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USING PUBLICATIONS COUNTS TO MEASURE AN INSTITUTION'S RESEARCH PRODUCTIVITY

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Studies that attempt to evaluate and rank institutions often overlook the research activities of an institution. In this article, we show how readily available data from the Institute of Scientific Inquiry (ISI) may be used to estimate the number of scholarly articles written by an institution's faculty. We show how institutions are ranked according to total publications and the ratio of publications to full-time faculty, how these measures vary by type of institution, and how they are correlated with other selected measures of research resources and institutional quality.

KEY WORDS: research; performance indicators; productivity.

INTRODUCTION

There have been many studies performed over time to examine various aspects of the productivity of faculty members, academic departments, and entire institutions in higher education (Baird, 1986, 1991; Braxton and Bayer, 1986; Creamer, 1998; Golden and Carstensen, 1992; Tien and Blackburn, 1996). By far, the majority of individual- and departmental-level studies have focused on measuring the research productivity of faculty. In his review of the literature on assessment efforts in higher education, Tan (1986) noted that assessments of individual and departmental research accomplishments are most often based at least in part on the number of publications produced over a specific time period and was critical of these studies for focusing almost exclusively on faculty research productivity and neglecting other aspects of quality.

Interestingly, studies that address institutional-level productivity often base their analysis solely on teaching activities and thus overlook the research activi-

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ties of an institution. This applies to both scholarly research studies as well as commercial publications such as *US News and World Report* (*USNWR*) and *Money Magazine* that rate institutions on the basis of readily accessible data on variables such as their expenditures per student and graduation rates. This also extends to institutions that use "performance indicators" to evaluate the effectiveness of their operations. As Toutkoushian and Danielson (2003) note, "The goal of advancement of knowledge through research is especially underrepresented among the sets of indicators that are used in higher education." Even institutional-level studies that use research measures as inputs, such as higher education cost studies, tend to rely on proxy measures for research productivity, such as dollars of sponsored research funding, rather than the same types of research output measures used in individual- and departmental-level studies (Cohn, Rhine, and Santos, 1989; de Groot, McMahon, and Volkwein, 1991; Nedwek, 1996). Furthermore, since these measures are rarely expressed on a per-capita basis, they tend to be biased in favor of larger institutions.

The lack of attention to institutional-level research output is surprising given the considerable resources that are devoted to its production. Full-time faculty on average published nearly two refereed or juried publications per year for 1997 and 1998, with the bulk of this activity being concentrated in research- and doctoral-level institutions (U.S. Department of Education, 2001b, Table 28). Institutions devote considerable resources to the production of research, spending a reported $19.5 billion on research in 1996–97 (U.S. Department of Education, 2001a, Tables 340 and 341). This figure substantially understates the financial commitment to research activities since faculty salaries are usually classified as an "instructional" expense and faculty report that over 25% of their work time is devoted to research (U.S. Department of Education, 2001b, Table 2). The federal government appropriated close to $16 billion in 1997 to support university research (U.S. Department of Education, 1997).

The focus on teaching-related measures and absence of research-related measures in institutional-level studies is driven by several factors. First, many of the higher education stakeholders who advocate for more accountability in higher education are primarily interested in the teaching functions of institutions of higher education (IHEs). This would certainly include college-bound high school students and their families who are looking for information to guide them in their college selection process. Second, information on the research output of institutions has not been readily available to those interested in evaluating and comparing institutions. Performance indicator systems, college rankings, and empirical studies are often forced to rely on accessible metrics such as expenditures per student, graduation rate, student–faculty ratios, and dollars received for sponsored research.

In this article, we show how readily available data on publications from the Institute of Scientific Inquiry (ISI) may be used to estimate the number of schol-

arly articles written by an institution's faculty. While there are some caveats and qualifiers with our approach, the resulting counts give rise to a reasonable proxy measure of an institution's research output that can be calculated for virtually any IHE and any year from 1990 forward. We also construct a standardized measure of research output by dividing total publications by the number of full-time faculty at the institution. We show how institutions are ranked according to these two publication measures, how the measures vary by type of institution, and how they are correlated with other selected measures of research resources and institutional quality.

LITERATURE REVIEW

The literature on faculty research productivity is quite voluminous and we will not attempt a comprehensive review of all relevant studies here. The vast majority of studies in this group have used either individual- or departmental-level data. These studies would include those that have tried to explain variations in research productivity as well as others that have used research productivity measures as independent variables in models of faculty earnings (Ransom and Megdal, 1993) and departmental reputations (Ehrenberg and Hurst, 1996). For our purpose, we focus on how individual- and departmental-level studies have represented research productivity. We then turn to studies using institutional-level data, and review how they have represented research productivity in their analysis. Finally, we review other institutional-level publications and studies, such as the *USNWR* rankings, performance indicators, and cost studies.

Individual- and Departmental-Level Studies

By far, the most commonly used measure of individual and departmental research productivity is the number of faculty publications in selected outlets such as academic journals (Baird, 1986, 1991; Creamer, 1998; de Groot et al., 1991; Dundar and Lewis, 1998; Fox, 1992; Golden and Carstensen, 1992; Johnes and Johnes, 1995; Jordan, Meador, and Walters, 1988; Porter and Umbach, 2001; Tien and Blackburn, 1996; Toutkoushian, Dundar, and Becker, 1998; Wanner, Lewis, and Gregorio, 1981), or a summative index constructed from counts of conference papers, journal publications, and books (Bellas and Toutkoushian, 1999; Buchmueller, Dominitz, and Hansen, 1999; Noser, Manakyan, and Tanner, 1996; Perry, Clifton, Menec, Struthers, and Menges, 2000). Usually these are limited to a specific period of time and are not adjusted for prestige of publication source or multiple authorships. (See Tan, 1986 for a review of the earlier literature on this topic.) It has also become quite common for researchers to rank departments within a specific field on the basis of their total publications (Bell and Seater, 1978; Borokhovich, Bricker, Brunarski, and

Simkins, 1995; Graves, Marchand, and Thompson, 1982; House and Yeager, 1978; Miller and Tollison, 1975).

Studies focusing on publication counts have, however, been criticized because they vary across disciplines due to the nature of the work being performed and the conventions for communicating research (Wanner et al., 1981) and do not take into account the quality of research (Braxton and Bayer, 1986), except to the extent that it has passed through peer review (Manis, 1951).[1] In response, some scholars have used the number of citations received by an individual faculty member to measure their research productivity (Diamond, 1986; Lindsey, 1989; Long and McGinnis, 1981; Toutkoushian, 1994) as well as rank departments (Davis and Papanek, 1984; Gerrity and McKenzie, 1978). Citation counts are also not without their concerns and limitations.[2] Other studies, such as Baird (1986), Gander (1999), Porter and Umbach (2001), have used the level of research grant dollars received as a measure of research activities. However, it may be argued that this measure is more properly viewed as an input to the production of research rather than an outcome from research activities.

