



No escape from the dominant theories: The analysis of intellectual pillars of technology management in developing countries

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ARTICLE INFO

Article history:

Received 8 December 2009

Received in revised form 26 August 2010

Accepted 3 October 2010

Keywords:

Bibliometric analysis

Knowledge sources

Keywords

Intellectual pillars

TM literature

Developing countries

ABSTRACT

This paper aims to identify the intellectual bases of the technology management (TM) literature generated in developing countries using citation and co-citation analyses and answer the question of whether the intellectual bases of the TM literature created by authors in developing countries diverge from those of the global TM literature. Based on a comprehensive bibliometric analysis of ten technology-innovation management (TIM) specialty journals through the period of 1998–2007, this study produces three important findings. First, the TM literature generated in developing countries is dominated by the knowledge and theories created in developed countries. Second, among these knowledge sources some authors from developing countries and focusing on the specialties of developing countries, such as Kim and Lall, come into prominence; however these authors are not even mentioned in the previous bibliometric studies covering overall TM research. Finally the researchers in developing countries tackle with the issues or topics specific to their own context through combining three major bulks of literature. These are (i) resource-based view (RBV)/core competencies and organizational learning related research; (ii) literature dealing with the evolutionary theorizing on economic change and growth and (iii) literature related to technological capabilities, technology transfer and industrialization in developing countries.

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1. Introduction

The share of the developing countries in the international technology management (TM) literature has grown rapidly in the recent period; in 2007 nearly one fourth of the literature was created with the contribution of researchers in developing countries (Table 1). However, TM literature created in developing countries mostly differs from its counterpart generated in developed world especially in terms of the research topics it focuses [1,2]. This study takes a step forward and investigates whether the researchers in developing countries utilize the same intellectual pillars with their colleagues in the developed world to understand the issues they specifically focused on. Thus the paper provides a comprehensive detailed bibliometric analysis of developing countries' TM literature covering articles published in ten technology-innovation management (TIM) specialty journals [3–6]. Considering that no study employs bibliometric techniques in the field of TM to understand the specific characteristics, knowledge maps and flows in the literature created in developing countries; this paper will contribute to the global TM literature. Furthermore, the understanding of theoretical development of TM in developing countries will contribute to the incorporation of particular issues, problems and theories of developing countries into the TM discipline.

Since the commencement of IEEE Transaction on Engineering Management in 1954 much progress has been accomplished both in the field of management of technology education [7,8] and in scholarly research with the launch of a number of TIM-specialty journals. In this process the number of researches focusing on the scholarly research generated by the scientific

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Table 1

Distribution of articles with authors from developing countries.

Journals	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Total
Technovation (TVN)	11	13	20	21	21	21	26	36	21	19	209
International Journal of Technology Management (IJTM)	14	9	11	14	12	10	21	29	19	41	180
Technological Forecasting and Social Change (TFSC)	4	13	5	7	7	8	4	17	23	21	109
IEEE Transactions on Engineering Management (IEEE)	14	4	4	8	7	7	8	10	10	12	84
Research Policy (RP)	5	2	6	9	6	10	7	7	6	9	67
R & D Management (RDM)	3	1	4	7	10	6	7	4	5	9	56
Research-Technology Management (RTM)	1	2	2		1	1	2	2	3	4	18
Journal of Engineering and Technology Management (JETM)	1	3	2		1	2	1		2	3	15
Technology Analysis & Strategic Management (TASM)	2	3	3			1		5		1	15
Journal Of Product Innovation Management (JPIM)		1		2	2	1	1	1	1		9
Total	55	51	57	68	67	67	77	111	90	119	762
% in total TM articles	14	12	14	16	16	16	17	23	19	24	18

community of the TM field has increased. Among those there are a number of studies using bibliometric techniques to evaluate the development of the discipline; however most of them focusing on a specific journal [1,9–12] instead of the whole literature. Furthermore, due to differences between these journals in terms of the issues on which they focus [5] these bibliometric studies cannot provide a clear picture of the field. In spite of the renewed interest in the scholarly communication in TM a very few examples [2,13,14] focusing on the certain aspects of the literature in developing countries exists. This study aims to overcome these limitations.

The paper is divided into five sections. Section 2 reviews bibliometric research in TM literature; and it is followed by a section on the methodology employed in this paper. Section 4 presents and discusses the results of the empirical study and finally, Section 5 presents a summary, makes suggestions for future research, and indicates the limitations of the study.

2. A review of bibliometric research in TM field

Pritchard [15] provides an early definition of bibliometrics as a method of applying mathematics and statistics to the media of written communication in order to understand the nature and course of development of a discipline. Albeit their limitations citation and co-citation analyses are important bibliometric techniques which are widely employed in order to analyze the developments of scientific disciplines or sub-disciplines.

Since the mid-1980s citation and co-citation analyses have been utilized to investigate different facets of management literature and its subfields. Citation and co-citation analyses in management studies have most frequently served for identification of emerging scientific fields/subfields/disciplines, their boundaries and intellectual developments of these fields [16]. Culnan [17] focused on the intellectual development of the management information systems literature through author co-citation analysis. Pilkington and Liston-Heyes [18] investigated the process in which production and operations management had struggled to establish itself as an academic discipline by examining its literature using citation data obtained from the International Journal of Operations & Production Management. Ramos-Rodriguez and Ruiz-Navarro [19] and Nerur et al. [20] used Strategic Management Journal as a base journal for their citation and co-citation analyses. Among these two complementary studies the first one identified the most influential works on the strategic management research; however the second delineated the subfields; determined their relationships with each other and identified the authors bridging two or more conceptual domains of the strategic management research. On the other hand, Martinson et al. [21] focused on journals cited in or cited by Strategic Management Journal and provided a longitudinal portrait of the strategic management sub-discipline and a map of changes in the relationships among journals. Acedo and Casillas [22] used co-citation analysis to understand the intellectual structure of the international management research; Gu [23] focused on knowledge management literature and identified the authors, journals, research teams in the field; the last but not least Cornelius and Persson [24] provided a bibliometric analysis of the venture capital research.

