RESEARCH ARTICLE

STUDIES ON RESEARCH OUTPUT OF NEURAL NETWORK AT INTERNATIONAL LEVEL: BIBLIOMETRIC ANALYSIS

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ABSTRACT

The present paper deals with the analysis of Relative Growth Rate and Doubling Time of Neural network research output at international level using time series data from 1969 to 2007. The research output at the international level in 1969 is 2 and it is reached to 123552 in 2007 and the increasing trend is observed year by year. The relative growth rate registers a declining trend at international level. The study period, 1969-2007 records the mean relative growth rate of 0.29 at the world level. The doubling time of neural network research output at the world level starts with 0.63 year in 1971 and it is 6.93 years in 2007.

INTRODUCTION

Bibliometrics is the organization, classification and quantitative evaluation of publication patterns of macro and micro communications along with their authorship. It is the quantitative study of literature as they are reflected in bibliographies. Bibliometric analysis of scientific publications is an important aspect of research endeavour in Information Science in recent years. It could be attributed to the fact that bibliometric studies are used to identify the pattern of publications, authorship, citations, secondary journal coverage, and so on. These factors can give an insight into the dynamics of a subject, which consequently leads to better information handling and management. Bibliometric analysis has received an adequate attention and it has been widely applied to evaluate the research performance of the scientists and the growth of various disciplines. Further it could be noted that bibliometric data could be used in the identification of emerging research areas, and in the evaluation of research performance of individual scientists, research groups and countries. It aims to integrate the cognitive or intellectual structure of research with a view to appraise the relations among the authors, institutions, journal articles and as a means of assisting the peer review procedure. Bibliometric analysis of literature in various disciplines has been carried out by using primary journals or secondary sources to examine the quantitative aspects of literature growth in a particular field of knowledge.

Quantitative measurement of publications, citations and other parameters have been largely applied and used in evaluating scientific research. Literature in the field of bibliometrics is constantly growing and a number of review articles, books and conference volumes on the development of bibliometrics have been published. The first review of the empirical laws of bibliometrics was by Fairthrone, 1969. The second was published by Hjerppe, 1980, which contains more than 200 references to bibliometrics. Basu and Garg (2000) analyzed the trends in the study of bibliometrics /scientometrics during the years 1970 to 1994.

Sanz-Casado *et al.* (2007) have stated that the purpose of their study was to analyze and map trends in research applying bibliometric tools to scientific literature published between 1973 and 2002. Lopez-Cozar, Torres-Salinas, Jimenez-Contreras and R. Ruiz-Perez (2006) have tried to explore the possibilities of SNA (social network analysis) for detecting scientific schools and academic networks in the university applying bibliometric tool to doctoral dissertations presented in Spanish universities between 1970 and 2002. Ming-Hsen, Lin Liang-Kung, Chen Shinn-Jang, Hwang Weiss, B.D. Li-Fang Chou and Tzeng-Ji Chen (2006), have scrutinized the science citation index (SCI), its coverage of journals that are the criterion for performance assessment of researchers world-wide. If the journals of a specialty were under-proportionally indexed, its development in research could be distorted in the long term. Patra and Mishra (2006) have analyzed the growth of scientific literature in the area of health as available from NCBI PubMed using standard

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bibliometric techniques. Bradford's law of scattering has been used to identify core journals and Lotka's law has been applied to analyze the productivity pattern of authors. Their study also has explored publication type, language and the country of publication. Anwar (2005) has made bibliometric analysis of literature on Nigella sativa (Habbat al-barakah or Black seed) to study the periodic growth of literature, author patterns, topical focus, and geographic origin of literature on the subject. Twenty related databases and several online catalogues of libraries have been searched to make a final list of 530 citations. This data set has been analyzed employing bibliographic techniques. Berenika Webster (2005) have applied bibliometric methods to assess the volume of research studies published and the impact and sources of funding of biomedical research in the UK. The analyses also include an examination of national and international collaboration, leading regions and institutions (by volume of output), types of research carried out and their potential impact factor.