Institution-Level Studies and Rankings

In contrast to the literature cited above, fewer studies compare institutions on the basis of institutional-level research data. The practice of using empirical data to compare and rank institutions dates back to Hughes (1925, 1934), who surveyed scholars in specific fields and used the results to rate 38 institutions on the basis of their aggregate ratings. Similar procedures were used by Keniston (1959), Webster (1983), Patrick and Stanley (1998), and Keith (1999). These studies all relied on subjective (survey) data to rate institutions.

One of the first efforts to use objective data for ranking institutions is by Bowker (1965). Bowker rated institutions on the basis of several criteria, including the number of faculty who have received the American Council of Learned Societies Award, or been named a Woodrow Wilson fellow, and the number of students attending the institution who have won National Science Foundation awards. Brown (1967) also devised college ratings on the basis of their average ranking for eight measures: (a) percentage of faculty possessing a doctorate degree, (b) average faculty compensation, (c) percentage of students going on to graduate school, (d) percentage of students at the graduate level, (e) total library volumes per student, (f) number of full-time faculty, (g) student–faculty ratio, and (h) current income per student. Adams and Krislov (1978) argued in favor of ranking institutions on the basis of average faculty salaries. They claimed that this approach had the advantage of readily accessible data and that faculty salaries were a good measure of faculty—and hence institutional—quality.

More recently, TheCenter at the University of Florida produced a report titled

The Top American Research Universities (Lombardi, Craig, Capaldi, Gater, and Mendonca, 2001). In this report, the authors derived rankings for universities based on nine measures that they argued were indicators of quality for research universities: (a) research expenditures, (b) federal research funding, (c) endowment assets, (d) alumni donations, (e) number of National Academy of Sciences members, (f) number of faculty receiving other awards, (g) number of doctorate degrees granted, (h) number of postdoctoral appointees, and (i) median SAT score of freshmen. TheCenter ranked institutions on the basis of the number of measures in which the institution was rated in the top 25 nationally. Interestingly, TheCenter does not utilize any direct measures of research output, such as publication counts, in their rankings of research universities. In contrast, Zheng and Stewart (2002) use data on faculty publications, citations, and research dollars awarded to rank public research universities using data envelopment analysis. Their analysis relies on a causal model to predict research output, and institutions are then ranked according to their efficiency in producing output.

The practice of evaluating and comparing IHEs has received greater attention due to efforts by commercial entities such as *USNWR*. The *USNWR* ratings are based on a weighted-average score derived from the following measures: (a) academic reputation, (b) retention and graduation rates, (c) faculty salaries, (d) student–faculty ratio, (e) percentage full-time faculty, (f) percentage small and large classes, (g) high school rank, SAT scores, acceptance rate and yield rates for freshmen, (h) expenditures per student, and (i) alumni giving rate. Notably absent from the *USNWR* criteria are any measures of the research activities of IHE. As noted by Graham and Thompson (2001), the *USNWR* rankings tend to measure the "school's wealth, reputation, and the achievement of the high school students it admits" (p. 3). Even vocal critics of the *USNWR* rankings admit, however, that prospective students often use this information to help them decide where to attend college. Empirical work has verified the strong impact that *USNWR* rankings have on admissions outcomes such as proportion admitted and proportion matriculating (Monks and Ehrenberg, 1999).

Finally, another set of research studies relies on institutional-level data to explain variations in costs per unit of output in higher education (Brinkman, 1981; Cohn et al., 1989; de Groot et al., 1991; Koshal and Koshal, 1999). These studies are relevant to the current discussion since they recognized early on that IHEs produce outputs in the areas of teaching and research, and thus had to address the measurement of institution-level research output. The most commonly adopted approach was to use sponsored research dollars or contracts as a measure of research activities/productivity (Brinkman, 1981; Cohn et al., 1989; Koshal and Koshal, 1999; Southwick, 1969; Toutkoushian, 1999).

A notable exception is de Groot et al. (1991), who used publication counts for graduate programs in 147 doctorate-granting institutions. The data, made

available through a study conducted by the Conference Board of Associated Research Councils (Jones, Lindzey, and Coggeshall, 1982), accounted for approximately 58% of all publications according to the authors of the study (de Groot et al., McMahon, and Volkwein,1991). Webster and Skinner (1996) and Diamond and Graham (2000) have also highlighted rankings of institutions on the basis of the graduate program assessments from the 1995 NRC study. One major limitation of using the graduate program survey as a means for collecting publication data are that there are substantial intervals between surveys (the two NRC studies were conducted in 1982 and 1993), and thus researchers may not be able to use current data in their analyses.

Two quick observations are worth noting at this point. First, in contrast to departmental-level studies, studies that attempt to evaluate and rank institutions often overlook the research activities and accomplishments of the faculty. When these studies do acknowledge research, it is usually through metrics, such as total spending on research, which can be readily obtained. These measures, however, often represent the resources available for producing research rather than the quantity or quality of research actually produced by the institution. Second, the wide variation in measures used to examine institutional quality suggests that developers of measures are not relying on a theoretical framework for the selection of measures to evaluate institutions. Such a framework would suggest that the measures be related to the goals and objectives of the organization, and accordingly research measures should be included along with teaching measures in the analysis.

There are also many instances where institutional researchers rely on institutional-level variables, commonly referred to as "performance indicators," in an attempt to evaluate and compare institutions. The general practice in higher education applications is to first identify a set of specific indicators, and then compare the values of these indicators to other institutions and track changes in them over time (Banta and Borden, 1994; Gaither, Nedwek, and Neal, 1994). The focus on empirical data means that the analyst must be able to calculate the indicator for his or her institution and for other institutions to which comparisons will be made.

The interest in assessment has seemingly taken on a life of its own in the past ten years. Most IHEs now rely on indicators to monitor how well they are doing, and states such South Carolina tie the level of higher education funding to such indicators (South Carolina Commission on Higher Education, 2002). Proponents of such assessment efforts argue that by tracking designated indicators, institutions can "take steps to improve their competitive position" (Taylor and Massy, 1996, p. xv), and determine "whether the college or university is accomplishing its goals" (Dolence and Norris, 1994, p. 64). With this in mind, it is curious to observe that most of the performance indicators in use in higher education have very little, if any, direct connection to the research mission of

postsecondary institutions. For example, of the more than 100 indicators identified by Taylor and Massy (1996), only one variable—federal grants and contracts as a percentage of total current funds revenues—even remotely serves as a proxy for the research productivity of faculty. Likewise, most of the examples of performance indicator systems described by Banta and Borden (1994) and Gaither et al. (1994) do not include the publishing frequency of faculty.

