ACM TRANSACTIONS ON INFORMATION SYSTEMS (1989-2006): A BIBLIOMETRIC STUDY

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The paper presents a study of bibliometric characteristics of scholarly research papers published in *ACM Transactions on Information Systems* (1989-2006). A total of 295 research papers have appeared during the period. A total of 4685 (average 260.3 per year) citations to the 295 research papers are reflected in *Science Citation Index*. The most prolific authors and authorship trends are identified. The average Degree of Collaboration is 0.837. The vast majority of the papers originated from the North America. The number of two-authored papers is higher than the number of single-authored papers. Common topics of the papers in information systems include data processing, storage, and use/retrieval techniques, computer applications and database systems.

1 INTRODUCTION

Bibliometric analysis is the quantitative analysis of the production, distribution and use of published or semi-published documents. ACM, the Association for Computing Machinery, is the world's oldest and largest educational and scientific computing society dedicated to advancing the arts, sciences and applications of information technology. Since 1947, ACM has been publishing *ACM Transactions on Information Systems (TOIS).* ACM has been providing a vital forum for the exchange of information, ideas and discoveries. Currently, ACM serves a world-wide membership of computing professionals and students in more than 100 countries in areas of industry, academia, government, and working in various fields of information technology; and ACM is also interpreting the impact of information technology on society [1].

The broad scope of *ACM Transactions on Information Systems (TOIS)* having an impact factor 4.529 (Web of Science, SCI 2005) appeals to industry practitioners for its wealth of creative ideas and to academic researchers for its coverage of research by fellow researchers. Though its scope encompasses all aspects of computerized information systems, *TOIS* most frequently addresses issues in information retrieval and filtering, information interfaces and information systems design.

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2   OBJECTIVES OF THE STUDY

A bibliometric analysis of papers published in the journal *ACM Transactions on Information Systems* (1989-2006) has been carried out to determine:

1. Quantitative growth of papers by year and citations;
2. Ranked list of most prolific contributors;
3. Authorship pattern;
4. Ranked list of geographical distribution of authors;
5. Ranking of the more productive institutions;
6. Collaboration among institutions;
7. Range and percentage of references per paper; and
8. Frequency distribution of subject descriptors.

3   MATERIALS AND METHODS

The data for the study was accessed from *ISI Web of Science*, *Science Citation Index,* published by Thomson Scientific. The bibliographic details for each record include author, author's affiliation, title, type of document, source of publication, year of publication, keywords, language(s) of papers and the country of input. The bibliographic details were transferred on to a spreadsheet. The data was analyzed as per the objectives of the study.

4   RESULTS AND DISCUSSION

4.1   Distribution of Publications and Number of Citations per Year

Table 1 gives data on the number of papers published each year from 1989 to 2006. During the 18 year period, the total number of papers published was 295. The number of papers was the highest in 2004, with 20 research papers. There was only a slight variation in the number of papers published each year throughout the period. *Global Citation Score* was accessed for the details regarding the total number of citations to each paper.

The highest number of citations 529 was in 1992, followed by 515 citations in 1989, 498 in 1994 and 393 in 1991. Fig. 1 gives the year-wise distribution of citations to the papers.

Table 1: Distribution of Papers by Year and Citations per Year

Publication Year	Number of Papers	%	Cumulative Total	TLCS[*]	TGCS[*]
1989	18	6.10	18	39	515
1990	15	5.08	33	14	380
1991	18	6.10	51	19	393
1992	18	6.10	69	10	529
1993	19	6.44	88	9	348
1994	18	6.10	106	7	498
1995	19	6.44	125	8	287
1996	15	5.08	140	6	215
1997	14	4.75	154	10	211
1998	14	4.75	168	4	183
1999	16	5.42	184	13	249
2000	12	4.09	196	9	164
2001	14	4.75	210	7	163
2002	16	5.42	226	9	163
2003	15	5.08	241	1	99
2004	20	6.78	261	5	245
2005	16	5.42	277	1	40
2006	18	6.10	295	0	3
Total	**295**	**100**	**295**	**171**	**4685**

* Total Local Citation Score (TLCS) and Total Global Citation Score (TGCS) as given in *Science Citation Index*

