

THE CITATION IMPACT OF FUNDED AND UNFUNDED RESEARCH IN ECONOMICS

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Is research which receives grant support more cited than unfunded research? The answer to this question for the field of economics is – at least tentatively – affirmative. However, in pursuing this query several methodological questions are encountered and discussed, ranging from the choice of the statistical model and of the population, through the control of covariates, to the selection of the unit of investigation. It is suggested that, in spite of their limitations, small bibliometric studies of selected populations, which control for at least some of the relevant covariates, might become a helpful tool in clarifying some issues in science policy.

Introduction

Every year considerable amounts of money are spent on scientific research by governments, non-profit agencies and private companies. The various funding agencies are putting much effort into the formulation of policies suited to their specific objectives, delineating areas of potential growth or encouraging research in promising fields which may have been neglected hitherto. On the other hand, much research is also produced – mainly by university faculties – without recourse to external funding. Evidently, there is some interest in trying to find out whether "funded" studies are more "significant" than unfunded endeavors.

The extent to which a given piece of research is "significant", "valuable", "useful", or "important" is hard to determine. A simple proxy measurement of this attribute can be obtained by means of citation analysis. The use of the number of times a certain study has been cited as a measure of its worth has been debated extensively in the literature. In the present paper an attempt is made to apply this measure to a comparison of funded and unfunded studies in one discipline – economics.

Clearly, any study of the associations of a variable with the number of citations must take into account the potential confounding effect of other covariates. Thus, it might be advisable to "keep constant" not only the discipline under study but also the

specific journal and subject area.¹ On a more technical level, one would want to compare only studies published in the same year (i.e. which have been "exposed" to citation for a similar length of time). Other potential covariates which had to be ignored in the present paper are the number, affiliation and seniority of the authors.²⁻⁴ The association between funding and citations was studied by *McAllister* and *Narin*⁵ with data on 925 biomedical publications from 120 medical schools. They showed that average citation influence per paper was positively associated with output of biomedical papers for each school. The latter, in turn, is strongly correlated with the extent of National Institutes of Health funding for that medical school. *Abt*⁶ looked at the association between funding and citation in astronomy. He concluded that funded research was more cited than unfunded research.

Methods

Two journals were selected for this study: the *American Economic Review* and the *Economic Journal* which is published in Great Britain. The reasons for selecting these journals were as follows: 1. According to *Social Sciences Citation Index, Journal Citation Reports* of 1979 these are frequently cited journals ranking sixth and tenth respectively with respect to their citation impact. All the journals with higher citation ranks are either specialized within a specific subfield of economics or are associated with a specific orientation within that discipline. The fact that both an American and a British journal are represented in this selection is also considered an advantage since funding policies might be different in the two countries.

2. Both funded and unfunded studies are represented in the two journals in roughly equal proportions.

3. The studies published in these journals can be readily divided into two subgroups, empirical and theoretical, both represented in substantial numbers in each of the two journals.

Selecting highly cited journals as one's population raises the possibility of a bias. Indeed, it is quite possible that comparisons between funded and unfunded papers would turn out differently in a population of less prestigious journals. On the other hand, comparisons between papers in less cited journals, whatever their outcome, might be of little intrinsic interest. On balance it would seem that in the present, exploratory stage of our investigation one should only select "elite" journals which are frequently cited.

The operational definitions of the two main variables were as follows:

a) A study was considered "funded" if acknowledgement of support by some granting agency is given either in a footnote or in the text, and "unfunded" otherwise.

b) A study was considered "empirical" if some real data are presented or analyzed in it (for whatever purpose), and "theoretical" otherwise.

All the articles published in the years 1978 and 1979 were included and their citations counted in *Social Sciences Citation Index* for the years 1978 (or 1979, respectively) till 1987 inclusive. As mentioned in the introduction, the studies published in 1978 were considered a separate stratum from those published in 1979 and the analysis was performed accordingly. Excluded from the study population were: lectures and addresses, notes and brief communications, etc.

