

# Estimates of the Returns to Quality and Coauthorship in Economic Academia

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Salaries of academic economists are studied to determine if individuals receive differential returns to publishing articles of varying quality and to coauthored versus single-authored articles. Estimates based on detailed data and a flexible nonlinear least-squares procedure indicate that substantial returns to quality exist and that an individual's return from a coauthored paper with  $n$  authors is approximately  $1/n$  times that of a single-authored paper.

It is enough to check the growth of science that efforts and labors in this field go unrewarded. [FRANCIS BACON; quoted in Merton (1973, p. 297)]

## I. Introduction

The reward structure in academia has been a subject of keen interest to economists, sociologists, and historians of science. Two topics in this inquiry are of particular interest to economists: (1) the existence of incentives capable of promoting the growth of knowledge, in which economists have tended to specialize; and (2) the consequences of competition among scientists within the structure of rewards (see esp. Merton 1973). The chief concern of this study is a more careful documentation of the incentives academicians face.

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This paper presents an empirical analysis of the earnings function for academic economists that is designed to address two questions. First and more important, what are the returns to quality in academic research? Second, what are the relative returns to single authorship versus coauthorship of published research? These questions have been neglected in previous investigations.

Earnings functions similar to the one used in this paper have been estimated in several studies for various academic disciplines. The most extensive of these is a study by Tuckman (1976, chap. 5), which examined rewards across disciplines for over 50,000 faculty at 301 institutions. Tuckman measured systematic and significant returns to publishing for 17 of 18 nonprofessional disciplines, including economics.<sup>1</sup> The exception, anthropology, was also the only field to lack a measurable return to administrative service. Finally, 16 of the 18 fields, including economics, failed to deliver significant salary increments for good teaching. This consistency of rewards across disciplines gives us confidence that the results of this study will not be peculiar to economics but will shed light on the incentives that exist elsewhere in academia.

Other studies with smaller samples and more narrow foci have confirmed and expanded on Tuckman's findings.<sup>2</sup> Yet virtually all have imposed stringent assumptions on the data that make it impossible for them to address the concerns of this paper. The nature of these assumptions and the manner in which they are relaxed in this paper are discussed in Section II. Section III outlines the estimation procedure used to calculate the returns to differences in research quality and the relative return to coauthorship. Section IV contains some concluding remarks.

## II. The Measurement of Research Output

### A. *Measurement Issues*

Previous studies of academic salaries typically estimate a linear equation in which academic salary is regressed on articles published, "ex-

<sup>1</sup> Tuckman reported that the median number of articles published was in the 5–10 category for 11 of the 18 fields. The figure was lower for music and higher for psychology and all the natural sciences. Further, in the natural sciences and psychology, a greater number of articles were required to obtain significant salary differentials than in other fields. Tuckman speculated that these differences were due to differential costs in producing an "article" (note that he did not distinguish coauthored articles). Merton (1973, pp. 470–74, 547) found that in the natural sciences, articles are shorter, more likely to be coauthored, and less likely to be rejected, which is consistent with Tuckman's conjecture.

<sup>2</sup> These include Siegfried and White (1973), Tuckman and Leahey (1975), Tuckman and Hagemann (1976), Hansen, Weisbrod, and Strauss (1978), Hamermesh, Johnson, and Weisbrod (1982), and Diamond (1986).

perience," and other productivity variables. This study proceeds in a similar fashion, with one important difference. In the past, researchers have assumed that a "publication is a publication," be it in *Economica* or *Econometrica*, be it a note or a full-length paper, be it written by one author or two. These restrictions are relaxed in this paper by utilizing more detailed data. Issues relating to each of these factors are discussed below.

Liebowitz and Palmer (1983) report results of a survey of department chairmen that indicate that chairmen ordinarily "assign a weight" to coauthored papers that exceeds  $1/n$  (with  $n$  being the number of authors), presumably to encourage collaborative research. But since economists are mobile, it is ultimately the market that would determine the relative value of coauthored papers, and it is not at all obvious what the market-determined value would be.

