A Study on the Productivity Review for Management of Technology Using Bibliometric Methodology

Chi-Yen Yin
National Chengchi University
No.64, Sec. 2, Zhinan Rd., Wenshan
District, Taipei City 11605, Taiwan
+886-2-2264-8940

97356509@nccu.edu.tw

Jan-Shan Lin
National Chengchi University
No.64, Sec. 2, Zhinan Rd., Wenshan
District, Taipei City 11605, Taiwan
+886-2-2356-9405

97356511@nccu.edu.tw

Jiann-Min Yang
National Chengchi University
No.64, Sec. 2, Zhinan Rd., Wenshan
District, Taipei City 11605, Taiwan
+886-2-2939-3091

jmyang@mis.nccu.edu.tw

ABSTRACT

This paper is mainly focusing on the literatures productivity review which subjects as renowned "Management of Technology" on SSCI database. The result indicated that the literature productions is titling as "Management of Technology" are still increasing tremendously. The distribution of frequency indexes of author productivity is suitable for Lotka's Law. The applications of management of technology are primary following by research aspects which in term of management; business, operations research and management science; engineering industrial; engineering multidisciplinary; information science and library science; computer sciences and information systems. The literatures of Management of Technology are usually generating by single author.

Keywords

Management of Technology, Lotka's law, Literature Production

1. INTRODUCTION

Management of technology is an integrated application of management, engineering and science capabilities to the management of life cycle of new technologies, to accomplish the strategic objectives of an organization or enterprise. The generic processes of management of technology are in terms of identification of technologies, selecting, procurement, assimilation and exploitation of technologies for the production of goods and services.

Since ROBERTS EB announced first paper at the journal of IEEE TRANSACTIONS ON ENGINEERING MANAGEMENT in 1964. The subject of management of technology began a full exploration of all the possibilities in every research domain in last two decades. This paper is utilizing bibliometric methodology toward onto productivity inspection. To get better understanding about the quantitative domains of recorded information such as research authors, institutions, languages and subjects, finally proceeding by Lotka's law on papers versus authors between 1964 and 2008 to perform author productivity inspection, discovering historical vein and collecting the results for research tendency forecasting in the near future.

2. LITERATURE REVIEW

Management of Technology is a relatively new academic discipline that focuses on the scientific, engineering, and management issues related to the commercial introduction of new technologies, technology management and innovation.

Management of technology has recently gained importance in a variety of research aspects. The concept was initially introduced by business and management. Researchers in organizational and managements sciences have shown an increased interest in this new territory. Management of technology is about the value proposition from being a member of organization or enterprise. Although the concept of management of technology has a much longer existence, it has become a prominent topic of discussion over last twenty years. Its emergence within the fields of management analytic perspective on business activities that is immanent in the neoclassic school of management science thinking.

3. RESEARCH FINDING AND DISCUSSION

This research is accessing the Social Sciences Citation Index (SSCI) on Web of Science created by ISI. The result is summarizing those 751 paper indexes which topics are "Management of Technology" or "Technology Management" from 1964 to 2008 as well as input datum for next stage analysis, shown as figure 1. Obviously, the literature production of management of technology is rising up since 1997, and

citation is also increasing steady and gradually by every year. It shows the research of management of technology is very popular and getting in the highly exploration period, referred to figure 2. The research of management of technology reached the highest record in 1996. After that, there are a lot of research announcements from 1995 to 2007 but the published is between 30 papers and 56 papers relatively.
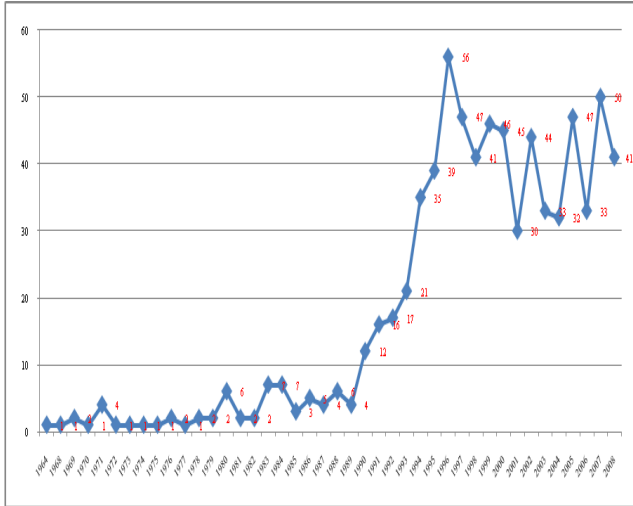