For the purpose of statistical analysis the dependent variable "funded vs. unfunded" was looked at separately in each of the eight strata defined by the two journals, the two publication years and the theoretical vs. empirical dichotomy. For each of these strata the mean and median citation count and its standard deviation are computed.

In view of the marked skewness of the number of citation counts, one may have some doubts about the use of the mean as an analytic tool. Following *McAllister et al.*⁷ one could transform the data to percentiles. In the present paper only the fiftieth percentile, the median, is used. As will be seen below, the conclusions do not differ much if medians, rather than means are studied.

A further descriptive statistic which is insensitive to outliers was also computed. This is:

$$U_i / m_i \cdot n_i \quad i = 1, \dots, 8 \tag{1}$$

where i denotes the stratum, m_i and n_i the number of funded and unfunded studies in stratum i , respectively, and U_i the corresponding Mann-Whitney statistic. The statistic (1) is an estimate of the following probability: suppose that one study is drawn at random from the funded group in stratum i and one from the corresponding unfunded group. Let X and Y be their respective citation counts. The statistic (1) estimates:

$$\text{Prob}(X > Y) + 1/2 \text{Prob}(X = Y) \tag{2}$$

For the purpose of hypothesis testing the eight statistics (1) are combined with weights proportional to the inverse of their variance yielding the well-known *Van Elteren*⁸ test:

$$z = \sqrt{12} \left[\sum_{i=1}^8 (U_i - m_i n_i / 2) (m_i + n_i + 1)^{-1} \right] \left[\sum m_i n_i (m_i + n_i + 1)^{-1} \right]^{-1/2} \tag{3}$$

The detailed results are given in the next section.

Results

The main descriptive results are given in Tables 1 and 2. It is readily seen that, with one exception, funded research tends to have higher citation counts than unfunded research. The single exception occurs among the theoretical studies published in 1978 in the *American Economic Review*. In some instances, however, the association between "fundedness" and citation counts is rather weak. In particular, the statistic (1) is equal or close to its null value in 3 out of the eight strata studied.

Table 1
Summary statistics of citation counts for funded and unfunded studies,
by type of study (theoretical vs. empirical). *American Economic Review*, 1978, 1979

	1978		1979	
	Theoretical	Empirical	Theoretical	Empirical
Number of source papers				
Funded	14	11	11	14
Unfunded	16	11	13	15
Total	30	22	24	29
Mean citation count				
Funded	11.9	30.7	25.5	30.6
Unfunded	19.5	19.1	17.2	30.5
SD of citation count				
Funded	10.8	20.4	26.0	30.7
Unfunded	20.2	17.3	21.9	36.0
Median citation count				
Funded	9	23	12	16.5
Unfunded	12.5	14	9	16
Statistic (1)	0.42	0.70	0.63	0.55

Van Elteren's summary test statistic yields a value of $z=1.64$. When referred to the standard normal tables this gives a P-value of 0.05 for the one-sided alternative which states that funded research is more cited than unfunded research. Formally, a P-value of 0.05 may be considered sufficient for a rejection of the null hypothesis in favor of the alternative but, in any case further investigation of the issue may be needed.

Table 2
 Summary statistics of citation counts for funded and unfunded studies,
 by type of study (theoretical vs. empirical). *Economic Journal*, 1978, 1979

	1978		1979	
	Theoretical	Empirical	Theoretical	Empirical
Number of source papers				
Funded	6	8	2	5
Unfunded	5	14	9	12
Total	11	22	11	17
Mean citation count				
Funded	72.5	15.4	13	12.8
Unfunded	20.4	16.6	7.5	6.9
SD of citation count				
Funded	63.3	15.9	–	13.9
Unfunded	24.8	25.9	7.5	3.8
Median citation count				
Funded	63	7	13	6
Unfunded	11	9	5	7.5
Statistic (1)	0.77	0.50	0.89	0.53

Discussion

It has been shown in the previous section – albeit in a preliminary and tentative manner – that funded research published in certain high-prestige economic journals tends to be cited more often than unfunded research published in the same journals. This apparently straightforward finding, however, gives rise to some very serious problems of interpretation. In this section an attempt to clarify these problems is made.

