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FUNDED RESEARCH, MULTIPLE AUTHORSHIP, AND SUBAUTHORSHIP COLLABORATION IN FOUR DISCIPLINES

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Increased financial support for science has contributed to a change in the social structure of research, as evidenced by the increase in collaborative research. The present paper examines the relationship between financial support, multiple authorship, and subauthorship in four disciplines. It is shown that financial support for research is associated with an increase in the total number of persons involved in the production of knowledge per journal article. However, the impact of funding is not the same for all modes of collaboration nor the same for all disciplines.

Introduction

A salient characteristic of 'big science' is team research. The extent of this collaboration in contemporary scientific investigation has been measured by the increase in the number of multiple-authored publications and is well-documented.[1]

Another important characteristic of 'big science' is massive financial support, which has been found to be associated with team research. For example, the number of multiple-authored publications and the number of authors per article are greater in the best-supported field, i.e., the natural sciences.[2] Even in sociology multiple authorship is related to financial support for the published research. In their study of articles published in the *American Sociological Review* and *Social Forces, Hirsch* and *Singleton*[3] found that supported articles in both journals had more authors per article than non-supported articles. And *Patel*'s study of collaboration in the growth of sociology found a similar relationship between financially aided articles and multiple authorship.[4]

Funding per se does not 'cause' an increase in collaborative research, for it is possible that the more people involved in a research project, the more they might have need for additional funding.[5] However, with financial support the researcher might have greater access to complicated, expensive equipment, which in turn, may

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require large numbers of people to operate. Furthermore, the researcher may now be able to pay others to do tasks that he himself might otherwise have done. Indeed, *Price* suggests that 'collaboration arises more from economic than from intellectual dependence.'[6]

In addition to collaboration at the authorship level, however, team research often involves the contributions of others who are mentioned only in the footnote acknowledgments of an article. Such an assistant, or 'subauthor' according to *Patel,* 'refers to any person who has rendered service in some capacity toward the research outcome, substantial enough to be acknowledged by the author'.[7]

The nature of the contribution of these subauthors is of two general types: 'technical aid' and 'theoretical aid.'[8] Technical subauthorship collaboration includes such assistance as collecting data, processing data, operating laboratory machinery, performing statistical analyses, etc. – what some refer to as 'hired hand research.'[9] Theoretical subauthorship collaboration includes such assistance as reading, editing, and/or commenting on a manuscript prior to publication; what *Mullins*[10] and others[11] refer to as 'trusted assessorship.'

The roles of subauthors are frequently mentioned in the literature,[12] but relatively little attention has been given to the relationship between financial support and subauthorship collaboration. An analysis of the relationship between financially supported research and teamwork needs to examine subauthorship collaboration as well as multiple authorship. For example, is funding associated with an increase in the total number of persons involved in the production of knowledge as reported in a scholarly publication? Stated differently, does financial support increase the utilization of personnel at the subauthorship level as well as at the authorship level, as *Price* and *Beaver*[13] and *Patel*[14] suggest? And if financial support is related to subauthorship collaboration, what type of subauthorship collaboration – technical or theoretical? Is the effect of funding on subauthorship collaboration greater than the effect of funding on multiple authorship? The present paper is concerned with the relationship between financial support, multiple authorship, and subauthorship, and examines the number of authors and subauthors per non-supported and supported articles in four disciplines.

Methodology

The data for this paper are from an earlier study of collaboration in scholarly publications.[15] In 1976, five hundred articles published during 1974–1975 were drawn from 28 journals in four fields.[16] The characteristics of these articles were then recorded – e.g., the number of authors, the number and type of subauthors

acknowledged by the author(s), the number of funding sources acknowledged, the authors' institutional affiliations, and so forth.

A questionnaire was then mailed to the author of each article (to the *first* author in the case of multiple-authored articles). The authors were asked to identify the *primary* contribution of each subauthor to the published article, whether or not the research was financially supported, the author's discipline, etc. The response rate was very good (N = 401, 80%).

Articles in which the author(s) gratuitously acknowledged the contributions of, say, an entire student class, were eliminated from the data reported here.[17] Thus the total number of articles utilized in this paper is 395.

The contributions of the subauthors were grouped into two categories on the basis of the nature of their contribution to the article – technical or theoretical. If a subauthor was credited with theoretical *and* technical contributions by the author respondent, we used the contribution the subauthor was acknowledged for *in the article.* If the article acknowledgment was ambiquous, we looked at the other information provided in the questionnaire to determine the *primary* contribution of a subauthor. For example, if the subauthor was a paid laboratory assistant at the time the research was conducted, we credited that subauthor with technical assistance.[18]

The articles themselves are classified on the basis of financial support for the author's research, using the categories of 'non-supported' and 'supported'. By 'financially supported' we mean that the actual research reported in the article was funded. For the purpose of this paper, we make no distinction between sources of support, as many of the authors received support from multiple sources.[19]

The respondents' disciplines were grouped as follows: political science, psychology, chemistry, and 'biological science.' In this study, 'biological science' is a heterogeneous category and includes genetics, bacteriology, developmental biology, molecular biology, parasitology, and virology.