Why, then, do institutional-level research studies, institutional rankings, and performance indicator systems rarely if ever utilize information on research publications when the literature on individual and departmental productivity clearly suggests that they should matter? In large part, the problem is that data on institution-level research productivity has been difficult to obtain. As noted by Cohn et al. (1989)

> Ideally, one should measure the various components of research output, such as publications, research reports, patents, public lectures, and other results of one's research work. Such a measure of output would be hard enough to produce for a single academic department, let alone for a large sample of IHEs. (p. 285)

Studies of individual- or departmental-level productivity often rely on surveys of faculty to collect data on their publications, since this information is rarely collected centrally by IHEs. In contrast, data on sponsored research dollars received are readily accessible to analysts for virtually all institutions through the IPEDS surveys sponsored by the National Center for Education Statistics.

MEASURING AN INSTITUTION'S PUBLICATIONS

To help bridge the gap between the treatment of research in individual/departmental studies and institutional studies, we show how readily accessible data on publications compiled by the ISI can be used to derive a proxy measure of an institution's research output. The Institute is responsible for producing the *Science Citation Index*, the *Social Science Citation Index*, and the *Arts and Humanities Index*. While these indexes are most often used for tracking the citations accrued to specific publications, they also function as a database for articles published in specific journals. The three indexes do not include all academic journals in each field, but are fairly comprehensive in their coverage; together they include more than 6,600 scholarly journals in over 200 academic disciplines.[3] Many institution libraries receive annual editions of the citation indexes in CD-ROM format, and other institutions subscribe to an on-line version of the databases. More details on the ISI databases and their coverage can be found on the ISI website (http://www.isinet.com/isi/).

The set of institutions that we examine are taken from the list of approximately 1,300 4-year colleges and universities appearing in the June 1998 edition

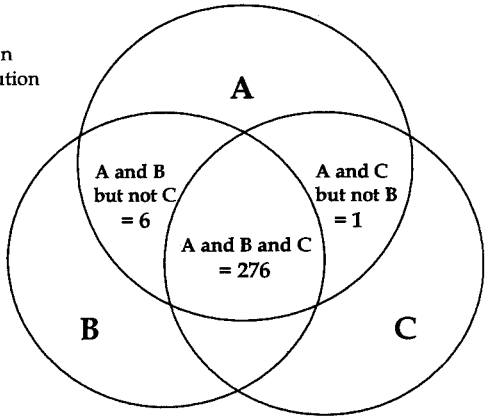
of *USNWR*'s "Best Colleges" issue with data on acceptance rates, graduation rates, and average SAT scores of freshmen. We used the ISI databases to estimate the total number of publications that were attributed to individuals at each of these institutions in 1996. Separate searches were conducted for the *Science Citation Index*, *Social Science Citation Index*, and *Arts and Humanities Index*.[4] We restricted our searches to English-language articles published in academic journals during the calendar year 1996.[5]

To obtain publication counts for each institution, we began by identifying the number of journal articles where one or more authors listed the institution as their affiliation. From this set, we only counted those publications where either the name of the town or the zip code matched the list of towns and zip codes that normally correspond with the institution. If publication counts were based solely on the institution name, then institutions with branch campuses or having the same name as an institution in another state would have inflated publication counts. The initial set of town names and zip codes for each institution were obtained from the *Higher Education Directory* (Rodenhouse, 2001), and then other towns and zip codes were added based on a manual review of the publications found for each institution name. The use of both town names and zip codes was done to ensure that we would not exclude publications with the correct town name but an incorrect or missing zip code, or the correct zip code and an incorrect/missing town name. We also reviewed all of the remaining publications to ensure that they either were associated with a branch campus of the institution in question or were from an institution with the same name but in another state.[6] The search process was then repeated for other possible variations of institutional names.

The counting process is perhaps best illustrated with an example for the University of Maine, as shown in the Venn diagram in Fig. 1. The University of Maine is located in the town of Orono, Maine, with the affiliated zip codes of 04469 and 04473. There were 431 publications where the institutional name for one or more authors was University of Maine (set A), 294 publications where the town of one or more authors was Orono (set B), and 285 publications where the zip code for one or more authors was 04469 or 04473 (set C). There were 148 articles that list the University of Maine as the institution but have a different town and zip code (118 from the University of Maine in France). Similarly, we found 12 publications that identified the town as Orono but the institution as something other than the University of Maine (including Argentina and the U.S. Geological Survey Wildlife Center).

The counts that we derived for each institution were based on the combination of institution name and either zip code or town. We found a total of 276 articles where the institution name was University of Maine, the town name was Orono, and the zip code was either 04469 or 04473. In addition, there were six articles with the correct institution name and town but a different zip code (four articles

Circle A = Institution Name
Circle B = Towns corresponding to Institution
Circle C = Zip codes corresponding to Institution



Breakdown of articles for the University of Maine:

Category	Number of articles	
University of Maine (A)	= 431	
Town of Orono (B)	= 294	
Zip codes of 04469 or 04473 (C)	= 285	
A and B	= 282	
A and C	= 277	
A and B and C		= 276
A and B but not C		= 6
A and C but not B		= 1
Total publication count for the University of Maine		= 283

FIG. 1. Venn diagram of search process used to count institutional publications for the University of Maine, 1996.

had missing zip codes and two articles had zip codes outside of Orono) and one article with the correct institution name and zip code but a different town (the town name was listed as Crono). Combined, there were 283 journal articles with the correct institutional name and either the correct town or zip code or both. This was the final count that we used for this institution.

There are, of course, some important limitations to this approach that must be explained before proceeding. First, our searches of the ISI databases only included scholarly journals and thus exclude many other forms of publication, including books, book reviews, corrections, editorial material, and letters. Thus, institutions that have a comparatively large focus on arts or humanities may appear less productive as these areas place less emphasis on publishing in scholarly journals. Second, despite the impressive breadth of coverage of the ISI databases, there are other academic journals and publication outlets that are not monitored by the Institute and therefore are not included in their databases.