4.2   Ranked List of the More Prolific Contributors

Table 2 gives a ranked list of the more prolific authors. A total of 642 authors contributed a total of 295 papers over the period of 18 years (1998-2006). The more prolific authors are WB Croft and N Fuhr, each contributing 7 papers, Molina H Garcia contributed 6 papers, J. Zobel contributed 5 papers, three authors contributed 4 papers each, nine authors contributed 3 papers each, and 68 authors contributed 2 papers each.
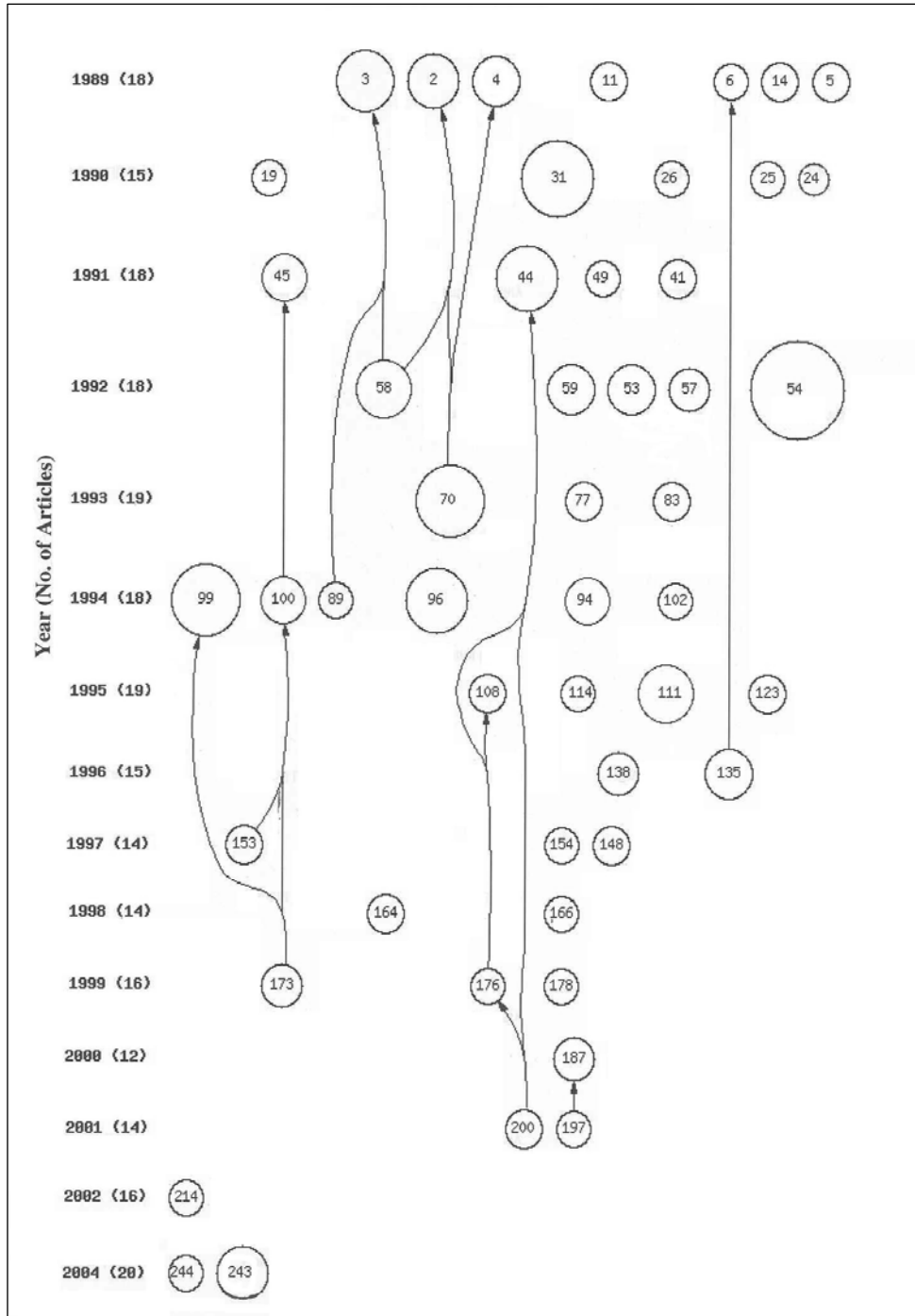
Fig. 1: Frequency distributions of citations per year