The choice of the study population

What population should be included in a study like this? Clearly a random sample of economics papers would not suit the objective: it would be overloaded with papers from obscure or rarely cited journals, or from journals specialized in subfields in which grant-supported research is either the rule or the exception. Questions of language are also likely to confound the issue: some papers may be cited only infrequently, regardless of their intrinsic worth, merely because they are published in some less-known language. Furthermore, grant allocation policies may well be

different in countries in which languages other than English are used for communication.

In the present paper two highly prestigious journals were selected for analysis. In consequence, one was fairly certain that some highly cited papers would be present in the study population, thus providing an adequate range for comparison between "funded" and "unfunded" studies. Furthermore, it soon became clear that the numbers of theoretical and empirical studies, as well as the number of funded and unfunded ones, were roughly similar and thus statistically comparable with respect to citation numbers. There was, therefore no doubt that the selection of this particular study population was convenient; one may wonder, however, whether it was – in some sense of the term – reasonable, or even representative.

The criteria for the selection of a "suitable" study population are, in the present instance, rather vague. One natural approach would be to look at the problem from the point of view of the funding agencies; the latter could, no doubt, produce a roster of grants which have resulted in published papers. A sample of these papers could then be taken, together with a "control group" of papers produced without funding which have been published in the same journals, at about the same time with similar content characteristics. Needless to say, the production of such a roster is not an easy matter and could not be attempted in the present exploratory paper. In the long run, however, it might turn out to be a useful tool in the decision-making process.

Selection of the unit of investigation

In the present context, the adoption of the individual published paper as a unit of investigation can also be challenged. Frequently one research project leads to more than one published paper. The manner in which a body of findings from a project is "packaged" into published papers is to some extent a matter of homogeneity of contents; it is, however, also a matter of convenience, expediency, courtesy to collaborators, etc. It is not clear at all whether a sample of papers or a sample of research projects should be taken. In the first instance, projects leading to a large number of papers (these are, in most instances, funded projects) will tend to be overrepresented while the average number of citations per paper will be relatively low; in the latter instance these projects will tend to be underrepresented while the average numbers of citations (for the entire project) will tend to be high. The final result of these differences is unknown. The investigation of the citation patterns in multi-paper projects would certainly be an interesting subject in itself; in the meantime the decision to view the individual research paper as the unit of investigation can be based only on one practical argument: larger research projects

tend to extend over long periods of time thus making it impossible to control for the length of exposure to citations.

Problems of analysis

The analysis of the data in the previous section ends with a significance test and yet no model assuming random variation is specified. The use of significance tests without a random model has been criticized by many authors;⁹ nevertheless, most investigators felt strongly the need to show that the conclusion they have reached is "not likely to be due to chance" – in spite of the fact that they are unable to state how chance operates in the specific instance in question.

A few authors have attempted to find a way out of this dilemma. One interesting effort in this direction is that of *Freedman and Lane*.¹⁰ Nevertheless, the "theory of nonrandom inference" is still in its infancy. In the meantime very few investigators are likely to refrain from using inferential procedures whenever no random model is specified. All one can hope for is that such procedures will be used sparingly and that, whenever possible, some attempt will be made to specify the nature of the random variation involved. Is it reasonable to assume that the number of citations to a given paper is a random variable (of unspecified form)? The question is closely connected with philosophical issues concerning the nature of randomness; it will, therefore, be left unanswered here.

Concluding remarks

Financial support of research projects is essential in order to ensure scientific progress in modern society. In the present paper a very modest and preliminary attempt was made to apply bibliometric methods to the evaluation of research funding activities. The results presented here seem to indicate that these methods, and in particular citation analysis, have a significant contribution to make to such an evaluation. However, the problems that arise in the interpretation of the results are far from simple: the proper definition of the study population requires the creation of an appropriate data base; the choice of the proper unit of investigation necessitates some basic research on the citation patterns of papers resulting from the same research project; finally, the analysis of the results and the consequent decision-making presuppose a more stringent specification of the nature of random variation in bibliometric studies.

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