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Business School Research: Measuring Value Contribution Through Citations of Journals in Patents

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Academic research from business schools should be relevant and rigorous; however, business school research has often been criticized for its lack of value and relevance to business. In addition, business schools have been asked to assess the impact of faculty research. This paper examines citations of journals in patents to assess one dimension of that value, relevance, and impact. In particular, this paper analyzes the number of patents that cite specific journals focusing on eight business disciplines, as an alternative approach for assessing this one dimension: patentable research. In addition, this paper uses citations of journals in patents to assess the leading journals in these eight disciplines.

Key words: business school research relevance; value contribution; citation analysis; patents; patent citations to journals; journal rankings.

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Three persistent issues associated with academic research from business schools are the criticism of its apparent lack of value to business, the need to demonstrate research impact, and the determination and ranking of leading research journals. In this paper, I use patent journal citations (i.e., citations of journals within patents) to provide one perspective to analyze these issues.

First, researchers have stressed that business school research should be rigorous and relevant (Tushman and O'Reilly 2007). However, numerous critics of academic research in business school disciplines, including Byrne (1990) and Bennis and O'Toole (2005), have argued that although business schools stress scholarship and rigor of methodology, their research does not provide much value to business. Unfortunately, assessing how research influences managerial decision making is difficult; an alternative way to counter this criticism is to investigate other sources of value creation to business, e.g., contributions of academic research to patents.

Although a patent's value at any particular time is difficult to gauge, its exclusivity gives the patent a generally recognized value. Some individuals on university campuses view patents as an opportunity to

create so much value that they have concerns about intellectual property issues and leveraging university research in patents. Thus, universities frequently have organizations or departments with patent responsibility, e.g., the Patent Foundation at the University of Virginia (<http://www.uvapf.org>). The Milken Institute Technology Transfer and Commercialization Index (http://www.milkeninstitute.org/pdf/m2m2006_uni_tech.pdf) ranks universities by measuring such factors as patents issued and start-up companies created. In general, business school faculty do not and are not expected to generate patents. However, knowing if or how much business school research is used in developing a particular patent is difficult; however, we can investigate the extent to which patents cite literature published in academic journals. Unlike authors of articles in academic journals, patent seekers are not required to cite particular literature. If patent seekers do cite literature, they do so because they find the literature critical to their research and patent development, and thus valuable and relevant. Furthermore, if patent examiners are responsible for the citation, the literature is still seen as relevant to the patent.

Second, business school faculties are often called upon to demonstrate that their research has impact. For example, faculty tenure and promotion processes frequently require assessment as to whether the research of a particular faculty member has a demonstrated impact on the field. Furthermore, the Association to Advance Collegiate Schools of Business (AACSB) recently recommended requiring schools to demonstrate the impact of faculty intellectual contributions on targeted audiences (AACSB 2008). One approach to assessing whether research has had impact is whether it has resulted in any journal citations from patents.

Third, in virtually all business school disciplines, researchers have ranked journals to identify key publications. Ranking journals is consistent with the AACSB's (2008) interest in studying and making recommendations to the management and business community, and is designed to highlight the impact of faculty research. Approaches to journal ranking include counting journal citations (Garfield and Welljams-Dorof 1992), gathering perceptions of journal rankings (Peffer and Ya 2003), and determining the publications in which researchers publish (Holsapple 2008). However, few research papers address citations of journals in patents and the relative rankings of journals that use patent citations. Accordingly, one perspective is that relevance, as measured by contribution to patent research (i.e., patent journal citations), is an alternative approach to ranking journals and journal contributions.

Patents and Citations of Journals in Patents

The United States Code Title 35, 102 (http://www.uspto.gov/web/offices/pac/mppe/documents/appxl_35_U_S_C_102.htm) states the conditions for patent eligibility. In particular, an invention must be novel and must not have been "known," "used by others," or "described in a printed publication."

Patent authors cannot seek to patent an "innovation" that is in published research. However, they can use information in the literature as the basis for generating an innovation. Thus, patents often cite other patents, existing literature in research journals, and patent and nonpatent literature. In particular, the

applicant must "justify with reasonable certainty that no references more pertinent than those already identified are likely to be found..." Applicants must provide "...each reference deemed most closely related to the subject matter of each of the claims" (United States Patent and Trademark Office 2006).