TM literature has grown with great speed and become an academic discipline in the last two decades [1,25] and “once a scientific discipline has reached a certain degree of maturity, it is common practice for its scholars to turn their attention towards the literature generated by the scientific community” [19]. Early examples of studies focusing on TM field were [25–27]. Adler [25] provided a systematic literature review identifying the underlying themes and concepts related to technology strategy. Drejer [26] dealt with the evolution of the management of technology discipline through four schools of thought which were identified by the author from the literature. On the other hand, Allen and Varghese [27] analyzed the changes in the field of R&D management through articles appearing in R&D Management journal from 1970 to 1987.

In the 2000s, the number of scholars turning their attention towards the TM literature has increased. Among those Beard [28] proposed a model of categorizing the literature on the management of technology; Liao [29] focused on the way in which TM methodologies and applications had developed; and Ball and Rigby [30] investigated the number of author entries and their affiliations throughout eleven journals selected due to their coverage of R&D and innovation management literature.

On the other hand, there is a bulk of literature analyzing the evolution of certain TIM specialty journals. Linstone [31] reviews the evolution of Technological Forecasting & Social Change from 1969 to 1999. Callon et al. [32] analyze the contents of Research

Policy for the first 28 years and states that the journal has succeeded to cover problems of government policy and those of industrial R&D and innovation. For the 50th anniversary of IEEE Transactions on Engineering Management, Allen and Sosa [33] scanned the contents of 50 years and presented a general history of the field of engineering management following the changes in topics, authors' affiliations and regions throughout five periods. Furthermore, Pilkington [9,10] reports a bibliometric analysis of IEEE Transactions on Engineering Management. Author uses citation and co-citation analysis, and social network tools to explore the central concepts, theories, and authors of the field and their relationships with each other. Merino et al. [34] focus on the content of Technovation created in its first 25 years. This study uses citation counts to determine the influential journals over the Technovation content and reveals that approximately 68% of articles drawn from bibliographic references cite TIM journals. Pilkington and Teichert [1] also focus on the TM literature as reported in Technovation. Authors use co-citation and social network analysis techniques to investigate the intellectual structure of the literature. Biemans et al. [12] provide a detailed analysis of Journal of Product Innovation Management (JPIM)'s evolution from 1984 to 2003. Authors investigate the contents of the journal to identify main research areas, research methods used in the articles, authors' background and affiliations; and finally the knowledge sources used by JPIM authors while developing their articles with using bibliometric analysis. McMillan [11] employs citation and co-citation analyses to examine R&D Management throughout four periods and aims to reveal changes in the journal's intellectual base.

Among these studies, [12,27,32,34] partially utilize citation analysis. Callon et al. [32] explore the most cited articles among those published in Research Policy; Merino et al. [34] use citation analysis to determine the influential journals over the Technovation content; and Biemans et al. [12] identify journals which are most frequently cited in and citing JPIM. Pilkington and Teichert [1], Pilkington [9,10] and McMillan [11] provide good examples of citation and co-citation analyses employed to fully understand and map out the intellectual pillars as well as the invisible colleges of the discipline. Moreover two additional studies [3,35] which utilize citation analysis to determine the most influential journals of TM must be mentioned.

None of these aforementioned studies focusing on the TM literature have paid special attention to the contribution of developing countries to the literature and the particularities of this contribution especially in terms of themes, theories, knowledge sources and flows. However three studies need to be mentioned as the very occasional examples of studies investigating the particularities of TM literature generated in developing countries; these are [2,13,14]. Seol and Park [14] analyze the knowledge sources of Korean innovation studies using citation analysis; they identify the most highly cited papers, books, authors, and journals in academic studies carried out by Korean researchers.

Some studies [32–34] prove that the majority of papers published in the prominent TIM-specialty journals are submitted by authors affiliated to institutions in North America and Western Europe. However, among those studies only [1] have questioned whether authors from geographically different regions exhibit different citation patterns. The results of citation and co-citation analyses indicate significant differences in the intellectual interests of authors from different regions which are categorized into four as North America, Europe, UK and rest of the world. Cetindamar et al. [2] state that “there are substantial differences among the topics investigated in developed and developing country studies”. Following the footsteps of previous studies (such as [1,2,14]) which investigate the particularities of TM research generated in the different parts of the world, this study examines, how the scholars in developing countries benefit from the previous literature in dealing with the topics which are proved to be different from those in the developed countries [1,2]. Therefore, in this study we not only consider the most highly cited academic studies, authors or journals by the scholars in these countries in order to support their views, ideas or methods but also how they tie these different pieces of literature in their researches or articles. This study contributes to the aforementioned literature investigating the TM literature itself by mapping the intellectual sources of TM literature produced by developing country scholars.

3. Data collection and methodology

The data used in this study include authors, keywords, the name and addresses of institutes, publication dates, source titles and references of ten leading TIM specialty journals (Journal of Product Innovation Management, Research Policy, Research – Technology Management, R&D Management, IEEE Transactions on Engineering Management, Technological Forecasting and Social Change, International Journal of Technology Management, Technovation, Technology Analysis & Strategic Management, and the Journal of Engineering and Technology Management) for a ten years period 1998–2007. The identification of leading journals in TM field is important but difficult because major journals of the discipline are not as apparent as those in established academic fields due to the interdisciplinary character of the field [3,35]. There are some studies [3,30,35–37] attempted to identify the major journals in TM field and rank them according to their importance to the field. Some of these studies are based on the subjective opinions of scholars [30,36] and some are on citation-based analysis [3,35]. The aforementioned ten journals we are using in this study are those identified by Linton and Thongpapanl [3]. Since, first of all at least four different studies [3,30,35,37] with various methodologies identify all or most of these ten journals of the TM field and second in spite of the years elapsed after the publication of [3] the same journals are still considered as the specialty journals in the management of technology and innovation [4–6] we prefer to rely on this list of journals in our study.

