Evaluating Global Technology Transfer Research Performance

*James K. C. Chen[1] Wen-Hong Chiu[2] Stacy F. L. Kong[3] Leo Y. T. Lin[4]
Department of Business Administration, Asia University, Taiwan, China
([1]kcchen@asia.edu.tw [2]andychiu@asia.edu.tw [3]stacyk@ms26.hinet.net [4]n1659n@gmail.com)

ABSTRACT

Technology transfer is one of the most important fields in research and development of new products and new technology knowledge services, technology transfer also one of key issues in knowledge economics era. This study evaluates the global technology transfer development trend of research for the past sixteen years and provides insights into the characteristics of technology transfer research activities to identify development map, tendencies, or regularities that may exist in papers. Data are based on the online version of SCI, Web of Science from 1992 to 2008. Articles referring to technology transfer were assessed according to many aspects including logarithmic model fitting publication outputs during 1992–2007. The result displays that the USA is number one in technology transfer research totaling 447 papers, followed by UK totaling 150 papers. Other leading countries in technology transfer research include Germany, Switzerland, Italy, Canada, Australia and France. This new bibliometric method can help researchers realize the panorama of global technology transfer research, and establish further research direction.

Keywords: Technology transfer, SCI, research performance, logarithmic model

I. INTRODUCTION

Technology transfer is one of the most important fields in research and development of new products or new technology service today, making research technology transfer an important topic. Technology transfer also is one of knowledge learning and knowledge management domain. During the past decade, many promising research results indicate that technology transfer is the most important element of organizational knowledge creating processes [1, 2, 3, 4, 5, 6]. Technology transfer promotes organizational learning resulting in more research performance. Continuing research on technology transfer has increased our understanding of some industry values like new products development, new technology transfer, new service procedures and new service business models [7]. Despite the high growth rate of technology transfer, scholars have shown little interest in topics such as fellow management, operations research & management science, engineering industrial and engineering multidisciplinary. The bibliometric method is a common research tool for this analysis, widely applied for the scientific production and research trends in many science and engineering disciplines [8, 9, 10].

The Science Citation Index (SCI), from the Institute for Scientific Information (ISI) Web of Science databases is the most important and frequently used database sources of choice for a broad review of scientific accomplishment in all fields of study [11]. Bibliometric analysis is a special advanced field of scientific research [12]. Conventional bibliometric methods often evaluate the research trend by publication outputs of countries, research institutes, journals, and research fields [13, 14] or by citation analysis [15, 16]. The bibliometric method could be used to outline the advance of technology transfer in the last sixteen years. However, finding show little bibliometric study on the topic of current technology transfer or even in the whole field of technology transfer study [13].

Technology transfer is the process of sharing of skills, knowledge, technologies, methods and samples of manufacturing, and facilities among governments, and other institutions to ensure that scientific and technological developments are accessible to a wider range of users who can then further develop and exploit the technology into new products, processes, applications, materials or services. Technology transfer has become a competitive weapon in business operational management that could help firms keep cost down, enhance competitiveness and improve operation performance. Research technology transfer trend is the most one of research issues in *e*-era.

II. DATA SOURCES AND METHODOLOGY

The data for this study are based on the online version of the Science Citation Index (SCI), Web of Science. The SCI are a multidisciplinary database of the Institute for Scientific Information (ISI), Philadelphia, USA. The Journal Citation Reports (JCR), indexes 1,980 major journals with citation references across fifty-six scientific disciplines in 2008. The current study researched the online version of SCI under the keyword “technology transfer” to compile a bibliography of all papers related on technology transfer research. This research reclassified articles originating from England, Scotland, Northern Ireland, and Wales as from the United Kingdom (UK), and obtained the reported impact factor (IF) of each journal from the 2008 JCR.

This investigation determined collaboration type by the addresses of authors, where the term “single country” was assigned if the researchers’ addresses were from the same country. The term “international collaboration” was designated to those articles coauthored by researchers from different countries. The term “single institute publication” was

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assigned if the researchers' addresses were from the same institute. The term "inter-institutionally collaborative publication" was assigned if authors were from different institutes. All articles referring to technology transfer during the past sixteen years, including the last seven years of the 20th century and the first nine years of the 21st century were assessed by the following aspects: document type and language of publications, characteristics of publication outputs during 1992–2007, distribution of output in subject categories and journals, publication outputs of country.