Accordingly, if a patent cites a research paper, the paper must be pertinent and closely related to the innovation and the patent. Thus, citations in patent descriptions appear to represent direct value to the patent and the patent-seeking organization. The patent statute (United States Patent and Trademark Office 2005) states that any person who "invents or discovers any new and useful process, machine, article of manufacture, or composition of matter, or any new and useful improvement thereof" may obtain a patent.

In 1998, the Federal Circuit Court of Appeals approved business method patents. Firms often claim that they have "patented business processes" (e.g., http://www.eplus.com/about_us.htm). *State Street Bank & Trust Co. v. Signature Financial Group, Inc.* (149 F.3d 1368) illustrates the relevance of patents and business school research (see <http://cyber.law.harvard.edu/property00/patents/StateStreet.html>). Lerner (2002) focused on finance patents and was among the first to investigate issues related to business-method patents, which apply to virtually all business school disciplines.

Hall et al. (2001, p. 3) noted that "patents are a proxy for inventive output, and patent citations are a proxy for knowledge flows or knowledge impacts." It is not surprising that the authors find a relationship between patents cited and value to the companies that own those patents. Although much of the literature examines patent citations to other patents, the focus of this paper is on patent citations to the literature as captured in journals, referred to as "citations of journals in patents."

Management science and operations research literature includes limited research of the US Patent database. Murphy (2002) studied the occurrence of key words or phrases, such as "optimization," and suggested that patent data include additional information of interest on operations research. This allowed him to trace the apparent emerging importance of key concepts in marketplace applications of operations research and management science. Thus, although the

literature includes both analyses of patent citations to other patents and analyses of the types of operations research and management science applications in the patents, the literature that uses citations of journals in patents is sparse.

Citations of Journals in Patents

Journal citations have been studied extensively in academic settings to assess many characteristics, including the high impact of papers and journals, leading universities and corporations, and national comparisons resulting in analysis of the so-called *Scientific Wealth of Nations* (Garfield and Welljams-Dorof 1992, May 1997). Accordingly, the use of academic citations has evoked some criticisms over the years. Some of these criticisms are not likely to be applicable in a patent journal citation setting. For example, one criticism is that authors unnecessarily cite their own publications, or that groups of authors (citation circles) cite others in the group to increase citation counts (Garfield and Welljams-Dorof 1992). However, patent citations to research papers have inherent self-citation disincentives. Few, if any, authors would go through the patent process to only generate citations to their own research. Self-citations could also suggest to patent evaluators that the patent research has been previously published, thus implying that the research is not novel and the patent should not be granted. Moreover, academic citations to patents are also not likely to disagree with the original research. Inciting controversy might negatively influence granting the patent. Such concerns could lead to questioning the invention's novelty. Therefore, patent citations usually provide a legitimate and positive reference from the patent.

What kind of relationship should we expect between numbers of citations of journals in patents and citations gathered from journals? If Bennis and O'Toole (2005) are correct in that some academic literature places too much focus on the methodology and not enough on relevant issues, we might expect some literature to be cited in academic literature, but not citations of journals in patents, for three reasons. First, some academic journal citations are likely to be generated to recognize academic methodologies. Because patents are more valuable to the patent holder, such

citations are not likely to make citations of journals in patents, unless the methodology is related to the patent. Second, some academic research uses a methodology that focuses on analysis of archival data. Such descriptive research is necessarily backward looking and historical, and rarely results in content that generates new or patentable results, but instead generally substantiates existing models or notions. Third, differences between general journal citations and citations of journals in patents often relate to a journal or discipline's content. Some journals and disciplines seek to invent new approaches that ultimately could create value for business; others are historical or descriptive in their orientation. I discuss this issue in depth later in this paper.

Methodology Findings

In my research, I used the following approach. On June 4, 2008, I used Google Patent Search (<http://www.google.com/patents>) to gather data on US patents granted or pending through October 31, 2007, and searched for journals by using previous research on journal rankings and influence.

I entered the title of each journal into "Search Patents" using quotation marks so that the search engine would search for the exact phrase. However, some journals have common names (e.g., *Decision Support Systems* is the name of both a journal and a type of system), and some have names that are subsets of other names (e.g., *Journal of Marketing* is a subset of *Journal of Marketing Research*); thus, searching can be difficult. Therefore, after entering each set of names, I printed the results and manually reviewed them to ensure that each item returned referred to a journal citation.

The results showed the number of patents granted and pending, and the total number of patents, which is the primary focus of this analysis. Because the number of patent applications could provide insights on the growth of patents in a particular area, I analyzed this number separately.