Figure 1, the tendency chart of literature growth of management of technology
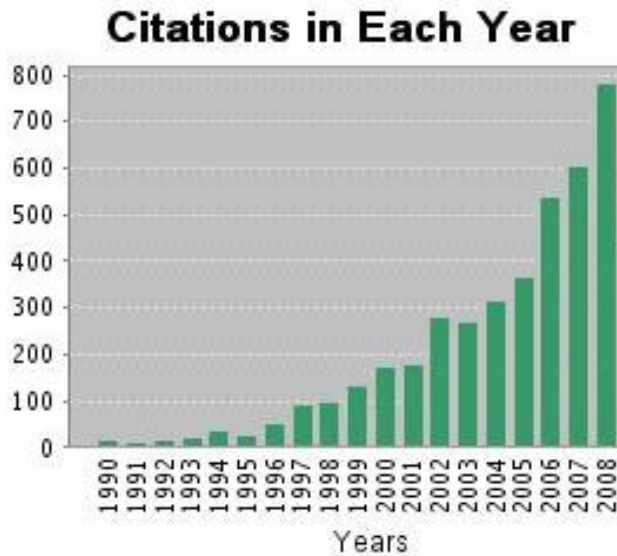

Figure 2, Citation of management of technology in Each Year (Source: SSCI database)

By viewing on table 1 and figure 3, they displayed that the distribution of Country/Territory. United States is a champion as well as 345 paper counts (45.94%), following by the England, Canada and Australia which achieved the record counts as 83(11.05%), 31(4.13%), and 27(3.60%) oppositely. Taiwan is ranking as No. 6 (18 paper counts, 2.40%) in this research

domain. Combining with the distribution of institutions name (as table 2) for deeply observation, it shown that United States is still the most productivity country within the research aspect of management of technology in the world.

Table 1, Distribution of Top 14 Institution Name from 1964 to 2008

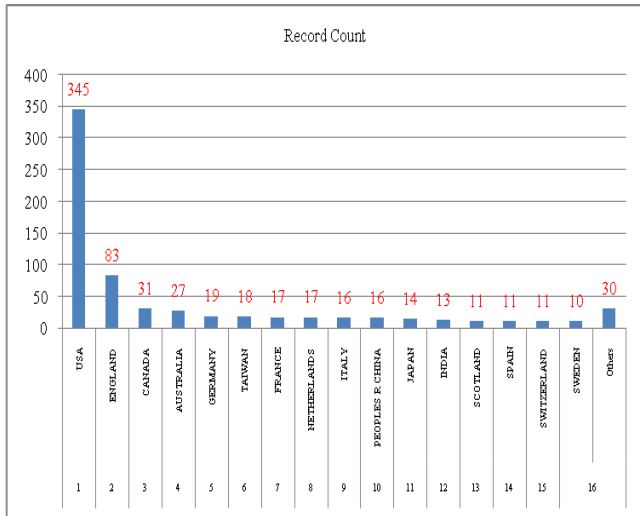| Ranking	Country/Territory	Record Count	% of 751
1	USA	345	45.94%
2	ENGLAND	83	11.05%
3	CANADA	31	4.13%
4	AUSTRALIA	27	3.60%
5	GERMANY	19	2.53%
6	TAIWAN	18	2.40%
7	FRANCE	17	2.26%
8	NETHERLANDS	17	2.26%
9	ITALY	16	2.13%
10	PEOPLES R CHINA	16	2.13%
11	JAPAN	14	1.86%
12	INDIA	13	1.73%
13	SCOTLAND	11	1.46%
14	SPAIN	11	1.46%
15	SWITZERLAND	11	1.46%
16	SWEDEN	10	1.33%
	Others	30	11.98%