In a market in which collaboration entailed no extra costs, one would expect to read very few single-authored papers if monetary rewards were as described above. On the other hand, if researchers were less productive at coauthored research than single-authored research, a reward scheme encouraging the former entails a considerable cost in terms of forgone research output. Clearly then, the "equilibrium" weight for coauthored work is a function of production (and "taste") parameters that are difficult to observe. Fortunately, one can estimate the sample weight for coauthored research by recording data on coauthored and single-authored productivity indicators separately, which is the approach taken in this paper.<sup>3</sup>

In addition, the following analysis recognizes the difference between notes and full-length articles. While few would object to the assertion that the former are less valuable than the latter, drawing a line to separate one from the other would be inappropriate. Yet if one assumes that journal editors allocate space as value maximizers, it naturally follows that articles of greater length are more valuable than those of lesser length (on average). This is addressed in the data by defining an individual's publication measure for each journal as the sum of pages published therein. Since page sizes vary between journals, pages in each journal are adjusted to pages of *American Economic Review* equivalent size (AEQ pages).

Finally, unlike the poetic rose, all 10-AEQ-page articles are not the same. Studies using citations in economics (Liebowitz and Palmer 1984) and the natural sciences (Garfield 1972) indicate that articles published in a small core of journals account for the majority of

<sup>3</sup> Coauthored work with  $n > 2$  authors was weighted at  $2/n$  times work with two authors. This was necessary because of the small number of papers written by three or four individuals. The Data Appendix discusses the implications of this weighting scheme.

references in the literature.<sup>4</sup> Liebowitz and Palmer (1984) constructed several rankings of economics journals based on citation frequencies. The ranking that "probably comes closest to an ideal measure of the impact on the economics profession of manuscripts published in various journals" (p. 83) shows a sharp decline in the impact-adjusted citation frequency as one moves down the list.<sup>5</sup> For example, articles in the tenth-ranked journal received 36.45 percent of the impact-adjusted citations per character of the top journal; this figure is 28.06 percent for the twentieth- and 7.15 percent for the fortieth-ranked journal.

A possible method of adjusting for differences in journal quality would be to weight an article by the impact-adjusted citation frequency of the journal in which it is published. Although this adjustment may be too severe, it does raise the question of just how steep the quality gradient may be. This question is examined in detail in Section III.

### B. *The Data Set*

The data set used in this study consists of 140 academic economists who are members of the associate or full professor rank at seven "top 40" departments. These departments are those that responded fully to a request for salary information and vitae of senior faculty that was sent to the top 40 departments listed in Graves, Marchand, and Thompson (1982). The average rank of the departments in the sample is 24.

The data were tabulated in light of the issues discussed above. Measures of research productivity were based on information provided on the vitae and in the *Social Science Citations Index*, with coauthored work recorded separately.<sup>6</sup> The data on each individual

<sup>4</sup> Citations have also been used to construct loose rankings of scientists. Quandt (1976, p. 741) stated that citation counts permit "tentative predictions as to who future [Nobel] prizewinners will be." Time has supported this conclusion. Quandt's list of the 26 most cited economists in 1970 contains seven subsequent prizewinners (among them the 1987 laureate) along with three who had been honored before the article was published. Similar figures for the natural sciences are reported in Garfield (1978) for both Nobel prizes and other highly regarded honors.

<sup>5</sup> This ranking is their table 2, col. 2, ranking. The impact adjustment refers to an iterative weighting scheme that gives greater weight to citations received from higher-ranked journals.

<sup>6</sup> The period for which citations were collected was 1976-82, which is something of a compromise between conflicting notions about the proper period for this analysis (see the Data Appendix for further discussion). Making an accurate count of the number of citations and coauthored citations, given the multiple listings of most authors, required an undue amount of patience and attention to detail. The great care taken by M. C. Matheson in collecting the data is much appreciated.

TABLE I  
 MEANS AND STANDARD DEVIATIONS OF 1982 9-MONTH SALARY AND PERSONAL  
 INDICATORS FOR 140 ECONOMISTS AT SEVEN UNIVERSITIES

| Variable                       | Mean   | Standard Deviation |
|--------------------------------|--------|--------------------|
| SALARY                         | 42,935 | 10,797             |
| PAGES ( $\alpha = 0$ )         | 67.2   | 73.8               |
| COPAGES                        | 48.2   | 56.0               |
| CITES                          | 95.4   | 184.9              |
| COCITES                        | 39.0   | 68.9               |
| OPAPER                         | 17.2   | 17.2               |
| CO-OPAPERS                     | 5.2    | 6.8                |
| BOOKS                          | 1.0    | 2.2                |
| COBOOKS                        | .4     | .7                 |
| EXPER                          | 17.7   | 8.9                |
| YRAD                           | 1.1    | 3.5                |
| QPAGES ( $\alpha = \alpha^*$ ) | 47.5   | 60.0               |
| COQPAGES                       | 29.4   | 38.2               |
| ARTICLES                       | 6.7    | 7.1                |
| COARTICLES                     | 4.3    | 4.9                |

