, the consistency between the results shown above and Biglan's interpretation of the nature of the "hard - soft" dimension, especially in conjunction with other indirect forms of evidence on disciplinary variation in consensus (Braxton and Hargens, 1996), provides a measure of support for Biglan's interpretation.

What should we make of the failure of the matroid reference network to show an overcitation of recent work? Although it is possible that matroid theory is unrepresentative of mathematics, it should be noted that mathematics has been previously identified as having an "anomic" social structure. Specifically, some researchers (Hagstrom, 1964; Fischer, 1967; Hargens, 1975) have reported results suggesting that mathematicians are so highly specialized that they often have difficulty recognizing the underlying connections between their own and their colleagues' research agendas and results. When scholars are unaware of the implications of their colleagues' research accomplishments, it is argued, they are unlikely to exhibit high levels of competition for priority and unlikely to build directly on those colleagues' recent work. If these arguments are correct, it may be that a high level of scholarly consensus, although predisposing a field toward exhibiting the kind of reference network structure that Price identified, is not alone sufficient for producing that structure. Unfortunately, these conjectures cannot be assessed without data on additional research areas in mathematics.

FOOTNOTES

1. Price (1965) originally suggested that the size of this interval, which he called "the research front" should be about 30 papers, but later (1970) speculated that it was probably closer to 50 papers. I chose 40 papers as a compromise between these two figures, but the results reported below are the same regardless of which figure one chooses. I counted all references to forthcoming work as being within the 40 paper "research front."

2. Specifically, the ratio in column 1 of Table 1 consists of f_o / f_e and the Pearsonian chi-squared statistic equals $\sum_{i=1}^{2} \frac{(f_o - f_e)^2}{f_e}$, where the index i denotes the two categories of references that either fall, or do not fall, within the most recent 40 papers from any given paper.

3. The results for matroid theory are not statistically significant because there are fewer references in the matroid theory papers. The average number of references in matroid theory papers to other papers in the matroid theory network equals 3.7, whereas the averages for the Stroop effect and organizational population ecology papers equal 6.3 and 9.1 respectively. Price's (1970) data on small samples of journals in a variety of fields showed that mathematics articles tend to have fewer references than articles in most other fields.

4. In a reanalysis of references in the N-rays literature, Baldi and Hargens (1995) found that the nearly all of the "recent" references in that network were self citations, and that the self citations mostly appeared in a journal that published the weekly proceedings of the French Academy of Sciences. Members of the academy had the privilege of publishing a short paper on the work they had done during the preceding week in that journal, and some of the French N-

ray researchers did this extensively. Most of these papers contained a single reference that cited the researcher's paper in the previous week's edition of the journal. By contrast, the non-self citations in the N-rays reference network tended to cite older rather than recent work. Thus, if one takes the peculiar nature of the self citations into account, it appears that the N-rays research literature was non-cumulative in nature, and that is also the verdict of history (Nye, 1980).

References

Baldi, S. and Hargens, L.L. (1995). Reassessing the N-rays reference network: The role of self citations and negative citations. Scientometrics 34: 239-53.

Bayer, A. E. (1987). The Biglan Model and the Smart messenger: a case study in eponym diffusion. Research in Higher Education 26:212-23.

Biglan, A. (1973a). The characteristics of subject matter in different academic areas. Journal of Applied Psychology 57: 195-203.

Biglan, A. (1973b). Relationships between subject matter characteristics and the structure and output of university departments. Journal of Applied Psychology 57: 204-13.

Braxton, J. M. and Hargens, L. L. (1996). Variation among academic disciplines: Analytical frameworks and research. Higher Education: Handbook of Theory and Research 11: 1-46.

Cole, S. (1992). Making Science. Cambridge, MA: Harvard University Press.

Collins, H. M. (1985). Changing Order. Beverly Hills, CA: Sage.

Fischer, C. S. (1967). The last invariant theorists: A sociological study of the collective biographies of mathematical specialists. European Journal of Sociology 8: 216-44.

Hagstrom, W. O. (1964). Anomy in scientific communities. Social Problems 12: 186-95.