III. RESULTS AND DISCUSSION

A. Document type and language of publication

This work analyzed the distribution of the document type identified by ISI and found fourteen document types in the total 1891 publications. Article (1,144) was the most frequently used document type comprising 60% of total production, followed distantly by, proceeding paper (341; 18%), editorial materials (154; 8.1%), review (80; 4.2%), meeting abstract (67, 3.5%), news item (54, 2.9%) and book review (20; 1.1%). The others showing less significance included discussion (10), note (7), letter (5), reprint (3), correction, addition (3), Correction (2) and biographical-item (1). Journal articles represented the majority of document types that were also peer–reviewed within this field. This study only used 1,144 original articles for further analysis as relevant citable items, and discards all others. Ninety–five percent of all these journal articles were published in English. Several other less used languages included: German (17), French (16), Spanish (15), Portuguese (2), Japanese (2), Rumanian (1), Slovak (1), Finnish (1), Italian (1) and Czech (1).

B. *Characteristics of publication outputs during 1965–2008*

Figure 1 displays the total publication amounts of SCI articles including "technology transfer" in their titles during the last 50 years. Technology transfer research continually grew along with SCI development during this long period, increasing significantly in the 1977, 1982, 1994 and 1996 year is peak point, and slow down in the 21st century. Built on many breakthroughs in the study period during 1975–2008, especially in the before 20st decade, technology transfer research has become one of the most important and dynamic fields of academic research [17, 18, 19].

In the past sixteen years, the annual number of published articles devoted to technology transfer research increased from 62 in 1993 to 91 in 2008, with a stable slightly increase in the number of journals article (Table 1). The average article length is ten papers and slightly fluctuated from eight to thirteen pages. The average number is 2.4 authors that from 1.9 authors to 3.6 authors with per article. Papers in 1993 cited eleven references, compared to thirty-two cited references per paper in 2008, averaging twenty-three cited references per paper.

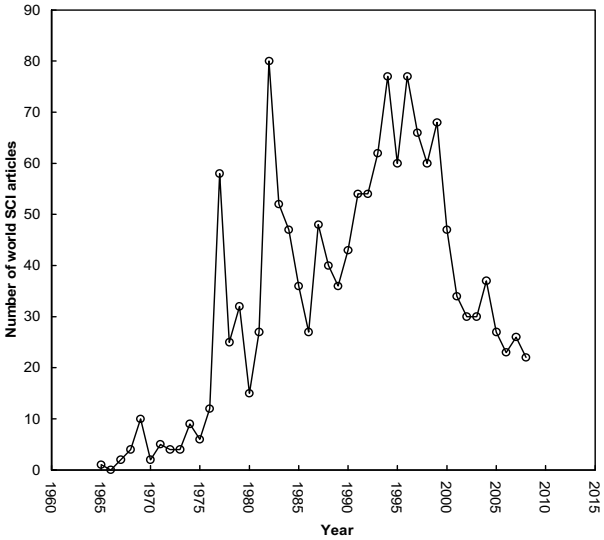

Fig. 1 Number of articles referring to "technology transfer" of SCI journal in last 50 years

Figure 2 shows the progression in the cumulative number of articles published each year from 1992 through 2007. This work simulated the growth pattern using logarithmic models. The logarithmic model plotted the regression curve first step from 1992 to 1998 and second step curve from 1998 to 2007. The data shows technology transfer low growth rate in second curve (1998~2007) that indicated technology transfer was replaced with new research topic. Examples, there are innovation, knowledge management, services science and the others new topic in 21st century.

TABLE I
CHARACTERISTICS OF PUBLICATION OUTPUTS FROM 1993 TO 2008

Year	TP	AU	AU/P	PG	PG/P	NR	NR/P
1993	62	152	2.5	509	8.2	678	11
1994	67	129	1.9	592	8.8	1049	16
1995	82	157	1.9	861	11	1508	18
1996	90	168	1.9	842	9.4	1730	19
1997	84	177	2.1	828	9.9	1697	20
1998	90	190	2.1	910	10	2007	22
1999	93	226	2.4	975	10	1931	21
2000	82	180	2.2	884	11	1795	22
2001	69	162	2.3	724	10	1589	23
2002	63	163	2.6	716	11	1798	29
2003	52	175	3.4	565	11	1230	24
2004	49	127	2.6	487	9.9	1196	24
2005	50	120	2.4	629	13	1307	26
2006	57	154	2.7	703	12	1868	33
2007	63	228	3.6	680	11	1825	29
2008	91	287	3.2	991	11	2914	32
Total	1144	2795		11896		26122	
Average			2.4		10		23

TP: Number of publications; PG: Page count; NR: Cited reference count; AU: Number of authors; PG/P: average of pages; NR/P: references of paper; AU/P: authors in a paper.