Table 2: Ranked list of Most Prolific Contributors

Rank	Contributor	Number of Papers	%	TLCS[*]	TGCS[*]
1	Croft WB	7	2.37	15	218
1	Fuhr N	7	2.37	16	143
2	Garcia-Molina H	6	2.03	3	63
3	Zobel J	5	1.69	5	76
4	Leggett JJ	4	1.36	8	56
4	Van Rijsbergen CJ	4	1.36	0	33
4	Williams HE	4	1.36	0	18
5	Bookstein A	3	1.02	4	40
5	Chen H	3	1.02	1	26
5	Frieder O	3	1.02	0	14
5	Gladney HM	3	1.02	1	7
5	Klein ST	3	1.02	4	40
5	Konstan JA	3	1.02	2	93
5	Lempel R	3	1.02	1	22
5	Shneiderman B	3	1.02	2	112
5	Zezula P	3	1.02	2	42
5	Ziviani N	3	1.02	2	26

4.3 Authorship Pattern

Table 3 presents data on authorship of the papers. Out of the total of 295 papers, 48 are single-authored, 124 two-authored, 68 three-authored, 41 four-authored, 7 five-authored, 4 six-authored and 3 seven-authored. The number of two-authored papers (42%) was much more than that of single-authored papers (16%).

Table 3: Authorship Pattern

Publication Year	Number of Papers and Authorship							Number of Papers
	One	Two	Three	Four	Five	Six	Seven	
1989	6	6	3	1	-	2	-	18
1990	4	7	2	1	1	-	-	15
1991	3	8	4	3	-	-	-	18
1992	4	5	4	4	-	-	1	18
1993	3	8	5	3	-	-	-	19
1994	4	12	2	-	-	-	-	18
1995	6	7	6	-	-	-	-	19
1996	2	10	2	1	-	-	-	15
1997	4	6	1	1	1	1	-	14

| Publication | Number of Papers and Authorship | | | | | | | Number of |
Year	One	Two	Three	Four	Five	Six	Seven	Papers
1998	2	9	2	1	-	-	-	14
1999	1	6	7	2	-	-	-	16
2000	1	6	4	1	-	-	-	12
2001	-	4	4	6	-	-	-	14
2002	1	6	4	2	2	-	1	16
2003	-	6	4	3	1	1	-	15
2004	4	4	9	3		-	-	20
2005	1	8	2	3	2	-	-	16
2006	2	6	3	6	-	-	1	18
Total	**48**	**124**	**68**	**41**	**7**	**4**	**3**	**295**
%	**16.3**	**42.03**	**23.05**	**13.89**	**2.37**	**1.35**	**1.01**	**100**

In recent years, most countries have realized the importance of scientific research for its socio-economic development, and have initiated programmes that encourage and support collaboration among scientists and researches, both at national and international levels. In order to measure the collaborative research pattern, an indicator known as Degree of Collaboration proposed by Subramanyam (1983) is used.

It is expressed mathematically as:

$$\text{Degree of Collaboration, } DC \frac{N_m}{N_m + N_s}$$

Where N_m = Number of Multiple authors during a specific period in a discipline

N_s = Number of single author publications in a discipline during a given period of time.

The computed data are presented in Table 4.

Table 4: Degree of Collaboration among Authors

Number of Author Paper	Number of Publications	% from total publications	Degree of Collaboration (DC)
Number of personal author publications	295		
Number of single author publications	48 (N_s)	16.30	0.837
Number of co-author publication	247 (N_m)	83.37	
Two-authored publications	124	42.03	0.7209

Number of Author Paper	Number of Publications	% from total publications	Degree of Collaboration (DC)
Three-authored publications	68	23.05	0.5862
Four-authored publications	41	13.89	0.4606
Five- and above authored publications	14	4.73	0.2258