We do not claim the findings reported here are representative of all disciplines nor of all members of the four disciplines discussed. Research problems, procedures, techniques, equipment, etc. can vary *between disciplines* and between specialties *within disciplines.* However, we do believe that by separating our data into these four disciplinary categories we can obtain a better understanding of the effects of funding on the social structure of research, viz. multiple authorship and subauthorship.

Results

It has been argued that increased financial support of research has contributed to a change in the social structure of scientific investigation. The data in this paper would appear to support this proposition.

Table 1
Financial support for each discipline

Discipline	Articles without financial support		Articles with financial support		Total	
	N	%	N	%	N	%
Political science	60	60.6	39	39.4	99	100
Psychology	31	29.5	74	70.5	105	100
Biological science	8	8.3	88	91.7	96	100
Chemistry	7	7.4	88	92.6	95	100

$\chi^2 = 77.99$, 3df, $P<0.001$

Table 2
Total contributors per article by financial support for each discipline

Discipline	Total contributors per non-supported article	Total contributors per supported article
Political science	3.13	3.95
Psychology	4.00	5.16
Biological science	3.38	4.57
Chemistry	2.00	3.65

Of the 395 articles in our sample, nearly three-quarters (73.2%, N = 289) received some form of financial support (Table 1). Support for an author's research increases the total number of contributors per article for each discipline (Table 2). The increase, as will be shown, is not the same for all disciplines for nor all types of collaboration.

Approximately two-thirds of the supported articles were in chemistry and biological science. The relationship between discipline and financial support was statistically significant ($p < 0.001$). And in regard to multiple authorship, the relationship between funding and multiple authorship was statistically significant for biological science ($p < 0.05$) and for chemistry ($p < 0.001$) only, (Table 3). The mean number of authors per supported article, compared to the mean number of authors per non-supported article, for biological science and chemistry were 1.62 vs. 2.16, and 2.00 vs. 2.60, respectively.

What is the relationship between financial support and technical subauthorship collaboration? As the data in Table 4 indicate, the availability of funds allows the author greater access to such technical assistance. The number of technical assistants

Table 3
Authors per article by financial support for each discipline

Discipline	Authors per non-supported articles	Authors per supported articles	No. of authors	Chi-square values*
Political science	1.33	1.33	132	($X^2 = 0.068$, ldf, p = n.s.)
Psychology	1.84	1.94	201	($X^2 = 0.69$, ldf, p = n.s.)
Biological science	1.62	2.16	203	($X^2 = 4{,}32$, ldf, $p < 0.05$)
Chemistry	2.00	2.60	243	($X^2 = 17.13$, ldf, $p < 0.001$)

*Chi-square values obtained for each discipline by crosstabulating number of authors (1, 2+) with financial support (non-supported, supported).

Table 4
Technical subauthors per article by financial support for each discipline

Discipline	Technical subauthors per non-supported article	Technical subauthors per supported article	No. of technical subauthors	Chi-square values*
Political science	0.50	0.97	68	($X^2 = 2.83$, ldf, $p < 0.10$)
Psychology	0.58	1.69	143	($X^2 = 4.4$, ldf, $p < 0.05$)
Biological science	1.25	1.64	154	($X^2 = 1.24$, ldf, p = n.s.)
Chemistry	0.00	0.72	63	($X^2 = 3.65$, ldf, $p < 0.10$)

*Chi-square values obtained for each discipline by crosstabulating number of technical subauthors (0.1+) with financial support (non-supported, supported).

acknowledged per supported article is greater than the number acknowledged per non-supported article. This applies to all four disciplines. The relationship between funding and technical subauthorship is statistically significant at the $p < 0.10$ level for political science and chemistry, and at the $p < 0.05$ level for psychology.

The non-funded or inadequately funded scientist is clearly at a disadvantage, then, when it comes to having access to the technical assistance of others with his research. This deprivation may retard his output and limit his visibility in the scientific community; which in turn may limit his access to funding.[20]

In the case of theoretical subauthorship, however, the availability of funds has much less impact as compared to the impact funding has upon technical subauthorship collaboration (Table 5). Although the number of theoretical subauthors per sup-

Table 5
Theoretical subauthors per article by financial support for each discipline

Discipline	Theoretical subauthors per non-supported article	Theoretical subauthors per supported article	No. of theoretical subauthors	Chi-square values*
Political science	1.30	1.64	142	($X^2 = 0.016$, ldf, p = n.s.)
Psychology	1.58	1.53	162	($X^2 = 0.69$, ldf, p = n. s.)
Biological science	0.50	0.77	72	($X^2 = 1.56$, ldf, p = n.s.)
Chemistry	0.00	0.33	29	($X^2 = 1.64$, ldf, p = n.s.)

*Chi-square values obtained for each discipline by crosstabulating number of theoretical subauthors (0.1+) with financial support (non-supported, supported)

ported article tend to be somewhat larger than the number per non-supported article, there is no significant relationship between financial support and theoretical subauthorship collaboration in any of the disciplines in this study. Collaboration here takes the form of discussion, not of specific tasks performed by technicians.