Distinguishing between developed and developing countries is the key to this research. However, there is no established convention on the distinction between developed and developing countries or areas. Moreover, for the purpose of this study, any list of country classifications based on income level or the level of human development is not very useful by itself since such lists do not provide evidences for the countries' technology and innovation management capabilities. Therefore inclusion of some countries which are not listed as a developing country by some global institutes i.e. World Bank, OECD or IMF in our research is simply based on this consideration. Instead of making a list of developing countries we first decided on the countries which are

developed not only in the sense of productivity, industrialization or income but also in the sense of technology and innovation management skills and capabilities of their firms. To start we used the list of 25 high-income OECD countries as of 25 July 2008 [38]; however we excluded Czech Republic and South Korea in our list of developed countries because TM practices and experiences in these two countries are “more closely related to circumstances in developing countries rather than developed countries” [2].

The bibliometric data including the full contents of these journals for a ten year period 1998–2007 were collected from the ISI Web of Science databases on 16 January 2009 (for the query see [Appendix A](#)). After the first set of results had been received, using pull-down menu on the web page the results were further refined to include only the original articles written by at least one author located in developing countries. We first removed book reviews, editorials, and brief notes from the set of results and we were left with 4349 original articles. In order to identify the articles with a developing country author or co-author a similar refinement process was repeated. We visualize a complete list of 74 countries ([Appendix B](#)) contributed to the articles by using pull-down menu; tagged only those countries out of 23 high income OECD countries we selected and refined the results based on this selection. Finally we had a list of 764 articles in which at least one researcher was linked to a developing country institution. Full bibliometric records (including cited references) of these articles were exported as a text file from ISI Web of Science. During the detailed examination of the data file, two more articles were discarded because only their reprint addresses include a developing country institute but authors were affiliated to developed country institutions. The number of these 762 articles by publication year and journal is shown in [Table 1](#).

The records of 762 articles retrieved from the ISI Web of Science were reformatted into a Microsoft Access 2003 database using a Visual Basic script. Each of these articles was given a unique number from 1 to 762 and all variables included in bibliometric content (i.e. authors, addresses, titles, keywords and references) are linked to each other through this unique identifier. Data manipulation and analyses were performed through created tables and queries in this database. Most of these tables and queries were recreated from bibliometric software tool Sitkis [39] which is also based on Microsoft Access. These different tables are used simple counting of articles, keywords or citations and queries allow matching different tables by the unique identifier in order to count the frequency of simultaneous occurrences of two different elements (i.e. citations and keywords) in the same document. This tool also allowed the manipulated data to be exported to MS Excel and UCINET [40] compatible tables. The networks were analyzed using the social network analysis software UCINET and were drawn with NetDraw package embedded to UCINET.

The developed database was analyzed in order to identify the intellectual pillars of the developing country TM literature through the most cited academic studies, authors and journals and the invisible colleges through examining how different pieces of previous academic studies and their authors had been linked in these set of articles. For this aim, citation and co-citation analyses were used. Citations are widely used tools for understanding the linkages between academic studies; the exchanges among scholars and hence scholarly knowledge flows [17,41]. Citation analysis is based on the argument that authors cite papers which embody the ideas they are discussing; and therefore these cited documents, in a general sense, are the symbols for these ideas [42]. On the other hand, co-citation analysis measures the frequency with which two documents are cited together [43]. It is widely assumed that co-citation patterns delineate the relationships between key ideas and therefore provides an objective way of modeling not only the intellectual structure of scientific fields/sub fields but also their historical developments [43,44]. Hence citation and co-citation analyses provide a well established procedure for measuring the dissemination and the extent of knowledge exchange in a given field [35], social and cognitive structure of research specialties [45] and identification of ‘invisible colleges’ [11,46,47] which focus on common problems in common ways.

For the citation analysis the cited references in 762 articles first collected in a table. However 1926 citations were immediately discarded because of their improper formats; those also include newspaper or magazine articles, various reports or documents. We started with 18,558 citations derived from 762 articles; however 695 of them were also removed to correct the problem of multiple entries occurred due to the inconsistencies in the spelling of author names, journals, and volume or page numbers. After all, citation and co-citation analyses are carried out with these 17,863 documents cited in these articles. In order to find out the most cited academic studies, journals and authors we simply counted how many times an academic study, a journal name or an author name had been occurred in our data set. Co-citation analysis also carried out through the counts of the co-occurrences of two different citations in the same document. However in co-citation analysis of academic studies and authors we counted the number of articles in which two academic studies or the names of two authors co-occurred. The tables including the data regarding to co-citation networks are imported into UCINET [40] and the standard centrality measures of degree, closeness, and betweenness are calculated. Netdraw is utilized for the visualization of networks. The same procedure was also repeated for the analysis and visualization of the keywords co-occurred in our set of articles.

As a final point, in these visual representations of networks the thickness of lines between nodes reflects the strength of the link which is measured by counts of the frequency with which the two items co-occurred and the size of circles indicates the degree centrality of nodes in the network; higher the degree centrality higher the size of circles. Degree centrality “measures the extent to which a node connects to all other nodes in a social network” [48]. In network studies it is proposed that nodes or actors with higher number of ties with other nodes may be advantaged positions since they occupy more central position than those having lower number of ties.

4. Results

TM literature has grown at an exponential pace especially for the last few decades. The number of articles published in these TIM specialty journals increased by nearly 164% from the period of 1986–1994 to 1995–2005 and in the same period the number of

articles focusing on developing countries increased by 388.5% [2]. On the other hand, the number of articles having at least one author affiliated to an institution in developing countries has displayed a 116% increase in the period 1998–2007. The share of the developing countries in the international TM literature has grown rapidly in this period; in 2007 nearly one fourth of the literature was created by the contribution of researchers in developing countries (Table 1).

The initial analysis reveals that 762 articles in our dataset are produced by 1237 authors from 66 countries of which 15 are classified as developed countries in this study. This discrepancy is due to the fact that some authors affiliated to developed country institutions are the co-authors of 177 articles which account for 91% of the whole international joint publications in the dataset. Moreover, due to international co-authorships some articles are counted more than once. Taiwan is the most productive country with 180 articles published in these ten TIM specialty journals between the years 1998 and 2007 and total citations of the articles created by researchers affiliated to Taiwanese institutions is the highest among all other countries. On the other hand Brazil, Singapore, Israel, China and South Korea produce higher number of articles with better citation per article ratios (Table 2). US, UK, Australia and Netherlands occupy higher ranks in Table 2 as the most collaborating developed countries with the so-called developing ones in the field of TM. On the other hand while the number of internationally collaborated articles increases by years its share in the whole number of articles changes in a range from 17.6 to 32.2%. Among the developing countries China and South Korea are the first and the second countries respectively which have the highest number of international links.