Knorr-Cetina, K. (1981). The Manufacture of Knowledge: An Essay on the Constructivist and Contextual Nature of Science. Oxford: Pergamon Press.

Price, D. J. dS. (1965). "Networks of scientific papers. Science 149: 510-515.

Nye, M. J. (1980). "N-rays: An episode in the history and psychology of science. Historical Studies in the Physical Sciences 11:125-56.

_____________ (1970). Citation measures of hard science, soft science, technology and nonscience. Pp. 3 - 22 in Carnot E. Nelson and Donald K. Pollock (Eds.), Communication among Scientists and Engineers. Lexington, MA: D. C. Heath.

Smart, J. C., and Elton, C. F. (1975). "Goal orientations of academic departments: A test of Biglan's model. Journal of Applied Psychology 60:580-88.

Smelser, N. J. and Gerstein, D. R. (Eds.) (1986). Behavioral and Social Sciences: Fifty Years of Discovery. Washington, D.C.: National Academy Press.

Whitehead, A. N. (1917). The Organization of Thought, Educational and Scientific. London: Williams and Norgate.

Price's N-rays Reference Network

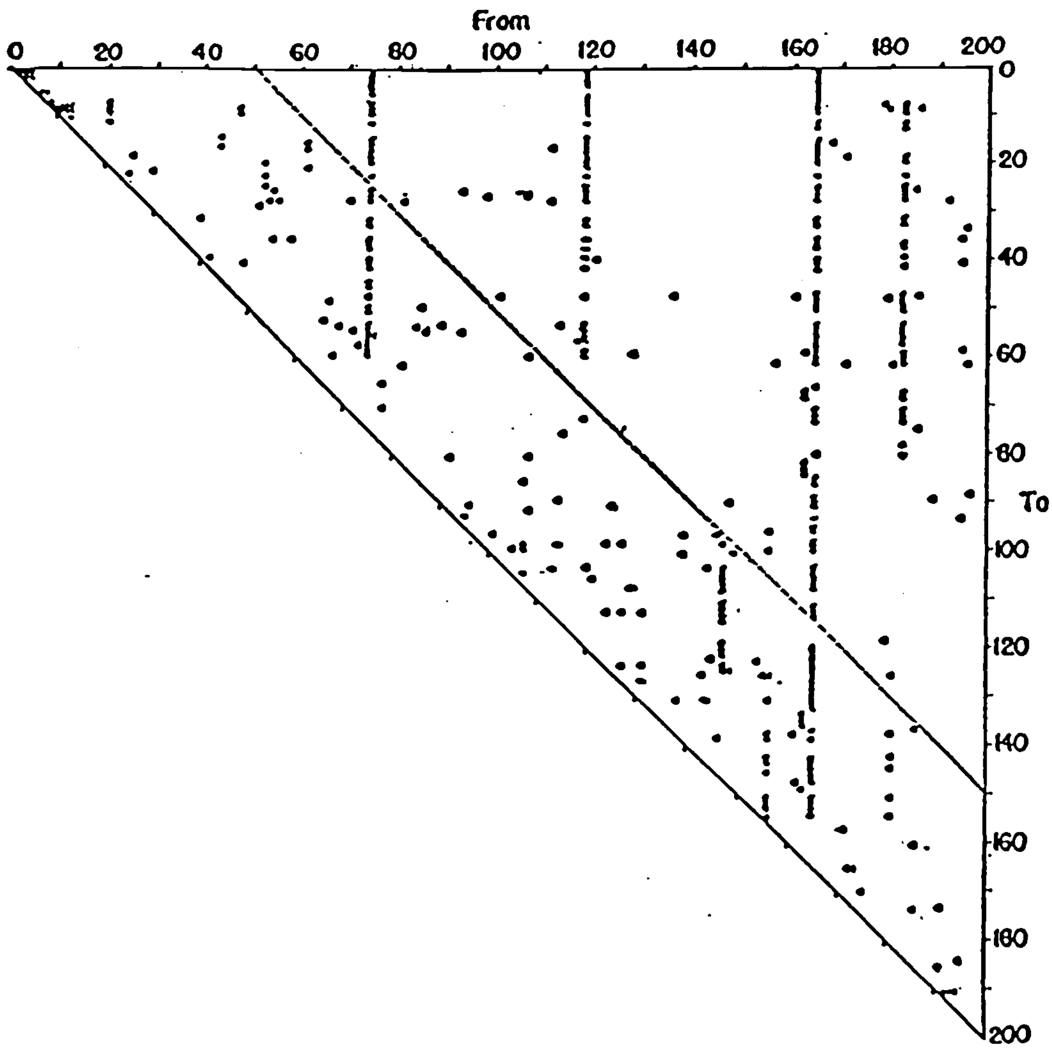

Figure 1

Reference Network for Celestial Masers

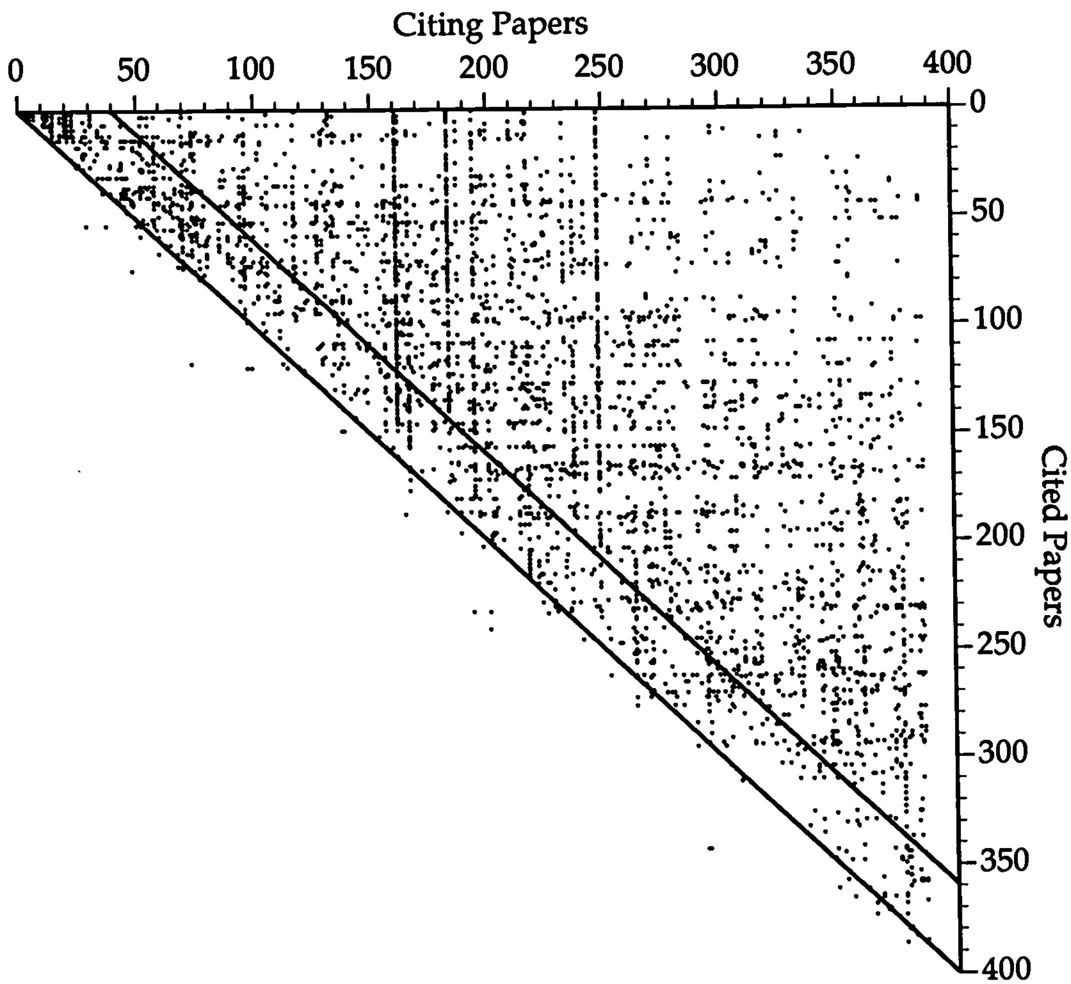

Figure 2

Reference Network for Rational Expectations

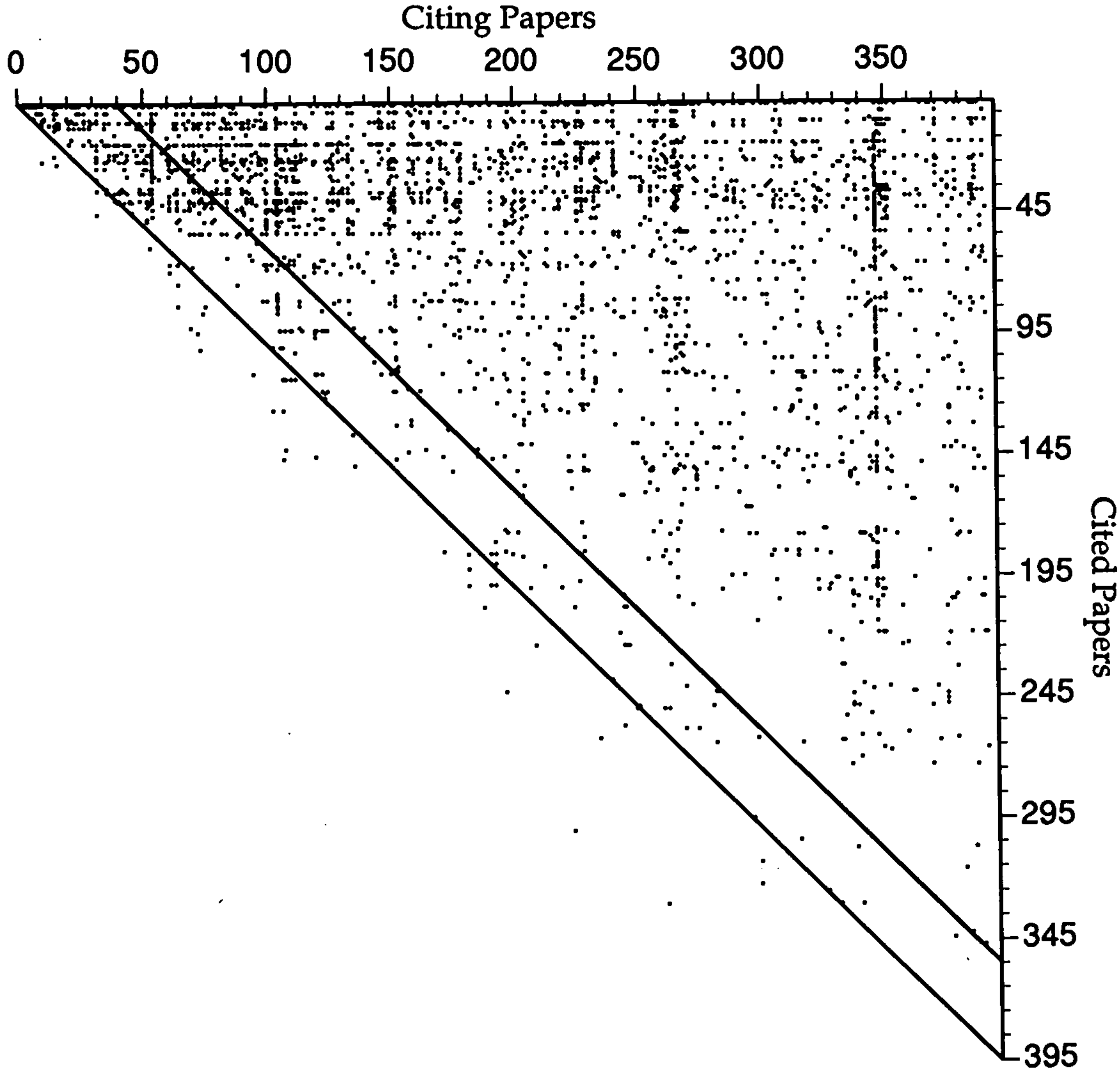

Figure 3

NOTICE

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