I chose journals in eight functional areas based on each journal's focus on the core business school areas. For example, for accounting, I focused only on accounting journals. Some journals, such as the

Harvard Business Review, might be in several functional areas. However, I assumed that each journal has its own primary “focus” and grouped them accordingly. I chose the leading five journals in each of business school disciplines by examining key references (external) that rank journals in those areas. The list below shows each discipline followed by the reference(s) used.

- Accounting: Chan and Liano (2008).
- Finance: Smith (2004).
- General management: Holsapple et al. (1994) and the relative rank of the five practitioner journals from Tahai and Meyer (1999).
- Management information systems: Mylonopoulos and Theoharakis (2001); I focused only on core information systems journals and did not include computer science-focused journals (e.g., *Communications of the ACM*), or journals (e.g., *Management Science*) that are not considered core information systems.
- Management and organization: Tahai and Meyer (1999); however, although the authors ranked the *Journal of Applied Psychology* and *Organizational and Human Decision Processes*, I did not include them because their primary focus is not on business issues.
- Marketing: Baumgartner and Pieters (2000); I selected only core marketing journals from this reference.
- Operations research and management science: Louisiana State University (2003), which is based on Goh et al. (1997), Barman et al. (1991), and Vokurka (1996).
- Production and operations management: Vokurka (1996). I did not include *IIE Transactions* because it is the official journal of the Institute of Industrial Engineers, a nonbusiness organization.

Findings

I found that patent applications and patents granted are likely to cite particular journals, and patents are likely to cite particular business school disciplines (Tables 1, 2, and 3).

The correlations between (1) external rank and total patents, (2) external rank and total patents granted, and (3) external rank and total applications pending, when computed across all the journals analyzed, were -0.283 (significant at the 0.0384

level), -0.236 (0.0713), and -0.372 (0.0090), respectively. These results have the expected negative sign, because we would expect a greater number of patents to cite more highly ranked journals (“1” represents the highest ranked journal). In addition, for each of the eight disciplines (except marketing), the correlations between the externally determined rank and the total, granted, and pending patents were negative.

I found that the three highest externally ranked accounting journals (Chan and Liano 2008) also included the most patent citations among accounting journals. *Accounting Review*, with 15 citations of journals in patents, included almost twice as many as the any other accounting journal. *Accounting, Organizations, and Society*, a management accounting journal, was cited in the fewest patents. Accounting had the second-lowest total number of patents, tied for the fewest patent applications for citations to journals, and comprised 2.65 percent of the total number of citations to journals from patents granted and patents pending.

The Journal of Finance, the highest-ranked finance journal, dominated the total number of citations of journals in patents in finance and was fifth overall among all disciplines. However, the *Journal of Financial Economics* had the highest percentage of citations from applications in finance, when compared to the total for journals with five or more citations. In addition, finance had the highest percentage of applications to total patents of any of the eight business disciplines. The *Journal of Money, Credit, and Banking* had the fewest in this category. Its focus on monetary and financial issues in macroeconomics, i.e., nonenterprise issues, likely resulted in its generating so few citations in patents. Finance, with 15.04 percent of patent citations, was second in total number of such citations. It had the greatest number of patent applications of any discipline described in this paper and therefore appears to be a patent growth area.

The *Harvard Business Review* was the leading general management journal in citations of journals in patents; it generated more citations than all other journals in this category and was second overall. The five journals that constitute the general management category were cited by 13.52 percent of the patents,