In order to scrutinize the main issues and topics discussed in these 762 articles we carried out a simple keyword co-occurrence analysis and mapped out how the keywords selected to define the content of the articles are linked to each other. Fig. 1 presents a network representation of the most frequently occurred keyword couples in the articles and shows those words which appear together in the same document more than seven times. The graphical representation of keyword co-occurrence network provides some clues about the main issues on which developing countries focused and about where developing countries' contribution to the international TM literature is concentrated.

Fig. 1 helps identify the focus of the articles created by developing country authors. While “innovation” is at the centre of the network, some keywords such as “performance”, “management”, “R&D” and “industry” are the other central terms in the map. By inspection we can identify some topics that the TM literature in developing countries is focused on such as *innovation management, R&D management, product development through R&D, networks and collaborations for innovation, emerging technologies (biotechnology and information technology) and innovation, determinants of innovation, diffusion of innovations, absorptive capacity, organizational change and innovation, R&D performance, innovation performance, industrial innovation, technology management, innovation strategy, innovation in developing countries* etc.

The immediate look to the map implies that the relationships between different areas of TM interests in developing countries do not diverge dramatically from general themes of the global TM literature. However, in the rest of this study we are going to further scrutinize the distinguishing interests of developing country authors and how they approach to their subjects of interests by understanding the intellectual structure of TM studies through citation and co-citation analysis of the articles in our sample.

4.1. Citation analysis: intellectual pillars of TM literature in developing countries

Citation analysis is generally used to detect the most influential documents or authors over the later ones. Our analysis of the main knowledge sources of developing country TM literature uses cited references in 762 articles in our dataset in order to understand the most influential sources of the literature at three levels (i) articles/books, (ii) authors and (iii) journals.

Table 3 gives a list of the most frequently cited individual academic studies. Most of these studies in the list question the role of strategy, differences in technology policy or performance and strategy by focusing at the level of nation and industry. These findings are consistent with [1] providing that academic studies which focus on national systems, diffusion and adoption of innovations are cited heavily by the authors out of North America, Europe and the UK. These findings also provide additional confirming evidence for

Table 2
Distribution of articles by country of origin (first 15 countries).

Rank	Country	Number of articles	Total citation	TC/number of articles	Rank acc. to sum of citations
1	Taiwan	180	575	3.19	2
2	USA	103	684	6.64	1
3	South Korea	103	439	4.26	4
4	Peoples R China	100	457	4.57	3
5	India	75	252	3.36	6
6	Singapore	52	316	6.08	5
7	Israel	40	200	5.00	9
8	UK	34	245	7.21	7
9	Brazil	34	218	6.41	8
10	Nigeria	33	53	1.61	16
11	Turkey	21	74	3.52	14
12	Thailand	21	44	2.10	17
13	South Africa	18	69	3.83	15
14	Australia	13	42	3.23	18
15	Netherlands	12	79	6.58	12

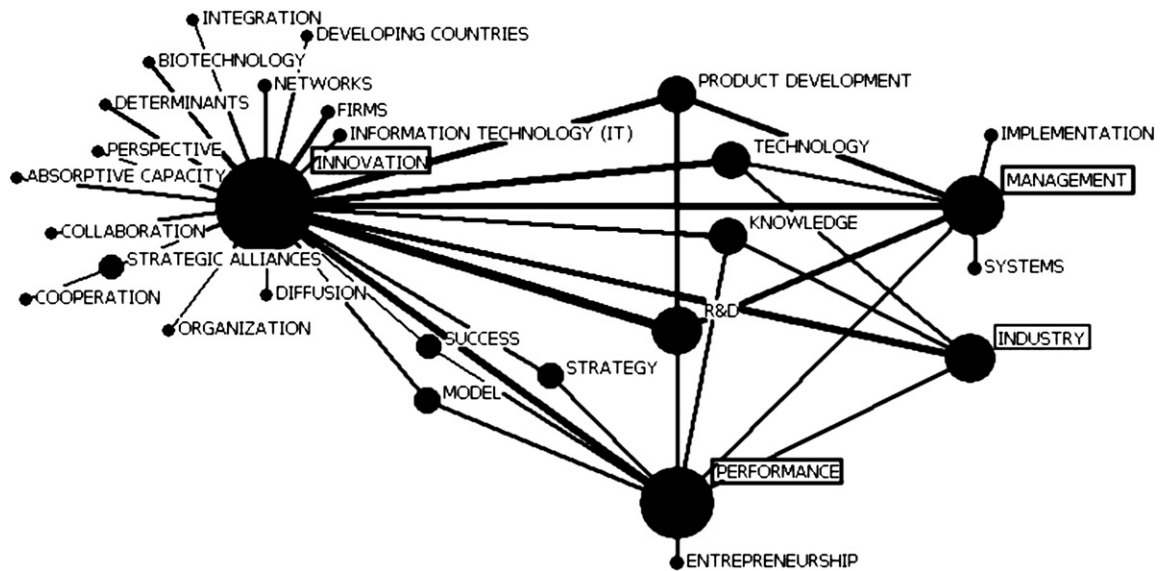


Fig. 1. Keyword co-occurrence network.

[2] showing that technology policy related issues i.e. national technology management policies and systems, innovation systems, national innovation systems, regional innovation systems, sectoral innovation systems, open innovation system are the most studied topics in developing country articles. However this special focus on national systems and differences does not fully eliminate the academic studies concentrating on the firm level analysis of competitiveness and the sources of competition. The higher ranks of four studies in Table 3 [49–52] prove the interests of these authors towards the issues related to resource-based view (RBV)/core competencies and organizational learning. Furthermore, the first rank is occupied by Cohen and Levinthal's study [49] on "absorptive capacity". The same study is listed at the second rank in [1], and at the first rank in [11] among the most cited articles in the period 2001–2005. The glaring presence of Kim's book "Imitation to Innovation" [53] in the sixth rank in Table 3 provides a strong support for the arguments about the particularities of the technological development and the importance of technology adoption and learning in developing countries.