Figure 3, Distribution of Country/Territory from 1964 to 2008

Table 2, Distribution of Top 14 Institution Name from 1964 to 2008

Ranking	Institution Name	Record Count	% of 751	Nationality
1	GEORGE WASHINGTON UNIV	12	1.60%	USA
2	RENSSELAER POLYTECH INST	12	1.60%	USA
3	UNIV CAMBRIDGE	12	1.60%	ENGLAND
4	MIT	10	1.33%	USA
5	UNIV COLORADO	8	1.07%	USA
6	UNIV MINNESOTA	8	1.07%	USA
7	UNIV TEXAS	8	1.07%	USA
8	NEW JERSEY INST TECHNOL	7	0.93%	USA
9	UNIV MANCHESTER	7	0.93%	ENGLAND
10	UNIV SO CALIF	7	0.93%	USA
11	UNIV WISCONSIN	7	0.93%	USA
12	VIRGINIA POLYTECH INST & STATE UNIV	7	0.93%	USA
13	HARVARD UNIV	6	0.80%	USA
14	UNIV UTAH	6	0.80%	USA
	Other	634	84.42%	
	Total	751	100.00%	

On table 3, it indicated that the most publication document type is "Article" (517 record counts, 68.84%), and the most popular language for writing is using "English" (747 record counts, 99.47%) in the research domain of technology of management. See the following table 4.

Table 3, Distribution of Document Type from 1964 to 2008

Document Type	Record Count	% of 751
ARTICLE	517	68.84%
BOOK REVIEW	100	13.32%
PROCEEDINGS PAPER	51	6.79%
EDITORIAL MATERIAL	49	6.52%
REVIEW	25	3.33%
MEETING ABSTRACT	4	0.53%
NOTE	2	0.27%
BIOGRAPHICAL-ITEM	1	0.13%
CORRECTION, ADDITION	1	0.13%
LETTER	1	0.13%
Total	751	100.00%

Table 4, Distribution of Language from 1964 to 2008

Language	Record Count	% of 751
ENGLISH	747	99.47%
GERMAN	2	0.27%
PORTUGUESE	2	0.27%
Total	751	100.00%

On the figure 4, it is to strengthen researchers to get understanding about the distribution of top 20 subject areas for future search trend and research directions. The top three ranking of research domains are management (509 record counts, 18.56%), following by the business (275 record counts, 12.89%); operations research and management science (204 record counts, 11.46%). Moreover, it also discovered that there are a lot of research domains for management of technology literature production such as engineering and industrial; engineering and multidisciplinary; information science and library science; computer science and information systems; planning and development and so on.
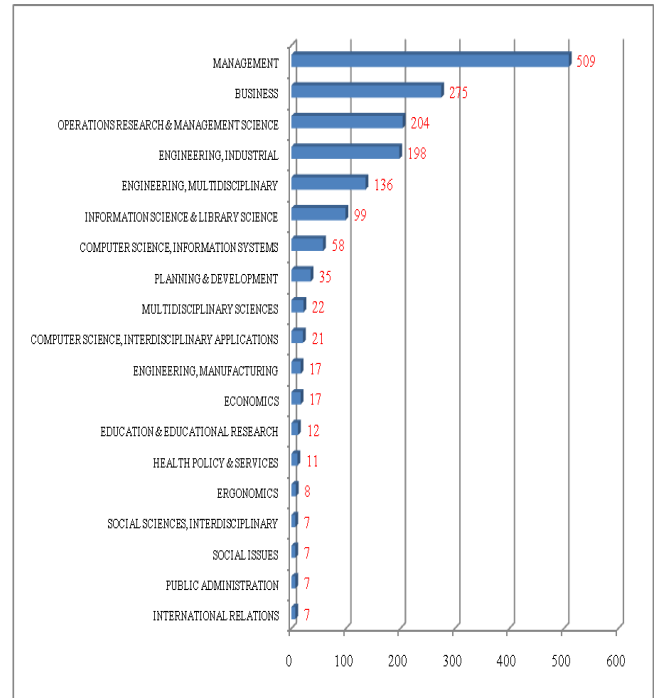