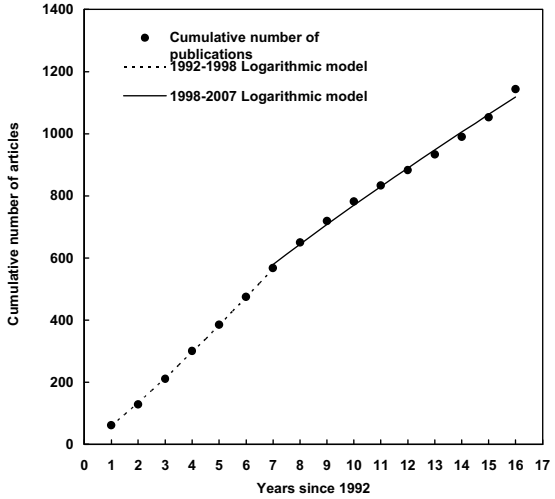

Fig. 2 Cumulative numbers of publications of 1993-2008

C. Distribution of publication output of subject categories and journals

Based on the classification of subject categories in JCR, the publication output data of technology transfer research is distributed in 164 subject categories in SCI journal. To further study global trends on technology transfer research, this work compares between "management," "Operations Research & Management Science," "Engineering & Industrial," and "Engineering & Multidisciplinary" of 1993–2008 (Fig. 3).

"Management" is a general topic issue (*e.g.*, knowledge management, technology management, operational management, business management, financial management and human resource). Knowledge management issue first appears in the technology study field, in the context of organizational knowledge creation in 1994. While individuals develop new technology knowledge, organizations play a critical role in articulating and amplifying that technology knowledge [20]. Scholars combines the concept of weak ties from social network research and the notion of complex knowledge to explain the role of weak ties in sharing knowledge across organization subunits in a multiunit organization [21]. During from1994 to 1995 years, the number of articles related to management had the highest growth rate, successfully transcending other subject in the past sixteen years.

Table 2 analyzes subject categories containing over 1,144 technology transfer related articles and the top ten most published journals on technology transfer. The analysis data displays that 21.6% of the articles reside in five core journals, whereas the remainder reside in another 510 journals. These top five core journals rank as follows: *International Journal of Technology Management* (104; 9.1%), *Technovation* (75; 6.6%), *Ieee Transactions on Engineering Management* (27; 2.4%), *Energy Policy* (22; 1.9%), *Research-Technology Management* (18; 1.6%). As the use of statistics in any scientific discipline can be considered a key element in evaluating its degree of maturity [22], the result provides a current view of technology transfer research emphases of this topic. A total of 1,144 articles were published in a wide range of 515 journals including specialty journals, but also in journals of other disciplines belonging to 164 subject categories above.

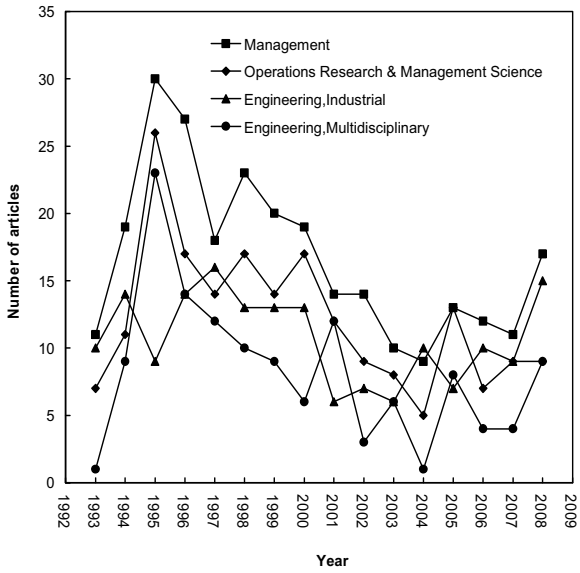

Fig. 3 Comparison the growth trends of main subject categories

D. Distribution of country publications

This study estimated the contribution of different countries by the location of at least one published author. The investigation ranked the top thirty countries by number of publications, including the number and percentage of single country articles and internationally collaborated articles (Table 3). The six major industrial countries (G6: Canada, France, Germany, Italy, UK, and the USA) ranked in the top eight for world publications and the Japan was ranked at ten. The G7 (seven major industrial countries) demonstrated high productivity in independent papers totaling 805 (75.9%). Publication domination was not surprising from mainstream countries since the technology issue has occurred in most scientific fields [23]. To a certain extent, the number of research papers reflecting the activity and academic level of these countries was likewise high [24, 25, 26]. The earliest technology transfer research occurred in these industrial countries, which conducted the earliest and the most relative research performances. The USA showed the greatest counts of world publications, followed distantly by other countries. The USA also had the most–frequent partners, accounting for 45 percent of all international collaborative articles during the last sixteen years.