Table 3

Most frequently cited academic studies.

First authors	Title (volume)	Year	Number of citations	Number in references
Cohen WM	Administrative Science Quarterly (35)	1990	50	[49]
Nelson RR	National Innovation Systems: A Comparative Analysis	1993	49	[64]
Porter ME	The Competitive Advantage of Nations	1990	46	[56]
Nelson RR	Evolutionary Theory of Economic Change	1982	45	[50]
Nonaka I	The Knowledge Creating Company: How Japanese Companies Create The Dynamics of Innovation	1995	39	[62]
Kim L	Imitation to Innovation: The Dynamics of Korea's Technological Learning	1997	36	[53]
Freeman C	The Economics of Industrial Innovation	1974 ^a	31	[81]
Lundvall BA	National Systems of Innovation : Towards a Theory of Innovation and Interactive Learning	1992	31	[67]
Rogers EM	Diffusion of Innovations	1962 ^a	31	[82]
Dosi G	Research Policy (11)	1982	27	[69]
Porter ME	Competitive advantage: creating and sustaining superior performance	1985	27	[55]
Leonard–Barton D	Wellsprings of knowledge: building and sustaining the sources of innovation	1995 ^a	26	[59]
Barney J	Journal of Management (17)	1991	24	[51]
Porter ME	Competitive strategy: techniques for analyzing industries and competitors	1980	23	[54]
Prahalad CK	Harvard Business Review (68)	1990	23	[52]
Utterback JM	Mastering The Dynamics of Innovation: how companies can seize opportunities in the face of technological change	1994	23	[83]
Utterback JM	Omega-International Journal of Management Science (3)	1975	23	[84]
Eisenhardt KM	Academy of Management Review (14)	1989	21	[85]
Teece DJ	Research Policy (15)	1986	21	[86]

^a Citations to later editions of the books were also included.

Table 4
Most frequently cited first listed authors.

Rank	Authors	Number of citations
1	Porter ME	152
2	Nelson RR	132
3	Kim L	109
4	Freeman C	104
5	Cohen WM	96
6	Cooper RG	94
7	Teece DJ	84
8	Nonaka I	76
9	Griliches Z	75
10	Lall S	72
11	Dosi G	71
12	Pavitt K	69
13	Utterback JM	65
14	Rothwell R	63
15	Leonard-Barton D	63

Table 4 shows the frequencies of authors of the cited documents. Although this list is based merely on the first authors and it includes bias against younger authors [1] it provides some insights into some authors' strong influences on the discipline. Among those influential authors Porter, Nelson, Kim and Freeman are prominent with more than a hundred citations. Porter is the most cited author thanks to his famous three books [54–56]. In the list, Kim in the third rank and Lall in the tenth rank are from developing countries.

Table 5
Most frequently cited journals (ranked based on the number of citations in the period 2003–2007).

Journals	1998–2002	2003–2007	Increase (%)
Research Policy	193	607	214.5
Strategic Management Journal	114	453	297.4
Management Science	138	261	89.1
Harvard Business Review	97	256	163.9
Technovation	78	255	226.9
Journal of Product Innovation Management	106	250	135.8
R&D Management	106	235	121.7
Academy of Management Journal	52	223	328.8
Administrative Science Quarterly	65	210	223.1
Organization Science	30	197	556.7
Academy of Management Review	62	192	209.7
IEEE Transactions on Engineering Management	143	188	31.5
Technological Forecasting and Social Change	81	182	124.7
Journal of Marketing	65	174	167.7
Research (Technology) Management ^a	106	172	62.3
International Journal of Technology Management	101	159	57.4
Sloan Management Review	67	117	74.6
Journal of Marketing Research	38	113	197.4
California Management Review	60	102	70.0
American Economic Review	20	100	400.0
MIS Quarterly	16	97	506.3
Journal of Business Venturing	21	85	304.8
European Journal of Operations Research	21	83	295.2
Industrial Corporate Change	17	81	376.5
Journal of Management	16	80	400.0
Journal of International Business Studies	17	72	323.5
Long Range Planning	33	71	115.2
Journal of Operations Management	20	67	235.0
Information and Management	30	63	110.0
Journal of Engineering and Technology Management	16	63	293.8
Journal of Political Economy	15	60	300.0
World Development	51	55	7.8
OMEGA-International Journal of Management Studies	23	54	134.8
Technology Analysis & Strategic Management	33	39	18.2
Total of 10 TIM Journals	963	2150	123.3
Total	7968	16,232	103.7
TIM Journals/total	12.1%	13.2%	

^a Citations of Research Management journal is added to Research-Technology Management.

The list of most cited journals is given in Table 5. This list indicates the problem stated by Pilkington and Teichert [1] regarding to the TM's having become an academic discipline. Similar to their list, the general management and strategy specific journals occupy highly prominent places in the list of the most cited journals. While a journal related to the development issue, World Development is listed as among the thirty most cited journals operations management focused titles are lower ranked in comparison to the list in ref. [1]. The comparison of the rankings of journals in these two lists (Table 5 in this study and Table 2 in ref. [1]) with 'Wilcoxon signed rank test' points out the fact that the rankings of these journals are significantly ($p \leq 0.05$) different; the paired samples *t*-test also produces the same result. This may indicate that knowledge sources of TM literature in developing countries differ from those of the international TM literature at the journal level.

