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THINKING INSIDE THE BOX? INTELLECTUAL STRUCTURE OF THE KNOWLEDGE BASE OF INNOVATION RESEARCH (1988–2008)

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Innovation is becoming increasingly popular as a concept as well as a field of research. As a field, it has accumulated a significant amount of scientific knowledge. Based on bibliometric data from four major social science disciplines—economics, sociology, psychology, and management—this study presents a 'global view' of the field by combining longitudinal and structural perspectives. It identifies major research traditions in the field, determines the content and disciplinary composition of each tradition, and maps the changes in the intellectual structure of the field over time. The study suggests that innovation research is becoming increasingly compartmentalized between economics and management disciplines and each segment is becoming increasingly self-contained. A strategy along with a framework is suggested for making research contribution to the field. Copyright © 2012 John Wiley & Sons, Ltd.

INTRODUCTION

The term 'innovation' has become increasingly popular as part of common vocabulary as well as a key component of policy and strategy.[1][2] Correspondingly, researchers from different disciplines have been participating in and contributing to the research related to innovation as an economic, social, and technological phenomenon. Owing to the growth and diversity in innovation-related literature, some have even suggested that it is an 'emerging scientific field' that is attracting scholarly interest from several disciplines (Fagerberg and Verspagen, 2009). Due to the growing importance and populatiry of the field, there is a need to learn about the subject matter and the intellectual structure of the field as well as the disciplinary roots of its knowledge base. This knowledge may help pave the way for the development of the field as it can help identify the opportunities for future intellectual investments in the field.

While some literature exists that sheds light on the content of innovation as a field of research and identifies a few prominent *research traditions*[3] in

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[1] It is hard to find any formal and widely accepted definition of the term 'innovation.' However, the term broadly refers to any act or artifact that is a significantly novel and valuable outcome of deliberate human activity in any sphere of human behavior that is spurred by an incentive to create value in a given environment and realized by acquiring and utilizing appropriate capabilities and resources. The concepts, 'incentive' and 'value,' are used here in a fairly broad sense and include all economic and noneconomic drivers of behavior.

[2] It is increasingly found in the discussions and speeches of corporate and political leaders. For instance, President Barack Obama of the United States of America, in his State of the Union address of January 2011, highlighted that innovation is the key to economic growth and prosperity.

[3] The term 'research tradition' here refers to a fairly broad but distinguishable part of scientific literature in a field of research. It is a coherent collection of various subgroups of research themes/fronts that are identifiable through shared topic and common theoretical perspectives.

the field (Freeman, 1994; Wolfe, 1994; Gopalakrishnan and Damanpour, 1997; Anderson, De Dreu, and Nijstad, 2004; Hauser, Tellis, and Griffin, 2006), there is hardly any literature that could provide a 'global view' of the field from a longitudinal and/or structural perspective. Traditionally, such objectives are attained through literature reviews by experts of a given field. However, the innovation field spans several disciplines and hence the breadth of its scope is prohibitive of a comprehensive review due to the limits to individual expertise. This problem can be solved by employing a quantitative approach. Hence, this paper is intended to fill this void as a descriptive study of the field by combining longitudinal and structural perspectives.

The emergence and growth of scientific fields is a dynamic process that involves several facets (Frickel and Gross, 2005; Hambrick and Chen, 2008). Since the most important output of these processes is the scientific knowledge actually produced, studying the kind and content of the knowledge produced by a scientific field can inform about the justification and contribution of the field as well as its evolution and future prospects. Scientific knowledge is cumulative, meaning that new knowledge is created based on existing knowledge (Jefferson, 1972; Cowan and Foray, 1997). Therefore, the term 'knowledge base' hereby refers to the ideas, perspectives, approaches, theories, and methods used in the creation of new knowledge in a given scientific domain. It can be empirically measured via the existing knowledge *used* in the creation of new knowledge. In the scientific literature, references to the previous literature are conventionally used as a proxy for the knowledge used, and hence, for the knowledge base.[4] Correspondingly, the term 'intellectual structure' hereby refers to a set of salient attributes of the knowledge base that can provide an organized and holistic understanding of the chosen scientific domain. Therefore, the intellectual structure of a scientific domain includes its constituent research traditions, their disciplinary composition, topics addressed by these, and the pattern of their interrelationships.

Any endeavor of measuring such conceptual entities of a field that spans several disciplines demands the adoption of objective methods and measures that have been tested, established, and accepted across disciplines. Therefore, this study employs *bibliometrics* which is a well-known science of measuring and mapping scientific communication within and across scientific domains and disciplines (White and McCain, 1989; Tabah, 2001; Borgman and Furner, 2002; Börner, Chen, and Boyack, 2003; Boyack, Klavans, and Börner, 2005). Bibliometrics uses citations and co-citations as indicators of scientific communication and flows of knowledge among domains and disciplines (Small, 1973, 1978; Garfield, 1979; Lievrouw, 1989). It has established scientific methods and approaches that are widely accepted in tracking and measuring scientific communication and development of scientific fields (de Solla Price, 1965; Garfield, 1979; White and Griffith, 1981; Cottrill, Rogers, and Mills, 1989; McCain, 1990). Due to its scientific authenticity and rigor, several studies have used bibliometrics to map the intellectual structure of various fields of research including the diffusion of innovations (Cottrill *et al.*, 1989), macroeconomics (McCain, 1983), organizational-behavior (Culnan, O'Reilly, and Chatman, 1990), consumer research (Hoffman and Holbrook, 1993), operations management (Pilkington and Liston-Heyes, 1999; Pilkington and Meredith, 2009), and strategic management (Ramos-Rodriguez and Ruiz-Navarro, 2004; Nerur, Rasheed, and Natarajan, 2008), to mention a few.

This study uses *publications* as the unit of analysis rather than *persons* who authored these because publications are permanent and lasting imprints in science that serve as long-term, impersonal, verifiable, and debatable sources of ideas, theories, and methods that can be used as an input for creation for further knowledge (Small, 1973, 1978, 1980; Griffith *et al.*, 1974; Small and Griffith, 1974; Cowan and Foray, 1997; Ramos-Rodriguez and Ruiz-Navarro, 2004). Furthermore, the study employs a combination of standard multivariate techniques and network tools for an objective analysis of the bibliometric data.

[4] Citations to previous literature may be motivated by numerous reasons. These include, for instance, need for evidence, comparison, contrast, refutation, rebuttal, and indication of further literature. Unfortunately, these may also include ritualistic citations meant to create a façade of standing on the shoulders of giants and seeking legitimacy without a careful reading and deliberation on the cited publication (Latour, 1987; DiMaggio, 1995). However, based on the presumption of academic integrity of researchers and conventions of practicing science, it seems reasonable to assume that a large part of the citations is attributable to the texts on which the writers deliberated and found relevant to some aspect of their argument presented in the publication. These assumptions are mandated by the need to study the history and sociology of scientific knowledge.

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The paper provides a global view of the field from longitudinal and structural perspectives by identifying and mapping various research traditions, characterizing their respective knowledge bases, and tracking the pattern of their development and diffusion over time. In addition to that, it provides a longitudinal view of the changes in the influence of key publications, journals, and major social science disciplines in innovation research. In this way, the study also makes an empirical contribution to the sociology of scientific knowledge as studied by Merton (1968, 1972, 1973), Kuhn (1970), and Latour (1987).

The methodology of the study is described in the next section followed by the presentation of the analysis. Then the implications of the study, its limitations, and directions for further research are discussed followed by some conclusions.

METHODOLOGY

Sample

Based on the understanding that innovation as a research field belongs to the broad domain of social sciences (Freeman, 1994), four closely related social science disciplines—economics, sociology, psychology, and management—were selected as a base for the study. These academic disciplines can be represented by relevant academic journals (Agarwal and Hoetker, 2007) that were selected using *Eigenfactor*™ classification (Eigenfactor Project, 2009) and ranking of Institute for Scientific Information (ISI)-listed journals for the year 2006 (cf. Palacios-Huerta and Volij, 2004). Further, upon the understanding that scientific communications are characterized by scale-free network topology (de Solla Price, 1965; Merton, 1968; Barabási, 2003), the top 20 journals were selected from each discipline. The publication and citation data for these journals was collected from Thomson Reuters' Web of Science covering a period of 21 years (January 1988–December 2008).

During the sample period, a total of 18,361 papers were published in selected economics journals, 14,423 in management journals, 9,592 in sociology journals, and 19,908 in psychology journals. From among these, innovation-related papers were identified using the string 'innovat*' in the search field of *topic* (which includes title, abstract, and author-supplied keywords).[5]

The electronic database search resulted in the identification of 3,517 innovation-related papers, of which 79 percent came from management, 15 percent from economics, five percent from sociology and one percent from psychology journals. After cleaning and normalizing the bibliographic references contained in these papers, the final sample included 21,008 cited publications that comprise the *knowledge base* of the innovation field during the period, and hence the base data for this study.

Again, based on the understanding of scale-free topology of scientific communication networks, the 50 most cited publications in each discipline were selected for further analysis.[6] This cut-off resulted in the selection of publications that had citation frequency as low as 79 in management, 15 in economics, seven in sociology, and 30 in *Research Policy*. The citations in psychology papers were excluded because the highest citation frequency of any publication in sample psychology papers was only three.

This data was organized in a binary (0, 1) matrix, henceforth referred to as the base matrix, where row vectors represented the cited publications and all 3,517 papers in the sample as column vectors citing the publications in rows. A discipline was attributed to each journal paper based on Eigenfactor™ classification of journals, whereas the

[5] It is acknowledged that the use of this string selects only those papers that have explicitly mentioned the term 'innovation' or any variant of it in the lead part. It can be expected that there would be numerous papers whose topics relate to innovation without having to mention it explicitly. However, including the latter would have caused a sampling bias. Therefore, by using this string, the study was deliberately limited to those papers where authors unambiguously noted that some aspect of their paper was related to innovation. Moreover, in order to detect the amount of noise by possible presence of such terms as 'methodological innovation,' 'innovative tool/technique/method/approach,' and so forth, the text analysis of all the titles, abstracts, and keywords was conducted using a text analysis software. The presence of such usage of the term was negligible and hence no arbitrary change was made in the sample with the assumption that subsequent procedures would naturally eliminate such papers.

[6] *Research Policy* (*RP*) was significantly correlated with economics as well as management disciplines in terms of the knowledge base. However, it was more closely linked to the management group (as its sample papers shared 5,297 citations with the sample from the management group) than to the economics group (1,335 shared citations) and sociology group (865 shared citations). For this reason, although *RP* was treated as a management journal in the final analysis, its top 50 cited papers were included in the base matrix separately.

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Library of Congress (LoC) online catalogue was used for attribution of disciplines to the books. The count data of cited publications and related disciplines is presented in Table 1.[7]

Initial core of innovation field

A typical challenge in this kind of study is the identification of the 'core' publications. Since there is no consensus about core publications of the innovation field across all disciplines, two seminal publications of Schumpeter (1934 [1911] and 1942) were used as the 'starter publications' to determine the initial core through 'snowball sampling' (Cottrill *et al.*, 1989; Tushman and Nelson, 1990; Freeman, 1994). Then, 100 publications most frequently co-cited with each of Schumpeter I (1934[1911]) and Schumpeter II (1942) were selected from the base matrix. This resulted in the selection of 134 publications, all of which were co-cited with Schumpeter I and/or II at least three times. These publications were used as the *initial core* and the subsequent analysis was focused only on those publications that cited or were co-cited with at least two publications from the initial core or subsequent cores derived from the preceding cores using the same criteria.

Citation and co-citation matrices

In order to ascertain the development of the field over time, the total period (1988–2008) was divided into three, equal, seven-year periods; 1988–1994, 1995–2001, and 2002–2008 (cf. Ramos-Rodriguez and Ruiz-Navarro, 2004). Then, by snowballing the initial core, citation matrices were constructed for each subperiod and the cumulative period. From these matrices, co-citation matrices were derived for each period (Small, 1973) and then transformed into respective correlation matrices because the co-citation correlation coefficient is conventionally used as a standard measure of similarity/dissimilarity between any two publications. This is due to the fact that it measures the correlation between complete co-citation profiles of each publication with regard to every other publication in the matrix (McCain, 1990). These matrices served as the basis for further analysis.

Multivariate analysis

Since the citation data represents a high-dimensional space, it necessitated the use of multivariate techniques, specifically multidimensional scaling (MDS) and principal component analysis (PCA).[8] Several similar studies have used these two techniques complementarily (e.g., White and Griffith, 1981; McCain, 1990; Ramos-Rodriguez and Ruiz-Navarro, 2004; Nerur *et al.*, 2008).

In order to perform the multivariate analysis, all the publications in the cumulative period matrix of citations (1988–2008) were ranked based on the frequency of received citations and then the top 100 among these were selected. The resulting 106 publications account for 46 percent of all citations during the whole period and serve as the input for multivariate analysis.[9]

The MDS map for a period represents certain *knowledge space* in two dimensions whereby the elements of the *knowledge base* (i.e., cited publications) are represented as data points. The distances among the data points represent their proximity based on the relative frequency of their co-participation (co-citation) in the knowledge base. Using the top 100 publications, MDS maps were

[7] It is worth mentioning here that there were only seven publications representing psychology in the base matrix. These included Nunnally (1978), Mumford and Gustafson (1988), Altman (1995), Frable (1997), Weick and Quinn (1999), Bargh and McKenna (2004), and Latham and Pinder (2005). Moreover, the LoC categorized some publications into 'industry' and 'technology' categories rather than in any specific discipline. These were treated as such.

[8] The citation and co-citation matrices represent unweighted/binary and weighted networks, respectively. There are two possible approaches to analyze this data; standard multivariate analysis and network analysis. The data for this study, in both forms, involved a significant amount of overlap across disciplines. In network analysis, this problem pertains to the detection of overlapping communities, which is only beginning to be explored (Fortunato, 2010). The use of the network approach in this case would require a combination of several network analytical algorithms to complement each other. The complexities and limitations of this approach necessitated the use of more compact methods which are well-known, widely used, and approved by the concerned scientific community.