Biradar and Thippeswamy (2004) have made an attempt to determine the average number of reference per dissertation, forms of documents, authorship pattern, obsolescence of literature and percentage of cited periodicals available in the library. A methodology for exploring the characteristic of a core international conference, a concept of Conference Impact Factor (CIF) has been explored by Clausen and Wormel (2001) on the pattern of Journal Impact Factor (JIF). This study is based on online citation databases in DIALOG and the CD versions of the LISA. A bibliometric study was conducted by Jacobs (2001) covering the period 1992-1996, which demonstrates that there is a direct relationship between status and publication productivity. Further there are significant differences in productivity between areas of sciences but that there is no direct relationship between institutional funding and productivity. A bibliometric analysis of 'LISA' covering 1994-1998 has been conducted by Parameswarn and Smitha (2001) which shows the vital role performed by 'LISA' in the dissemination of information in Library and Information Science. It was found that not only the proportion of Indian contributions compared to the total output of LIS literature is meager but also the representation of contributions from the third world countries.

Macias-Chapula (2000) analyzed AIDS research contributions from Haiti with the help of AIDSLINE database for the period 1980-1998 to identify the growth pattern in AIDS literature, as well as the types of documents published, authorship pattern, institutional affiliation of authors and subject contents. The publication output of 25 major countries in 10 sub fields of Physics drawn from INSPEC database for the period 1989-1994 were analyzed by Nagpaul and Bhattacharya (2000) to study the national patterns of research output and priorities with the help of statistical techniques such as Research Priority Index, Typological Analysis, Multidimensional Analysis and Correspondence Analysis, to monitor the changes in the structure of research in Physics. From the above literature, it was found that, no such study has been conducted either at macro or micro level on the growth pattern of literature in the field of Neural Network. The present study deals to examine the Relative Growth Rate and Doubling Time of Neural network research output at international level from 1969 to 2007.

Database and Statistical tools employed

Relative Growth Rate

The relative growth rate is the increase in the number of publications /pages per unit of time. The growth rate of total publications has been calculated on the relative growth rate and doubling time model developed by Mahapatra (1985).

Doubling Time

There exists a direct relation between the relative growth rate and doubling time. If the number of publications /pages of subject double during a given period, then the difference between the logarithms of the numbers at the beginning and at the end of the period must be the logarithms of the number 2. If one uses natural logarithms, this difference has the value of 0.693. Thus, the corresponding doubling time for publications and pages can be calculated by the following formula. Doubling time $(D_t) = 0.693/R$

Analysis

Publication output on neural network at International level

The study of the quantum of neural network research publications at the International (World) level is a much felt need these days because of its importance. It is a yardstick to measure the performance of scholars at the international level. It is also a measure for rating the performance of researchers of a country in that particular discipline of scientific research. Neural network research at the international level is comparatively clustered and data pertaining to it at that level have been culled out and analyzed in relation to the performance of the Indian research output in the same area. This chapter presents the analysis of neural network research output at various levels using time series data from 1969 to 2007.

Fig.1 Distribution of Neural network Publications Output at the International Level
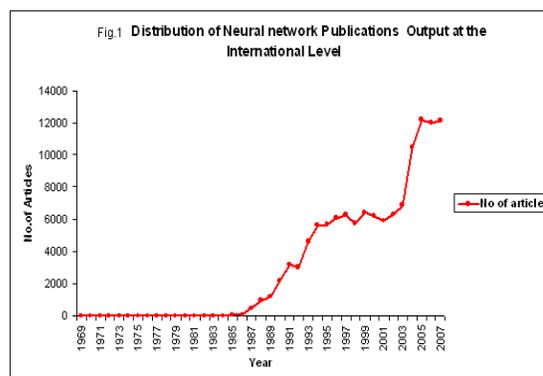
Fig.1 shows the distribution of neural network publications output at the international level. Data presented in Table 1 indicate the International level research output on Neural network. The research output at the international level in 1969 is 2 and it reached the number 123552 in 2007. An increasing trend is registered year by year. International Neural network research output indicates a multifold increase from 1969 to the end of the year 2007. Research on Neural network seems to be one of the most pursued research activity and the scientists at the International level have paid more attention to it and have published more number of papers on Neural network from the years 1989 onwards. A perusal of Table 1 will show that with