Table 5 supports the findings of previous studies [1,3,35] which emphasize the great variety of cited journals from different disciplines and sub disciplines of management, social sciences, economics as well as those in science, engineering and technology. While the number of articles has increased by 116% the number of citations has increased by 227% from 1998 to 2007. This increase in the number of references in articles indicates a growth in the developing country TM literature. On the other hand citations of TIM-specialty journals have increased by 123.3% from the first period of 1998–2002 to the second period; its share in total has stayed nearly the same. Cheng et al. [35] find out that as citation data is considered TM discipline "has not shown any symptoms of inbreeding" and the authors contributing to the discipline are generally more open to citing from sources outside of TM. However this great variety in citations can also be explained by the fact that TM researchers prefer to publish their work in more established journals such as Administrative Science Quarterly, Management Science, The Academy of Management Journal, Harvard Business Review or Strategic Management Journal [1].

Whilst above lists of most cited documents, authors and journals provide some insight about the intellectual pillars of TM literature created by developing country scholars they are not sufficient having a clear picture of how different academic studies and authors are linked to each other and hence where the interests of these scholars are concentrated. The answers for these questions are provided through co-citation analysis [43–45] and the main findings are presented in the following section.

4.2. Co-citation analysis: invisible colleges

The network for co-cited academic studies which appear together with a frequency greater than seven is shown in Fig. 2. Three segments of literature as grounding the TM literature generated in developing countries can be easily identified in the map. One of these segments is centered on the seminal work of Cohen and Levinthal [49] and includes academic studies mostly related to RBV/core competencies and organizational learning, i.e. [57–62]. RBV is based on the argument that "sources of sustained competitive advantage are firm resources that are valuable, rare, imperfectly imitable, and non-substitutable" [51]. Organizational knowledge is seen as the most strategically significant resource of the firm [63].

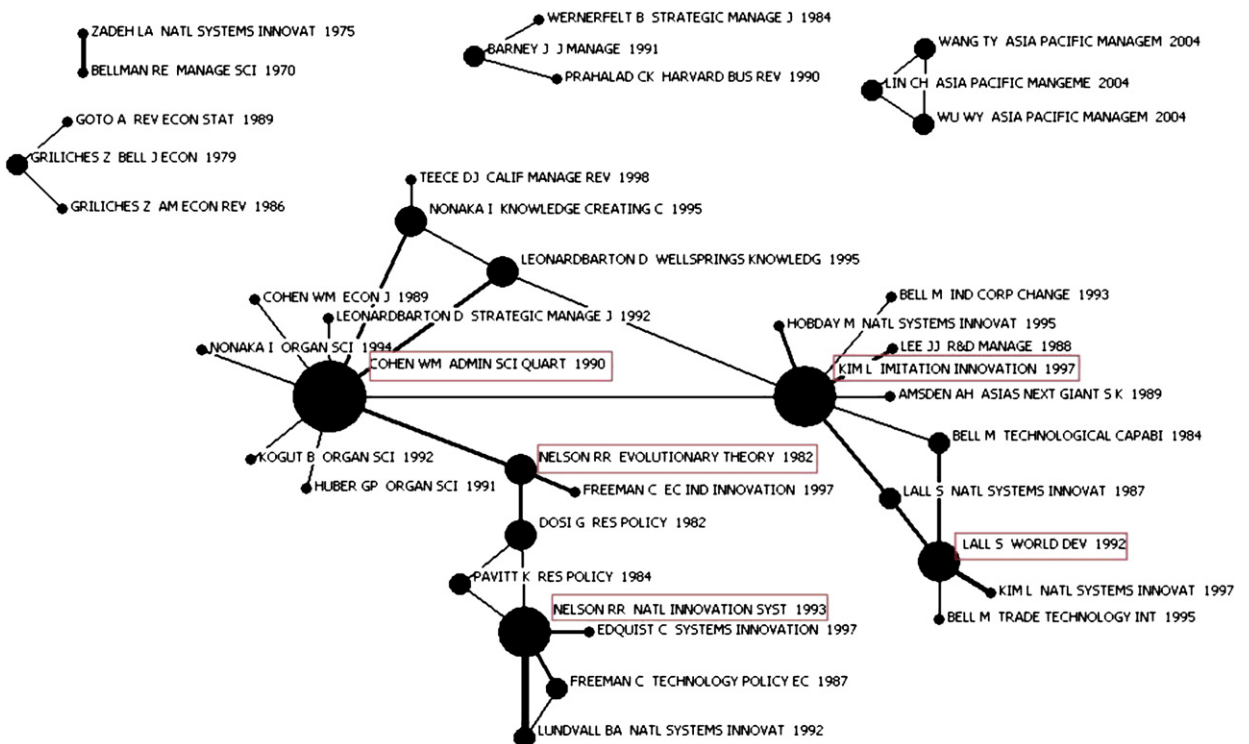


Fig. 2. Core literature – network of co cited articles/books.

The second segment of literature in the map is focused on national systems, centered on the influential book edited by Nelson “National innovation systems: a comparative analysis” [64]. Heterogeneity of economic agents operating in national innovation systems [50] is the starting point in the evolutionary theorizing for the understanding of complexities associated with the process of growth and transformation in the long run [65,66]. Systemic approach [64,67,68] provides a framework to investigate these complexities. Another strand of literature contributing evolutionary growth theorizing covers some academic studies focusing on the macro economic impacts of radical innovations in the long run [69,70]. In this segment, a very strong link exists between [64] and [67] both focused on national innovation systems, these two studies appear together in 17 of the articles.

The third segment of literature is centered on the seminal work of Korean author Kim [53]. Studies in this group attempt to understand differences in technology policy and performance. They include the articles focusing on the particularities of developing countries, especially those of Asian newly industrialized countries, in terms of the development of technological capabilities, technological accumulation and change, industrialization and growth [71–76].

The position of [49] as bridging different segments of the literature needs further discussion. Zahra and George [77] highlight that Kim’s [78] definition of “absorptive capacity” requires learning capability which is the capacity to assimilate knowledge for imitation and develops problem solving skills to create new knowledge for innovation. Kim [79] argues that technological trajectory has been reversed in developing countries; starts with mature technology state (for duplicative imitation) evolves to the intermediate technology stage (for creative imitation) and finally to the emerging technology stage (for innovation). In this process from imitation to innovation technological capabilities acquired through learning play a very crucial role; and “effective technological learning requires absorptive capacity” [53]. The emphasized role of technological learning and absorptive capacity in the development of technological capabilities, technological change and industrialization explains why [49] is so heavily cited by authors affiliated in developing countries and why it is closely linked to Kim’s famous book “Imitation to Innovation”. Hence number one rank occupied by [49] in Table 3 and its central position in the cognitive map of TM literature in developing countries graphically represented in Fig. 2 indicate that the concept of “absorptive capacity” is widely used by the authors from developing countries however it has been rebuilt or reified as different from the original ones and from its counterparts rebuilt by the authors of the other regions.

