Identifying Common Characteristics among Researchers through Citation Analysis

Introduction

Citation studies are not new. Citation analysis and publication counts are well-known techniques with a long history in studies of scholarly communication (Borgman, 1990). Both techniques can be used to obtain information about individual researchers. Major advantages of citation analysis are its high reliability and unobtrusiveness. Citation analysis overcomes the problem of possible non-response bias associated with surveys. "Citations indicate that a person's work has been read, or at least referenced, and thus had some impact on the discipline" (Hancock, 1992).

The published contributions of a scientists are often measured in terms of quantity and quality. The quantity of an individual's work can be measured through publication counts. Publication counts are commonly used in evaluating the research productivity and performance of individuals or institutions. The quality of a given publication is often judged by the reputation of the journal in which it is published. Similarly, the number of times an individual has been cited in the literature is taken as a measure of the quality of that person's work. A citation is a reference to some previously published work that is relevant to the argument the author wants to make (Baird, 1994). It is assumed that the number of times an author or article is cited in the literature in a given period reflects the impact the paper has made or the influence it has had and is therefore a measure of quality.

Quality and quantity are, in general, highly correlated (Lawani, 1977). For example, a study of the bibliographies of 41 American scientists who had reached age 70 and had been distinguished by election to the National Academy of Sciences, found that the average number of publications for the group was 203; the highest was 768 items, the lowest was 27. The results suggested that the greater the number of a scientist's professional publications, the broader that scientist's professional reputation was likely to be (Dennis, 1954).

A variety of studies have suggested that " whatever else is required to achieve eminence in science, sustained effort is one prerequisite" (Lawani, 1977). "The eminent scientist works hard at being a scientist. Hard work is not the whole story, but the scientists who achieve recognition are industrious, and as a result their bibliographies are long" (Dennis, 1954). The literature reflects an overall pattern -- those who publish the most are cited most often. Also, there are high correlations between scientific eminence and number of publications and between papers of known high quality and the number of citations to them.

There has been some discussion about the validity of citation studies. Various research has shown that citation counts can be used as an indication of research effort. "What is embarrassing for the critics of citation counting is this fact: whatever measure you take for the eminence of an individual scientist or of a journal or of an institution, citation counts provide strong correlation with that result" (Baird , 1994).

Purpose

The factors that influence research productivity are an important research issue (Hancock, 1992). In this paper a simple count (Roe, 1965) of publications is used as an indication of researcher productivity. No distinction between the different types of publications (e.g. articles, books, reports, etc.). The objective of this paper is to identify the characteristics of a specific group of researchers and their motivations for performing research. The research questions are:

1) What characteristics do corporate fellows have in common?
2) Has the productivity of corporate fellows remained constant over time?
3) What factors motivate these individuals to do research?

The assumptions are that corporate fellows will have a large number of publications, they are cited frequently and they will have similar motivations for performing research.

Method

A group of researchers at Oak Ridge National Laboratory (ORNL), known as corporate fellows, were identified as the focus of this study. From 1976 to the present, a total of 54 corporate fellows have been recognized by the Laboratory. This study includes only the corporate fellows who are currently employed at the Laboratory.

ORNL is a multi-purpose laboratory, operated by Lockheed Martin for the Department of Energy. The Laboratory conducts research in varied areas such as energy production, biological and environmental science, advanced materials synthesis, and the physical sciences. Research can be defined or categorized in several ways. For institutions such as ORNL, that do federally-funded work, the National Science Foundation has specific definitions for basic and applied research. *Basic research* is defined as research directed toward increases in knowledge or understanding of the fundamental aspects of phenomena and observable facts without specific application toward processes or products in mind. *Applied research* is defined as research directed toward gaining knowledge or understanding necessary for determining the means by which a recognized or specific need may be met.