Figure 4, Distribution of Top 25 Subject Area from 1964 to 2008

To sum up all investigation on collected information, the research field of management of technology is going to the exploded period. Most of literatures announced by United States, England, Canada and Australia, the United Nations positively appealed that governments and highly developed countries should invest massive resources within the research on the management of technology which also carry onto the studies for each kind of phenomena such as nature, society, and proposed the related discovery. It will be empowering the human knowledge in near future.

4. THE LITERATURES PRODUCTIVITY ANALYSIS OF MANAGEMENT OF TECHNOLOGY BY LOTKA'S LAW

This section is mainly discussing the author distribution situation of the rule which certificated by Lotka's law. It is now calculating the author quantity by the equality method from 751 literatures which retrieved by index on SSCI. That is indicated that the degree of contribution of each author in one literature is the same, which could counts separately. Thus, it obtained altogether 1,101 of authors on research aspect of management of technology. See the table 5.

Table 5, Distribution of author productivity of management of technology from 1964 to 2008

Record Count	Author(s)	Record Count%	Accumulated Record	Accumulated Record%	Accumulated Author(s)	Accumulated Authors%
7	1	7	7	0.53%	1	0.09%
6	1	6	13	0.99%	2	0.18%
5	6	30	43	3.26%	8	0.73%
4	6	24	67	5.09%	14	1.27%
3	35	105	172	13.06%	49	4.45%
2	93	186	358	27.18%	142	12.90%
1	959	959	1317	100.00%	1101	100.00%

4.1 Lotka's law

The research of discipline literature author distribution via productivity, may utilize the Lotka's law to discuss on it. The Lotka's law is called "a reverse square law of the scientific productivity", its connotation is: the number of author which published x literature is the number of author which published one literature total to divide x^2. By performing Lotka's law to carry on the analysis, which confirms the management of technology literatures whether to be suitable or not, it should also calculated the slope n value, the constant c value by using the K-S examination determination whether the distribution is conform to or not [2] (Prof. Dr. Tsai Ming-Yue, 2003). Viewing on the datum, author has only 1 literature is 87.10%, which is almost matched of primitive c value 89.60% generated by Lotka's law. After that, it can follow the calculation to get n and c value by the least squares law, carry onto the further proceeding examination for Lotka's law compliance.

Table 6, productivity analysis of author via record count of management of technology from 1964 to 2008 - I

Record Count	Author(s)	X=ln x	Y=ln y	XY	XX
7	1	0.85	0.00	0.00	0.71
6	1	0.78	0.00	0.00	0.61
5	6	0.70	0.78	0.54	0.49
4	6	0.60	0.78	0.47	0.36
3	35	0.48	1.54	0.74	0.23
2	93	0.30	1.97	0.59	0.09
1	959	0.00	2.98	0.00	0.00
Total	1,101	3.70	8.05	2.34	2.49

By the result of calculation on table 6, it could bring into the following equation.

The n = -3.61104898

$$n = \frac{N\sum XY - \sum X \sum Y}{N\sum X^2 - \left(\sum X\right)^2}$$

After that, we also found c= 0.896040754, the equation is shown as below:

$$c = \frac{1}{\sum_{1}^{P-1}\frac{1}{x^n} + \frac{1}{(n-1)(p^{n-1})} + \frac{1}{2p^n} + \frac{1}{24(p-1)^{n+1}}}$$