NOTE.—QPAGES is the sum of single-authored AEQ pages in each journal weighted by  $(w_j)^{\alpha^*}$ , where  $w_j$  is the impact-adjusted citation frequency for journal  $j$ , and  $\alpha^*$  is the optimal exponent obtained in Sec. III

consist of the following variables (see the Data Appendix for details): SALARY: 9-month salary for the 1982–83 academic year; PROD: a single-author productivity vector consisting of PAGES: AEQ pages in each of the top 100 journals ranked in Liebowitz and Palmer (1984), OPAPERS: other papers listed on the vitae, BOOKS: number of books written, and CITES: citations received to published work, 1976–82; COPROD: the coauthored counterpart to PROD; EXPER: years since receipt of the Ph.D.; YRAD: years of administrative service; and DUMMY: a department-specific 0-1 dummy variable.

Means and standard deviations for these variables (using the sum of PAGES for each individual) are listed in table 1. Also listed are means for the number of single- and coauthored articles (in ranked journals), which are 6.7 and 4.3, respectively.<sup>7</sup> But how does this sample compare with the universe of publishing economists? One available yardstick is citation frequency. Liebowitz and Palmer (1983) compiled a frequency distribution of citations for over 3,000 academic economists from more than 100 departments. Table 2 lists the number of economists from this sample within each percentile. It seems that the sample distribution encompasses a broad range of the profession. If anything, the top 20 percent of Liebowitz and Palmer's tabulation is

<sup>7</sup> The journals most frequently published in by this sample are *American Economic Review*, *Journal of Political Economy*, *Review of Economics and Statistics*, *Econometrica*, and *Quarterly Journal of Economics*, accounting for 37 percent of all articles.

TABLE 2

AVERAGE CITATIONS PER YEAR FOR THE SAMPLE RELATIVE TO THE PROFESSION

| Number of Citations | Percentile for Profession | Sample Frequency | Sample Percentage |
|---------------------|---------------------------|------------------|-------------------|
| $\geq 167$          | 99                        | 1                | .7                |
| $61 \leq x < 167$   | 95                        | 5                | 3.6               |
| $30 \leq x < 61$    | 90                        | 17               | 12.1              |
| $12 \leq x < 30$    | 80                        | 27               | 19.3              |
| $6 \leq x < 12$     | 70                        | 21               | 15.0              |
| $4 \leq x < 6$      | 60                        | 13               | 9.3               |
| $2 \leq x < 4$      | 50                        | 22               | 15.7              |
| $1 \leq x < 2$      | 40                        | 21               | 15.0              |
| 0                   | < 40                      | 13               | 9.3               |

NOTE.—Coauthored citations are weighted at  $1/n$ .

overrepresented here, as one might expect since the sample is restricted to the top 40 departments.

Before we go any further, it is useful to consider the possible effects of the sample selection process on the results. Perhaps the biggest concern is self-selection among the respondents. For the most part, departments in this sample keep vitae on file. Thus the chief criterion for inclusion in this study is the low cost of detailed information on faculty members.<sup>8</sup> Offers of information on self-selected faculty were turned down from two departments. However, one department voluntarily sent such information, which was retained. In this case, a reasonable conjecture is that nonresponse is concentrated among the less productive. This is unfortunate if nonresponse entails a reduction in pages published in lower-ranked journals since it would make estimates of differential returns to quality less precise.

### III. Estimation of the Returns to Quality and Coauthorship

#### A. Specification of the Model

The two primary questions of interest are the relative return to quality and the relative return to coauthorship of published research. These questions are addressed using an iterative nonlinear least-squares procedure to find the optimal adjustment of AEQ pages for differences in quality.<sup>9</sup> Quality-adjusted AEQ pages for each individ-

<sup>8</sup> Not all the schools in this sample are public. Chairs of some public departments gave as a reason for nonresponse the cost of gathering together the information; others were unwilling to report salary figures.