Publication in a scientific or technical journal is not the primary result of all ORNL research, but journal publications are considered a key indicator when looking at the health of the research effort at the institution. (Genung 1998) The prestige attributed to an institution directly affects its ability to attract funding and researchers. Since that prestige is closely tied to research and publication records, many institutions place heavy emphasis on research productivity in making decisions on hiring, raises and promotion. With this idea in mind, ORNL implemented a formal procedure for recognizing "technical staff in science and engineering whose contributions are recognized nationally and internationally." This procedure created the group of staff known as the Corporate Fellows. Nomination and selection of candidates to become corporate fellows takes place by mid-October of each year. The candidates' contributions must have a significant impact on the technical community, ORNL, and the Department of Energy

(DOE) mission. DOE uses publication of reviewed articles as one of the "critical outcomes" in its evaluation of ORNL's research and development (R&D) performance.

To identify common characteristics of corporate fellows, cited author searches were performed for each of the current corporate fellows for the years 1988-1997 using the web-based version of Science Citation Index (SCI). The web version of SCI overcomes a limitation of the online version of the database by allowing searches of all citations to an author regardless of whether the individual is first, second or other author. Science Citation Index (SCI) is a standard tool for use in citation-based studies. It covers over 5,300 top ranking scientific journals. One of the limitations in using SCI is that monographs and technical reports tend to be excluded from the citation index.

The citation information for each researcher was determined and recorded in a spreadsheet. The data includes the total number of citations by year for each researcher and the total number of publications over a ten-year period. Information was also gathered on whether an author is listed as the first or second author of a publication.

Description of Survey Instrument

A self-administered questionnaire containing eight questions was used to obtain information about the individuals' motivation for doing research. Respondents were asked to:

- describe the length of time involved in research
- describe types of research performed
- rank motivating factors which influence their desire to do research
- describe the number and types of items published during their careers
- describe the number of society memberships and value of participation in societies
- rank the methods used to stay current in their field of research
- rank overall feelings about their research achievements

SPSS (the Statistical Package for the Social Sciences) was the software program used to analyze the survey results. Descriptive statistics of the variables, such as the measures of mean,

median, and mode were used to compare data sets. The correlation analysis technique was applied to explore linear relationships between variables. The Spearman rank order correlation coefficients were calculated. Histograms were also used in evaluation and analysis of the data.

Survey Results

Questionnaires were mailed to twenty-five researchers. Fifteen researchers responded to the survey. The average length of time individuals have been involved in research is 31.4 years. The least amount of time involved in research was 20 years and the most was 45 years. Each researcher was asked to estimate his/her total number of publications. The most publications claimed by a researcher was 711; the least was 80. A scatterplot was generated to determine what type of relationship exists between the a researcher's years of experience and the number of publications produced. The graph (Appendix B) seems to show that the more years of experience a researcher has, the greater the number of publications.

When asked to describe the type of research they were involved in, seven of the 15 researchers indicated activity in both basic and applied research. The other eight respondents were equally divided in doing either basic or applied research only. Researchers reported an average of 3.8 memberships in professional organizations. One individual did not belong to any

Description of Corporate Researchers

This group of researchers shares some common characteristics. As a group, the corporate fellows are all Ph.D. researchers who have been involved in research for more than twenty years. They range in age from 45 to 89 years old. Only one of the corporate fellows is a woman. The subject areas of the researchers reflect the multipurpose character of the Laboratory. On the questionnaire individuals indicated that they perform research in some of the following areas: energy and environmental change, mechanics of materials, atomic and molecular physics, enzymology, ecology, and metallurgy.

Based on publication counts for the period studied, this group of corporate fellows produced an average of 167 publications each year. One researcher consistently produced more than 10 publications each year. On the other hand at least two researchers produced less than 5 publications over the 10 year period. Further examination of the results for these two researchers may be necessary to determine if some sort of problem occurred either during the citation search or some other part of the data gathering phase. Out of the total number of publications for the group, the corporate fellows were listed as the first author for less than half (28.8 percent) of the publications. They were listed second or later on the remaining 71.2 percent of publications.