Author co-citation analysis provides insights about underlying schools of thought in scientific discourse [44]. The underlying arguments of author co-citation analysis are that studies of the same author represent a body of knowledge and authors having related works are cited together. Fig. 3 shows a representation of the network for co-cited authors which appear together at least 20 of the articles in our data set.

RR Nelson, L Kim and DJ Teece seem to be at the centre of the co-citation map with their higher number of links to other authors. The body of knowledge created by Nelson is not only linked to Neo-Schumpeterian view such as Freeman, Dosi and Pavitt focusing on technological change and industrialization or strategy related topics Porter and Teece but also to the literature on the industrialization in developing countries represented by Kim and adjacent authors. Kim also occupies a central position in the map of knowledge sources of literature generated in developing countries.

Studies focusing on single TIM-specialty journals [9–11] include mostly different schemes of co-cited authors. The central positions of Kim and the segment of literature including Kim, Lall, Lee, Amsden and Bell present the main particularities of the TM research generated with the contribution of developing country authors. The networks of co-cited authors and co-cited documents reveal that although researchers in developing countries utilize similar knowledge pillars and intellectual bases of the global TM literature, in order to understand and analyze some issues specific to the context of developing countries such as industrialization,

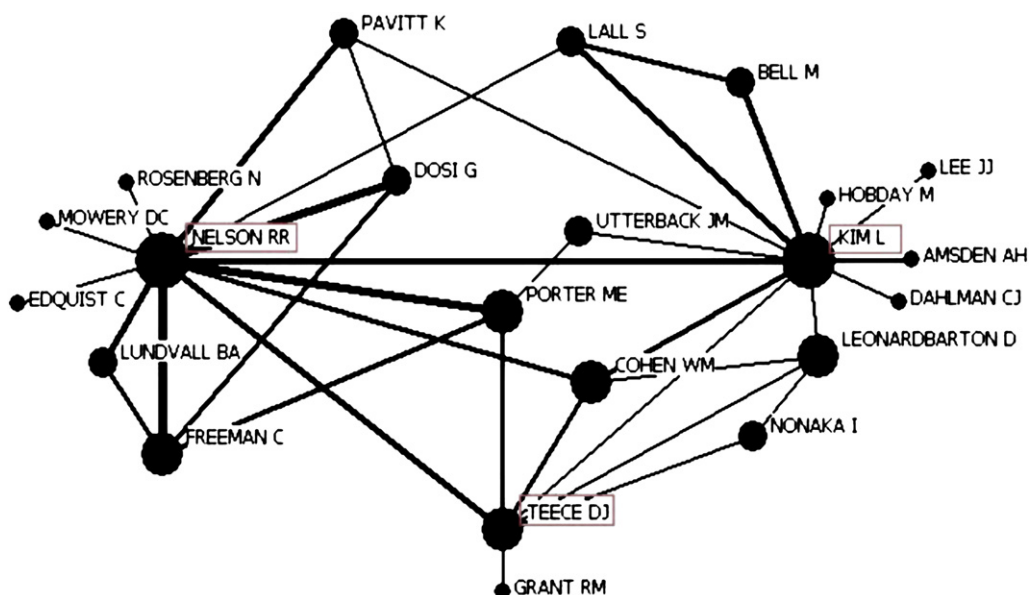


Fig. 3. Network of co-cited authors.

technology adoption or transfer they use a different body of knowledge focusing on the specialties of technology development and industrialization in developing countries and partly created by scholars in developing countries such as L. Kim, S. Lall and J. Lee.

In the process of the emergence of TM as a discipline in its own right the major academic works, in other words “discipline-forming titles” [1], and invisible colleges have been substantially occurred. Undoubtedly, along this dynamic process some academic studies are replaced by others [11]. Yet we have a more or less formed map of TM knowledge areas [1,9–11] which are associated with certain authors and academic studies. The analyses carried out in this research show that although TM literature created by the scholars in the developing countries can be distinguished from its counterparts in terms of the issues questioned in the articles, the knowledge bases grounding their research are mostly covers the academic studies or authors which are globally associated with these issues i.e. [49,50,57–59,64,67–70]. The only particularity in the map of literature grounding TM literature in developing countries occurs in the issues related to the development of technological capabilities, technological change and industrialization in developing countries.

5. Concluding remarks, future research and limitations

This study mainly investigates the intellectual structure of the academic TM research in developing countries. The contribution of developing countries to the international TM literature has been growing substantially in the last decade [2]. Our analysis shows that in 2007 nearly one fourth of the articles published in the ten specialized journals in TIM under study are written with the contribution of at least one author affiliated to developing country institutions. Although [1] and [2] provide evidence that the TM literature generated in developing countries differs from its counterparts generated in developed countries in terms of themes and concepts that are focused on, these studies do not present a detailed analysis of knowledge sources and intellectual pillars that developing country studies are based on. Nonetheless the understanding of theoretical development of TM in developing countries will also contribute to the incorporation of particular issues, problems and theories of developing countries into the TM discipline.

Based on a comprehensive bibliometric analysis, this study produces three important findings. First, the TM literature generated in developing countries is dominated by the knowledge and theories created in developed countries. The most influential studies and authors on the TM research held in such countries underline that developing country researchers utilize theories that are created in developed countries to understand even the issues specific to developing countries. Not only studies published in international journals but Seol and Park [14] show that those published in national journals also mostly utilize foreign knowledge sources. Second, among these knowledge sources, some authors from developing countries such as L Kim and S Lall and authors with a focus on the specialties of developing countries like M. Bell and A.H. Amsden, come into prominence; however these authors are not even mentioned in previous bibliometric studies covering overall TM research. Finally, although the TM literature created in developing countries is mainly dominated by the knowledge and theories coming from the developed countries, the researchers in such countries tackle with the issues or topics specific to their own context through combining three major bulks of literature. These are (i) RBV/core competencies and organizational learning related research; (ii) literature dealing with the evolutionary theorizing about economic change and growth, and (iii) literature related to technological capabilities, technology transfer and industrialization in developing countries.