Third, publications that list a particular institution but have an address that is not regularly associated with the institution will not be included in the institution's total publication count. This would pertain to faculty who are on sabbatical and might report a different town and zip code as their location. Fourth, publications that do not list the institutional affiliations of the authors will not be included in the publication count. Fifth, publications are not weighted by number of authors, so a publication with three authors at three different institutions is counted three separate times and is weighted the same as a single-author piece. Despite these limitations, we believe that the resulting publication counts provide a reasonable proxy for the institutional total. While some of the issues described here could be addressed through searches on lists of individuals, presuming that one could obtain lists of appropriate individuals for a large number of schools, this would be extremely time consuming and difficult to conduct, especially on an annual basis.

In an effort to produce a more standardized measure of institutional research output, we divided the total publication counts by the number of full-time faculty to calculate the ratio of publications to full-time faculty.[7] The faculty headcounts were obtained from the IPEDS Faculty Salary survey for the 1996 academic year and include only full-time faculty at the ranks of Full Professor, Associate Professor, Assistant Professor, and Instructor. It is important to note, however, that this ratio should not be confused with the average publications per faculty for several reasons. First, as described earlier, not all publications will be included in the institution's total. More importantly, some of the publications attributed to the institution may have been written by individuals who are affiliated with the institution but are not full-time faculty. This would potentially include graduate students, adjunct faculty, part-time but tenure-eligible faculty, other faculty not reported by institutions to IPEDS, and professional/administrative staff who might be engaged in research. Finally, using this procedure means that the credit for publications that are coauthored by faculty members at the same institution is only attributed to one individual, even though each would claim some credit for the publication.

EMPIRICAL RESULTS

Figure 2 shows the distribution of institutional publications, along with selected descriptive statistics for the whole sample. Not surprisingly, the distribution of institutional publications is highly skewed to the right, with the skewness being even greater than is apparent in the figure since institutions are placed into groups of unequal size based on their publication level. This skewness can also be seen by the fact that the mean number of publications (168) greatly exceeds the median (6). Close to 20% of the 1,309 4-year institutions in our

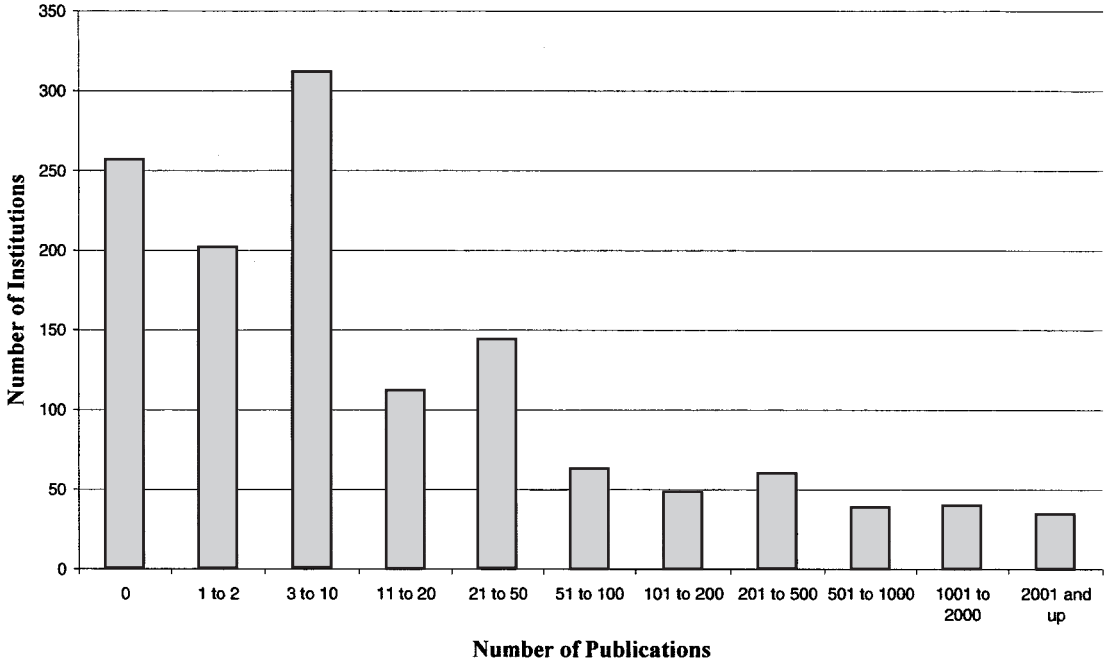


FIG. 2. Frequency distribution of total publications by institution, 1996.
Notes: Mean = 167.19; Median = 6.00; Standard Deviation = 553.17; Minimum = 0; Maximum = 7,243.

analysis had zero publications in 1996, and at the other extreme, only 13% of the institutions were found to have 200 or more publications.

Figure 3 presents similar descriptive information on the ratio of publications to faculty for the institutions in our sample. Due to missing values for some institutions on the number of faculty, our sample decreases to 1,283 institutions. Again, we found that the distribution of the ratio of publications to faculty is highly skewed to the right, with two thirds of the institutions having a ratio of 0.10 or lower (meaning that there are 10 or more faculty for every one publication). Likewise, less than 7% of the institutions have a ratio of publications to faculty than exceeds one.

We next ranked all of the institutions from highest to lowest according to total publications in 1996 and list the top 100 institutions in descending order in Table 1. Harvard University was easily the leading producer of total publications, with 7,243 for the calendar year 1996. The University of California System placed four of its institutions among the top 20 in the nation, with UCLA placing second, UC–Berkeley ranking third, UC–San Diego eleventh, and UC–Davis in seventeenth place. Other institutions that appeared in the top 10 based on their total publications were the University of Washington, the University of Minnesota, Stanford University, The University of Michigan, the University of Wisconsin, Johns Hopkins University, and the University of Pennsylvania. The rankings based on total publications are similar to those produced by TheCenter, with 19 institutions appearing in the top 24 for both lists.

One limitation of the rankings of institutions shown in Table 1, however, is that they will be biased toward larger institutions since total publications are not expressed on a per-capita basis. Accordingly, we also ranked institutions from high to low on their ratio of publications to full-time faculty. These results are shown in Table 2.

While many of the institutions that are highly ranked on the basis of total publications are also highly ranked according to the ratio of publications to full-time faculty, some smaller institutions that are nonetheless heavily involved in research rank higher in terms of per-capita research production. We found that California Institute of Technology had the highest ratio of publications to full-time faculty (7.63) and easily outpaced the second place institution Harvard (6.48), even though they were in 37th place based on total publications. Some "smaller" institutions that managed to move up in the rankings when output was expressed on a per-capita basis include Case Western Reserve University (10), the University of Maryland at Baltimore County (11), the University of Rochester (15), Tufts University (17), Wake Forest University (26), UC–Riverside (33), and Yeshiva University (40).