[9] The list of top 100 publications is given in Table B1 in Appendix B. Incidentally, these publications included the 50 most cited publications in each period. It is worth noting that this set includes 18 of the 'top twenty contributions' and 44 of the 'core innovation literature' identified in a similar bibliometric study of six handbooks and textbooks of innovation by Fagerberg and Sapprasert (Innovation: exploring the knowledge base. Working paper No. 20100616, Centre for Technology, Innovation and Culture, University of Oslo, 2010). Bibliography of the top 100 publications is freely available from the author.

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Table 1. Distribution of all citations among disciplines

	Citing papers														
	1988-1994					**1995-2001**					**2002-2008**				
	Man	Eco	Soc	Psy	Total	Man	Eco	Soc	Psy	Total	Man	Eco	Soc	Psy	Total
No. of citing papers	207	47	6	1	**261**	728	107	27	2	**864**	1277	135	39	0	**1451**
No. of cited publications:															
Books	801	153	31	1	**986**	2548	231	140	1	**2920**	3867	224	129	0	**4220**
Papers	794	213	19	0	**1026**	5540	555	165	13**62**	**73**	15073	753	257	0	**16083**
Total cited	*1595*	*366*	*50*	*1*	***2012***	*8088*	*786*	*305*	*14**91***	***93***	*18940*	*977*	*386*	*0*	***20303***
Disciplinary distribution of total cited:															
Management	53%	18%	14%	0%	**46%**	66%	12%	28%	86%	**60%**	73%	15%	29%	0%	**70%**
Economics	23%	71%	30%	0%	**32%**	16%	78%	13%	0%	**21%**	15%	80%	10%	0%	**18%**
Sociology	12%	1%	36%	0%	**10%**	8%	1%	47%	14%	**9%**	6%	0%	52%	0%	**5%**
Psychology	0%	0%	0%	0%	**0%**	1%	0%	0%	0%	**1%**	0%	0%	0%	0%	**0%**
Industry	4%	7%	6%	0%	**5%**	3%	6%	5%	0%	**3%**	1%	3%	2%	0%	**1%**
Technology	2%	2%	0%	0%	**2%**	2%	2%	1%	0%	**2%**	1%	2%	0%	0%	**1%**
Other	6%	0%	14%	100%	**5%**	5%	0%	6%	0%	**4%**	3%	0%	6%	0%	**4%**
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**0%**	**100%**

Industry: Scherer (1980), Piore and Sabel (1984), Tirole (1988), Schmalensee and Willig (1989), Fligstein (1990), Porter (1990), and Clark and Fujimoto (1991).
Technology: Schmookler (1966), Allen (1977), Kline and Rosenberg (1986), and Nelson (1993).

prepared for each subperiod and the whole period (Figures A1–A4 in Appendix A).[10]

In co-citation correlation data, distinct research traditions are supposedly represented by major principal components (McCain, 1990; Acedo, Barroso, and Galan, 2006; Nerur *et al*., 2008). Therefore, using the co-citation correlation matrices and corresponding scree graphs, seven principal components were selected for the first period, seven for the second period, nine for the third period, and eight for the cumulative period. The total variance (proportion of knowledge base) explained by these components was 65.9 percent, 65.5 percent, 76.7 percent, and 63.7 percent for each period, respectively (Tables B2–B5 in Appendix B).

In order to make MDS and PCA comparable, every publication was assigned to the component where it had the highest loading.[11] Then the MDS data points corresponding to each component were manually demarcated as a group and labeled on the MDS map.

For each principal component, the publications with factor loadings $\geq +0.4$ were identified and the percentage of total loadings attributable to each discipline was determined. This percentage was used to ascribe a descriptive title to each component (research tradition). For instance, management and sociology publications accounted for 61 percent and 39 percent, respectively, of the loadings total for the first component of the first period. Therefore, its disciplinary composition is represented in its title as 'management and sociology.' Furthermore, research themes/fronts were identified within each research tradition by complementing the information from multivariate analysis with the relevant content analysis (publication titles, abstracts, editorial policy of concerned publication outlets, and contents pages and published reviews of the concerned books) (Table 2).[12]

Finally, in order to measure and map the relationships among the knowledge bases of different traditions within and across three subperiods, an affiliation matrix was constructed for the 100 most cited/influential publications and the 23 principal components. The correlation matrix of the affiliation matrix is a tabulation of the coefficients of similarity/dissimilarity among the knowledge bases of different traditions (McCain, 1990) (Table 3) and its weighted-line network is a visual representation of these relationships (Figure A5 in Appendix A).[13]

ANALYSIS

Composition of the knowledge base

This study uses two *ad hoc* measures—contribution and influence—to evaluate the knowledge base of innovation research. As noted earlier, disciplines are represented by journals. Thus, *contribution* of a discipline to a research field can be measured by the number of relevant papers published by its corresponding journals as well as the books related to the field. On the other hand, *influence* of a discipline is measured by the number of citations received by the publications that belong to the discipline. Similarly, the contribution of a journal to a particular research field can be measured by the number of related articles published by the journal. However, while contribution is also a dimension of influence, the latter specifically involves the amount of knowledge that is contributed by a journal and actually *used* in the creation of further knowledge in the field. Therefore, although the term *'influence'* is relative, here it refers to the proportion of all citations that a publication/journal/discipline actually received during a given period. Accordingly, change in the influence can be measured via the change in the relative share in received citations during the period as following:

$$\Delta_t = \frac{x_t}{n_t} - \frac{x_{t-1}}{n_{t-1}}$$

Where Δ is percentage change over previous period, t is the relevant base period, and n is the total number of citations in the respective period

[10] The correspondence between these data points on each MDS plot and publications is indicated in the Table B1 under respective period.

[11] Certain publications loaded on several components, often with slight difference in their loadings on different components. The grouping was only meant to represent distinct domains of knowledge to which they most closely belonged.

[12] It is acknowledged that this process involved a significant amount of reading and qualitative judgment, which was necessitated by the unavailability of appropriate objective measures for the purpose.

[13] The network was created by using network analysis software Pajek® 1.27 (de Nooy, Mrvar, and Batagelj, 2005). The factors presented in this network correspond to the factors in relevant MDS maps and the thickness of connecting lines represents the degree of similarity/dissimilarity between the knowledge bases of different research traditions. This matrix/network is more comprehensive than the MDS maps because it accounts for the factor loadings of each publication on all the components, which was precluded by the need for demarcation on the MDS maps.

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Table 2. Summary of principal components and MDS maps

Period	Principal components		Disciplinary composition	Academic fields/ research traditions	Major themes
	No.	% of total var. for the period			
1988-1994	F1	20.5	Man & Soc	Organization theory; strategic management	Organizational learning and change w.r.t. external environments; theory of firm and competitive strategy
	F2	12.8	Eco, Man & Tech	Economics and management of innovation	R&D, learning, technological innovation, and appropriation
	F3	11.6	Eco, Man & Tech	Economics of industrial innovation	Industrial dynamics, technological innovation, and technical change
	F4	9.0	Eco	Industry/market structure and innovation	Firm size, industry/market structure, and innovation performance
	F5	5.5	Man	Strategy, innovation and competitive performance	Product innovation, technological capabilities, and competitive strategy
	F6	3.5	Eco & Man	Economics and management of innovation	Technological innovation, network externalities, and dominant designs
	F7	3.1	Man	Strategic management	Competitive strategy and firm performance
	Total	**65.9**			
1995-2001	F1	21.3	Man, Eco & Soc	Strategic management	Knowledge-based view (KBV), RBV, dynamic capabilities, and competitive advantage
	F2	13.0	Soc & Man	Organization theory	Organizational learning and change; social structure of competition
	F3	11.7	Eco, Man & Tech	Economics of industrial innovation	R&D, industry/market structure, technological innovation, technical change, and innovation systems
	F4	9.2	Man & Tech	Organization theory	Product innovation; dynamics of knowledge creation, replication, and transfer
	F5	4.2	Man	Organization theory	Technological discontinuities and dominant designs
	F6	3.8	Eco	Economics of industrial innovation	Technological innovation, network externalities, and standard setting
	F7	2.3	Eco	Endogenous growth theory	Endogenous technological change and economic growth
	Total	**65.5**			

Table 2. (*Continued*)

Period	Principal components		Disciplinary composition	Academic fields/ research traditions	Major themes
	No.	% of total var. for the period			
2002-2008	F1	14.0	Man, Eco & Psy	Organization theory	Dynamics of organizational knowledge, learning, and capability development
	F2	12.4	Eco, Man & Tech	Economics of industrial innovation	R&D, geography of knowledge, inter-firm collaboration, and knowledge spillovers
	F3	12.2	Man & Eco	Strategic management	Resource-based theory, dynamic capabilities, technological competences, appropriability
	F4	11.9	Man & Soc	Organization theory	Organizational change, organizational learning, external environments.
	F5	10.3	Man & Eco	Economics and management of innovation	Pattern of technological innovation and diffusion over time
	F6	6.3	Man & Commerce	Organization theory	Product innovation management
	F7	4.6	Soc, Man & Tech	Strategic management	Social structure, innovation, and competition
	F8	2.8	Eco	Endogenous growth theory	Endogenous technological change and economic growth
	F9	2.2	Eco & Tech	Economics of industrial innovation	Systems of innovation
	Total	**76.7**			
1988-2008	F1	22.0	Man, Eco & Soc	Strategic management; organization theory	KBV, RBV, dynamic capabilities, competitive advantage, organizational learning and change
	F2	9.4	Soc & Man	Organization theory	Social structure, innovation, diffusion and competition
	F3	8.0	Man, Commerce & Psy	Organization theory	Product innovation management
	F4	6.6	Man & Tech	Economics and management of innovation	Technological innovation and diffusion processes, life cycles, and dominant designs
	F5	5.7	Eco & Tech	Economics and management of innovation	R&D, technological innovations, learning, innovation performance, spillovers, and appropriability
	F6	4.5	Man & Soc	Organization theory; strategy	Inter-firm networks, social structure, innovation, and competition
	F7	4.2	Man, Eco & Tech	Economics of industrial innovation	Systems of innovation
	F8	3.2	Eco	Endogenous growth theory	Endogenous technological change and economic growth
	Total	**63.7**			

Table 3. Correlation among selected principal components

Period		Variables	Mean	s.d.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1988-1994	1.	F1	0.21	0.30																						
	2.	F2	0.13	0.21	−0.04																					
	3.	F3	0.14	0.23	−0.07	0.55*																				
	4.	F4	0.10	0.17	−0.04	0.59*	0.53*																			
	5.	F5	0.03	0.13	0.31*	−0.11	−0.12	−0.07																		
	6.	F6	0.06	0.14	0.14	0.06	0.39*	0.14	−0.09																	
	7.	F7	0.06	0.12	0.07	0.47*	0.25	0.48*	−0.03	0.07																
1995-2001	8.	F1	0.35	0.28	0.17	0.17	−0.11	0.12	0.11	−0.07	0.29*															
	9.	F2	0.18	0.24	0.71*	−0.18	−0.18	−0.17	−0.01	0.1	−0.01	0.23														
	10.	F3	0.20	0.26	−0.22	0.55*	0.47*	0.54*	−0.17	0.08	0.21	−0.06	−0.30*													
	11.	F4	0.18	0.23	0.16	−0.11	−0.15	−0.26*	0.41*	−0.13	−0.21	0.26*	0.05	−0.31*												
	12.	F5	0.10	0.16	0.40*	0.2	0.26*	0.13	0	0.45*	0.02	0.17	0.40*	0.21	0.14											
	13.	F6	0.06	0.14	−0.02	0.07	0.35*	0.18	−0.17	0.67*	0.13	0.03	0.03	0.24	−0.13	0.43*										
	14.	F7	0.01	0.14	−0.18	0.11	−0.03	0.2	−0.15	−0.1	0.03	−0.22	−0.32*	0.35*	−0.46*	−0.2	−0.08									
2002-2008	15.	F1	0.23	0.23	−0.08	−0.02	−0.25	−0.22	−0.01	−0.27*	−0.12	0.47*	0.06	−0.29*	0.37*	−0.11	−0.23	−0.31*								
	16.	F2	0.19	0.24	−0.39*	0.24	0.01	0.05	−0.29*	−0.26*	0.05	−0.14	−0.34*	0.44*	−0.43*	−0.2	−0.07	0.24	−0.04							
	17.	F3	0.23	0.23	0.03	0.14	−0.08	0.11	0.06	−0.16	0.31*	0.71*	0.02	−0.08	0.13	0.01	0	−0.21	0.44*	−0.03						
	18.	F4	0.22	0.23	0.42*	−0.13	−0.18	−0.08	−0.11	−0.04	0.01	0.32*	0.65*	−0.32*	0.08	0.26*	0.05	−0.29*	0.32*	−0.23	0.37*					
	19.	F5	0.20	0.22	−0.07	0.31*	0.37*	0.32*	−0.09	0.05	0.12	0.16	−0.08	0.40*	0	0.37*	0.27*	−0.08	−0.01	0.13	0.36*	0.29*				
	20.	F6	0.13	0.19	−0.03	−0.14	−0.22	−0.2	0.19	−0.17	−0.17	0.27*	−0.06	−0.40*	0.81*	−0.01	−0.15	−0.37*	0.51*	−0.48*	0.23	0.16	0.02			
	21.	F7	0.11	0.17	0.01	−0.08	−0.23	−0.2	−0.03	−0.13	0.02	−0.01	0.17	−0.27*	0.03	−0.19	0.01	−0.34*	0.31*	0.11	0.03	0.25*	−0.18	0.13		
	22.	F8	0.02	0.16	−0.24	0.09	0.11	0.12	−0.14	−0.04	−0.02	−0.38*	−0.35*	0.45*	−0.41*	−0.21	0.01	0.81*	−0.38*	0.39*	−0.33*	−0.42*	−0.01	−0.45*	−0.35*	
	23.	F9	0.04	0.14	−0.11	0.11	0.23	0.07	−0.04	−0.07	0.04	−0.21	−0.15	0.52*	−0.18	−0.14	0	0.11	−0.34*	0.3*	−0.19	−0.26*	0.12	−0.28*	−0.13	0.28*

The coefficients represent the correlation among the factor loadings of 100 most influential publications on the selected principal components.
The signs (±) represent similarity/dissimilarity between the knowledge bases of the pair.
* $p < 0.01$

The statistics suggest that management and economics are two major contributors in the field (Table 1). However, the contribution of management journals has been consistently increasing from 79 percent in the first period to 84 percent in the second, and 88 percent in the third. On the other hand, the contribution of mainstream economics journals steadily declined from 18 percent in the first period to 12 percent in the second, and 9 percent in the third. This may be an indication that researchers from different disciplines increasingly tended to publish their innovation-related research in management journals. It may also be that innovation-related research in economics was increasingly channeled via hybrid journals (e.g., *Research Policy, Industrial and Corporate Change*) or non-mainstream/specialized economics journals (e.g., *Journal of Evolutionary Economics*).