Analysis of the researchers' citations showed that this group was cited an average of 71 times from 1988-97. That means each researcher was cited 2.8 times per year over this ten year period. There has been a steady increase in the number of times the corporate fellows have been cited. For instance, in 1988 each researcher was cited an average of 1.5 times while in 1997 each researcher was cited an average of 4.2 times during the year. The researcher cited most often was cited 1975 times during the ten-year period studied. The researcher cited the least was cited nine times.

Motivating Factors

Researchers were asked to rank nine factors on a scale of 1 to 5, with 1 being not a all important and 5 being extremely important, which influence their research. The factors which respondents ranked highly are intellectual challenge, career advancement, personal enjoyment, economic reward. These are summarized in Table 1.

TABLE 1

Question 3. How important would each of the following be in influencing your desire to do research?

Percent (Number of Responses)

Variable	Not At All Important	Somewhat Important	Important	Very Important	Extremely Important
Intellectual Challenge			6.7% (1)	20% (3)	73.3% (11)
Social Status	40% (6)	33.3% (5)	26.7% (4)		
Career Advancement		26.7% (4)	53.3% (8)	13.3% (2)	6.7% (1)
Professional Recognition		13.3% (2)	40% (6)	33.3% (5)	13.3% (2)
Contribution to new knowledge			6.7% (1)	40% (6)	53.3% (8)
Personal enjoyment	6.7% (1)		6.7% (1)	46.7% (7)	40% (6)
Economic Reward	6.7% (1)	33.3% (5)	53.3% (8)	6.7% (1)	
Participation in professional organizations	13.3% (2)	53.3% (8)	13.3% (2)	20% (3)	
Development of new products and processes*	6.7% (1)	13.3% (2)	40% (6)	26.7% (4)	6.7% (1)

* Missing Data - There are less than 15 total responses for this item.

Eleven researchers (73 percent) indicated that intellectual curiosity was an extremely important factor in their desire to do research. It seems significant that none of the researchers ranked this factor as *not important* or only *somewhat important.* Seven (46 percent) ranked personal enjoyment as very important, and eight (53 percent) ranked economic reward and career advancement as important factors.

Participation in professional organizations does not appear to be a great motivating factor.

Only three individuals (20 percent) ranked this factor as *important*, while eight (53 percent) of the individuals ranked this as *somewhat important.* Membership in professional organizations appear to play a greater role in helping researchers stay current in the field rather than in motivating them to do research. Only one of the respondents did not belong to or participate in a professional organization. Other researchers held memberships in one or more organizations, with ten memberships being the most held by one researcher.

Staying Current in the Field

The Internet and electronic access to information have become prevalent in the research environment. Oak Ridge National Laboratory makes electronic resources, such as Internet access and electronic journals available to all researchers. Using the same scale as question three shown in Table 1, the corporate fellows were asked to rank the factors which were most useful in helping them stay current in their subject areas. In general, the researchers appear to place less value on electronic access to information than on other, more traditional, methods of access to information. Their responses are summarized in Table 2. Thirteen (86 percent) of the researchers indicated that participating in electronic discussion groups was not important. Eight (53 percent) indicated that reading electronic journals was not particularly useful in helping them stay current within their field. Browsing the Internet was considered somewhat important by eight (53 percent) researchers. The factors which seven individuals (46 percent) ranked as extremely important were attending workshops and conferences, reading printed journals (as opposed to electronic), and informal contacts with other researchers. Personal contact, such as attendance at workshops and informal contacts with other researchers, seems to be the method perferred by most of the researchers for staying current.

TABLE 2

Question 7. Which methods are most useful in helping you stay current in your field?