<sup>9</sup> Quality adjustment is made only on journal pages and not on citations. Where citations occur is probably significant (and expensive to record), although frequency and quality are likely to be more closely related here than with journal pages.

ual is given by

$$\text{QPAGES} = \sum_{j=1}^{100} p_j \cdot w_j^\alpha, \quad 0 \leq \alpha \leq 1,$$

where  $p_j$  is pages and  $w_j$  is the impact-adjusted citation frequency for journal  $j$ . The transformation  $w_j^\alpha$ , for  $0 \leq \alpha \leq 1$ , is useful since it encompasses a wide range of alternatives. Using  $\alpha = 0$  results in no distinction between journals. For  $\alpha = 1$ , the quality weights are simply the impact-adjusted citation frequencies, which would force an AEQ page in the fortieth journal to equal 7.15 percent of an AEQ page in the top journal. Intermediate values of  $\alpha$  yield more modest declines as one moves down the journal rankings. The calculated QPAGES replaces PAGES in PROD and COPROD.

The following equation was estimated using values of  $\alpha = (0.00, 0.05, 0.10, 0.15, \dots, 1.00)$  in sequence:

$$\begin{aligned} \text{LOG(SALARY)} = & \text{INTERCEPT} + \beta_1 \cdot \text{PROD} + \beta_2 \cdot \text{PROD}^2 \\ & + \Gamma \cdot \beta_1 \cdot \text{COPROD} + \Gamma \cdot \beta_2 \cdot \text{COPROD}^2 \\ & + \beta_3 \cdot \text{EXPER} + \beta_4 \cdot \text{EXPER}^2 + \beta_5 \cdot \text{YRAD} \\ & + \beta_6 \cdot \text{YRAD}^2 + \beta_7 \cdot \text{DUMMY} + \epsilon, \end{aligned}$$

where  $\beta_1$  is the estimated coefficient vector for single-authored research indicators ( $\beta_2$  for the squared variables), and  $\Gamma$  is the estimated weight for coauthored research. The value of  $\alpha$  that minimized the sum of squared residuals was taken to be the optimum. The resulting estimates are listed in the first column of table 3.

These estimates all have the expected signs and are reasonably precise. However, regression diagnostics (see Belsley, Kuh, and Welsch 1980) identify five observations with excessive influence on the coefficient and variance estimates. Three of these are heavily cited "superstars," whose effects are to dramatically reduce the coefficient estimate for CITES.<sup>10</sup> In the light of this evidence, it was determined to calculate the returns to quality using estimations from both the full sample of 140 and a restricted sample that excludes these observations.

The specification search outlined above was repeated with the restricted sample. The coefficient estimates for the regression equation employing the optimal value of  $\alpha^* = 0.30$  are listed in column 2 of table 3. Note that for either sample a test of the hypothesis that  $\alpha = 0$  against  $\alpha = \alpha^*$  is rejected at the .01 level.

<sup>10</sup> The minimum effect of adding only one of these three observations to the remainder of the sample is to reduce the coefficient estimate for CITES by .001 (about 1/2 the value when the remainder of the sample is used).

TABLE 3  
COEFFICIENT ESTIMATES OF THE MONETARY RETURNS TO PUBLICATION

| Variable                   | Full Sample<br>(1) | Restricted Sample<br>(2) |
|----------------------------|--------------------|--------------------------|
| Page weight ( $\alpha^*$ ) | .15                | .30                      |
| Intercept                  | 10.06<br>(150.9)   | 10.08<br>(131.4)         |
| $\Gamma$                   | .614<br>(3.2)      | .560<br>(3.2)            |
| QPAGES                     | .0030<br>(4.6)     | .0033<br>(3.2)           |
| QPAGES <sup>2</sup>        | -7.2E-06<br>(2.8)  | -1.4E-05<br>(2.0)        |
| CITES                      | .0005<br>(2.2)     | .0021<br>(3.9)           |
| CITES <sup>2</sup>         | -1.6E-07<br>(.7)   | -4.6E-06<br>(3.3)        |
| BOOKS                      | .0014<br>(.1)      | .0122<br>(.5)            |
| BOOKS <sup>2</sup>         | .0005<br>(.6)      | -.0047<br>(.8)           |
| OPAPERS                    | .0012<br>(.6)      | .0011<br>(.5)            |
| OPAPERS <sup>2</sup>       | -1.6E-05<br>(.6)   | -1.5E-05<br>(.6)         |
| EXPER                      | .0178<br>(3.3)     | .0129<br>(1.9)           |
| EXPER <sup>2</sup>         | -2.5E-04<br>(2.1)  | 1.3E-04<br>(.7)          |
| YRAD                       | .0565<br>(4.9)     | .0560<br>(4.9)           |
| YRAD <sup>2</sup>          | -.0024<br>(3.8)    | -.0024<br>(3.8)          |
| Standard error             | .0212              | .0198                    |
| $\bar{R}^2$                | .696               | .656                     |