Journals sorted by discipline	Total patents	Granted patents	Pending patents	External ranking
Accounting				
<i>Journal of Accounting Research</i>	8	6	2	1
<i>Journal of Accounting and Economics</i>	8	5	3	2
<i>Accounting Review</i>	15	10	5	3
<i>Accounting, Organizations, and Society</i>	3	3	0	4
<i>Contemporary Accounting Research</i>	6	6	0	5
Finance				
<i>Journal of Finance</i>	127	75	52	1
<i>Journal of Financial Economics</i>	45	16	29	2
<i>Review of Financial Studies</i>	31	19	12	3
<i>Journal of Financial and Quantitative Analysis</i>	22	10	12	4
<i>Journal of Money, Credit, and Banking</i>	2	2	0	5
General management				
<i>Harvard Business Review</i>	140	94	46	1
<i>Academy of Management Executive</i>	2	2	0	2
<i>California Management Review</i>	11	11	0	3
<i>Sloan Management Review</i>	36	33	3	4
<i>Business Horizons</i>	15	15	0	5
Management information systems				
<i>Management Information Systems Quarterly</i>	29	27	2	1
<i>Information Systems Research</i>	4	1	3	2
<i>Journal of Management Information Systems</i>	66	54	12	3
<i>Decision Support Systems</i>	16	15	1	4
<i>Information & Management</i>	12	12	0	5
Management and organization theory				
<i>Strategic Management Journal</i>	8	5	3	1
<i>Academy of Management Journal</i>	10	6	4	2
<i>Organization Science</i>	5	5	0	3
<i>Administrative Science Quarterly</i>	3	0	3	4
<i>Journal of Management</i>	2	2	0	5
Management science and operations research				
<i>Management Science</i>	241	189	52	1
<i>Operations Research</i>	129	112	17	2
<i>Decision Science</i>	30	27	3	3
<i>Journal of the Operational Research Society</i>	38	28	10	4
<i>European Journal of Operational Research</i>	136	117	19	5
Marketing				
<i>Journal of Marketing Research</i>	47	36	11	1
<i>Journal of Consumer Research</i>	15	15	0	2
<i>Journal of Marketing</i>	32	29	3	3
<i>Marketing Science</i>	57	46	11	4
<i>Journal of Advertising Research</i>	66	48	18	5
Production and operations management				
<i>Journal of Operations Management</i>	21	18	3	1
<i>International Journal of Production Research</i>	24	19	5	2
<i>Production and Inventory Management Journal</i>	17	15	2	3
<i>Naval Research Logistics</i>	29	22	7	4
<i>International Journal of Operations and Production Management</i>	1	1	0	5

Table 1: The data show the number of patents that include a citation to particular journals.

Discipline	Correlation between external ranking and total patents	Correlation between external ranking and patents granted	Correlation between external ranking and patents pending
Accounting	−0.322	−0.124	−0.522
Finance	−0.895	−0.828	−0.948
General management	−0.601	−0.543	−0.694
Management information systems	−0.142	−0.125	−0.197
Management and organization theory	−0.894	−0.756	−0.592
Management science and operations research	−0.553	−0.527	−0.612
Marketing	0.624	0.645	0.552
Production and operations management	−0.519	−0.597	−0.234

Table 2: The data show the correlation between external rankings and number of patents (total, granted, and pending).

approximately the same percentage as in the finance and marketing categories. In addition, general management had the third most patent applications, thus indicating future growth.

The *Journal of Management Information Systems* had the highest number of patent citations in each category (total, granted, and pending) of any information system journal by more than a factor of two. It also had more citations in each of the three categories (of citations of journals in patents) than the total number of the other four journals in the management information systems category. The most surprising finding in information systems was the few (i.e., four) citations in patents to the widely acclaimed academic journal, *Information Systems Research*. However, three of these four citations are in patent applications, suggesting future growth potential.

Management and organization theory, with only 28 patents citing the five leading journals, had the fewest citations of journals in patents. Only 1.86 percent

of the citations identified were in this category, and applications cited it only 10 times. This discipline tied with accounting for the fewest citations, thus indicating limited near-future growth in patent citations. Thus, consistent with the findings of Tushman and O'Reilly (2007, p. 770), there has apparently been "...very little impact on practice" of management research, at least as measured by patent citations.

The management science and operations research discipline had the highest number of patent citations, 38.04 percent, among the top five journals of any of the eight disciplines; the highest number of patents cited *Management Science*. Two operations research journals (*European Journal of Operational Research* and *Operations Research*), respectively, had the fourth and fifth most citations among all 40 journals. Thus, three of the five journals in this discipline were among the most cited.

Marketing was the only discipline in which the correlation coefficients between external rank and

Discipline	Granted patents	Pending patents	Total patents	Percentage
Accounting	30	10	40	2.65
Finance	122	105	227	15.04
General management	155	49	204	13.52
Management information systems	109	18	127	8.42
Management science and operations research	473	101	574	38.04
Management and organization theory	18	10	28	1.86
Marketing	174	43	217	14.38
Production and operations management	75	17	92	6.10
	1,156	353	1,509	
	76.61%	23.39%		

Table 3: The data show the number of patents by discipline.

number of citations (granted, pending, and total) were not negative. This was principally because *Marketing Science* and the *Journal of Advertising Research*, the fourth- and fifth-ranked marketing journals in journal rankings, had the highest numbers of patent citations. Of the total number of patent citations, 14.38 percent related to marketing, which ranked third among the eight disciplines. In addition, marketing was less than a percentage point behind finance for the second highest percentage of citations.