TABLE II
TOP TEN MOST PUBLISHED JOURNALS ON TECHNOLOGY TRANSFER

Journal name	IF	TP (%)	Subject Category	Position
International Journal of Technology Management	0.526	104 (9.1)	Engineering, Multidisciplinary; Management; Operations Research & Management Science	
Technovation	1.907	75 (6.6)	Engineering, Industrial; Management; Operations Research & Management Science	
IEEE Transactions on Engineering Management	1.156	27 (2.4)	Business; Engineering, Industrial; Management	
Energy Policy	1.755	22 (1.9)	Energy & Fuels; Environmental Sciences; Environmental Studies	
Research-Technology Management	0.676	18 (1.6)	Business; Engineering, Industrial; Management	
Chimia	1.283	16 (1.4)	Chemistry, Multidisciplinary	
Journal of Electrocardiology	1.126	14 (1.2)	Cardiac & Cardiovascular Systems	
Technology Analysis & Strategic Management	N/A	13 (1.1)	Management; Multidisciplinary Sciences	
Journal of Forestry	1.263	11 (1)	Forestry	
Journal of Engineering and Technology Management	0.923	11 (1)	Business; Engineering, Industrial; Management	

IF: impact factor; TP: total published articles in the 16 years; %: percentage of all articles published in the years

TABLE III
TOP THIRTY MOST PRODUCTIVE COUNTRIES OF ARTICLES DURING 1993-2008

Country	TP	TPR (%)	SPR (%)	CPR (%)	FAR (%)	RPR (%)
USA	477	1 (45)	1 (45)	1 (46)	1 (43)	1 (43)
UK	150	2 (14)	2 (12)	2 (25)	2 (13)	2 (13)
Germany	44	3 (4.2)	6 (3.1)	3 (11)	6 (2.9)	4 (3.1)
Switzerland	39	4 (3.7)	4 (3.2)	6 (6.7)	3 (3.3)	3 (3.2)
Italy	39	4 (3.7)	3 (3.4)	12 (5.3)	4 (3.1)	4 (3.1)
Canada	38	6 (3.6)	4 (3.2)	10 (6)	4 (3.1)	6 (3)
Australia	37	7 (3.5)	7 (3)	6 (6.7)	7 (2.9)	7 (2.8)
France	33	8 (3.1)	8 (2.2)	5 (8.7)	8 (2.4)	8 (2.3)
Netherlands	27	9 (2.6)	12 (1.4)	4 (9.3)	12 (1.5)	12 (1.6)
Japan	24	10 (2.3)	11 (1.7)	10 (6)	10 (1.7)	9 (1.9)
India	23	11 (2.2)	10 (1.9)	17 (4)	11 (1.6)	11 (1.7)
Taiwan	22	12 (2.1)	9 (2)	22 (2.7)	9 (1.9)	9 (1.9)
Spain	21	13 (2)	13 (1.2)	6 (6.7)	13 (1.4)	13 (1.5)
Sweden	19	14 (1.8)	15 (1)	6 (6.7)	14 (1.1)	15 (1.2)
Brazil	16	15 (1.5)	15 (1)	15 (4.7)	16 (1)	17 (1)
Hong Kong	15	16 (1.4)	13 (1.2)	22 (2.7)	14 (1.1)	14 (1.3)
Finland	14	17 (1.3)	15 (1)	20 (3.3)	16 (1)	16 (1.1)
Austria	13	18 (1.2)	20 (0.55)	12 (5.3)	19 (0.76)	23 (0.6)
South Africa	12	19 (1.1)	18 (0.89)	22 (2.7)	18 (0.86)	18 (0.8)
Portugal	11	20 (1)	31 (0.33)	12 (5.3)	23 (0.57)	19 (0.7)
China	10	21 (1)	31 (0.33)	15 (4.7)	23 (0.57)	26 (0.5)
Mexico	10	21 (1)	23 (0.44)	17 (4)	21 (0.67)	19 (0.7)
Belgium	9	23 (0.86)	23 (0.44)	20 (3.3)	23 (0.57)	23 (0.6)
South Korea	9	23 (0.86)	31 (0.33)	17 (4)	23 (0.57)	23 (0.6)
Norway	8	25 (0.76)	18 (0.89)	N/A	19 (0.76)	19 (0.7)
Greece	7	26 (0.67)	23 (0.44)	26 (2)	23 (0.57)	26 (0.5)
Chile	7	26 (0.67)	20 (0.55)	30 (1.3)	21 (0.67)	19 (0.7)
Israel	6	28 (0.57)	31 (0.33)	26 (2)	28 (0.48)	31 (0.4)
Cuba	5	29 (0.48)	20 (0.55)	N/A	28 (0.48)	26 (0.5)
Venezuela	5	29 (0.48)	23 (0.44)	39 (0.67)	31 (0.38)	31 (0.4)

TP (%): the number of total publications;
TPR (%): the share in total publications;
SPR (%):the rank and percentage of single country publications,
CPR (%):internationally collaborative publications,
FAR (%):first author publications,
RPR (%):corresponding author publications in total publications.