As regards the influence, the statistics about the 20 most influential journals—which represent 67 percent of the knowledge base of the field—indicate that management journals gradually ascended in their influence while the mainstream economics journals lost in relative influence (Table 4, Figure 1). During the whole study period (1988–2008), the top 20 journals included 12 from management (including *Research Policy*), six from economics, and two from sociology.

Similarly, the *influence* of individual publications can be measured. The 100 most influential publications in the whole study period represent 71 percent of all citations in the first period, 54 percent in the second period, 41 percent in the third period, and 46 percent in the cumulative period (Table B1 in Appendix B). This suggests that they constitute about one half of the knowledge base of the innovation field, though this share has significantly decreased over time. As is typical of 'normal science' (Kuhn, 1970; Latour, 1987), newer publications gradually replaced older ones, which is an indication of healthy growth of the field (Figure 2). Moreover, the presence of some methodological publications—such as Greene (1990) and Yin (1994)—in this list indicates the use of quantitative as well as qualitative approaches, which is also a healthy sign.

The influence of journal papers compared to books has been steadily increasing from 51 percent in the first period to 68 percent in the second and 79 percent in the third (Table 1). This trend is accompanied by a steady increase in the influence of top 20 journals; from 46 percent in the first period to 62 percent in the second and 72 percent in the third (Table 4).

Besides publication type and the outlets, the distribution of all citations across disciplines indicates two major trends (Table 1). First, innovation research in each discipline has consistently become less multidisciplinary as measured by the proportion of citations in the journals of a discipline coming from outside the discipline. For instance, 53 percent of citations in management during the first period were from within the discipline, 23 percent from economics, and 12 percent from sociology. In the second period, this composition changed to 66 percent, 16 percent, and eight percent, respectively, which further deteriorated to become 73 percent, 15 percent, and six percent, respectively. This suggests that each discipline became more self-referential, hence more self-contained and increasingly detached from other disciplines. Second, sociology got closer to management in the knowledge space by drawing on the knowledge base of the latter while distancing from economics.

Research traditions and their interrelationship

The complementary results of the MDS and PCA indicate the prevalence of several distinct research traditions during each period, whereby each principal component assumingly represents a tradition encompassing several interrelated research fronts (McCain, 1990; Acedo *et al*., 2006; Nerur *et al*., 2008). The following analysis is based on the information derived from the structure of the MDS maps (Figures A1–A4), content of the research traditions and their correlation (Tables 2 and 3, Figure A5), and factor loadings of the publications (Tables B2–B5).

First period (1988–1994)

The analysis of factor loadings and MDS map for the first period suggests that the 'mainstream' of innovation research during this period comprised economics-based traditions as indicated by clustering of principal components F2 (Eco, Man & Tech), F3 (Eco, Man & Tech), and F4 (Eco) near the vertex (Figure A1). It is also indicated by the fact that the most widely cited Nelson and

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Table 4. Twenty most influential journals in innovation studies

1988-94					1995-01					2002-08					1988-2008				
Rank	Journal	No. of innov. papers published	Times cited in period matrix	% of n* = 2012	Rank	Journal	No. of innov. papers published	Times cited in period matrix	% of n* = 9193	Rank	Journal	No. of innov. papers published	Times cited in period matrix	% of n* = 20303	Rank	Journal	No. of innov. papers published	Times cited in period matrix	% of n* = 31946
1	RP	88	124	6.2%	1	SMJ	98	751	8.2%	1	SMJ	135	2527	12.4%	1	SMJ	272	3333	10.4%
2	ASQ	10	116	5.8%	2	ASQ	30	725	7.9%	2	RP	418	2130	10.5%	2	RP	748	3009	9.4%
3	AER	10	86	4.3%	3	RP	242	708	7.7%	3	ASQ	30	1783	8.8%	3	ASQ	70	2636	8.3%
4	EJ	10	58	2.9%	4	JPIM	111	524	5.7%	4	OS	92	1505	7.4%	4	OS	179	2053	6.4%
5	AJS	2	56	2.8%	5	OS	67	508	5.5%	5	ManSc	128	1126	5.5%	5	ManSc	224	1448	4.5%
6	JPIM	63	51	2.5%	6	AER	10	271	2.9%	6	AMJ	88	840	4.1%	6	JPIM	288	1356	4.2%
7	ROB	8	49	2.4%	7	ManSc	71	269	2.9%	7	JPIM	114	732	3.6%	7	AMJ	165	1077	3.4%
8	ASR	3	48	2.4%	8	AJS	10	240	2.6%	8	AMR	33	646	3.2%	8	AER	46	916	2.9%
9	SMJ	39	47	2.3%	9	AMR	39	203	2.2%	9	AER	26	555	2.7%	9	AMR	84	883	2.8%
10	Econmet	7	36	1.8%	10	AMJ	63	200	2.2%	10	AJS	12	434	2.1%	10	AJS	24	735	2.3%
11	JPE	12	34	1.7%	11	ROB	11	168	1.8%	11	RJE	23	372	1.8%	11	RJE	67	557	1.7%
12	OS	20	32	1.6%	12	ASR	9	161	1.8%	12	EJ	24	272	1.3%	12	EJ	50	466	1.5%
13	ManSc	25	31	1.5%	13	RJE	30	156	1.7%	13	HBR	118	251	1.2%	13	ASR	20	447	1.4%
14	HBR	30	29	1.4%	14	HBR	53	147	1.6%	14	ASR	8	232	1.1%	14	ROB	27	446	1.4%
15	JEL	5	26	1.3%	15	EJ	16	129	1.4%	15	JoM	35	223	1.1%	15	HBR	201	435	1.4%
16	RJE	14	19	0.9%	16	JoM	22	119	1.3%	16	ROB	8	215	1.1%	16	JoM	68	354	1.1%
17	BPE	2	18	0.9%	17	JEL	2	102	1.1%	17	JPE	9	210	1.0%	17	JPE	26	348	1.1%
18	TR		17	0.8%	18	JPE	5	100	1.1%	18	Econmet	7	189	0.9%	18	Econmet	25	327	1.0%
19	AMR	12	16	0.8%	19	Econmet	11	93	1.0%	18	JEL	4	189	0.9%	19	JEL	11	318	1.0%
20	ARS	2	15	0.7%	20	JoMktg		87	0.9%	20	MISQ	40	184	0.9%	20	QJE	25	259	0.8%
20	JoMktg		15	0.7%															
			923	**45.9%**				**5,661**	**61.6%**				**14,615**	**72.0%**				**21,403**	**67.0%**

* Total number of citations in the respective matrix.

Abbr.	Journal	Dis.	Abbr.	Journal	Dis.	Abbr.	Journal	Dis.
AER	*American Economic Review*	Eco	EJ	*Economic Journal*	Eco	QJE	*Quarterly Journal of Economics*	Eco
AJS	*American Journal of Sociology*	Soc	HBR	*Harvard Business Review*	Man	OS	*Organization Science*	Man
AMJ	*Academy of Management Journal*	Man	JEL	*Journal of Economic Literature*	Eco	RJE	*RAND Journal of Economics*	Eco
AMR	*Academy of Management Review*	Man	JoM	*Journal of Management*	Man	ROB	*Research in Organizational Behavior*	Man
ARS	*Annual Review of Sociology*	Soc	JoMktg	*Journal of Marketing*	Bus. & Mktg	RP	*Research Policy*	Man
ASQ	*Administrative Science Quarterly*	Man	JPE	*Journal of Political Economy*	Eco	SMJ	*Strategic Management Journal*	Man
ASR	*American Sociological Review*	Soc	JPIM	*Journal of Product Innovation Man.*	Man	TR	*Technology Review*	Multidisc.
BPE	*Brookings Papers on Economic Activity*	Eco	ManSc	*Management Science*	Man			
Econmet	*Econometrica*	Eco	MISQ	*MIS Quarterly*	Man			

Winter (1982) was located in close proximity to the 'mainstream' though it did not load significantly on any of the principal components noted here. It loaded almost equally on the first four components and loaded negatively on the fifth component (Man). The knowledge base of these economics-based traditions was related to research and development (R&D), technological innovation, technical change, industrial dynamics, firm size, market structure, and innovation performance of firms.

On the other hand, while being major influencers of the field, management-related traditions, F1 (Man & Soc) and F5 (Man) were more sociology-oriented and detached from economics-based research as indicated by their negative correlation with the former group. These traditions pertained to organizational learning and change with respect to external environments, product innovation, technological capabilities, competitive strategy, and theory of the firm. Straddling between the two groups, but significantly tied to economics, was F6 (Eco & Man), which studied technological innovation, dominant designs, and network externalities from sociological and organizational theory perspectives. A small tradition, representing strategic management (F7: Man), also began to emerge in the innovation field during this period. It is no surprise that due to its intellectual roots in economics and influence of Williamson (1985) and Porter (1985), it was significantly positively correlated with economics-based traditions, F2 (Eco, Man, & Tech) and F4 (Eco).

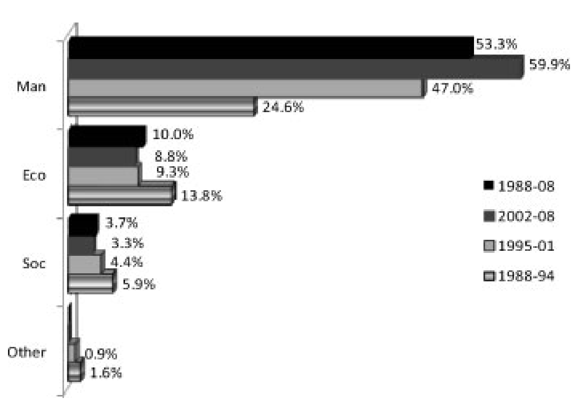

Figure 1. Changes in influence of top 20 journals of each discipline

Overall, this period in innovation research is marked by the detachment between the economics-based and organizational-theory-based approaches.

Second period (1995–2001)

This period witnessed more than a threefold increase in the number of published papers related to innovation; much of this research was contributed by management journals (Table 1). Probably due to this reason, the most noticeable development of this period was that the locus of 'mainstream' in innovation research migrated from economics to management as indicated by the position of management-related traditions F1 (Man, Eco & Soc), F2 (Soc & Man), F4 (Man & Tech), and F5 (Man) on the MDS map (Figure A2). A second noticeable development was the remarkable ascent of strategic management tradition from seventh place (F7) in the previous period to first place (F1) in this period (Figure A5). What makes it remarkable is its 'endogenous growth,' as its knowledge base did not significantly draw from any other tradition in the previous period except its parent tradition. The dominance of this tradition is due mainly to the popularity of resource-based and dynamic capabilities perspectives during this period.

On the other hand, the organization theory tradition of the previous period (F1: Man & Soc) split into two streams (F2: Soc & Man and F4: Man & Tech). One of these traditions, F2, seemed to focus more on the macro level by incorporating the social structural aspects of competition while shifting the emphasis from external factors to internal/organizational factors. The other tradition, F4, was more focused on internal environments and studied product innovation, dynamics of knowledge-creation, replication, and transfer. Moreover, a new tradition (F5: Man) emerged in organization theory by fusing knowledge from organization theory and economics-based traditions of the previous period (F1: Man & Soc; F3: Eco, Man & Tech; and F5: Man). It focused mainly on technological discontinuities and dominant designs. This was the only organization theory tradition that had significant positive correlation with a predominantly economics-based tradition (F6: Eco). It is probably due to the reason that both were studying the dynamics of technological innovation and standard setting, though from different perspectives.