No production or operations management journal dominated the number of patents citing it. Of the total number of citations, 6.10 percent related to this discipline, ahead of only accounting, and management and organization theory.

In summary, Table 3 shows the total number of patents with citations to the respective business disciplines. Note that management and organization theory had the fewest patent citations to journals, and management science and operations research had the highest number of patent citations to journals.

Impact on Journal Rankings

Patent citations to journals provide another approach to ranking journals. As noted above, the external rankings are statistically significantly correlated with the three statistics—numbers of patents granted, patents pending, and the total of both. Therefore, patent citations and other approaches to rank journals have some significant similarities. However, the correlation was not perfect; thus, additional information is associated with using patent citations.

The correlation between citations associated with patents granted and patents pending was 0.788, significant at better than the 0.0001 level. Thus, total citations associated with patents granted and pending provide both backward- and forward-looking views of the contribution of research to patents.

To determine how ranking the journals based on patent citations would compare to other approaches, I ranked them on a scale of 1–5, based on the total number of patent citations in each category, and correlated the rankings. The correlation was 0.371 (0.0092); therefore, the journal rankings based on number of patent citations are statistically significant when correlated with other external ranking approaches.

Implications of Citations of Journals in Patents on Relevance and Impact

It is tempting to take these results and say that management science and operations research clearly have the most relevance and impact, and thus create the greatest value, and that finance is second, and that it is the fastest growing because it has the most patent applications. However, doing so would substantially overstate the findings. This research provides only one point of view about the value of research—the value of patents.

Because patents are incremental discoveries over a substantial existing body of knowledge, they provide a point of view that is incremental over existing established value. That is, the new citations of journals by patents refer to generating knowledge that is new and additional to the existing knowledge on which they are based.

In addition, researchers in some functional areas might have greater interest in patentable research than researchers in other areas because of the potential for immediate results. For example, accounting system developments might not generate as high an interest as tools aimed at finding or leveraging stock market inefficiencies.

Unless they propose process changes, citations of journals in patents generally ignore the day-to-day relevance of providing management value. For example, most companies could not exist without their accounting systems; therefore, both accounting and accounting systems are clearly major contributors to the companies' overall value. Patents on new developments do not capture the underlying value and relevance established by earlier developments. However, journal citations in patents are an indication about the future use of knowledge and its corresponding relevance to business.

Science vs. Engineering

Why does such an apparent difference in the number of patent citations to journals exist among different disciplines? One potential explanation involves the research paradigms that are within the disciplines and ultimately implemented in particular journals. In particular, if we think of research occurring across a spectrum that ranges from “engineering” to “science,”

we can gather some potential insights into the extent to which research is likely to result in patents. In general, engineering is concerned with designing and building (inventing) useful products that solve problems; science is more concerned with discovering the world's composition and nature. Engineering is seen as prescriptive; science is seen as descriptive. Accordingly, patents seem more likely to cite engineering approaches.

Simon (1985) and others have distinguished between engineering (also referred to as designing), a discipline that deals with building artifacts, and approaches that attain goals. Engineering and designing prescriptively determine how things should be or "ought" to be. From Simon's point of view, engineers and designers are concerned with synthesis or composition. Consistent with an engineering point of view, in a discussion of the role of inventions, such as those that may be patentable, there is a concern with "design for function and invention, which is the grandest form of design, in both engineering and nature" (French 1994, p. xvii). French (p. 283) notes also that "invention is nothing but a grander word for a particularly important or important step in design."

In contrast, Simon (1985) suggests that science is concerned with analysis. Simon (p. 7) also suggests that science has "found a way to exclude the normative and to concern itself solely with how things are." Kuhn (1970, p. 10) notes that "normal science means research firmly based upon one or more past scientific achievement, achievements that some particular scientific community acknowledges for a time as supplying the foundation for further its practice." Kuhn (pp. 25–27) also describes three normal foci of normal scientific investigation. "First, is that class of facts that the paradigm has shown to be particularly revealing of the nature of things A second usual but smaller class of factual determinations is directed to those facts that, though often without much intrinsic interest, can be compared directly with predictions from the paradigm theory A third class of experiments and observations . . . consists of empirical work undertaken to articulate the paradigm theory . . ." Rather than invention, science is concerned with discoveries that either support or supplant existing scientific paradigms.