Table 1. Distribution of Neural network Publications Output at International Level

Year	No of articles	Cumulative articles	Percentage	Cumulative percentage
1969	2	2	0.02	0.02
1970	0	2	0	0
1971	4	6	0.00	0.02
1972	7	13	0.01	0.03
1973	5	18	0.00	0.03
1974	10	28	0.01	0.04
1975	7	35	0.01	0.04
1976	3	38	0.00	0.05
1977	5	43	0.00	0.05
1978	14	57	0.01	0.06
1979	10	67	0.01	0.07
1980	13	80	0.01	0.08
1981	11	91	0.01	0.09
1982	7	98	0.01	0.09
1983	17	115	0.01	0.11
1984	15	130	0.01	0.12
1985	32	162	0.03	0.15
1986	34	196	0.03	0.17
1987	479	675	0.39	0.56
1988	979	1654	0.79	1.35
1989	1191	2845	0.96	2.32
1990	2157	5002	1.75	4.06
1991	3160	8162	2.56	6.62
1992	3021	11183	2.45	9.07
1993	4597	15780	3.72	12.79
1994	5614	21394	4.54	17.33
1995	5673	27067	4.59	21.92
1996	6069	33136	4.91	26.83
1997	6244	39380	5.05	31.89
1998	5732	45112	4.64	36.53
1999	6411	51523	5.19	41.72
2000	6188	57711	5.01	46.72
2001	5946	63657	4.81	51.54
2002	6302	69959	5.10	56.64
2003	6876	76835	5.57	62.20
2004	10452	87287	8.46	70.66
2005	12152	99439	9.84	80.50
2006	12014	111453	9.72	90.22
2007	12099	123552	9.79	100

2 publications on neural network in the year 1969 the number has been more or less static but for the spurt in 1974 in which year there were 10 papers on the subject. It continues to be a very slow growth till the year 1986 when it was 34 papers a year. What was in three digit numbers in the year 1987 and 1988 begins to be four digits until 2003 and in 2004 the number was in five digits and in 2007 it stood at 12099 with a cumulative number of 123552 papers. The growth number has been uniform until 2003.

Relative growth rate and doubling time of neural network literature at the International level

One of the objects of the present study is to evaluate the performance of research and development in neural network. The analysis of the growth rate of Neural network research output aims at identifying the growth prospects of the subject of the present study. However, proliferation of neural network literature makes it difficult for scientists to keep in touch with recent advances in that field. Hence the prime duty of the library professionals is to meet the information needs of scientists of various disciplines. Published literature is a yardstick to measure the knowledge in a discipline, and the growth rate study of publications would provide some useful information. The rate of growth of neural network literature is determined by calculating relative growth rates and doubling time of publications. Table 2 presents data of the relative growth rate and doubling time of research output on neural network at the international level. In 1969, neural network research output published was 2 at the international level, and it rose to 123552 by the end of 2007, which is a phenomenal increase in numbers. The relative growth rate has shown a declining trend. It could be seen that its relative growth rate decreased gradually from 0.57 in 1975 to 0.11 in 2005. The study period records the mean relative growth rate of 0.29. Contrarily, the doubling time of publication of Neural network research output has increased from 0.63 in 1971 to 6.93 in 2007.