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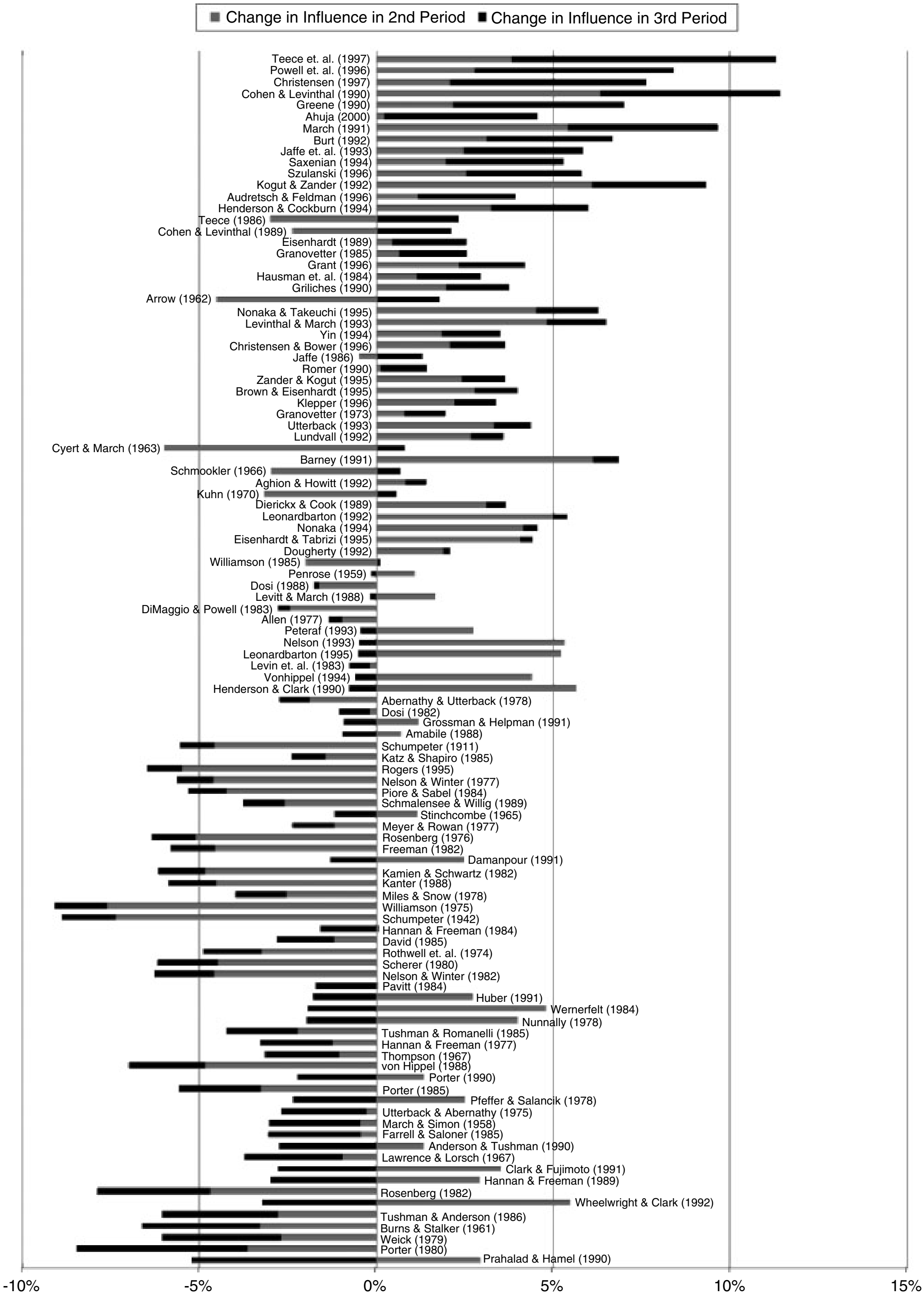

Figure 2. Changes in the influence of 100 most cited publications in the knowledge base of innovation research (1988–2008)

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A third major development during this period was the *convergence*[14] of three economics-based traditions of the previous period (F2: Eco, Man & Tech; F3: Eco, Man & Tech; and F4: Eco) and consequent emergence of one broad tradition (F3: Eco, Man & Tech). This situation emerges when cross-fertilization across the knowledge bases of different traditions makes them homogeneous to such an extent that they become a consolidated domain that serves as a common field for the creation of new knowledge. Not surprisingly, this tradition continued to build on the parent knowledge bases with noticeable emergence of a new research front—systems of innovation.

A fourth prominent change during this period was the appearance of a new island (F10: Eco) on the map asserting the 'endogenous growth theory.' It is no surprise that it is significantly positively correlated with its economics-based counterpart (F3: Eco, Man & Tech), but significantly negatively correlated with organization theory traditions, F2 (Soc & Man) and F4 (Man & Tech).

A comparison of the MDS maps of the first and the second periods also indicates some other interesting developments during the second period. First, economics-based traditions exhibited a tendency of consolidation while the management-related traditions followed the path of diversification. Second, the discipline of management emerged as the largest contributor and influencer in the field. Third, sociological perspectives gained significant influence in innovation research as indicated by the emergence of three separate organization theory traditions and the location of F2 (Soc & Man) on the MDS map. All these developments indicate significant progress in the field of innovation research during the period 1995–2001.

[14] Adapting the idea of Rosenberg (1963), the term 'convergence' here refers to the *overlap* between the knowledge bases of different knowledge domains (research fronts, research traditions, academic fields, disciplines, etc.). It should not be confused with the concepts of merger or consolidation whereby participating entities form a larger whole and the participants lose their identiy. For instance, convergence between biology and chemistry would be a measure of the amount of their knowledge that is related/complementary. However, when the overlap among the knowledge bases of different domains reaches a threshold due to their interaction, convergence may result into the formation of hybrid subdomains (for instance, biochemistry).

Third period (2002–2008)

The innovation research continued to grow during this period and the discipline of management remained the major contributor and influencer (Table 1). The most prominent development that indicates increasing influence of management was the convergence of two traditions of the previous period (F1: Man, Eco & Soc; and F4: Man & Tech) that bred a new organization theory tradition (F1: Man, Eco & Psy) during this period. This influence seems to be the outcome of a general shift of focus from the external environments to the internal environments, particularly toward the dynamics of knowledge creation, learning, and capability development in both organization theory and strategic management traditions.

However, externally oriented branches of organization theory continued to grow alongside, as represented by F4 (Man & Soc). Additionally, there appeared two other distinct traditions related to the organization theory, one focused more on product innovation management (F6: Man & Commerce) and the other represented the emergence of social structural perspective of innovation and competition (F7: Soc, Man & Tech). Another closely related but distinct tradition pertained to strategic management (F3: Man & Eco). While the resource-based and dynamic capability perspectives remained a prominent influence in this tradition, it visibly incorporated the perspectives of technological competences and appropriability in its folds during this period.

On the other hand, consolidation of economics-based traditions during the previous period seems to have resulted in the emphasis on the dynamics of knowledge creation, its geography, and spillovers (F2: Eco, Man & Tech). Furthermore, while the endogenous growth theory remained a niche in economics (F8: Eco), the systems of innovation perspective ascended from a research theme/front in the previous period to a distinct research tradition during this period (F9: Eco & Tech).

Overall, the fragmentation between management and economics persisted—probably widened—during this period as indicated by significant negative correlations among their respective principal components and their positions on the MDS map (Figures A3 and A5). However, increasing focus on the role of knowledge is visible in almost all traditions of this period.

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Cumulative period (1988–2008)

An overview of the field for the whole study period indicates two prominent trends. First, as indicated by the share of variance explained and the coverage of the MDS map by different research traditions, management discipline has been the largest influencer in the field besides being the largest contributor to it (Table 1, Figures 1 and A4). This finding is even more significant given the fact that the publications cited in management needed to have a minimum of 79 received citations in order to be included in the base matrix compared to 30 for *Research Policy*, 15 for economics, and seven for sociology. However, what is unexpected and disconcerting is the fact that innovation-related research in each discipline has been relying more and more on the internal knowledge base of its respective discipline (Table 1, Figure 1). This implies increasing fragmentation and compartmentalization, which may undermine the prospects of innovation becoming a unified and/or coherent scientific field.

DISCUSSION

The aim of this research was to ascertain the subject matter of innovation as a field of research, delineate its intellectual structure by identifying the major research traditions that comprise it, and describe the disciplinary composition of their knowledge base. Based on the understanding that scientific communications within and across disciplines can be empirically measured through bibliometrics, the study used citation data of innovation-related papers published in the 80 most influential journals of four major disciplines of social sciences during the period 1988–2008. Using some careful procedures on citation data matrices, the 20 most influential journals and the 100 most influential publications were identified, which constituted 67 percent and 46 percent, respectively, of the knowledge base of the field during the period. Then, using these 100 publications as the core of the knowledge base and applying standard multivariate techniques, major research traditions and their constituent themes were identified for three subperiods. Following that, relationships among these research traditions were identified using a correlation matrix and its network diagram. Consequently, this is probably the first systematic and comprehensive study that provides a 'global view' of the field from longitudinal and structural perspectives combined.

The research provides evidence supporting the idea that science normally progresses due to the dynamics of convergence (and divergence) among different knowledge domains (e.g., academic fields and disciplines). Convergence takes place due to the fusion and recombination of related knowledge across the boundaries of different knowledge domains. This phenomenon manifests in the emergence of relatively temporary subdomains, such as 'research fronts' and 'research traditions.' While the domains and subdomains compete for resources (Merton, 1968), these tend to 'import' complementary knowledge from other domains and subdomains for the creation of new knowledge. The knowledge 'trade' across the domains and subdomains creates and expands the overlap among their knowledge bases. The greater the overlap among the knowledge bases of different domains and subdomains, the closer they exist in the knowledge space and the greater the possibility of knowledge fusion across their boundaries. This seems to be a dynamic process—which is also likely to be self-reinforcing—that continuously feeds the growth of science.

On the other hand, certain domains or subdomains may start exploring complementary knowledge in hitherto distant domains or subdomains. Those which succeed in finding new reservoirs of complementary knowledge in distant regions may begin feeding more on that knowledge. This process may gradually distance them from their old neighbors in the knowledge space depending on the proportional changes in the composition of their knowledge bases over time. However, the process of divergence is likely to be slower than convergence due to the stickiness of existing knowledge bases, linkages with existing communities of domains and subdomains, and lack of knowledge *about* the new terrain(s). It also seems more likely that domains and subdomains would move in packs rather than individually in the knowledge space.

This study provides some rudimentary evidence regarding the dichotomous phenomenon of knowledge convergence and divergence. For instance, due to increasing convergence among their knowledge bases, three economics-based traditions in the first period (F2: Eco, Man & Tech; F3: Eco, Man & Tech; and F4: Eco) bred a new tradition (F3: Eco, Man & Tech) in the second period (Figure

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A5). Then building on the consolidated knowledge base of this tradition, three distinct research traditions (F2: Eco, Man & Tech; F5: Man & Eco, and F9: Eco & Tech) emerged in the third period.

Similarly, a small tradition in first period (F6: Eco & Man) grew and split into two distinct traditions (F5: Man and F6: Eco) in the second period, whereby one leaned toward organization theory (F5) while the other tilted toward economics (F6). In this process, F5 seems to be the outcome of the management-related part feeding more on other management-related traditions, while F6 resulted from the economics-based part feeding more on the economics-based traditions. Due to the ongoing process of cross-fertilization with related traditions, the economics-based tradition (F6) morphed into another economics-based tradition (F5: Man & Eco), while the management-related tradition (F5) became part of the knowledge bases of F4 (Man & Soc) and F5 (Man & Eco) in the third period, both of which belong to organization theory. This phenomenon of convergence is present among other traditions as well.

The innovation field itself started as a research tradition in Schumpeterian economics. Over time, it became fairly multidisciplinary, which is also indicated by the composition of cross-citations across different disciplines in the early period of the study. However, the evidence from this study suggests that innovation research is gradually losing this attribute. While psychology made very little contribution and influence in the field, the contribution of sociology increased slightly, but its relative influence has been consistently decreasing. Consequently, innovation research seems to be getting compartmentalized between two major disciplines—management and economics—whereby each discipline exhibits the tendency of being inwardly focused and using less and less of the related knowledge outside its disciplinary boundaries (Table 1). This tendency of self-containment is disconcerting because it may hinder tapping the full potential of research in this innately multidisciplinary field. These findings have important implications for the future development of the field.

Implications

This study constitutes an empirically grounded framework that can be used by all researchers to identify the opportunities for research contribution in the field according to the state of their expertise. Since the experts have greater qualitative knowledge, they may contribute reviews at various levels—research-fronts, research traditions, academic fields, and disciplines. The mid-career researchers may do well by following the recommendations of the resource-based view (RBV) of strategy. They may evaluate their existing knowledge base *vis-à-vis* the knowledge bases of various research traditions. If their expertise is concentrated in one tradition, they may consider the avenues for diversification through fusion of knowledge across related traditions. On the other hand, if their expertise is scattered across traditions, they may do well by narrowing their focus. Similarly, the beginners may do well by carefully evaluating the point of entry and ‘positioning’ into the field. By matching their own goals and knowledge base with the knowledge bases of reasonably grounded and likely to emerge traditions, they may choose to specialize in one tradition or carefully diversify in a few closely related ones. Aside from serving as a compass for expertise-based research opportunities, the framework may also be used as an aid in problem-based research. For instance, locating the position of an issue in relation to research traditions may help spot related knowledge/literature within and across research traditions and disciplines.

Limitations

The study inherits several limitations that are typical of any sample-based research. The choice of the sample is the most important among these. Due to the purpose and nature of the study and availability of reliable data, the study was based upon the understanding of scale-free topology in scientific communication networks. Consequently, it focused upon four disciplines and the 20 most influential journals from each discipline, which supposedly represent the ‘mainstream’ of the respective discipline. Although the 100 most influential publications identified here and used as the basis of analysis have significant overlap with the core innovation literature identified by others, the differences suggest that the basis of the sample (e.g., journals vs. handbooks and ISI-listed vs. non-ISI-listed journals) may affect the results. Therefore, this study essentially pertains to the diffusion of Schumpeterian perspective of innovation in the ‘mainstream’ of each discipline and its integration with influential perspectives thereof.

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Consequently, it does not exhaustively cover all the innovation research or the whole field.

Second, the study used *publications* rather than *persons* as the unit of analysis. Due to the dilemmas of this dichotomy, this study did not take into account the disciplinary affiliation of authors of the publications. Unfortunately, both the approaches could not be simultaneously incorporated in a single study of this scale due to the inconsistencies in their methodological demands. It is quite possible that scholars from economics, sociology, and psychology disciplines may have been publishing their innovation-related research in management journals rather than the journals of their respective disciplines. In such a case, the contribution of management as proxied by its journals would be inflated and the impression of decreasing multidisciplinarity may be erroneous. However, it is expected that even the person-based approach may not produce significantly different results unless there is a compelling reason to believe that non-management scholars do not use the knowledge base of their parent disciplines when they publish in management journals. For that matter, such 'multidisciplianrity' is probably irrelevant from the perspective of knowledge flows across disciplinary boundaries.