The analysis data in Figure 4 display USA predominance in global technology transfer research. The publications share of the USA distinctly increased in our study period, especially in the latest decade. The UK ranked second position in global technology transfer research fields. The global trend of technology transfer research accords with developmental trends toward world multi-polarization and scientific research globalization, while other countries in the world gradually increased their disparities with the USA. This figure displays the time–trend analysis among six others major countries. The figure shows an obvious rise in the number of articles related to innovation research in all six countries, while the rapid development of global technology transfer research in the last sixteen years was partly driven by these countries' contributions [27, 28, 29, 30, 31].

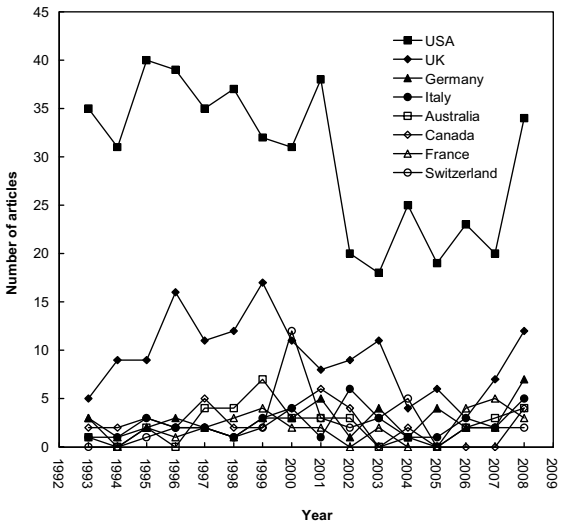

Fig. 4 Growth comparison trends of the top eight countries

The Germany has the high growth rate in the past ten years, with the high share (11%) of international collaborative articles in its total publications among the top thirty productive countries, representing its powerful independence in technology transfer related research field. The scholars draft report outlines a process for both public and private funded scientists to follow in deriving and working with technology innovation [32, 33]. A series of positive policies undoubtedly motivate the rapid development of the technology transfer research in the Germany. Another significant point is that Switzerland (3.7%) and Italy (3.7%), have kept ahead of other countries in the last decade. The percentage of publications from Canada, Australia and France in the period of 1993–2008 has slightly increased, indicating that the growth rate of technology transfer research in these three countries is a little slower than in other productive countries. The increase could be attributed to various factors, while technology transfer research itself refers to science, technology, competitiveness and national politics. Innovation has become an important indication of national competitiveness, the research and development facility of products, and widespread application of marketing and brand building [34, 35, 36, 37]. How do to combine innovation concept into technology transfer processing become one of the most success factor.

IV. Conclusion

This study on technology transfer papers dealing with SCI, obtained some significant points on research performance throughout the period from 1992 to 2008. This study used a logarithmic model analysis from 1992 to 2007. The logarithmic model fitting showed that yearly publicans had a distinct growth with a high rate during from 1992 to 1998, and little slow down from 1998 to 2007. There were a total of 515 journals listed in the 164 subject category. Subject categories for mainstream research on technology transfer included four domains of management, operations research & management science, engineering & industrial, and engineering & multidisciplinary while increasing attention was paid to the field of technology transfer in the 21st century. As the flagship journal of the field, *International Journal of Technology Management* published the most articles. The G7 country which had a longer tradition in research in this field, held the majority of total world production. The USA notably contributed the most independent and international collaborative articles, and had the most first author and corresponding author publications in total publication articles. This study concludes that adopt innovation concept/approach into business operation management, especially research related on "management", "operations research", "management science" and "engineering" are the orientation of all technology transfer research in the 21st century. The result display with bibliometric method can help relevant researchers realize the panorama of global technology transfer research, and establish the further research direction.

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James K. C. Dr. Chen is Assistant Professor of Department of Business Administration, Asia University. He got ph. D. degree from the Institute of Management of Technology, National Chiao Tung University, in Taiwan. His research interests include MIS (management information systems) planning, technology forecasting, technology of management and innovation management.