The struggle between engineering prescriptive and scientific descriptive research in academics has manifested a number of responses in different fields. For example, Simon (1985) provides guidelines for doing research that is aimed at what seems to be the first reference to design science. March and Smith (1995) discuss the relationship between the two perspectives in information systems, further developing the notions of design science.

Extension: Citations Weighted by Number of Pages

One issue influencing the relative number of citations to journals by patents might be the relative number of pages of articles in the journals. To normalize the number of citations to the journals, I gathered information about the number of journal pages and computed the average number of total citations per page (Table 4).

However, it is unlikely that a 2009 patent would cite many papers from the early years of a 50-year-old journal. In addition, journals have different publication dates and calendars, and the number of pages and articles varies substantially by publication. Therefore, I gathered all pages for each journal from 2000–2008 to provide a standard basis of comparison. Because *Production and Inventory Management Journal* discontinued publication in 2002, I normalized the number of pages used for it to fit the period (I used normalization as a basis for estimating missing data for other journals, which were minimal).

I found that marketing, general management, and management science and operations research had the highest number of citations to journal, weighted by the number of pages. In addition, the *Journal of Advertising Research*, *Management Science*, *Operations Research*, *Harvard Business Review*, and *Sloan Management Review* were the highest individually ranked journals when I considered number of pages.

The correlation between total citations to journals by patents and number of pages was 0.331 (0.0184), patents granted and number of pages was 0.330 (0.0188), and patents pending and number of pages was 0.281 (0.0394). These results suggest that the number of citations to journals by patents and number of journal pages are closely related for these highly ranked external journals.

	Total patents	Granted patents	Pending patents	External ranking	Pages	Total/Pages
Accounting						
<i>Accounting Review</i>	15	10	5	3	10,321	0.00145
<i>Journal of Accounting and Economics</i>	8	5	3	2	7,500	0.00107
<i>Journal of Accounting Research</i>	8	6	2	1	8,863	0.00090
<i>Contemporary Accounting Research</i>	6	6	0	5	8,632	0.00070
<i>Accounting, Organizations, and Society</i>	3	3	0	4	7,477	0.00040
Total	40	30	10	15	42,793	0.00093
Finance						
<i>Journal of Finance</i>	127	75	52	1	26,399	0.00481
<i>Journal of Financial and Quantitative Analysis</i>	22	10	12	4	7,752	0.00284
<i>Review of Financial Studies</i>	31	19	12	3	14,705	0.00211
<i>Journal of Financial Economics</i>	45	16	29	2	21,805	0.00206
<i>Journal of Money, Credit, and Banking</i>	2	2	0	5	13,169	0.00015
Total	227	122	105	15	83,830	0.00271
General management						
<i>Harvard Business Review</i>	140	94	46	1	11,662	0.01200
<i>Sloan Management Review</i>	36	33	3	4	3,081	0.01168
<i>Business Horizons</i>	15	15	0	5	4,832	0.00310
<i>California Management Review</i>	11	11	0	3	5,565	0.00198
<i>Academy of Management Executive</i>	2	2	0	2	5,136	0.00039
Total	204	155	49	15	30,276	0.00674
Management information systems						
<i>Journal of Management Information Systems</i>	66	54	12	3	10,349	0.00638
<i>Management Information Systems Quarterly</i>	29	27	2	1	6,259	0.00463
<i>Information and Management</i>	12	12	0	5	6,987	0.00172
<i>Decision Support Systems</i>	16	15	1	4	14,031	0.00114
<i>Information Systems Research</i>	4	1	3	2	3,943	0.00101
Total	127	109	18	15	41,569	0.00306
Management and organization theory						
<i>Academy of Management Journal</i>	10	6	4	2	11,241	0.00089
<i>Organization Science</i>	5	5	0	3	7,202	0.00069
<i>Strategic Management Journal</i>	8	5	3	1	11,783	0.00068
<i>Administrative Science Quarterly</i>	3	0	3	4	6,000	0.00050
<i>Journal of Management</i>	2	2	0	5	36,102	0.00006
Total	28	18	10	15	72,328	0.00039
Management science and operations research						
<i>Management Science</i>	241	189	52	1	16,653	0.01447
<i>Operations Research</i>	129	112	17	2	10,086	0.01279
<i>Decision Science</i>	30	27	3	3	6,764	0.00444
<i>Journal of the Operational Research Society</i>	38	28	10	4	13,402	0.00284
<i>European Journal of Operational Research</i>	136	117	19	5	65,995	0.00206
Total	574	473	101	15	112,900	0.00508
Marketing						
<i>Journal of Advertising Research</i>	66	48	18	5	4,417	0.01494
<i>Marketing Science</i>	57	46	11	4	5,957	0.00957
<i>Journal of Marketing Research</i>	47	36	11	1	5,333	0.00881
<i>Journal of Marketing</i>	32	29	3	3	5,657	0.00566
<i>Journal of Consumer Research</i>	15	15	0	2	6,492	0.00231
Total	217	174	43	15	27,856	0.00779
Production and operations management						
<i>Production and Inventory Management Journal</i>	17	15	2	3	2,055	0.00827
<i>Naval Research Logistics</i>	29	22	7	4	7,771	0.00373
<i>Journal of Operations Management</i>	21	18	3	1	7,407	0.00284
<i>International Journal of Production Research</i>	24	19	5	2	47,528	0.00050
<i>International Journal of Operations and Production Management</i>	1	1	0	5	12,695	0.00008
Total	92	75	17	15	77,456	0.00119