Third, given the ever-increasing competition for space in top-tier journals, it is quite possible that some important research in innovation did not appear in the mainstream journals and diverted toward newer or more specialized journals that are not among the top 20 or not yet listed by the ISI. This seems plausible given the consistent decrease in the contribution of mainstream journals of economics, which is the parent discipline of the field. Interestingly, if this is taken to be the case, then the innovation field may be seeking a distinct identity by establishing its own specialized journal(s) (Frickel and Gross, 2005; Hambrick and Chen, 2008).

Fourth, a significant part of research is published in the form of books, which may have not been cited in journals due to increasing influence of electronic databases that provide instant access to electronic journals. Electronic access gives journals a decided advantage over books, which are printed in limited number, are not included in commonly used electronic indexes, and do not reach every research institution.

Finally, this study is focused only on social science disciplines, which means that it does not account for innovation-related research in the science and technology fields. Therefore, it is related only to the economic, sociological, and management perspectives of innovation and leaves out the engineering and technological perspectives of the field. These disciplines and fields can be promising avenues for similar research.

Future directions

The evidence from this study gives rise to a new set of interesting questions from the perspective of the theory of social intellectual movements, which seek to establish a distinct identity as a field (Frickel and Gross, 2005; Hambrick and Chen, 2008). Although innovation-related research seems to be growing, it is getting fragmented and compartmentalized in different disciplines. Despite some indications of unification and coherence—such as the establishment of the Technology and Innovation Management Division at the Academy of Management in the United States and DRUID in Europe, as well as several other fora focused on innovation—it is an open question whether innovation can be considered a unified, or at least a coherent, field; or whether it could be or should be a distinct scientific or academic field like, for instance, strategic management (cf. Hambrick and Chen, 2008). If so, why could it not attain such a status in more than half a century of active research that strategic management attained in a few decades? An inherently multifaceted (and hence multidisciplinary) character of the phenomenon of innovation is expected to be at the heart of all such issues.

Conclusion

Innovation essentially involves the creation of new knowledge based on existing knowledge. The organization of knowledge in various domains or 'boxes' helps understand as well as create new knowledge. At various levels of aggregation, research traditions, academic fields and disciplines are few such 'boxes' in which scientific knowledge can be organized on the basis of their respective knowledge base. Correspondingly, every agent in any field has a certain knowledge base that determines their absorptive capacity as well as their creative capacity. The opportunities for knowledge creation, and hence, innovation within a domain and/or by an agent, depend on the breadth,

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diversity, and external linkages (relatedness) of the knowledge base, due to the simple reason that greater variety of related and complementary knowledge offers greater possibilities of new combinations of knowledge. On ther other hand, the lack of diversity and scarcity of the linkages are indicative of overspecialization, self-containment, and stagnation, if not obsolescence.

History of science suggests that it progresses through cross-fertilization across various 'boxes.' Be it the adoption of biological theory of evolution in economics or incorporation of insights from military strategy in management, science has progressed through fusion, recombination, and reconfiguration of extant knowledge. By the same token, it is expected that the evolution and progression of technology fields involve similar dynamics of knowledge creation and innovation emanating from the linkages among different technology fields as well as the linkages across science and technology fields.

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APPENDIX A: MAPS OF THE INTELLECTUAL STRUCTURE OF INNOVATION FIELD

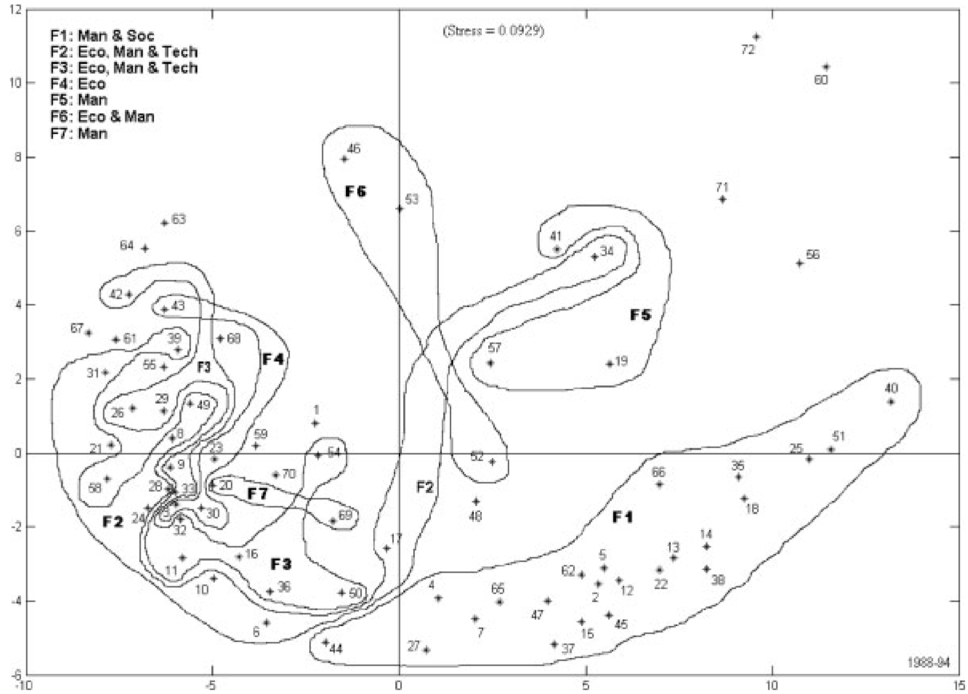

Figure A1. MDS map of period co-citation correlation matrix (1988–1994)

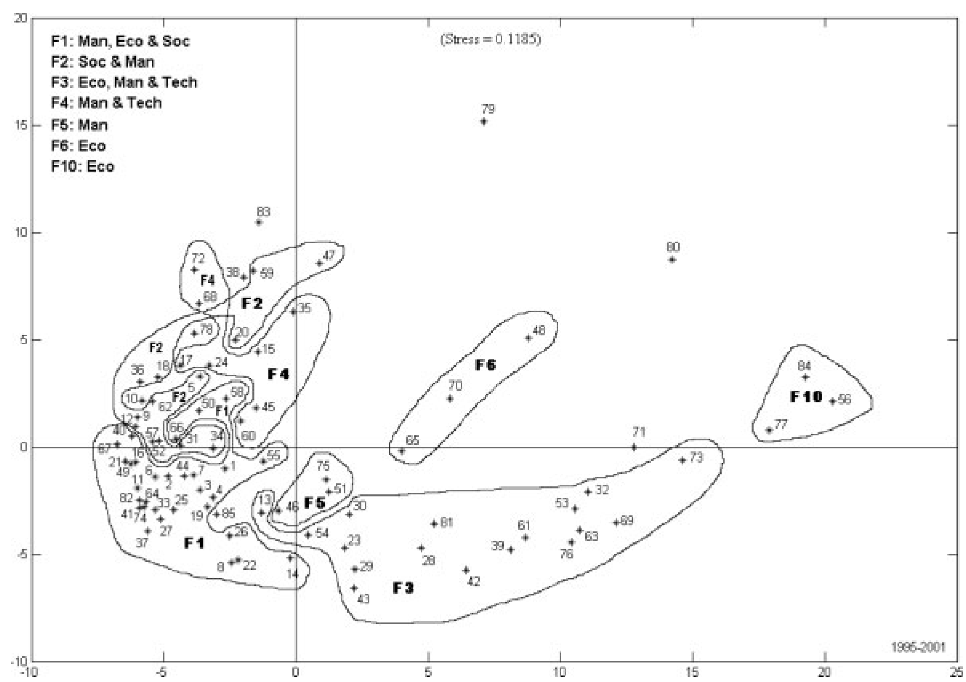

Figure A2. MDS map of period co-citation correlation matrix (1995–2001)

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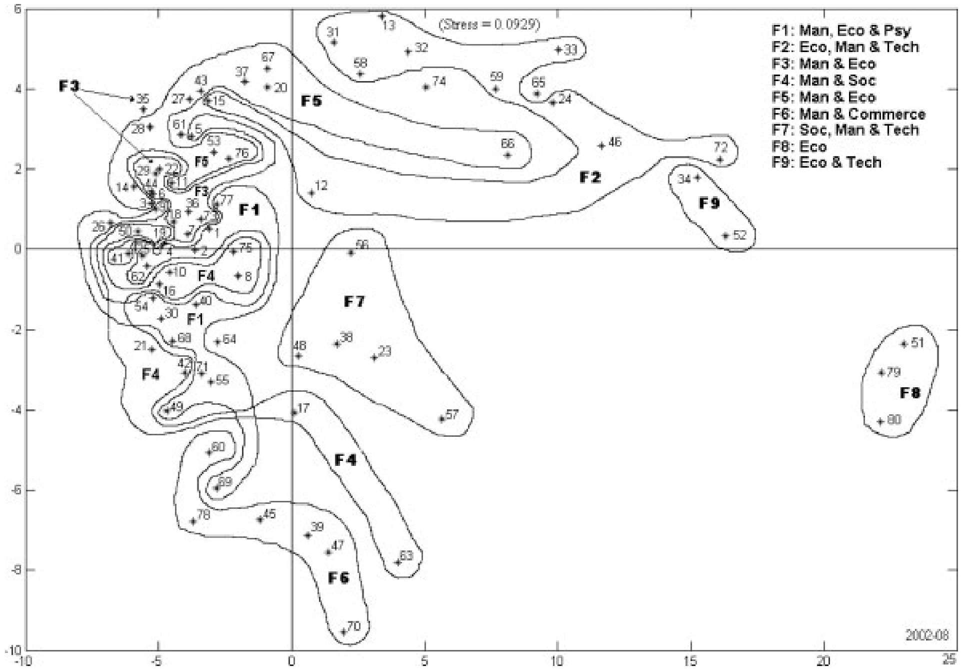

Figure A3. MDS map of period co-citation correlation matrix (2002–2008)

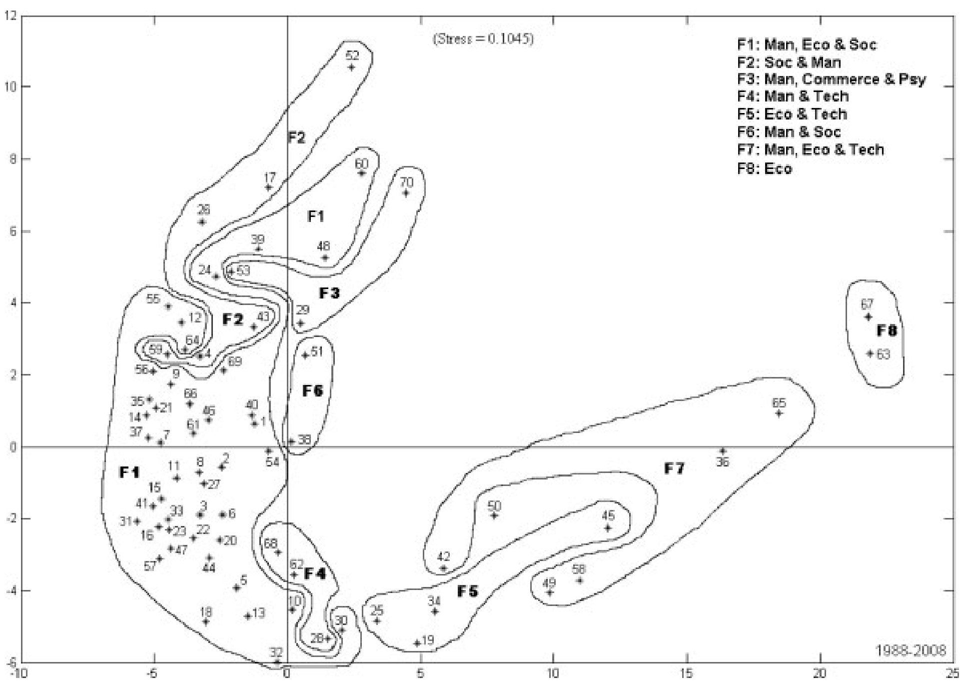

Figure A4. MDS map of cumulative co-citation correlation matrix (1988–2008)

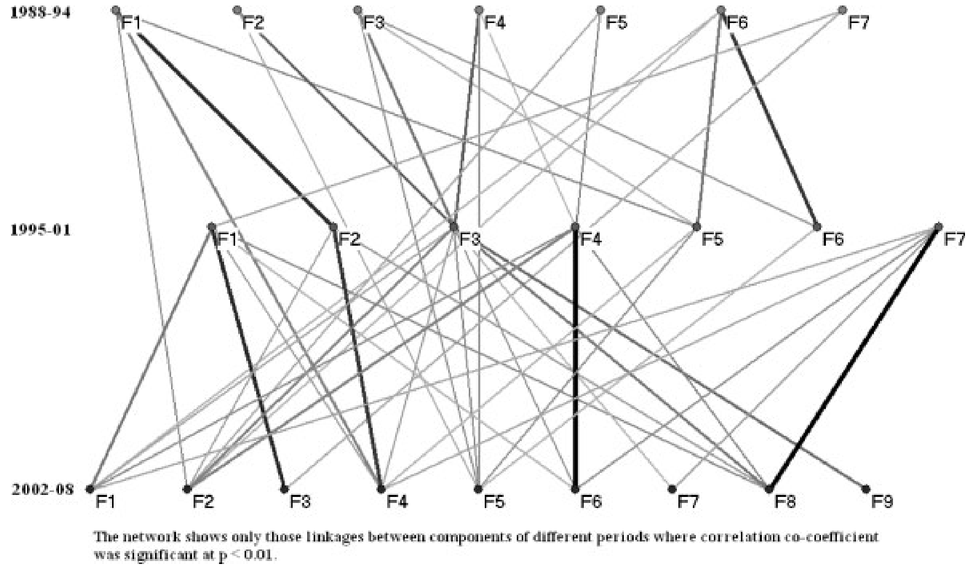

Figure A5. Relationship among the research traditions of the three periods

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Table B1. The 100 most influential publications in innovation field (1988–2008)[a]