NOTE.—Numbers in parentheses are *t*-statistics.  $\Gamma$  is the estimated weight for coauthored research relative to single-authored research. Department-specific 0-1 dummy variables (DUMMY) range from -.074 to .209 for the col. 2 equation and are jointly significant at the .01 level. Pages in each journal are weighted by  $(w_j)^{\alpha^*}$ , where  $w_j$  is the impact-adjusted citation frequency for journal *j* and  $\alpha^*$  is the optimal weight.

It is clear from these estimates that citations and journal articles are the most important of the productivity indicators in determining salary. The coefficient estimates for BOOKS and OPAPERS are both low and imprecise. This result is in accord with earlier studies and may reflect the relatively poor measurement of these research indicators. The returns to administrative service are sizable, although they decline very fast. Given the opportunity costs involved, it may pay to be the chairperson, but not for very long.

The estimated  $\Gamma$  is 0.56 with a standard error of 0.18. Such a point estimate cannot tell us whether coauthors each receive returns more than  $1/n$  times that of a single author ( $1/n = 0.50$  here), yet it does

indicate that some form of discounting takes place. In particular, the maintained hypothesis that  $\Gamma = 1$  that has commonly been used can be rejected at the .05 level.<sup>11</sup> Following Leamer (1983), a battery of regressions were run to examine the sensitivity of the regression estimates to alternative specifications. The range of the  $\Gamma$  estimates was 0.429–0.689 with a mean of 0.555. We thus know that the table 3 estimate of  $\Gamma$  is not an outlier and can have some confidence in asserting that the weight for coauthored work is not much different from  $1/n$ .<sup>12</sup>

### B. Calculation of the Quality Gradient

Publication of an article appears to have a measurable impact on salary independent of citations.<sup>13</sup> The estimates in column 2 indicate that the incremental return from an AEQ page in the top-ranked journal (1.6 pages in the *J.P.E.*) is 0.17 percent of salary at the sample mean (\$72.27 in 1982 dollars). The gradient is such that an article of equivalent size in the tenth-ranked journal returns  $(0.3645)^{30}$  or 73.9 percent of an article in the top journal. Subsequent benchmarks are 45.3 percent for the fortieth- and 21.0 percent for the eightieth-ranked journals.

The full return from publication includes the additional effects from being cited. Articles published in the top journal during the 1975–79 period received 0.2522 citations per AEQ page in 1980 (Liebowitz and Palmer 1984). With a constant citation rate over the 7-year “citation period” in this study, the average 10-AEQ-page article in the top journal would yield an increment of 17.65 citations, which are estimated to yield 0.12 percent each, for a 2.09 percent increase in salary. For other journals, citations are less frequent. The estimated returns from citations as a percentage of the top journal range from 51.5 percent for the tenth-ranked journal to 17.2 percent for the eightieth-ranked journal.<sup>14</sup>

<sup>11</sup> With a  $\chi^2$  test based on the likelihood function, a 95 percent confidence interval for gamma was calculated as the range (0.29, 0.93).

<sup>12</sup> The alternative specifications used were all possible subsets obtained by (a) deleting all variables other than QPAGES, CITES, and DUMMY and (b) repeating the procedure above using (unlogged) salary as the dependent variable. Note that fairly narrow ranges for the incremental returns from QPAGES and CITES in *a* were obtained; these were 0.0012–0.0017 and 0.0012–0.0019, respectively, at the sample means.

<sup>13</sup> One would naturally expect QPAGES and CITES to be highly correlated, which is indeed the case. However, an analysis of the variance decompositions suggested by Belsley et al. (1980) revealed that the coefficient estimates for QPAGES and CITES are not degraded by collinearity problems. However, there is a “moderate” linear dependency between the intercept, EXPER, and EXPER<sup>2</sup>, which may help explain the imprecise estimates of the latter coefficients.

<sup>14</sup> See the Data Appendix for details on the construction of these estimates.