In Table 4 it may be noted that the value of the highest Degree of Collaboration (DC) was 0.837 during the period 1989-2006. The DC among two authors was 0.7209, and the minimum was 0.2258 among the five and above authors. See also Fig. 2.
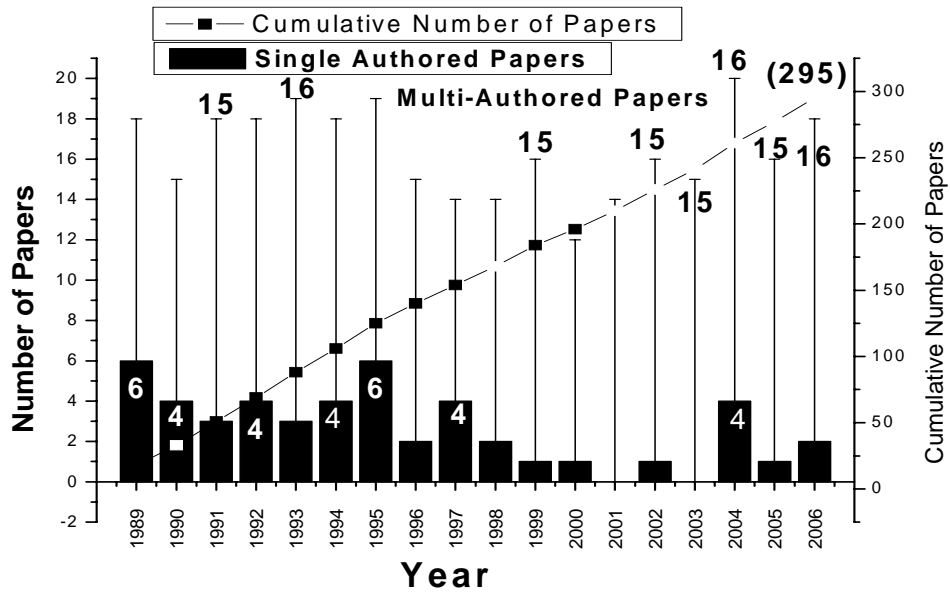

Fig. 2: Single- and Multi-authored papers

4.4 Ranked List of Geographical Distribution of Authors

Table 5 shows that out of the total of 295 papers published by 642 authors during the period 1989-2006, 183 papers, that is, 60% originated from the USA, followed by 21 papers from Canada (that is, 68% originated in North America), 20% from 6 European countries,, 6% from UK,, 10% from 5 Asian countries (China 11, Japan 7), 5.5% from Australia. It is evident that most of the authors are geographically affiliated to institutions in the USA.

Table 5: Ranked List of Geographical Distribution of Authors

Rank	Country of author's affiliation	Number of Papers
1	USA	183
2	Canada	21
3	Italy	18
4	Australia	16
4	Germany	16
5	Peoples R China	11
6	England	10
7	Israel	7
7	Japan	7
8	Finland	6
8	France	6
8	Netherlands	6
9	Brazil	5
9	Scotland	5
9	Singapore	5
10	Fed Rep Ger	3
10	Hong Kong	3
10	Taiwan	3

4.5 Ranking of the More Productive Institutions

Table 6 presents data on the most prolific institutions (Keshava and Sujata Kumbar, 2006). The more productive institution is the IBM Corporation with 11 papers, followed by the University of Massachusetts with 10 papers and MIT, Stanford University and University of Arizona with 9 papers each.

Table 6: Ranking of Most Productive Institutions

Rank	Institution Name	Number of Papers	%	TLCS	TGCS
1	IBM Corporation	11	3.73	4	120
2	University of Massachusetts	10	3.39	18	304
3	Massachusetts Institute of Technology (MIT)	9	3.05	2	92
3	Stanford University	9	3.05	4	96
3	University of Arizona	9	3.05	1	68
4	University of Maryland	8	2.71	8	252
5	Politecn Milan	7	2.37	0	53
6	Carnegie Mellon University	6	2.03	4	68
6	Hong Kong University of Science & Tech.	6	2.03	0	35
6	RMIT University	6	2.03	1	35
6	University of Minnesota	6	2.03	2	119
6	University of Waterloo	6	2.03	11	121
7	New York University	5	1.69	0	59

Rank	Institution Name	Number of Papers	%	TLCS	TGCS
7	University of Colorado	5	1.69	0	41
7	University of Dortmund	5	1.69	4	67
7	University of Glasgow	5	1.69	0	40
7	University of Toronto	5	1.69	3	71
					Truncated

4.6 Institutional Collaboration

Table 7 presents data regarding collaboration patterns of different types of institutions. Among the academic institutions, universities occupy top positions in terms of collaboration.

Table 7: Collaboration among Institutions

Institute Name	Number of Papers
Dublin City University and University College Dublin	2
George Mason University and University of Milan	2
Hong Kong University of Science & Technology and University of Patras	2
IBM Corporation and Technion Israel Institute of Technology	2
Oak Ridge National Laboratory and University of Maryland	2
Politecn Milan and University of Maryland	2
Politecn Milan and University Milan	2
Texas A&M University and University of Colorado	2
Francisco Marroquin University and Texas A&M University	2
University of Iowa and University of Utah	2
University of North Carolina and Texas A&M University	2
University of Patras and CWI	2
University of Toronto and University of Waikato	2

4.7 Range and Percentage of References per Paper

Table 8 presents data on the range and percentage of references per paper. The papers having references ranging from 21-40 form the largest group, that is, 128 (43.39%). This is followed by 78 (26.44%) papers having between 41-60 references, 60 (20.34%) papers with 0-20 references, 22 (7.46%) papers with 61-80 references, 5 (1.69%) papers with 81-100 references, 2 papers with 103 and 124 references respectively.