S# T50/ T100	Publication	Book/ Journal	Jounal	Discipline	1988-1994 Period Rank	1988-1994 No. of times cited in the period matrix (n = 261)*	1988-1994 % of n = 261	1988-1994 MDS Point Label**	1995-2001 Period Rank	1995-2001 No. of times cited in the period matrix (n = 864)*	1995-2001 % of n = 864	1995-2001 MDS Point Label**	2002-2008 Period Rank	2002-2008 No. of times cited in the period matrix (n = 1451)*	2002-2008 % of n = 1451	2002-2008 MDS Point Label**	1988-2008 Overall Rank	1988-2008 No. of times cited in the period matrix (n = 2750)	1988-2008 % of n = 2750	1988-2008 MDS Point Label**
1	Nelson & Winter (1982)	B		Eco-Theory	1	70	27%	1	1	192	22%	1	2	298	21%	2	**1**	561	20%	1
2	Cohen & Levinthal (1990)	J	ASQ	Man	16	24	9%	17	2	134	16%	2	1	299	21%	1	**2**	459	17%	2
3	Henderson & Clark (1990)	J	ASQ	Man	25	20	8%	27	3	115	13%	3	3	182	13%	3	**3**	317	12%	3
4	Rogers (1995)	B		Soc	2	43	16%	2	5	95	11%	5	8	145	10%	8	**4**	296	11%	4
5	Teece (1986)	J	RP	Man	9	32	12%	9	8	80	9%	8	5	168	12%	5	**5**	282	10%	5
6	Tushman & Anderson (1986)	J	ASQ	Man	4	39	15%	4	4	105	12%	4	11	129	9%	11	**6**	273	10%	6
7	March (1991)	J	OS	Man	88	7	3%		15	70	8%	16	4	179	12%	4	**7**	256	9%	7
8	Barney (1991)	J	JOM	Man	64	10	4%	69	7	86	10%	7	7	155	11%	7	**8**	251	9%	8
9	Cyert & March (1963)	B		Man	5	38	15%	5	12	74	9%	12	10	136	9%	10	**9**	249	9%	9
10	Schumpeter (1942)	B		Pol Eco	3	41	16%	3	14	72	8%	14	20	99	7%	20	**10**	216	8%	10
11	Porter (1980)	B		Man	7	37	14%	7	6	91	11%	6	41	83	6%	41	**11**	212	8%	11
12	Thompson (1967)	B		Man	13	26	10%	14	10	77	9%	10	20	99	7%	21	**12**	203	7%	12
13	von Hippel (1988)	B		Eco-Hist	8	35	13%	8	12	74	9%	13	27	93	6%	27	**12**	203	7%	13
14	March & Simon (1958)	B		Man	15	25	10%	15	9	79	9%	9	25	95	7%	25	**14**	200	7%	14
15	Kogut & Zander (1992)	J	OS	Man	183	1	0%		32	56	6%	33	9	141	10%	9	**15**	198	7%	15
16	Teece *et al*. (1997)	J	SMJ	Man					71	33	4%	74	6	164	11%	6	**16**	197	7%	16
17	DiMaggio & Powell (1983)	J	ASR	Soc	13	26	10%	13	20	65	8%	20	17	104	7%	17	**17**	196	7%	17
18	Schumpeter (1911)	B		Eco-Theory	10	31	12%	10	22	63	7%	22	28	92	6%	28	**18**	187	7%	18
19	Cohen & Levinthal (1989)	J	EJ	Eco	24	21	8%	24	42	49	6%	42	13	113	8%	13	**19**	185	7%	19
20	Levitt & March (1988)	J	ARS	Soc	42	15	6%	47	21	64	7%	21	16	105	7%	16	**20**	184	7%	21
21	Williamson (1985)	B		Eco-Theory	18	23	9%	20	26	59	7%	26	18	101	7%	18	**20**	184	7%	20
22	Williamson (1975)	B		Man	5	38	15%	6	25	60	7%	25	44	79	5%	44	**22**	177	6%	22
23	Penrose (1959)	B		Man	42	15	6%	44	26	59	7%	27	22	97	7%	22	**23**	171	6%	23
24	Lawrence & Lorsch (1967)	B		Man	18	23	9%	18	17	68	8%	17	49	74	5%	49	**24**	168	6%	24
25	Levin *et al*. (1983)	J	BPE	Eco	31	18	7%	31	28	58	7%	28	31	89	6%	31	**25**	167	6%	25
26	Pfeffer & Salancik (1978)	B		Man	49	14	5%	51	17	68	8%	18	42	80	6%	42	**26**	163	6%	26
27	Wernerfelt (1984)	J	SMJ	Man	79	8	3%		17	68	8%	19	36	86	6%	36	**27**	162	6%	27
28	Dosi (1982)	J	RP	Man	31	18	7%	32	28	58	7%	29	37	85	6%	37	**28**	161	6%	28

Table B1. (*Continued*)

S# T50/ T100	Publication	Book/ Journal	Jounal	Discipline	1988-1994 Period Rank	1988-1994 No. of times cited in the period matrix (n = 261)*	1988-1994 % of n = 261	1988-1994 MDS Point Label**	1995-2001 Period Rank	1995-2001 No. of times cited in the period matrix (n = 864)*	1995-2001 % of n = 864	1995-2001 MDS Point Label**	2002-2008 Period Rank	2002-2008 No. of times cited in the period matrix (n = 1451)*	2002-2008 % of n = 1451	2002-2008 MDS Point Label**	1988-2008 Overall Rank	1988-2008 No. of times cited in the period matrix (n = 2750)	1988-2008 % of n = 2750	1988-2008 MDS Point Label**
29	Clark & Fujimoto (1991)	B		Industry	57	12	5%	57	15	70	8%	15	45	77	5%	45	**29**	160	6%	29
30	Leonardbarton (1992)	J	SMJ	Man	138	3	1%		36	53	6%	37	25	95	7%	26	**30**	151	5%	31
31	Rosenberg (1982)	B		Eco-Hist	10	31	12%	11	23	62	7%	23	67	58	4%	67	**30**	151	5%	30
32	Dierickx & Cook (1989)	J	ManSc	Man	88	7	3%		39	50	6%	41	28	92	6%	29	**32**	149	5%	33
33	Dosi (1988)	J	JEL	Eco	28	19	7%	28	42	49	6%	43	42	80	6%	43	**32**	149	5%	32
34	Arrow (1962)	B		Man	18	23	9%	21	61	37	4%	61	32	88	6%	32	**34**	148	5%	34
35	Hannan & Freeman (1984)	J	ASR	Soc	34	17	7%	37	31	57	7%	31	50	73	5%	50	**35**	147	5%	35
36	Nelson (1993)	B		Technology	138	3	1%		32	56	6%	32	34	87	6%	34	**35**	147	5%	36
37	Levinthal & March (1993)	J	SMJ	Man	183	1	0%		49	45	5%	49	19	100	7%	19	**37**	146	5%	37
38	Powell *et al.* (1996)	J	ASQ	Man					98	24	3%		12	122	8%	12	**37**	146	5%	38
39	Allen (1977)	B		Technology	34	17	7%	34	44	48	6%	45	48	75	5%	48	**39**	142	5%	40
40	Burns & Stalker (1961)	B		Man	12	27	10%	12	24	61	7%	24	78	54	4%	78	**39**	142	5%	39
41	Prahalad & Hamel (1990)	J	HBR	Man	42	15	6%	48	11	75	9%	11	86	50	3%		**39**	142	5%	41
42	Porter (1990)	B		Industry	49	14	5%	49	28	58	7%	30	57	65	4%	59	**42**	140	5%	42
43	Granovetter (1973)	J	AJS	Soc	64	10	4%	66	53	40	5%	55	38	84	6%	38	**43**	134	5%	43
44	Greene (1990)	B		Eco-Theory	183	1	0%		110	22	3%		15	107	7%	15	**44**	133	5%	44
45	Griliches (1990)	J	JEL	Eco	96	6	2%		61	37	4%	63	32	88	6%	33	**45**	131	5%	45
46	Nonaka & Takeuchi (1995)	B		Man					57	39	5%	58	30	91	6%	30	**45**	131	5%	46
47	Christensen (1997)	B		Man					131	18	2%		14	111	8%	14	**47**	130	5%	47
48	Yin (1994)	B		Soc Sc. (Gen)	96	6	2%		65	36	4%	66	38	84	6%	39	**48**	128	5%	48
49	Jaffe *et al.* (1993)	J	QJE	Eco	156	2	1%		81	28	3%	81	24	96	7%	24	**49**	126	5%	50
50	Pavitt (1984)	J	RP	Man	42	15	6%	43	39	50	6%	39	66	59	4%	66	**49**	126	5%	49
51	Burt (1992)	B		Man					83	27	3%		22	97	7%	23	**51**	124	5%	51
52	Meyer & Rowan (1977)	J	AJS	Soc	34	17	7%	35	47	46	5%	47	63	60	4%	63	**52**	123	4%	52
53	Nunnally (1978)	B		Psy	110	5	2%		38	51	6%	38	71	57	4%	71	**53**	121	4%	53
54	Porter (1985)	B		Man	18	23	9%	19	44	48	6%	44	94	47	3%		**54**	119	4%	54
55	Huber (1991)	J	OS	Man	79	8	3%		39	50	6%	40	67	58	4%	68	**55**	116	4%	56

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Table B1. (*Continued*)

S# T50/ T100	Publication	Book/ Journal	Jounal	Discipline	1988-1994 Period Rank	1988-1994 No. of times cited in the period matrix (n = 261)*	1988-1994 % of n = 261	1988-1994 MDS Point Label**	1995-2001 Period Rank	1995-2001 No. of times cited in the period matrix (n = 864)*	1995-2001 % of n = 864	1995-2001 MDS Point Label**	2002-2008 Period Rank	2002-2008 No. of times cited in the period matrix (n = 1451)*	2002-2008 % of n = 1451	2002-2008 MDS Point Label**	1988-2008 Overall Rank	1988-2008 No. of times cited in the period matrix (n = 2750)	1988-2008 % of n = 2750	1988-2008 MDS Point Label**
56	Weick (1979)	B		Soc	18	23	9%	22	36	53	6%	36	106	40	3%		**55**	116	4%	55
57	Henderson & Cockburn (1994)	J	SMJ	Man					81	28	3%	82	34	87	6%	35	**57**	115	4%	57
58	Freeman (1982)	B		Man	16	24	9%	16	53	40	5%	53	89	49	3%		**58**	114	4%	58
59	Eisenhardt (1989)	J	AMR	Man	88	7	3%		83	27	3%		47	76	5%	47	**59**	113	4%	60
60	Hannan & Freeman (1989)	B		Man	73	9	3%		34	55	6%	34	89	49	3%		**59**	113	4%	59
61	Leonardbarton (1995)	B		Man					49	45	5%	50	54	68	5%	54	**59**	113	4%	61
62	Abernathy & Utterback (1978)	J	TR	Multi	34	17	7%	36	53	40	5%	54	75	55	4%	76	**62**	112	4%	62
63	Szulanski (1996)	J	SMJ	Man					110	22	3%		38	84	6%	40	**65**	106	4%	66
64	Wheelwright & Clark (1992)	B		Commerce	156	2	1%		35	54	6%	35	99	44	3%		**70**	101	4%	70
65	Anderson & Tushman (1990)	J	ASQ	Man	61	11	4%	62	44	48	6%	46	104	41	3%		**71**	100	4%	
66	Farrell & Saloner (1985)	J	RJE	Eco	42	15	6%	46	47	46	5%	48	111	39	3%		**71**	100	4%	
67	Utterback & Abernathy (1975)	J	Omega	Man	49	14	5%	52	51	44	5%	51	111	39	3%		**74**	98	4%	
68	Saxenian (1994)	B		Eco-Hist					138	17	2%		45	77	5%	46	**77**	94	3%	
69	Schmalensee & Willig (1989)	B		Industry	34	17	7%	39	69	34	4%	69	106	40	3%		**81**	91	3%	
70	Katz & Shapiro (1985)	J	AER	Eco	49	14	5%	53	69	34	4%	70	100	43	3%		**81**	91	3%	
71	Schmookler (1966)	B		Technology	42	15	6%	42	98	24	3%		86	50	3%		**81**	91	3%	
72	Hannan & Freeman (1977)	J	AJS	Soc	42	15	6%	45	57	39	5%	57	118	36	2%		**84**	90	3%	
73	David (1985)	J	AER	Eco	49	14	5%	54	65	36	4%	65	115	37	3%		**87**	87	3%	
74	Tushman & Romanelli (1985)	J	ROB	Man	34	17	7%	38	61	37	4%	62	131	33	2%		**87**	87	3%	
75	Kamien & Schwartz (1982)	B		Eco-Hist	23	22	8%	23	76	31	4%	76	131	33	2%		**89**	86	3%	
76	Miles & Snow (1978)	B		Man	40	16	6%	40	76	31	4%	78	135	31	2%		**90**	82	3%	
77	Kanter (1988)	J	ROB	Man	25	20	8%	25	83	27	3%	83	160	26	2%		**93**	77	3%	
78	Kuhn (1970)	B		Science (Gen)	49	14	5%	50	123	19	2%		106	40	3%	**95**	75	3%		
79	Nelson & Winter (1977)	J	RP	Man	28	19	7%	29	102	23	3%		174	24	2%		**104**	66	2%	

Table B1. (*Continued*)