Table 2 . Showing Relative Growth Rate (R) and Doubling Time (D_t) of World Neural Network Literature

Year	No of Articles	Cumulative number of Articles	W_1	W_2	R(a)	Mean R(a)	Doubling time D_t(a)	Mean Doubling time
1969	2	2	0	0.69	0			
1970	0	2	0.69	0.69	0.00			
1971	4	6	0.69	1.79	1.10		0.63	
1972	7	13	1.79	2.56	0.77		0.90	
1973	5	18	2.56	2.89	0.33		2.10	
1974	10	28	2.89	3.33	0.44		1.58	
1975	7	35	3.33	3.56	0.23	0.574		1.644
1976	3	38	3.56	3.64	0.08		8.66	
1977	5	43	3.64	3.76	0.12		5.78	
1978	14	57	3.76	4.04	0.28		2.48	
1979	10	67	4.04	4.2	0.16		4.33	
1980	13	80	4.2	4.38	0.18	0.164		5.02
1981	11	91	4.38	4.51	0.13		5.33	
1982	7	98	4.51	4.58	0.07		9.90	
1983	17	115	4.58	4.74	0.16		4.33	
1984	15	130	4.74	4.87	0.13		5.33	
1985	32	162	4.87	5.09	0.22	0.142		5.608
1986	34	196	5.09	5.28	0.19		3.65	
1987	479	675	5.28	6.51	1.23		0.56	
1988	979	1654	6.51	7.41	0.90		0.77	
1989	1191	2845	7.41	7.95	0.54		1.28	
1990	2157	5002	7.95	8.52	0.57	0.686		1.496
1991	3160	8162	8.52	9.01	0.49		1.41	
1992	3021	11183	9.01	9.32	0.31		2.24	
1993	4597	15780	9.32	9.67	0.35		1.98	
1994	5614	21394	9.67	9.97	0.30		2.31	
1995	5673	27067	9.97	10.21	0.24	0.338		2.166
1996	6069	33136	10.21	10.41	0.20		3.47	
1997	6244	39380	10.41	10.58	0.17		4.08	
1998	5732	45112	10.58	10.72	0.14		4.95	
1999	6411	51523	10.72	10.85	0.13		5.33	
2000	6188	57711	10.85	10.96	0.11	0.15		4.826
2001	5946	63657	10.96	11.06	0.10		6.93	
2002	6302	69959	11.06	11.16	0.10		6.93	
2003	6876	76835	11.16	11.25	0.09		7.70	
2004	10452	87287	11.25	11.38	0.13		5.33	
2005	12152	99439	11.38	11.51	0.13	0.11		6.444
2006	12014	111453	11.51	11.62	0.11		6.30	
2007	12099	123552	11.62	11.72	0.10		6.93	
			11.72			0.29		4.03

network at the international level. In 1969, neural network research output published was 2 at the international level, and it rose to 123552 by the end of 2007, which is a phenomenal increase in numbers. The relative growth rate has shown a declining trend. It could be seen that its relative growth rate decreased gradually from 0.57 in 1975 to 0.11 in 2005. The study period records the mean relative growth rate of 0.29. Contrarily, the doubling time of publication of Neural network research output has increased from 0.63 in 1971 to 6.93 in 2007.

Period	Doubling time
1971-1975	1.64
1976-1980	5.02
1981-1985	5.61
1986-1990	1.50
1991-1995	2.17
1996-2000	4.82
2001-2005	6.44

The doubling time for publications at the aggregate level has been computed as 4.03 years. It could be deduced that in general there is a progressive increase in the number of publications of research output on neural network. However, its relative growth rate has shown a declining trend, which means the rate of increase is low in terms of proportion, and this has been highlighted by the doubling time for publications, which is more than the relative growth rate.