Rankings based on the ratio of publications to full-time faculty give rise to notably different rankings than those shown by TheCenter, with only 12 institutions appearing in the top 24 for both lists. In particular, larger institutions

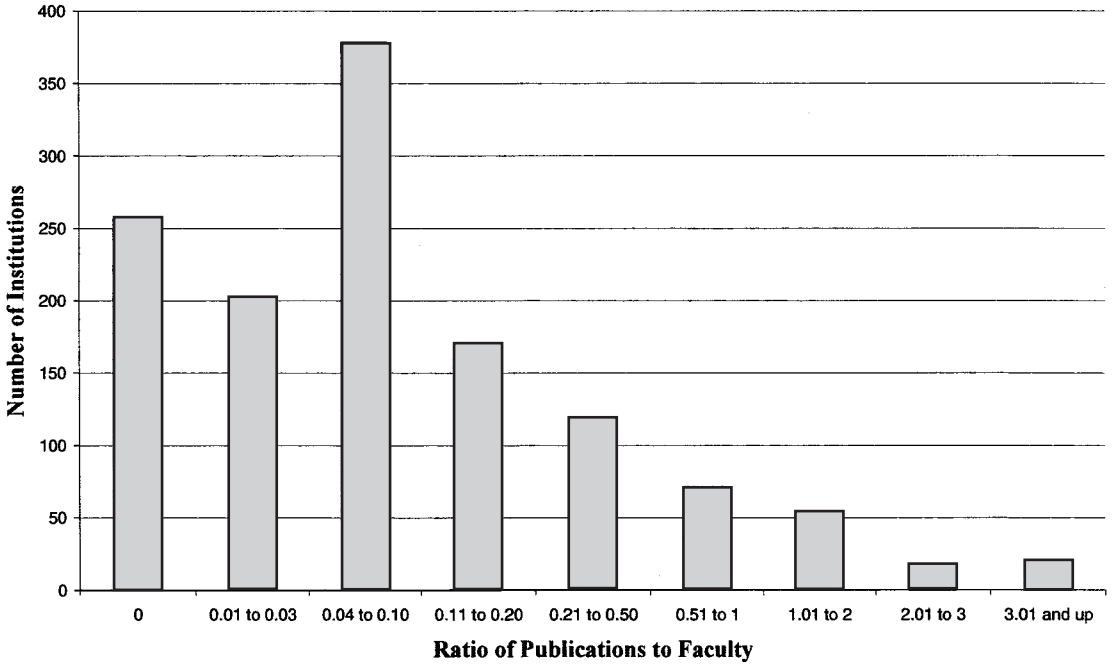


FIG. 3. Frequency distribution of ratio of publications to faculty, 1996.
Notes: Mean = 0.260; Median = 0.056; Standard Deviation = 0.643; Minimum = 0; Maximum = 7.63.

TABLE 1. Total Publications by Institution, 1996

Rank	Institution	Number of Publications	Rank	Institution	Number of Publications
1	Harvard University	7,243	51	U. Alabama–Birmingham	1,446
2	UC–Los Angeles	4,428	52	University of Georgia	1,437
3	UC–Berkeley	3,900	53	Iowa State University	1,433
4	University of Washington	3,797	54	U. Colorado–Boulder	1,404
5	U. Minnesota–Twin Cities	3,783	55	Northwestern University	1,381
6	Stanford University	3,759	56	UC–Santa Barbara	1,372
7	University of Michigan	3,758	57	Wayne State University	1,324
8	Univ. of Wisconsin-Madison	3,634	58	Brown University	1,310
9	Johns Hopkins University	3,420	59	U. Maryland-Baltimore Cnty	1,308
10	University of Pennsylvania	3,417	60	Tufts University	1,295
11	UC–San Diego	3,264	61	Virginia Tech	1,259
12	University of Pittsburgh	3,110	62	Tulane University	1,248
13	Columbia University	2,982	63	Georgia Institute of Tech.	1,175
14	MIT	2,920	64	Indiana University	1,151
15	Duke University	2,911	65	Arizona State University	1,150
16	Yale University	2,841	66	U. Missouri–Columbia	1,147
17	UC–Davis	2,774	67	SUNY–Buffalo	1,142
18	University of Florida	2,724	68	Louisiana State U.	1,098
19	U. Illinois	2,584	69	Colorado State University	1,035
20	Emory University	2,563	70	Univ. of Tennessee–Knoxville	1,006
21	Cornell University	2,447	71	University of New Mexico	1,005
22	University of Chicago	2,389	72	Virginia Commonwealth U.	967
23	Ohio State University	2,339	73	Georgetown University	961
24	Washington University	2,337	74	U. Massachusetts–Amherst	938
25	University of Arizona	2,266	75	Carnegie Mellon University	933

26	Univ. of Southern California	2,262	76	Oregon State University	917
27	Pennsylvania State U.	2,185	77	University of South Florida	903
28	Michigan State U.	2,174	78	University of Nebraska	901
29	U of North Carolina	2,166	79	Washington State University	882
30	University of Iowa	2,151	80	Florida State University	845
31	University of Texas-Austin	2,133	81	University of Connecticut	840
32	Texas A and M Univ. College	2,117	82	Temple University	837
33	U. Maryland–College Park	2,044	83	University of Delaware	801
34	Purdue Univ–West Lafayette	2,006	84	UC–Riverside	784
35	Case Western Reserve U.	1,934	85	University of Houston	761
36	New York University	1,908	86	Kansas State University	754
37	California Institute of Tech.	1,900	87	Auburn University	753
38	University of Virginia	1,837	88	Wake Forest University	752
39	Rutgers-New Brunswick	1,740	89	U. South Carolina–Columbia	687
40	Boston University	1,664	90	George Washington U.	682
41	U. Illinois–Chicago	1,655	91	University of Kansas	666
42	University of Utah	1,633	92	St. Louis Univ.	640
43	University of Rochester	1,584	93	University of New Orleans	636
44	UC–Irvine	1,571	94	West Virginia University	625
45	SUNY–Stony Brook	1,561	95	UC–Santa Cruz	612
46	North Carolina State U.	1,519	96	University of Vermont	605
47	Princeton University	1,509	97	University of Nebraska	601
48	Vanderbilt University	1,500	98	University of Notre Dame	599
49	University of Cincinnati	1,458	99	University of Louisville	552
50	University of Kentucky	1,455	100	SUNY–Albany	551

Notes: Publication counts for each institution were derived from the *Science Citation Index, Social Science Citation Index,* and *Arts and Humanities Index*. Counts are for English-language articles indexed in one of the three databases for 1996.