S# T50/ T100	Publication	Book/ Journal	Jounal	Discipline	1988-1994 Period Rank	1988-1994 No. of times cited in the period matrix (n = 261)*	1988-1994 % of n = 261	1988-1994 MDS Point Label**	1995-2001 Period Rank	1995-2001 No. of times cited in the period matrix (n = 864)*	1995-2001 % of n = 864	1995-2001 MDS Point Label**	2002-2008 Period Rank	2002-2008 No. of times cited in the period matrix (n = 1451)*	2002-2008 % of n = 1451	2002-2008 MDS Point Label**	1988-2008 Overall Rank	1988-2008 No. of times cited in the period matrix (n = 2750)	1988-2008 % of n = 2750	1988-2008 MDS Point Label**
80	Piore & Sabel (1984)	B		Industry	31	18	7%	33	102	23	3%		191	23	2%		**106**	65	2%	
81	Rothwell *et al*. (1974)	J	RP	Man	40	16	6%	41	93	25	3%		257	18	1%		**106**	65	2%	
82	Rosenberg (1976)	B		Eco-Hist	25	20	8%	26	110	22	3%	240	19	1%	**116**	61	2%			
83	Scherer (1980)	B		Industry	28	19	7%	30	98	24	3%		283	16	1%		**120**	59	2%	
84	Romer (1990)	J	JPE	Eco	73	9	3%		76	31	4%	77	51	71	5%	51	**62**	112	4%	63
85	Stinchcombe (1965)	B		Soc	64	10	4%	65	52	43	5%	52	75	55	4%	75	**64**	108	4%	64
86	Lundvall (1992)	B		Eco-Hist	138	3	1%		71	33	4%	73	52	69	5%	52	**65**	106	4%	65
87	Grossman & Helpman (1991)	B		Eco-Hist	73	9	3%		53	40	5%	56	78	54	4%	79	**67**	103	4%	67
88	Nonaka (1994)	J	OS	Man					65	36	4%	67	55	66	5%	55	**68**	102	4%	69
89	Utterback (1993)	B		Man	183	1	0%		75	32	4%	75	52	69	5%	53	**68**	102	4%	68
90	Eisenhardt & Tabrizi (1995)	J	ASQ	Man					68	35	4%	68	60	64	4%	60	**73**	99	4%	
91	Peteraf (1993)	J	SMJ	Man	120	4	2%		61	37	4%	64	73	56	4%	73	**75**	97	4%	
92	Dougherty (1992)	J	OS	Man	110	5	2%		71	33	4%	72	67	58	4%	69	**76**	96	3%	
93	Vonhippel (1994)	J	ManSc	Man					59	38	4%	60	75	55	4%	77	**77**	94	3%	
94	Hausman *et al*. (1984)	J	Econmet	Eco	120	4	2%		102	23	3%		57	65	4%	58	**79**	92	3%	
95	Granovetter (1985)	J	AJS	Soc	110	5	2%		110	22	3%		57	65	4%	57	**79**	92	3%	
96	Aghion & Howitt (1992)	J	Econmet	Eco	96	6	2%		83	27	3%	84	78	54	4%	80	**85**	88	3%	
97	Damanpour (1991)	J	AMJ	Man	110	5	2%		59	38	4%	59	96	45	3%		**85**	88	3%	
98	Brown & Eisenhardt (1995)	J	AMR	Man					98	24	3%		67	58	4%	70	**90**	82	3%	
99	Grant (1996)	J	SMJ	Man					119	20	2%		62	61	4%	62	**92**	81	3%	
100	Jaffe (1986)	J	AER	Eco	88	7	3%		123	19	2%		84	51	4%		**93**	77	3%	
101	Zander & Kogut (1995)	J	OS	Man					115	21	2%		82	53	4%		**96**	74	3%	
102	Amabile (1988)	J	ROB	Man	96	6	2%		90	26	3%		140	30	2%		**97**	71	3%	
103	Christensen & Bower (1996)	J	SMJ	Man					131	18	2%		82	53	4%		**97**	71	3%	
104	Ahuja (2000)	J	ASQ	Man					548	2	0%		55	66	5%	56	**99**	68	2%	
105	Audretsch & Feldman (1996)	J	AER	Eco					230	10	1%		71	57	4%	72	**99**	68	2%	
106	Klepper (1996)	J	AER	Eco					123	19	2%		89	49	3%		**99**	68	2%	

[a] First 83 publications represent the total set of 50 most influential studies in each period. The remaining (84-106) publications are those which were not among top 50 in any period but are among the 100 most cited publications in the whole study period.
* Total number of citing publications in the respective matrix.
** The MDS point label of each publication for each period is unique and corresponds only to the MDS map of the respective period.

Table B2. Principal components for the period 1988-1994

1988-1994	F1	F2	F3	F4	F5	F6	F7
	Tushman & Romanelli (1985)	*Levin etal. (1983)*	*Pavitt (1984)*	*Scherer (1980)*	*Rothwell etal. (1974)*	Farrell & Saloner (1985)	Williamson (1985)
	Thompson (1967)	*Cohen & Levinthal (1989)*	*Rosenberg (1976)*	*Kamien & Schwartz (1982)*	Clark & Fujimoto (1991)	Katz & Shapiro (1985)	Barney (1991)
	Hannan & Freeman (1977)	*von Hippel (1988)*	*Nelson & Winter (1977)*	Schmalensee & Willig (1989)	Porter (1985)	Anderson & Tushman (1990)	Porter (1985)
	Hannan & Freeman (1984)	Dosi (1988)	*Dosi (1982)*	Schumpeter (1911)	Allen (1977)	Utterback & Abernathy (1975)	Piore & Sabel (1984)
	Pfeffer & Salancik (1978)	Schmalensee & Willig (1989)	*Schmookler (1966)*	Schumpeter (1942)	Prahalad & Hamel (1990)	Kuhn (1970)	
	DiMaggio & Powell (1983)	Arrow (1962)	*Abernathy & Utterback (1978)*	Arrow (1962)			
	Lawrence & Lorsch (1967)	Porter (1990)	Piore & Sabel (1984)	Freeman (1982)			
	March & Simon (1958)	Barney (1991)	David (1985)	Schmookler (1966)			
	Weick (1979)	Cohen & Levinthal (1990)	Kuhn (1970)	Williamson (1975)			
	Cyert & March (1963)	Rosenberg (1982)	Rosenberg (1982)				
	Kanter (1988)	Allen (1977)	Freeman (1982)				
	Burns & Stalker (1961)	Schumpeter (1911)	Teece (1986)				
	Rogers (1995)	Penrose (1959)	Schumpeter (1942)				
	Miles & Snow (1978)	Schumpeter (1942)	Schumpeter (1911)				
	Meyer & Rowan (1977)	Teece (1986)	Williamson (1975)				
	Stinchcombe (1965)	Piore & Sabel (1984)	Williamson (1985)				
	Levitt & March (1988)	Williamson (1975)					
	Granovetter (1973)	Williamson (1985)					
	Anderson & Tushman (1990)						
	Porter (1980)						
	Tushman & Anderson (1986)						
	Henderson & Clark (1990)						
	Penrose (1959)						
	Cohen & Levinthal (1990)						
	Williamson (1975)						
	Schmookler (1966)	Miles & Snow (1978)	Miles & Snow (1978)	Weick (1979)	Nelson & Winter (1982)	Granovetter (1973)	Lawrence & Lorsch (1967)
	Pavitt (1984)	Pfeffer & Salancik (1978)	Kanter (1988)	Allen (1977)	Stinchcombe (1965)	Allen (1977)	Allen (1977)
	Levin *et al*. (1983)	Thompson (1967)	Pfeffer & Salancik (1978)	Kanter (1988)	Teece (1986)	Pfeffer & Salancik (1978)	Burns & Stalker (1961)
	Arrow (1962)	Lawrence & Lorsch (1967)	Tushman & Romanelli (1985)	Meyer & Rowan (1977)	Cohen & Levinthal (1989)	Lawrence & Lorsch (1967)	Kuhn (1970)
	Rosenberg (1976)	Porter (1985)	Porter (1985)	Miles & Snow (1978)	David (1985)	Miles & Snow (1978)	March & Simon (1958)
Total var. expl.	14.759	9.238	8.319	6.456	3.955	2.514	2.197
% var. expl.	20.498	12.831	11.554	8.967	5.493	3.491	3.052

Total variance explained = 65.9%
Table includes all the publications with factor loadings $\geq +0.4$ on selected principal components. Publications with factor loadings $\geq \pm 0.7$ are italicized.
The lower block includes five publications with the highest negative loadings on the component.

Table B3. Principal components for the period 1995-2001

1995-2001	F1	… F1	F2	F3	F4	F5	F6
	Peteraf (1993)	… ctd. from previous column	*Meyer & Rowan (1977)*	*Pavitt (1984)*	*Allen (1977)*	Anderson & Tushman (1990)	*Katz & Shapiro (1985)*
	Dierickx & Cook (1989)	Yin (1994)	*DiMaggio & Powell (1983)*	*Freeman (1982)*	*Wheelwright (1992)*	Utterback & Abernathy (1975)	*Farrell & Saloner (1985)*
	Penrose (1959)	Scherer (1980)	*Pfeffer & Salancik (1978)*	*Nelson (1993)*	*Brown & Eisenhardt (1995)*	Utterback (1993)	David (1985)
	Teece etal. (1997)	Cyert & March (1963)	*Tushman & Romanelli (1985)*	*Schmookler (1966)*	*Eisenhardt & Tabrizi (1995)*	Abernathy & Utterback (1978)	
	Kogut & Zander (1992)	Porter (1990)	*Hannan & Freeman (1984)*	*Lundvall (1992)*	*Dougherty (1992)*	Hannan & Freeman (1989)	
	Henderson & Cockburn (1994)	Thompson (1967)	*Rogers (1995)*	*Cohen & Levinthal (1989)*	*Clark & Fujimoto (1991)*	Dosi (1982)	
	Prahalad & Hamel (1990)	Vonhippel (1994)	*Stinchcombe (1965)*	*Arrow (1962)*	*Burns & Stalker (1961)*	Tushman & Romanelli (1985)	
	Nonaka (1994)	Miles & Snow (1978)	*Hannan & Freeman (1977)*	*Dosi (1988)*	Vonhippel (1994)	Hannan & Freeman (1977)	
	Porter (1980)	Powell *et al*. (1996)	*Cyert & March (1963)*	*Kamien & Schwartz (1982)*	Lawrence & Lorsch (1967)	Tushman & Anderson (1986)	
	Porter (1985)	Tushman & Anderson (1986)	Hannan & Freeman (1989)	*Schmalensee & Willig (1989)*	Thompson (1967)		
	Barney (1991)	Stinchcombe (1965)	Granovetter (1973)	*Rosenberg (1982)*	Utterback (1993)		
	Leonardbarton (1992)	Lawrence & Lorsch (1967)	March & Simon (1958)	Dosi (1982)	Rothwell *et al*. (1974)		
	Williamson (1975)	Hannan & Freeman (1977)	Weick (1979)	Griliches (1990)	Eisenhardt (1989)		
	Cohen & Levinthal (1990)	March & Simon (1958)	Levitt & March (1988)	Levin *et al*. (1983)	Damanpour (1991)		
	Williamson (1985)	von Hippel (1988)	Damanpour (1991)	Porter (1990)	Leonardbarton (1995)		
	Leonardbarton (1995)	Eisenhardt (1989)	Levinthal & March (1993)	Jaffe *et al*. (1993)	Kanter (1988)		
	Wernerfelt (1984)	Weick (1979)	March (1991)	Abernathy & Utterback (1978)	Nonaka & Takeuchi (1995)		
	Teece (1986)	Dosi (1988)	Huber (1991)	Utterback & Abernathy (1975)	Leonardbarton (1992)		
	Schumpeter (1911)	Hannan & Freeman (1989)	Burt (1992)	Schumpeter (1942)	Abernathy & Utterback (1978)		
	Huber (1991)	Hannan & Freeman (1984)	Thompson (1967)	von Hippel (1988)	March & Simon (1958)		
	Levinthal & March (1993)	Burt (1992)	Amabile (1988)	Teece (1986)	von Hippel (1988)		
	Nonaka & Takeuchi (1995)	Cohen & Levinthal (1989)	Tushman & Anderson (1986)	Schumpeter (1911)	Yin (1994)		
	Levitt & March (1988)	Nunnally (1978)	David (1985)	Romer (1990)	Weick (1979)		
	March (1991)	Clark & Fujimoto (1991)	Kanter (1988)	Grossman & Helpman (1991)			
	Henderson & Clark (1990)			Utterback (1993)			
	Schumpeter (1942)			Scherer (1980)			
	Nelson & Winter (1982)			Anderson & Tushman (1990)			
	… ctd. to next column			Williamson (1985)			
		Grossman & Helpman (1991)	Grossman & Helpman (1991)	Dougherty (1992)	Grossman & Helpman (1991)	Damanpour (1991)	Kanter (1988)
		Lundvall (1992)	Rothwell *et al*. (1974)	Kanter (1988)	Aghion & Howitt (1992)	Nunnally (1978)	Powell *et al*. (1996)
		Romer (1990)	Aghion & Howitt (1992)	Brown & Eisenhardt (1995)	Schmookler (1966)	Nonaka & Takeuchi (1995)	Amabile (1988)
		Aghion & Howitt (1992)	Griliches (1990)	Eisenhardt (1989)	Schmalensee & Willig (1989)	Porter (1990)	Schmalensee & Willig (1989)
		Freeman (1982)	Arrow (1962)	Meyer & Rowan (1977)	Romer (1990)	Nonaka (1994)	Brown & Eisenhardt (1995)
Total var. expl.		21.534	13.096	11.835	9.329	4.238	3.806
% of var. expl.		21.321	12.967	11.718	9.237	4.196	3.768

Total variance explained = 65.5%
Table includes all the publications with factor loadings ≥ +0.4 on selected principal components. Publications with factor loadings ≥ ±0.7 are italicized.
The lower block includes five publications with the highest negative loadings on the component.