In ref. [1], the results of citation and co-citation analyses indicate significant differences in the intellectual interests of authors from different regions which are categorized into four as North America, Europe, UK and rest of the world. Cetindamar et al. [2] also emphasize on the substantial differences among the topics investigated in developed and developing country studies. Our study provides further evidence that developing country researchers utilize different knowledge sources to understand these divergent topics they deal with. The authors, studies or journals they mostly cite exhibit certain differences from those cited by their colleagues affiliated to developed country institutes. However while doing so they utilize the seminal works of the TM literature and combine these theories with a strand of literature on the specificities of industrialization in developing countries which is partly created by the authors of developing countries. As we consider citations as “the symbols of concepts or methods” [42] this study shows that the symbols used by TM scholars in developing countries such as [49,50,54–56,59,62,64,69] do not fully diverge from those of global TM literature as listed by Pilkington and Teichert [1].

One likely avenue for future research is the investigation of the observed convergence of theories. Our study shows that developing country researchers utilize theories created in developed countries to understand even the issues specific to developing countries, however our study does not pass any judgment on reasons/mechanisms behind it. One likely explanation for convergence of theories might be the argument of the diffusion of capitalist economical and industrial infrastructures in developing and developed countries. Another, rather skeptic, explanation might be the limitation faced by authors in developing countries when they submit their papers to theoretical outlets such as management journals might not accept out-of-the-norm papers in the TM field, as is the case for management studies [80]. Another interesting stream of research could be the analysis of international co-authorship patterns. As the number of studies co-authored by developed and developing country scholars is increasing, their analysis might add new insights on the process of theory building in TM in different parts of the world.

This study is rather limited to report on what is being studied, not what should be studied for developing countries. We believe what should be studied that is not part of the developed country model can offer interesting findings for developing country researchers. For example, appropriate technology and technology integration are two such areas that can shape the research projects with high value of practical implications. We strongly advise TM scholars to conduct research in this avenue of research.

Finally, we have to mention that this study inevitably has its limitations, some resulting from the research design and some from the bibliometric techniques we use for analyses. The main limitation related to the research design arises from the selection of journals as TM outlets. As mentioned by Pilkington and Teichert [1] and Cheng et al. [35] the researchers in the TM field prefer to

publish their works in more established management journals rather than TIM-specialty journals. Indeed, some significant changes might occur in these analyses if the range of journals included were extended. However, when the number of articles included in the research is considered it can be confidently argued that the literature analyzed in this study represents the major efforts of developing countries researchers in the TM field. Limitations as direct consequences of bibliometric studies are mainly due to the fact that citation and co-citation analyses are independent from the context, or in other words it is not possible to distinguish the motives behind these citations [19]. However, in spite of all these limitations bibliometric analyses employed in this study provide a good insight to the development of the TM discipline created with the contribution of developing country researchers; and how it diverges from its counterparts generated in the developed world especially in terms of knowledge sources employed.

Supplementary data to this article can be found online at doi:10.1016/j.techfore.2010.10.001.

Appendix A

The initial query used in order to find out the articles published in ten TIM-specialty journals between the years 1998 and 2007.

Publication name (SO)=RESEARCH POLICY OR TECHNOVATION OR R&D MANAGEMENT OR RESEARCH TECHNOLOGY MANAGEMENT OR IEEE TRANSACTIONS ON ENGINEERING MANAGEMENT OR JOURNAL OF ENGINEERING AND TECHNOLOGY MANAGEMENT OR INTERNATIONAL JOURNAL OF TECHNOLOGY MANAGEMENT OR JOURNAL OF PRODUCT INNOVATION MANAGEMENT OR TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE OR TECHNOLOGY ANALYSIS & STRATEGIC MANAGEMENT.

Publication years (PY)=1998–2007.

Databases=SCI-EXPANDED, SSCI, A&HCI.

Appendix B

Distribution of 4349 original articles published between 1998 and 2007 by country of origin.

Developed countries	Number of articles	Developing countries	Number of articles	Developing countries	Number of articles
Australia	131	Argentina	5	Lebanon	1
Austria	64	Bahrain	1	Lithuania	1
Belgium	48	Bangladesh	1	Malaysia	5
Canada	184	Barbados	1	Mexico	11
Denmark	82	Bolivia	1	Moldova	1
Finland	75	Botswana	1	Morocco	1
France	166	Brazil	34	Nigeria	33
Germany	213	Bulgaria	1	Oman	1
Greece	33	Chile	5	Peoples R China	100
Iceland	1	Colombia	1	Poland	7
Ireland	23	Croatia	2	Romania	2
Italy	171	Cuba	1	Russia	4
Japan	158	Cyprus	8	Saudi Arabia	6
Luxembourg	1	Ecuador	1	Singapore	52
Netherlands	294	Egypt	3	Slovenia	4
New Zealand	28	Fiji	1	South Africa	18
Norway	21	Ghana	1	South Korea	103
Portugal	33	Hong Kong	7	Taiwan	181**
Spain	135	Hungary	6	Thailand	21
Sweden	127	India	75	Trinidad & Tobago	3
Switzerland	80	Indonesia	3	Turkey	22**
UK (England)	571	Iran	1	U Arab Emirates	2
UK (North Ireland)	13	Israel	40	Uganda	1
UK (Scotland)	65	Jordan	2	Uruguay	2
UK (Wales)	28	Kenya	2		
USA	1496	Kuwait	3		
San Marino*	2				

* Although San Marino was not among our list of developed countries, the articles co-authored by scholars from San Marino were excluded from the set of results because it is a very small country completely surrounded by Italy and both of these articles are about Italy.

** One article was discarded because only its reprint address includes an institute from this country.

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