TABLE 4  
ESTIMATES OF THE QUALITY GRADIENT

| AVERAGE FULL RETURN<br>TO 10 AEQ PAGES<br>IN THE TOP JOURNAL | RETURNS FOR OTHER JOURNALS<br>AS A PERCENTAGE OF THE<br>TOP JOURNAL |        |        |        |
|--|---|--------|--------|--------|
|  | No. 10  | No. 20 | No. 40 | No. 80 |
|  | Restricted Sample   |        |        |        |
| .0380  | 61.6  | 53.1   | 34.1   | 18.9   |
|  | Full Sample   |        |        |        |
| .0286  | 74.3  | 68.5   | 53.0   | 36.2   |

NOTE.—The full return includes the calculated return from QPAGES and expected CITES. Each row is based on the corresponding coefficient estimates in table 3, the quality weights  $w_j^q$ , and the expected citations for each journal.

The full return to a 10-AEQ-page article in the top journal is thus estimated to be a 3.80 percent increase in salary (\$1,602 in 1982 dollars), which seems a sizable sum. For other journals, the return as a percentage of the top journal declines to 18.9 percent at the eightieth rank. This quality gradient is presented in greater detail in the first row of table 4. A gradient using the full-sample results is also presented in this table. Both estimates for the full return in the top journal are large, and the gradients are steep. Once one moves below the twentieth- or fortieth-ranked journal, returns drop to roughly one-half the return from the top journal. These figures clearly indicate that there are significant monetary returns to high-quality research in the economics profession.

#### IV. Concluding Remarks

The estimates given in this paper are obtained from a sample of academic economists from seven of the top 40 departments in the United States. While estimates of the coefficients of interest are both reasonably precise and insensitive to alternative specifications, the calculated monetary values will not be representative of particular departments, much less other disciplines. However, the broad commonalities in academic reward structures discussed above imply that qualitative inferences for other fields can be made from this study. Hence, one may infer that monetary returns to research quality in academia are measurably large and provide nonnegligible incentives to produce high-quality research. How effective these incentives are at influencing the behavior of scientists is a question that awaits further investigation.

## Data Appendix

This Appendix provides a more detailed description of the data collection and definition procedures. First, note that all coauthored work was recorded separately from single-authored work. Coauthored work with  $n > 2$  authors was weighted at  $2/n$  times work with two authors. Hence, for an article with three authors, each would receive  $2/3$  of what authors contributing to a two-author paper would receive. This means that if the coauthorship weight in the sample does not differ substantially from  $1/n$  ( $\Gamma = 0.50$ ), the three coauthors would receive a monetary return of  $2/3$  that of a single author.

Journal pages for articles listed on the vitae were recorded for each individual. Only articles published in the 108 journals listed in Liebowitz and Palmer (1984) were recorded under this variable. More often than not, recording pages entailed looking up the journal in which the article was published since page numbers were infrequently listed on the vitae. Comments and replies were not counted. Articles in annual conference proceedings (including the *A.E.R. Papers and Proceedings*) were included in the OPAPERS category.

All citations for the period 1976–82 other than self-citations and citations to textbooks were counted. Note that since the *Social Science Citations Index* attributes citations only to the first listed author, making an accurate count of citations to coauthored work often required searching for particular citations listed under a coauthor's name. The 1976–82 period was used for two reasons. First, it is unclear whether a stock of lifetime citations or the flow of very recent citations is the appropriate variable to use. Selecting a 7-year period amounts to a compromise on this issue. Second, this period is convenient since the *Social Science Citations Index* has a 5-year cumulative volume for 1976–80, which substantially reduces the cost of looking up citations for several years. The years 1981 and 1982 were also included since current citations are likely to measure current influence.

Any working paper or publication not listed in Liebowitz and Palmer (1984) was classified in OPAPERS. Similarly, any published book other than a textbook was counted in BOOKS. The varying qualities of the members of these variables may be partly responsible for the lack of precision in their estimated coefficients. Adopting a more rigorous classification scheme for these research indicators may yield more informative estimates but is beyond the scope of the current paper.

The ranking used in the paper is based on impact-adjusted citation frequencies. To calculate monetary returns from expected citations, estimates of (unadjusted) citation frequencies were used rather than actual measures. This was done to avoid problems stemming from the nonmonotonic relationship between the two actual measures. However, the differences between quality gradients based on the estimated and actual citation frequencies are very minor. Note also that Oromaner (1981, p. 89) and others have found that the frequency of citations to an article is "quite stable during the first (post-publication) decade." Hence, the simple method used to estimate the increment of citations due to publication of an article (cites per page times pages times years) has empirical justification.

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