Table 8: Range and Percentage of References per Paper

Publication Year	0-20	21-40	41-60	61-80	81-100	101-120	121-140	Number of Papers
1989	6	8	3	1				18
1990	1	8	5	1				15
1991	4	9	3	1	1			18
1992	7	7	2	1	1			18
1993	4	10	5					19
1994	4	11	2			1		18
1995	4	5	10					19
1996	3	7	3	2				15
1997	1	5	6	2				14
1998	1	6	6	1				14
1999	11	5						16
2000	3	7	1		1			12
2001	1	7	5	1				14
2002	3	8	2	2	1			16
2003	1	5	9					15
2004	2	8	5	4			1	20
2005	3	5	4	3	1			16
2006	1	7	7	3				18
Total	**60**	**128**	**78**	**22**	**5**	**1**	**1**	**295**
%	**20.34**	**43.39**	**26.44**	**7.46**	**1.69**	**0.34**	**0.34**	**100**

4.8   Subject Keywords

A list of controlled keywords which describe the content, concepts, methods, and models used in the paper complement most of the bibliographic databases. Keywords or descriptors assigned to a record of any bibliographic database together represent the thought content of the paper and sometimes they decide what to be or not to be retrieved (Prakasan, 2008). Table 9 shows the descriptors (which have at least 20 occurrences) with their respective frequencies reflected in the database.

Table 9: Related Keywords with their Respective Occurrences

Keywords/Descriptors	Frequency
Data Processing	99
Information Retrieval & Use	96
Computer Applications	71
Information Retrieval Techniques	67

ACM Transactions on Information Systems (1989-2006)

Keywords/Descriptors	Frequency
Database Systems	66
Computer Programming Languages	45
Computer Theory, Includes Formal Logic Automata Theory, Switching Theory, Programming Theory	44
Information Storage and Retrieval	41
Document Processing Techniques	38
Computer Software, Data Handling and Applications	38
Computer Programming	37
Search Engines	36
Information Networks	36
User Interfaces	33
Information Sources & Analysis	31
Applied Mathematics	27
Artificial Intelligence	27
Computer Peripheral Equipment	26
DBMS	26
File Organization	26
Information Analysis and Indexing	25
Digital Computers & Systems	24
Natural Language Processing	23
Multimedia	22
Knowledge Engineering Techniques	22
Ergonomics	22
Information Dissemination	21
Data Storage, Equipment & Techniques	21
Programming Support	20
Spatial and Pictorial Databases	20
Control Systems	20
	Truncated

5   CONCLUSIONS

Based on the findings the following conclusions can be drawn:

1. The number of papers per year during the period is in the range of 20 to 12. The average number of papers per year works out to be a little over 16. There is a slight variation in the number of papers published during the period. Therefore, it can be inferred that ACM brings out research-oriented scientific papers.

2. The year 1992 records the highest (529) number of citations, followed by 1989 (515), 1994 (498) and 1991 (393). It may be due to the fact that the papers may receive citations after certain period of time. The quality of the work reported in the paper may be another reason why some papers receive more citations than others.

3. A total of 642 authors have contributed 295 papers during the period of 18 years (1998-2006). The most prolific authors are WB Croft (University Massachusetts-USA) and Fuhr N (University of Duisburg-Essen, Duisburg, Germany) contributing 7 papers each.

4. The number of single-authored papers has shown a decreasing trend while the number of multiple-authorship shows an increasing trend. Collaborative research has gained importance in recent years especially in the S&T field due to factors like emergence of interdisciplinary subjects, mission-oriented and specialized research activities.

5. During the period 1989-2006, a higher percentage (75%) of papers had their origins from North America and Europe. The brain drain from developing countries talked of so much these days is intimately linked with this aspect.

6. The most productive institution is the IBM Corporation which recognizes the importance of collaborative innovation, working with other companies, individuals and academia through the years to bring unique technology and solutions. For instance, IBM joins the World Business Council for Sustainable Development, along with Nokia, Pitney Bowes and Sony, to establish the Eco-Patent Commons, committing dozens of innovative, environmentally responsible patents to the public domain.

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