TABLE 2. Top 50 Institutions Based on Ratio of Publications to Full-Time Faculty

Rank	Institution	Number of Publications	Number of full-time faculty	Publications to FT Faculty
1	California Institute of Technology	1,900	249	7.63
2	Harvard University	7,243	1117	6.48
3	Johns Hopkins University	3,420	666	5.14
4	Univ. of California–San Diego	3,264	644	5.07
5	Emory University	2,563	546	4.69
6	Stanford University	3,759	827	4.55
7	Duke University	2,911	649	4.49
8	Yale University	2,841	718	3.96
9	Washington University	2,337	604	3.87
10	Case Western Reserve Univ.	1,934	519	3.73
11	U. of Maryland–Baltimore County	1,308	354	3.69
12	University of Pennsylvania	3,417	977	3.50
13	Univ. of California–Los Angeles	4,428	1311	3.38
14	University of California–Berkeley	3,900	1161	3.36
15	University of Rochester	1,584	489	3.24
16	University of California–Davis	2,774	861	3.22
17	Tufts University	1,295	413	3.14
18	Massachusetts Inst. of Technology	2,920	936	3.12
19	University of Chicago	2,389	814	2.93
20	Tulane University	1,248	436	2.86
21	University of California–Irvine	1,571	572	2.75
22	Brown University	1,310	488	2.68
23	Univ. of Minnesota–Twin Cities	3,783	1499	2.52
24	University of Pittsburgh	3,110	1252	2.48
25	Wake Forest University	752	318	2.36
26	Univ. of Wisconsin–Madison	3,634	1546	2.35
27	Univ. of California–Santa Barbara	1,372	593	2.31
28	Vanderbilt University	1,500	653	2.30
29	Princeton University	1,509	662	2.28
30	University of Washington	3,797	1698	2.24
31	University of Michigan–Ann Arbor	3,758	1712	2.20
32	Univ. of California–Riverside	784	371	2.11
33	University of Alabama–Birmingham	1,446	714	2.03
34	SUNY–Stony Brook	1,561	780	2.00
35	University of Iowa	2,151	1080	1.99
36	Univ. of Southern California	2,262	1165	1.94
37	University of Virginia	1,837	955	1.92
38	U of North Carolina–Chapel Hill	2,166	1156	1.87
39	Yeshiva University	387	208	1.86
40	Georgia Institute of Technology	1,175	634	1.85
41	Carnegie Mellon University	933	507	1.84

TABLE 2. (*Continued*)

Rank	Institution	Number of Publications	Number of full-time faculty	Publications to FT Faculty
42	University of Utah	1,633	905	1.80
43	Georgetown University	961	546	1.76
44	University of Arizona	2,266	1303	1.74
45	Cornell University	2,447	1417	1.73
46	Wayne State University	1,324	784	1.69
47	Univ. of Maryland–College Park	2,044	1221	1.67
48	Univ. of California–Santa Cruz	612	371	1.65
49	St. Louis University	640	388	1.65
50	New York University	1,908	1,189	1.60

Notes: Publication counts for each institution were derived from the *Science Citation Index*, *Social Science Citation Index*, and *Arts and Humanities Index*. Counts are for English-language articles indexed in one of the three databases for 1996. Faculty headcounts were obtained from the IPEDS Faculty Salary survey for 1996.

such as the University of Michigan, the University of Minnesota, and Columbia University tended to be lower when based on the ratio of publications to full-time faculty. In Table 3, we provide a comparison of how the top 10 institutions according to total publications or the ratio of publications to full-time faculty compare with the top 10 lists from three alternative institutional rankings: (a) TheCenter's research university rankings for 2001 (Lombardi et al., 2001), (b) the average scholarly quality of faculty in 1993 according to the National Research Council study (Diamond and Graham, 2000; Webster and Skinner, 1996), and (c) the overall institutional score in 1996 for national universities according to *USNWR* (1998). The first column shows the top 10 institutions when ranked according to either total publications or the ratio of publications to full-time faculty. The numbers shown in each column denote the respective ranking for the same institution in the alternative rankings. *USNWR* also groups institutions into four "tiers," with tier 1 being those institutions with the highest ranking and tier 4 the lowest rankings. The numbers shown for most of the institutions in the *USNWR* column denote their ranking within the top tier.

One might expect some differences in rankings to emerge due to the timing at which the various measures were produced (1993, 1996, and 2001) and the types of metrics being examined. As noted earlier, however, only the *USNWR* rankings are updated on an annual basis, making comparisons across rankings tenuous at best. Nonetheless, there is a fair amount of overlap between the rankings based on research output and the other three rankings. The rankings produced by TheCenter clearly are more closely aligned with the institutional

TABLE 3. Comparison of Alternative Institutional Rankings

Rankings Based on Total Publications		Rankings Based on		
Rank	Institution	TheCenter[a]	NRC Reputation Score[b]	USNWR Overall[c]
1	Harvard University	1	3	1
2	UC–Los Angeles	12	12	28
3	UC–Berkeley	8	2	23
4	U Washington	15	17	Tier 2
5	U Minnesota	8	23	Tier 2
6	Stanford University	1	6	5
7	U Michigan	8	12	23
8	U Wisconsin	12	15	38
9	Johns Hopkins U	6	20	14
10	U Pennsylvania	1	14	7

Rankings Based on Ratio Publications to FT Faculty		Rankings Based on		
Rank	Institution	TheCenter[a]	NRC Reputation Score[b]	USNWR Overall[c]
1	California Institute of Tech.	26	4	9
2	Harvard University	1	3	1
3	Johns Hopkins U	6	20	14
4	UC–San Diego	21	10	33
5	Emory University	38	32	9
6	Stanford University	1	6	5
7	Duke University	8	20	3
8	Yale University	16	8	3
9	Washington U	16	34	17
10	Case Western Reserve U	50+	50+	37

[a]Rankings of research universities for 2001 as derived by TheCenter (Lombardi et al., 2001). *The Top American Research Universities*. Gainesville, FL: TheCenter, University of Florida.
[b]Rankings for 1993 based on the average scholarly quality of faculty, 1993 NRC graduate program survey. See Diamond and Graham (2001), Table II.
[c]Rankings based on overall score in 1996 as reported by *U.S. News and World Report* (1998).

rankings based on total publications. Interestingly, the *USNWR* rankings are the most similar to the rankings based on the ratio of publications to full-time faculty. Except for Case Western Reserve University, most of the institutions that were in the top 10 on the basis of total publications or the ratio of publications to full-time faculty rated highly in the other lists as well.