Table 3. Country wise distribution of Neural Network Research

Country	No of articles	Cumulative articles	Percentage	Cumulative percentage
United States	35279	35279	28.55	28.55
China	25870	61149	20.94	49.49
Japan	8363	69512	6.77	56.26
United Kingdom	6119	75631	4.95	61.21
Taiwan	3859	79490	3.12	64.34
Canada	3813	83303	3.09	67.42
Italy	3701	87004	3.00	70.42
Germany	3386	90390	2.74	73.16
Korea	2898	93288	2.35	75.51
India	2414	95702	1.96	77.46
Spain	2382	98084	1.92	79.39
France	2243	100327	1.82	81.20
Brazil	1740	102067	1.41	82.61
Singapore	1517	103584	1.23	83.84
Hong Kong	1355	104939	1.10	84.94
Turkey	1325	106264	1.07	86.01
Poland	1186	107450	0.96	86.97
Greece	1143	108593	0.93	87.89
Australia	1090	109683	0.88	88.77
Iran	991	110674	0.80	89.58
Austin	941	111615	0.76	90.34
Finland	926	112541	0.75	91.09
Russia	776	113317	0.63	91.72
Mexico	677	113994	0.55	92.26
Netherlands	664	114658	0.54	92.80
Belgium	612	115270	0.50	93.30
Switzerland	600	115870	0.49	93.78
Sweden	537	116407	0.43	94.22
Egypt	477	116884	0.39	94.60
Israel	473	117357	0.38	94.99
Hungary	440	117797	0.36	95.34
Portugal	434	118231	0.35	95.69
Malaysia	370	118601	0.30	95.99
Austria	338	118939	0.27	96.27
Thailand	336	119275	0.27	96.54
South Africa	326	119601	0.26	96.80
Czech Republic	318	119919	0.26	97.06
Romania	283	120202	0.23	97.29
Slovenia	255	120457	0.21	97.49
New Zealand	245	120702	0.20	97.69
Denmark	228	120930	0.18	97.88
Ireland	226	121156	0.18	98.06
Saudi Arabia	201	121357	0.16	98.22
Ukraine	192	121549	0.16	98.38
Algeria	187	121736	0.15	98.53
Chile	172	121908	0.14	98.67
Norway	170	122078	0.14	98.81
Argentina	143	122221	0.12	98.92
Yugoslavia	136	122357	0.11	99.03
Tunisia	136	122493	0.11	99.14
Venezuela	133	122626	0.11	99.25
Czechoslovakia	121	122747	0.10	99.35
Kuwait	112	122859	0.09	99.44
Slovakia	111	122970	0.09	99.53
Croatia	109	123079	0.09	99.62
Serbia	109	123188	0.09	99.71
Cyprus	96	123284	0.08	99.78
Jordan	95	123379	0.08	99.86
Bulgaria	90	123469	0.07	99.93
United Arab Emirates	83	123552	0.07	100.00
Total	123552			

Country-Wise Publication Output on Neural Network

The study of country wise publications of neural network research output is the matter under discussion. The publication of research output is a yardstick to observe the performance of a country in a particular discipline of scientific research. The research output on neural network is taken in this study to evaluate the performance of the scientist's country wise. This type of study would help information seekers and researchers to be aware of current trends in the respective field and find which country has made the maximum contribution to neural network research. Data on country-wise research output on Neural network are presented in Table 3 (28.55%) with respect to their published research output on neural network during the period under examination. Chinese scientists are next in order (20.94 %) in the quantum of their research output on neural network. The neural network scientists of Japan occupy the third position with (6.77%) of research output on neural network to their credit. The scientists of the United Kingdom take the fourth place (4.95%) during the period of study. Taiwan Scientists hold the fifth position with 3859 papers

(3.12%). The neural network scientists of Canada take the sixth place (3.09 %) contributing research papers on neural network research and India is in the tenth place with 2414 (1.96%) articles. The scientists of the United Arab Emirates are the last in order contributing 0.07% neural network research papers. It could be deduced from the above discussion neural network scientists of the United States top the list with their research output. This is because of the existence of specialized research institutions on neural network studies with provision for its infrastructure. It is discouraging in the much remaining countries.

Conclusion

Bibliometric data provide precise and accurate observations. A major challenge to bibliometric studies is to continue to develop newer and more useful techniques, that will prove more reliable and useful for evaluation and prediction for, bibliometric data mirror the actual published results of the work of researchers. It could be found that in general the world level there is a progressive increase in the number of publications of research output on neural network and the doubling time of these publications also has increased considerably.

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