Table B4. Principal components for the period 2002-2008

2002-2008	F1	F2	F3	F4	F5	F6	F7	F8	F9	
	Nonaka (1994)	*Jaffe etal. (1993)*	*Peteraf (1993)*	*Hannan & Freeman (1989)*	*Klepper (1996)*	*Wheelwright (1992)*	*Granovetter (1985)*	*Grossman & Helpman (1991)*	Lundvall (1992)	
	Huber (1991)	*Hausman etal. (1984)*	*Wernerfelt (1984)*	*Meyer & Rowan (1977)*	*Abernathy & Utterback (1978)*	*Brown & Eisenhardt (1995)*	*Granovetter (1973)*	*Aghion & Howitt (1992)*	Pavitt (1984)	
	Nonaka & Takeuchi (1995)	*Jaffe (1986)*	*Porter (1985)*	*Stinchcombe (1965)*	*Utterback (1993)*	*Eisenhardt & Tabrizi (1995)*	*Burt (1992)*	Romer (1990)	Porter (1990)	
	Leonardbarton (1995)	*Griliches (1990)*	*Prahalad & Hamel (1990)*	*Hannan & Freeman (1984)*	*Rosenberg (1982)*	Clark & Fujimoto (1991)	Ahuja (2000)	Jaffe (1986)	Nelson (1993)	
	Zander & Kogut (1995)	*Audretsch*	*Feldman (1996)*	*Dierickx & Cook (1989)*	*Pfeffer & Salancik (1978)*	*Dosi (1982)*	Dougherty (1992)	Allen (1977)	Schmookler (1966)	Freeman (1982)
	Szulanski (1996)	*Saxenian (1994)*	*Penrose (1959)*	*DiMaggio & Powell (1983)*	*Christensen & Bower (1996)*	Burns & Stalker (1961)	Rogers (1995)			
	Grant (1996)	*Arrow (1962)*	*Porter (1980)*	Cyert & March (1963)	*Schumpeter (1942)*	Eisenhardt (1989)	Powell *et al.* (1996)			
	Dougherty (1992)	*Cohen & Levinthal (1989)*	Barney (1991)	Levitt & March (1988)	Freeman (1982)	Yin (1994)	Katz & Shapiro (1985)			
	Kogut & Zander (1992)	*Porter (1990)*	Williamson (1975)	Levinthal & March (1993)	Tushman & Anderson (1986)	Allen (1977)	von Hippel (1988)			
	March & Simon (1958)	*Levin etal. (1983)*	Teece *et al.* (1997)	Katz & Shapiro (1985)	Christensen (1997)	Lawrence & Lorsch (1967)	Zander & Kogut (1995)			
	Levitt & March (1988)	Schmookler (1966)	Grant (1996)	March & Simon (1958)	Pavitt (1984)	Nonaka (1994)	Nunnally (1978)			
	Nunnally (1978)	Greene (1990)	Teece (1986)	Damanpour (1991)	Schumpeter (1911)	Nonaka & Takeuchi (1995)				
	Henderson & Cockburn (1994)	Powell *et al.* (1996)	Williamson (1985)	Thompson (1967)	Dosi (1988)					
	March (1991)	Ahuja (2000)	Henderson & Cockburn (1994)	Rogers (1995)	Henderson & Clark (1990)					
	Leonardbarton (1992)	Nelson (1993)	Leonardbarton (1992)	Burns & Stalker (1961)	Katz & Shapiro (1985)					
	Levinthal & March (1993)	Henderson & Cockburn (1994)	Greene (1990)	March (1991)	Teece (1986)					
	Cyert & March (1963)	Lundvall (1992)	Kogut & Zander (1992)	Huber (1991)	von Hippel (1988)					
	Vonhippel (1994)	Vonhippel (1994)	Nelson & Winter (1982)	Christensen (1997)	Porter (1980)					

Table B4. (*Continued*)

2002-2008	F1	F2	F3	F4	F5	F6	F7	F8	F9
	Lawrence & Lorsch (1967)	Dosi (1988)	Schumpeter (1911)	Porter (1980)	Hannan & Freeman (1984)				
	Allen (1977)	von Hippel (1988)	Henderson & Clark (1990)	Christensen & Bower (1996)	Levin *et al*. (1983)				
	Nelson & Winter (1982)		Christensen (1997)	Lawrence & Lorsch (1997)	Schmookler (1966)				
	Barney (1991)		Pfeffer & Salancik (1978)	Tushman & Anderson (1986)	Porter (1985)				
	Cohen & Levinthal (1990)		Thompson (1967)	Leonardbarton (1992)					
	Clark & Fujimoto (1991)		Cohen & Levinthal (1990)	Williamson (1975)					
	von Hippel (1988)		Lawrence & Lorsch (1967)	Henderson & Clark (1990)					
	Teece *et al*. (1997)		Schumpeter (1942)	Granovetter (1973)					
	Dierickx & Cook (1989)		von Hippel (1988)	Greene (1990)					
	Thompson (1967)		Leonardbarton (1995)	Penrose (1959)					
	Damanpour (1991)		Vonhippel (1994)						
	Eisenhardt & Tabrizi (1995)		Tushman & Anderson (1986)						
	Henderson & Clark (1990)		Levin *et al*. (1983)						
	Dosi (1988)								
	Schumpeter (1911)								
	Prahalad & Hamel (1990)								
	Audretsch & Feldman (1996)	Burns & Stalker (1961)	Romer (1990)	Romer (1990)	Audretsch & Feldman (1996)	Romer (1990)	Romer (1990)	Nelson & Winter (1982)	Nelson & Winter (1982)
	Schmookler (1966)	Meyer & Rowan (1977)	Grossman & Helpman (1991)	Grossman & Helpman (1991)	Brown & Eisenhardt (1995)	Schmookler (1966)	Freeman (1982)	Burt (1992)	Hausman *et al.* (1984)
	Aghion & Howitt (1992)	Wheelwright (1992)	Aghion & Howitt (1992)	Lundvall (1992)	Granovetter (1973)	Griliches (1990)	Aghion & Howitt (1992)	Eisenhardt (1989)	Ahuja (2000)
	Romer (1990)	Yin (1994)	Granovetter (1985)	Griliches (1990)	Granovetter (1985)	Grossman & Helpman (1991)	Schmookler (1966)	Stinchcombe (1965)	Greene (1990)
	Klepper (1996)	Clark & Fujimoto (1991)	Jaffe *et al*. (1993)	Aghion & Howitt (1992)	Szulanski (1996)	Jaffe *et al*. (1993)	Griliches (1990)	Christensen & Bower (1996)	Arrow (1962)
Total var. expl.	14.144	12.513	12.307	12.013	10.368	6.402	4.675	2.856	2.237
% var. expl.	14.004	12.389	12.185	11.894	10.266	6.338	4.628	2.828	2.214

Total variance explained = 76.7% Table includes all the publications with factor loadings $\geq +0.4$ on selected principal components. Publications with factor loadings $\geq \pm 0.7$ are italicized. The lower block includes five publications with the highest negative loadings on the component.

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Table B5. Principal components for the whole study period (1988-2008)

1988-2008	F1	…F1	F2	F3	F4	F5	F6	F7	F8
	Grant (1996)	Christensen & Bower (1996)	*Meyer & Rowan (1977)*	*Wheelwright (1992)*	*Utterback & Abernathy (1975)*	*Schmalensee & Willig (1989)*	*Ahuja (2000)*	*Lundvall (1992)*	*Aghion & Howitt (1992)*
	Kogut & Zander (1992)	Eisenhardt & Tabrizi (1995)	*DiMaggio & Powell (1983)*	*Rothwell etal. (1974)*	*Klepper (1996)*	*Kamien & Schwartz (1982)*	Powell *et al.* (1996)	*Nelson (1993)*	*Grossman & Helpman (1991)*
	Leonardbarton (1995)	Hannan & Freeman (1984)	Pfeffer & Salancik (1978)	Brown & Eisenhardt (1995)	*Anderson & Tushman (1990)*	*Arrow (1962)*	Burt (1992)	*Pavitt (1984)*	*Romer (1990)*
	Henderson & Cockburn (1994)	Tushman & Anderson (1986)	Rogers (1995)	Nunnally (1978)	*Abernathy & Utterback (1978)*	Schmookler (1966)	Granovetter (1985)	Porter (1990)	Jaffe (1986)
	Teece etal. (1997)	Dosi (1988)	Hannan & Freeman (1989)	Clark & Fujimoto (1991)	*Utterback (1993)*	Jaffe (1986)	Granovetter (1973)	Rosenberg (1976)	
	Leonardbarton (1992)	Porter (1985)	Granovetter (1973)	Eisenhardt & Tabrizi (1995)	Dosi (1982)	Levin *et al.* (1983)	Saxenian (1994)	Freeman (1982)	
	Zander & Kogut (1995)	Powell *et al.* (1996)	Hannan & Freeman (1984)	Dougherty (1992)	Christensen & Bower (1996)	Griliches (1990)	Hausman *et al.* (1984)	Nelson & Winter (1977)	
	Nonaka & Takeuchi (1995)	Hannan & Freeman (1977)	Hannan & Freeman (1977)	Miles & Snow (1978)	David (1985)	Cohen & Levinthal (1989)	Greene (1990)	Saxenian (1994)	
	Nonaka (1994)	Stinchcombe (1965)	Stinchcombe (1965)	Burns & Stalker (1961)	Kuhn (1970)	Scherer (1980)		Piore & Sabel (1984)	
	Dierickx & Cook (1989)	Yin (1994)	Damanpour (1991)	Allen (1977)	Nelson & Winter (1977)	Hausman *et al.* (1984)		Rosenberg (1982)	
	Szulanski (1996)	Ahuja (2000)	Cyert & March (1963)		Tushman & Anderson (1986)	Dosi (1988)		Schmookler (1966)	
	Barney (1991)	Hausman *et al.* (1984)	Tushman & Romanelli (1985)		Christensen (1997)	Schumpeter (1942)		Dosi (1982)	
	Huber (1991)	Tushman & Romanelli (1985)	Levitt & March (1988)		Hannan & Freeman (1977)	Pavitt (1984)		Cohen & Levinthal (1989)	
	Prahalad & Hamel (1990)	Clark & Fujimoto (1991)	Weick (1979)		Tushman & Romanelli (1985)	Freeman (1982)		Audretsch & Feldman (1996)	
	Wernerfelt (1984)	Hannan & Freeman (1989)	March & Simon (1958)		Rosenberg (1976)	Greene (1990)		Dosi (1988)	
	Penrose (1959)	Schumpeter (1942)	Granovetter (1985)		Rosenberg (1982)	Jaffe *et al.* (1993)		von Hippel (1988)	
	March (1991)	Utterback (1993)	Thompson (1967)		Schumpeter (1942)			Kuhn (1970)	
	Levinthal & March (1993)	Scherer (1980)			Freeman (1982)				
	Peteraf (1993)	Eisenhardt (1989)			Hannan & Freeman (1989)				

Table B5. (*Continued*)

1988-2008	F1	…F1	F2	F3	F4	F5	F6	F7	F8
	Cohen & Levinthal (1990)	Pfeffer & Salancik (1978)			Henderson & Clark (1990)				
	Levitt & March (1988)	Burns & Stalker (1961)			Katz & Shapiro (1985)				
	Vonhippel (1994)	Levin *et al*. (1983)			Schumpeter (1911)				
	Christensen (1997)	Brown & Eisenhardt (1995)			Hannan & Freeman (1984)				
	March & Simon (1958)	Cohen & Levinthal (1989)			Farrell & Saloner (1985)				
	Henderson & Clark (1990)	Porter (1990)			Dosi (1988)				
	Greene (1990)	Nunnally (1978)			Teece (1986)				
	Nelson & Winter (1982)	Granovetter (1973)			Scherer (1980)				
	Porter (1980)	Anderson & Tushman (1990)			von Hippel (1988)				
	Cyert & March (1963)	Rogers (1995)			Porter (1980)				
	Schumpeter (1911)	Abernathy & Utterback (1978)			Pavitt (1984)				
	Dougherty (1992)	Rosenberg (1982)							
	Teece (1986)	Miles & Snow (1978)							
	Thompson (1967)	Burt (1992)							
	Williamson (1975)	Jaffe *et al*. (1993)							
	Williamson (1985)	Damanpour (1991)							
	Allen (1977)	Dosi (1982)							
	Lawrence & Lorsch (1967)	Granovetter (1985)							
	von Hippel (1988)	Wheelwright (1992)							
	Weick (1979)	Kamien & Schwartz (1982)							
	… ctd. in next column …	Arrow (1962)							
		Aghion & Howitt (1992)	Griliches (1990)	Audretsch & Feldman (1996)	Szulanski (1996)	Eisenhardt (1989)	Wheelwright (1992)	Miles & Snow (1978)	Burt (1992)
		Grossman & Helpman (1991)	Grossman & Helpman (1991)	Romer (1990)	Zander & Kogut (1995)	Dougherty (1992)	Weick (1979)	Amabile (1988)	Rothwell *et al*. (1974)
		Romer (1990)	Romer (1990)	Griliches (1990)	Nonaka (1994)	Yin (1994)	Rothwell *et al*. (1974)	Kanter (1988)	Wheelwright (1992)
			Aghion & Howitt (1992)	Hausman *et al*. (1984)	Audretsch & Feldman (1996)	Wheelwright (1992)	Nelson & Winter (1977)	Brown & Eisenhardt (1995)	Amabile (1988)
			Jaffe (1986)	Grossman & Helpman (1991)	Granovetter (1985)	Kanter (1988)	Kanter (1988)		Kanter (1988)
Total var. expl.		78.63	33.64	28.60	23.72	20.18	16.02	15.16	11.56
% of var. expl.		22.02	9.42	8.01	6.64	5.65	4.49	4.25	3.24

Total variance explained = 63.73% Table includes all the publications with factor loadings ≥ +0.4 on selected principal components. Publications with factor loadings ≥ ±0.7 are italicized.
The lower block includes five publications with the highest negative loadings on the component.