Correlates of Research Productivity

The rankings of institutions shown in Tables 1 and 2 provide no information as to why some institutions are more highly ranked than others are. When looking at the research output of a large number of institutions, it is important to acknowledge that not all IHEs place the same emphasis on teaching and research. This emphasis is likely to vary according to mission, which can be reflected in part by classification. In Table 4, we provide breakdowns of average total publications and average ratios of publications to faculty by type of institution. The breakdowns are shown for both the Carnegie classifications of institutions in 1996 as well as the classification scheme used by *USNWR*.

Table 4 shows that, not surprisingly, the vast majority of research is produced by research- and doctoral-level institutions. Likewise, institutions that are not in the National University category for *USNWR* on average produce fewer than 30 publications per year. Interestingly, we can see that the Carnegie classifications are not a completely linear predictor of research productivity. The ratio of publications to faculty drop as we move down from Research I institutions to Doctoral I institutions, but Doctoral II institutions produce more publications per faculty member than Doctoral I institutions. In addition, Baccalaureate I institu-

TABLE 4. Breakdown of Mean Total Publications and Ratio of Publications to Full-Time Faculty by Institution Type

Institution Type	Mean: Total Publications	Mean: Ratio of Publications to Faculty	Number of Observations
Carnegie Classification			
Research I	1,886	2.04	83
Research II	548	0.91	36
Doctoral I	171	0.35	48
Doctoral II	205	0.56	54
Master's I	30	0.10	398
Master's II	4	0.04	88
Baccalaureate I	19	0.14	158
Baccalaureate II	2	0.03	404
USNWR Classifications			
National universities	891	1.12	227
National liberal arts	19	0.14	159
Regional universities	25	0.09	500
Regional liberal arts	2	0.03	421
All Institutions	168	0.26	1,309

Notes: Totals of categories do not add up to 1,309 due to some institutions having missing data on either the number of faculty and/or institutional classifications.

tions are slightly *more* productive than both Master's I and Master's II institutions, while Master's II and Baccalaureate II institutions appear very similar. The reasons for these variations are unclear, but suggest that the criteria previously used by the Carnegie Commission for assigning institutions to various classes (based on degrees awarded and sponsored research dollars) provide less information about the production of research output at levels below the Research II category.

In Table 5 we explore how these two measures of research output are correlated with commonly used research measures and other popular higher education quality indicators. The first variable is the level of research expenditures at the institution, as reported on line 023 of the IPEDS Finance Survey, Part B. As we mentioned in the Introduction, this quantity understates the true level of research expenditures at the institution since some portion of faculty salaries, normally reported on line B013, are also used to support research. The second variable we examine is the level of federal research dollars received by the institution (line 063 from IPEDS Finance Survey, Part A). We created two additional variables by dividing these dollar totals by the number of full-time faculty, in an effort to express these metrics on a per-capita basis, and also considered the average salary for Full Professors. The final three variables we focus on here are not directly related to the research activities of an institution but are often considered to be measures of institutional quality. These three factors, all obtained from the June 1998 Best Colleges edition of *USNWR*, are the average 6-year graduation rate for the institution, the percentage of applicants admitted to the institution, and the 25th percentile of SAT scores for freshmen.

TABLE 5. Correlations of Total Publications and Ratio of Publications to Full-Time Faculty with Other Measures

Variable	Total Publications	Ratio: Publications to FT Faculty
Research expenditures	+0.93**	+0.78**
Research expenditures/faculty	+0.77**	+0.84**
Federal research revenues	+0.91**	+0.81**
Federal research revenues/faculty	+0.63**	+0.74**
Average full professor salary	+0.40**	+0.48**
6-Year graduation rate	+0.03	+0.04
Freshman acceptance rate	+0.03	+0.03
Freshman SAT score (25th)	+0.15**	+0.17**

Notes: Data on research expenditures, federal research revenues, number of faculty, and average full professor salary are taken from IPEDS Finance and Faculty Salary surveys for FY96. Data on the six-year graduation rate, freshman acceptance rate, and freshman SAT score are taken from *U.S. News and World Report* (1998). $N = 1{,}309$.

**$p < .01$ (two-tailed test).

The correlations in Table 5 show that the two institutional publication output measures we present here are highly correlated with the level of research expenditures and revenues at the institution. Clearly, one of the main reasons why some institutions are more highly ranked than others is that they devote more financial resources to the production of research. Significant, but smaller, correlations were found between the two publication measures and average faculty salaries, suggesting that institutions with higher average salaries are more successful at attracting faculty who are productive in research. Other factors not examined here, such as the institution's relative emphasis on engineering and natural sciences, could also contribute to some of the observed variations across institutions in their research output. Finally, with the exception of freshmen SAT scores, we found little evidence that publications were correlated with the three nonresearch measures that we considered. Although statistically significant, the correlations for SAT scores are quite low, especially in comparison to the correlations for research money and salaries.

SUMMARY AND DISCUSSION

In this study, we showed how available data on the publications of faculty can be used to derive institution-level measures of research output. The construction of these measures has been aided in recent years by the release of data on CD-ROM and on-line databases, allowing users to quickly perform searches by institution. By combining publication data with information on the number of faculty at an institution, the total output measure can also be expressed on a per-capita basis. We have shown that this can be especially relevant for smaller institutions that still provide a significant amount of emphasis toward research.

Institutional researchers, especially those employed by doctoral-granting institutions, would also find this measure to be valuable for developing output-related strategic indicators for their institution. The University System of New Hampshire, for example, uses data on institutional publications to compare the ratio for our institutions to their officially adopted comparator institutions. This information is reported on an annual basis to the Board of Trustees and other education stakeholders through the *USNH Strategic Indicator* report. Table 6 shows, for example, how the University of New Hampshire compares in terms of their ratio of publications to faculty to the other five land-grant universities in New England.

The lack of attention given to an institution's research accomplishments is troubling because the resulting assessments and rankings of institutions overlook an important facet of their mission. The importance of this omission depends in part on whether teaching and research are net substitute or complementary activities. If teaching and research are not substitute activities, as suggested by Braxton (1996), Gavlick (1996), Bray, Braxton, and Smart (1996), Feldman (1987),

TABLE 6. UNH and New England Land Grant Institutions Ratio of Publications to Faculty for Calendar Year 2000

Institution	Total Publications: Science[a]	Social Science[b]	Arts & Humanities[c]	Total	Number of Faculty	Ratio: Publications Per Faculty
University of Vermont	525	98	16	639	440	1.45
Univ of Massachusetts–Amherst	890	174	34	1098	1049	1.05
University of Connecticut–Storrs	675	202	33	910	994	0.92
University of Maine–Orono	228	43	5	276	327	0.84
University of New Hampshire	*306*	*73*	*7*	*386*	*546*	*0.71*
University of Rhode Island	204	61	6	271	623	0.43
Mean (w/o UNH)						0.94
UNH relative to Mean						*–0.23*
UNH Rank (1 = high)						*5*

Sources: Institute for Scientific Information (ISI) Citation Databases, 2000—based on calendar year; Number of faculty data from Academe, Mar/Apr 2001.