p=6 (max(x) -1), x=1, 2, 3, 4, 5, 6, 7

when we got n= - 2.448919，c= 0.731766, it explored, $f(x)=0.731766/x^{2.448919}$. According to Pao [2] suggested that the absolute value of n should be in between 1.2 and 3.8 which formed by the generalized Lotka's law, and the outcome is also matched the reference data by observation. The distribution chart is shown as figure 6. Discussing on the value of both n and c, primitive n approximately is -2, c is 0.6079 that generated by Lotka's law, it demonstrated that the management of technology literature author distribution and the primitive Lotka's law are matched appropriately. In order to examine the theoretical value and the observation value whether to tally. Regarding the n and c value which gained by the formula, it is possible to calculate the expected value and the accumulation value of author, following by K-S test examination.
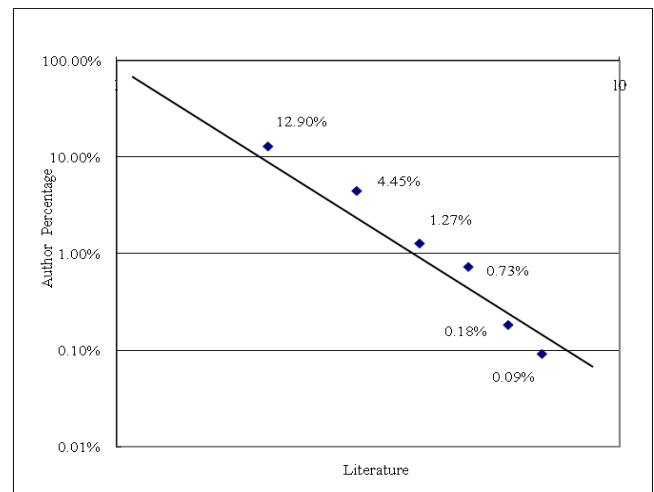

Figure 6：Distribution of literature productivity by author on management of technology research aspect

According to K-S test, table 7 demonstrated D_{max}=0.0250, but the sampling number is bigger than 35, therefore the threshold value is $1.63/((1101)^{1/2}) = 0.04912$. Because D_{max} is less than the threshold value, the result is this distribution of author productivity and the Lotka's law is matched, which means the Lotka's law is exactly suitable for the literature author productivity distribution in management of technology research field.

Table 7, productivity analysis of author via record count of management of technology from 1964 to 2008 – II

Record Count	Observation by Author	Accumulated Value	Expected Value by Author	Accumulated Value	ABS Value
		$S_n(X)$		$F_0(X)$	$|F_0(X)-S_n(X)|$
1	0.8710	0.8710	0.8960	0.8960	0.0250
2	0.0845	0.9555	0.0733	0.9694	0.0139
3	0.0318	0.9873	0.0170	0.9863	0.0009
4	0.0054	0.9927	0.0060	0.9923	0.0004
5	0.0054	0.9982	0.0027	0.9950	0.0031
6	0.0009	0.9991	0.0014	0.9964	0.0027
7	0.0009	1.0000	0.0008	0.9972	0.0028

5. CONCLUSION

Management of technology is one of fast growing research topics in recent years, this historical review and trend forecast of this research field by each kind of literature characteristic and author productivity distribution is in growing period, it might be knowing that the current management of technology literatures is still continually to grow, the main research development facility with delivered the large production is United States, but England, Canada, Australia, even some Asia countries such as Taiwan, Japan and South Korea, these non-US individual authors delivered literatures generally are also very popular. The frequency indexes of author productivity distribution certainly follow by Lotka's Law. The applications of management of technology are mainly following by research aspects which in term of management; business, operations research and management science; engineering industrial; engineering multidisciplinary; information science and library science; computer sciences and information systems. The literatures of management of technology are usually generating by single author.

6. REFERENCE

[1] Kropsu-Vehkapera, H., Haapasalo, H. & Rusanen, J-P. (2009). "Analysis of Technology Management Functions in Finnish High Tech Companies". *The Open Management Journal* 2: 1–10

[2] Prof. Dr. Tsai, Ming-Yue (2003). The characteristic of informetrics and bibliometric. Hwa-Tai bookstore, Taiwan