In summary, financial support for research was found to be associated with an increase in the *total* number of persons involved in the production of knowledge per published article in each of the disciplines in our sample. However, the impact of funding is not the same for all modes of collaboration nor for all disciplines.

In the data presented in this paper, funding would appear to have the greatest impact upon technical subauthorship collaboration, particularly for psychology and chemistry, then political science and biological science, in that order.

Secondly, financial support had a statistically significant impact on multiple authorship in chemistry and biology only (the two disciplines having the greatest percentage of funded articles in our sample).

Finally, there was no significant relationship found between financial support and theoretical subauthorship in any of the disciplines included here.

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Notes and references

1. For example, D. J. de SOLLA PRICE, Citation Measures of Hard Science, Soft Science, Technology and Nonscience, in: *Communication Among Scientists and Engineers,* C. E. NELSON, D. K. POLLACK (Eds), Lexington, Mass.: D. C. Heath, 1970, p. 3–22; H. A. ZUCKERMAN, Nobel Laureates in Science: Patterns of Productivity, Collaboration and Authorships, *American Sociological Review,* 32 (1967) 391–403; and many others.
2. D. de B. BEAVER, R. ROSEN, Collaboration in Science: Response to Professionalism. Unpublished, undated draft kindly provided by Prof. BEAVER in 1975, Williams College.
3. W. HIRSCH, J. F. SINGLETON, Research Support, Multiple Authorship, and Publications in Sociological Journals, 1936–1964. Unpublished paper, Purdue University, 1964. (The present paper has been considerably influenced by the HIRSCH and SINGLETON paper.)
4. N. PATEL, Collaboration in the Professional Growth of American Sociology, *Social Science Information,* 12 (1973) 77–92.
5. I wish to thank the referee for reminding me of this important distinction.
6. D. de SOLLA PRICE, op. cit. note 1, 7.
7. N. PATEL, op. cit. note 4, 87.
8. N. PATEL, op. cit. note 4 utilizes the following categories of subauthorship collaboration: 'reading, editing and commenting', 'providing research facilities', 'data gathering', 'data processing', and 'statistical analysis', and includes institutions. This paper utilizes only the two categories of technical and theoretical subauthorship collaboration discussed in the text, and excludes institutions, journal referees, and anonymous reviewers acknowledged by the authors. For the difficulties in classifying subauthorship collaboration, see K. H. MACKINTOSH, Acknowledgment Patterns in Sociology. Unpublished doctoral dissertation, University of Oregon, 1972, p. 27–37.
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12. See notes 4, 8, 9, 11 op. cit., and W. O. HAGSTROM, *The Scientific Community,* Basic Books, New York, 1965, p. 105–58.
13. D. J. DE SOLLA PRICE, D. BEAVER, Collaboration in an Invisible College, *American Psychologist,* 21 (1966) 1011–18.
14. N. PATEL, op. cit. note 4.
15. A. G. HEFFNER, Patterns of Collaboration in Scholarly Publications: Recognition, Deference, and Exploitation. Unpublished doctoral dissertation, Purdue University, 1976. See pages 34–48 for an extended discussion of the methodology involved.
16. The journals were: *American Journal of Political Science, American Political Science Review, Comparative Politics, The Journal of Politics, Political Science Quarterly, Western Political Review, World Politics, American Journal of Psychology, Journal of Abnormal Psychology, Journal of Experimental Psychology, Journal of Experimental Social Psychology, Journal of Personality and Social Psychology, Psychological Bulletin, Psychological Review, American Journal of Physiology, Anatomical Record, Biological Bulletin, Genetics, Journal of Bacteriology, Jorunal of Parasitology, Journal of Virology, Analytical Chemistry, Inorganic Chemistry, Journal of the American Chemical Society, Journal of Biological Chemistry, Journal of Chemical Education, Journal of Organic Chemistry,* and *Journal of Physical Chemistry.*

17. For example, one author acknowledged, as a 'sounding board for his ideas', 15 students in a class he had taught! Review essays, research notes, and presidential addresses were also excluded.
18. See note 8.
19. The exact question was: 'Was the research for this article financially supported? —— Yes —— No IF YES: Please indicate source(s) of funding: —— University —— Government —— Foundation —— Private —— Other (please specify)' ——
20. For further discussion and research regarding the relationship between a scientist's visibility in the social stratification system of science and the reward system of science, see R. K. MERTON, The Matthew Effect in Science, in *The Sociology of Science: Theoretical and Empirical Investigations,* N. W. STORER (Ed.) University of Chicago Press, Chicago, 1973, p. 439–59; J. R. COLE, S. COLE, *Social Stratification in Science,* University of Chicago Press, Chicago, 1973; P. D. ALLISON, J. A. STEWART, Productivity Differences among Scientists, *American Sociological Review,* 39 (1974) 596–606; and R. J. LIEBERT, Productivity, Favor, and Grants among Scholars, *American Journal of Sociology,* 82 (1976) 664–73.