Notes: Number of Faculty includes Full Time only for both 9/10 month and 11/12 month contracts. Data sorted on *Ratio: Publications per Faculty.*

[a]Science Citation Index Expanded indexes more than 5,800 major journals across 164 scientific disciplines.

[b]Social Sciences Citation Index includes more than 1,725 journals spanning 50 disciplines.

[c]Arts and Humanities Citation Index is a multidisciplinary database that indexes 1,144 journals.

and others, then institutional policies aimed at devoting more time and resources to teaching will not have a detrimental effect on research and vice-versa. At the same time, Fox (1992), Bellas and Toutkoushian (1999), and Porter and Umbach (2001) have found that faculty who devote more time to teaching have lower research output. If true, then increased pressure from parents and state governments to give greater emphasis to teaching outcomes could result in a reduction in the production of research. Less institutional support for research activities would be especially problematic for many faculty members in the humanities and social science disciplines where they typically do not rely on federal research dollars to support their research activities.

It is worth reiterating at this point that the publication counts obtained through this procedure will likely understate the true quantity of publications attributed to a particular institution. Some of the limitations to our approach that we dis-

cuss here could be addressed if searches were done using names of individual faculty at specific institutions. However, such lists would be difficult in practice to obtain for a large number of institutions, and the resulting searches for each institution would be very time consuming and expensive to implement. Our methodology is meant to provide a reasonable proxy to this total that can be obtained in a consistent and fairly time-efficient manner. It is encouraging to note that the resulting publication measure is very highly correlated with other commonly used measures of resources devoted to research and that the rankings based on institutional publication counts do not produce results that are counter-intuitive.

Given the increasing emphasis on performance indicators, the measure of the ratio of publications to full-time faculty member can fill an important gap in how institutions are evaluated and compared. Although measures of the teaching aspect of institutional mission are numerous (see, for example, the measures used in the *USNWR* rankings), corresponding measures of the research activities and accomplishments of postsecondary institutions are few and far between. Having information on an institution's research output along with other metrics would allow institutions to examine the possible complementarities and trade-offs that exist in engaging in teaching, research, and public service and can help institutions define more reasonable targets for specific metrics. And while research grants and research expenditures are important components of most institutions, the research production of the faculty is the output that most closely corresponds with research aspect of institutional mission. Nonetheless, there is a very high correlation between the level of resources expended or received by institutions for research and the number of publications produced.

It should be understood by decision makers that as is true for other commonly reported indicators, there could be legitimate reasons for variations across institutions in their production of research publications. The breakdowns by institution type in Table 4 and the correlations presented in Table 5 suggest that research output varies by institutional mission and is related to the financial resources devoted to its production. More work is needed to better understand how research production is related to other goals and objectives of higher education institutions and how selected inputs contribute to the joint production of these outcomes. This research could also help inform college and university administrators as to possible steps that they might take to improve their rankings with regard to research output.

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ENDNOTES

1. Data from the 1999 National Survey of Postsecondary Faculty (U.S. Department of Education, 2001b, p. 44) show that the average number of refereed/juried publications over a 2-year period by full-time faculty varied by field, with publication rates being highest in the areas of Engineering (7.9), Natural Sciences (6.5), and Health Sciences (6.2) and lowest in the Fine Arts (2.6), Business (2.9), Education (2.9), and Humanities (3.3).
2. Citation counts of individual faculty members have been subject to several criticisms in the literature. First, it is not clear whether citation counts capture the quality or quantity of an individual's research. Second, citation counts can be influenced by self-citation practices. Third, researchers can cite other researchers for a wide variety of reasons, and the act of citing may not reflect positive judgments of one's peers. Finally, citation counts have also been made more difficult by the fact that the ISI databases attribute all citations to the first-listed author of a study. These and other limitations are discussed in more detail by Garfield (1979) and Toutkoushian (1994).
3. Since the list of journals monitored by ISI is subject to change, caution should be used when tracking changes in the total publications of an institution over time.
4. Some journals are indexed by more than one of the citation indexes. As a result, searches that are conducted separately on each of the three databases may result in the double counting of a small subset of articles. This problem can be addressed by conducting searches on all three databases simultaneously; however, this requires access to the on-line version of the citation indexes and cannot be done with searches using the CD-ROM versions of the databases.
5. The searches that we conducted were restricted to "articles" since this is the largest single category of publications. Expanding the searches to other categories of publications would dramatically increase the amount of time necessary to derive publication counts and would introduce problems with regard to how to combine and weight various types of publications. The ISI databases allow separate searches to be conducted for each of the following types of publications: Article, Abstract of Published Item, Art Exhibit Review, Bibliography, Biographical—Item, Book Review, Chronology, Correction, Dance Performance Review, Database Review, Discussion, Editorial Material, Excerpt Fiction, Creative Prose, Film Review, Hardware Review, Item About an Individual Letter, Meeting Abstract, Music Performance Review, Music Score, Music Score Review, News Item, Note, Poetry, Record Review, Reprint, Review, Script, Software Review, TV Review, Radio Review, and Video Theater Review.
6. It is still possible that in some instances the use of institution name, town, and zip code will not properly isolate the institution in question. For example, the University of Texas at Dallas and the Southwest Medical Center for the University of Texas System are two separate institutions and yet share the same town, zip codes, and institutional name ("Univ Texas") in the ISI databases. We would like to thank Nicholas Valcik and Geri Malandra in the University of Texas System for bringing this to our attention.
7. We used the number of full-time faculty to standardize each institution's publication count for several reasons. First, part-time faculty are usually not expected to be engaged in research. Second, entities such as the U.S. Department of Education typically follow this practice when reporting information on the publication activities of faculty (U.S. Department of Education, 2001b). Finally, the full-time faculty headcounts reported to the U.S. Department of Education are generally more consistent than the part-time faculty headcounts across institutions. However, similar

calculations to those shown here could be performed by standardizing publication counts based on estimated faculty full-time equivalents.

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