Percent (Number of Responses)

Variable	Not At All Important	Somewhat Important	Important	Very Important	Extremely Important
Attending workshops and conferences			13.3% (2)	40% (6)	46.7% (7)
Reading printed journals			6.7% (1)	46.7% (7)	46.7% (7)
Reading electronic journals*	53.3% (8)	13.3% (2)	13.3% (2)	13.3% (2)	
Browsing the Internet	33.3% (5)	53.3% (8)	6.7% (1)	6.7% (1)	
Participating in electronic discussion groups	86% (13)	6.7% (1)		6.7% (1)	
Informal contacts with other researchers			6.7% (1)	46.7% (7)	46.7% (7)

*Missing data - item was not ranked so there are less than 15 total responses

Feelings about Research Achievements

In the last survey question, researchers were asked to rate their feelings about their research achievements on a scale of 1 to 5, with 1 being *disagree strongly* and 5 being *agree strongly*. As a group, the researchers indicated positive feelings about their research achievements. Their responses are summarized in Table 3.

TABLE 3

Question 8. How would you rate your overall feeling about your research achievements?

Percent (Number of Responses)

Variable	Disagree Strongly	Disagree Somewhat	Neither Agree nor Disagree	Agree Somewhat	Agree Strongly
I like the work I do				13.3% (2)	86% (13)
I feel successful in my work			6.7% (1)	33.3% (5)	60% (9)
My research gives value to my life*			6.7% (1)	20% (3)	66% (10)
I feel rewarded for my work*		13.3% (2)	6.7% (1)	46.7% (7)	26.7% (4)
My research achievements meet my expectations*	13.3% (2)	6.7% (1)	13.3% (2)	33.3% (5)	26.7% (4)

* Missing data - Some items were not ranked so there are less than 15 total responses for some variables.

Corporate fellows seem to like the work they do because thirteen of them (86 percent) indicated strong agreement with the statement, “I like the work I do,” and none of them disagreed with the statement. Nine researchers (60 percent) indicated feelings of success regarding their work accomplishments. The fact that ten (66 percent) of the individuals consider research a valuable part of their lives is reflected in their strong agreement with the statement: “My research gives value to my life.” Seven of the 15 researchers indicated feeling rewarded for their work efforts.

It was difficult to analyze the results of the rankings of the last item, which asked researchers to indicate their sastisfaction with their research achievements. Only four (26.7 percent) researchers expressed strong agreement with this statement. There did not appear to be a clearly dominant indication the researcher’s opinion of this factor.

Conclusion

The results from the publication counts show that the corporate fellows have maintained a consistent level of productivity over time. This reflects the sustained effort that Lawani (1977) considers one of the defining characteristics of an “eminent” scientist. The cited author data shows that the corporate fellows are cited often. It is difficult to determine how significant the citation information is unless it is compared to similar information. Additional support for corporate fellows as “eminent” scientists is the fact that of the twenty-five researchers included in this study, seventeen (68 percent) were listed in the 1998-99 edition of *American Men and Women of Science (AMWS)*. AMWS is a biographical directory of active American scientists. It does not include all scientists. “Entrants are limited to those who have made significant contributions in their field” (AMWS, 1997).

Corporate fellows share similar motivations for performing research. They list intellectual challenge, personal enjoyment, career advancement, and economic reward as motivating factors. As group, they express positive feelings about their research achievements. The corporate fellows did not appear to value electronic access to information as a method for staying current within the field. It was slightly surprising to see that electronic methods appear

to be less important than the more traditional methods for staying current within the field of research. On further reflection, electronic methods may appear to be less important because most of the researchers in this study are older and possibly less comfortable with computers.

It was difficult to identify statistical correlations among the variables in this study because the group was too small to generate a significant amount of data. The information in this study cannot be used to make generalizations to the world at large. The results of this survey could be very different if done with a larger group and additional information. One possibility for further research would be to use information from this study to compare this local group of researchers with other "eminent researchers", such as Nobel prize winners. It might also be interesting to see how researchers differing according to their subject areas.

Citation counts provide an easily calculated measure of productivity. This study reinforces the idea that citation analysis, if carefully done, can generate a good deal of information about the quality and quantity of research done by individuals and institutions.

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