Table 4: The data show the number of patent citations normalized by number of pages.

The rankings that are generated by using the absolute number of patent citations to journals correlate highly with the rankings that are weighted by number of pages—0.727 (0.000001). The correlation between the external rankings and the rankings based on weighted citations per page within each discipline also correlate highly at 0.3494 (0.0136). Thus, patent citations to journals, weighted by number of pages and the unweighted patent citations to journals, both correlate highly to external rankings.

Other Extensions

This research could be extended by examining additional journals in other business school disciplines. The number of journals could also be extended beyond five, or to include other external ranking results. Moreover, the data might be broken down by year and analyzed for trends, such as the extent to which the number of patent citations to a journal or discipline is increasing or decreasing.

Additional research could focus on particular aspects of the cited literature, such as the research papers or researchers that patents or patent applications cite most frequently. Research might also examine the faculty functional areas to provide insights into the fields of contributors.

This paper and most other citation analyses treat each discipline as independent. Accordingly, another extension could involve investigating the relationship between citations to journals by patents and the extent to which they use multiple disciplines. Future research also could examine the extent to which patents cite literature from multiple disciplines, generating influence networks with nodes from different disciplines to capture the relationships. Although I studied patent citations to journals weighted by page numbers, other approaches or intervals could be used. For example, the number of articles over some period could be examined for its influence on number of patent citations to journals. Finally, previous literature, such as Hall et al. (2001, 2002), has found that the number of times a patent has been cited by other patents relates to company value. However, this paper would suggest a related question: does the cited literature (i.e., citations of journals in patents) influence the value of the patent? For example, could patents

signal, falsely signal, or camouflage they are of a particular type of invention by using particular journal citations?

Summary and Contributions

This paper has proposed that patent citations to journals be used as the basis for one dimension of determining the relevance, impact, and resulting value of business school research. Patent citations could also be used to rank journals and evaluate the contribution of business school disciplines. Such a use of citations stresses incremental increase of knowledge from patents beyond existing knowledge in processes.

The high number of citations I found indicates the substantial value that business school research is generating. The highest number of citations was in management science and operations research, the fewest in management and organization theory. The second-largest and fastest-growing area was finance. The correlations between the rankings in the number of citations of journals in patents and the external ranking in each discipline (except marketing) and over the entire sample were negative as expected; higher numbers of citations were associated with higher externally ranked journals.

I did find some anomalies in the journal rankings and citations of journals in patents. For example, although *Information Systems Research* is consistently rated a top information systems journal, only four patents cited it.

Academic research has been criticized for its lack of relevance to business, and business schools have been asked to assess the impact of faculty research. Patent citations to leading academic journals illustrate that research published in these journals provides direct value to firms, and that the research cited in patents is relevant and has impact. The citations show that disciplines make different types of contributions. For example, from the perspective of these patent citations, the management science and operations research discipline has dominated the patents. However, the finance discipline is now gaining momentum; both areas have approximately the same number of patent applications. Finally, the use of patent citations can provide a new approach to journal ranking. It is important to realize that this

analysis is across a single dimension of value: patent knowledge. Moreover, because this paper analyzes patents, its approach is incremental and does not consider existing value contributions from the disciplines.

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