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CITATION ANALYSIS OF *JOURNAL OF NATURAL RUBBER RESEARCH*, 1988-1997

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ABSTRACT

An analysis was carried out on 4181 citations appended to the References Section of 250 research articles and 8 short communications in ***Journal of Natural Rubber Research****. It was found that journals/serial publications were the most cited source of information among rubber scientists (72.4%). The study also revealed the trend towards collaborative research among rubber scientists as two or more authors authored 61.56% of rubber literature. Rubber scientists are also quite up-to-date in their search for knowledge, as references cited were fairly recent with 55.97% covering the period of 1978-1997. The study also found that* ***Rubber Chemistry and Technology*** *toped the list (6.60%) as the most cited serial publication in the field of rubber research.*

Keywords: Citation analysis, *Journal of Natural Rubber Research*, Natural rubber, Bibliometrics, Malaysia.

INTRODUCTION

Bibliometric studies on rubber literature are quite lacking notwithstanding the very importance of rubber to the world today. One of the earliest bibliometric studies on rubber literature was by John McGavack (1962) who published a list of 100 top contributors to the world's rubber literature from 1932-1958 derived from a total of 56,296 rubber publications. According to the list, the top contributor was J. R. Scott who worked for the Research Association of British Rubber Manufacturers since 1923. He contributed as many as 173 publications comprising 3 patents and 170 articles. The study also found that of the 100 top rubber scientists, more than 50% were from the United States of America (USA) (52) indicating the important role played by the USA in rubber research.

In 1966, McGavack revised his list to cover the years 1932-1963 bringing the total number of rubber literature to 84,696, contributed by 46,500 authors. In the second list, B. A. Dogadkin of Russia was the leading contributor with 246 publications comprising 26 patents and 220 articles. A new feature of the list is a brief biographical sketch of a few top contributors prepared by the contributors themselves.

In 1967, McGavack again published a new list of rubber literature's top contributors for the years 1932-1966. Again J.R. Scott is the top contributor with a rating of 137.5. This rating is derived by dividing the total number of publications of each author by 0.9 of his Author Index. On the whole, Scott authored 191 contributions comprising 5 patents and 186 articles.

McGavack (1968) presents an analysis of the most frequently cited authors' references in rubber literature for the past twenty years using the rubber journal, *Rubber Chemistry and Technology*. A total of 22,524 references appended in 1,899 articles were examined and analyzed. All these references came from a wide geographical area, namely 26 nations all over the world. Surprisingly, Malaysia, better known as Malaya before gaining independence in 1957, has a total of 120 citations indicating the presence of rubber research activities in the country. The study indicated that P. J. Flory from USA was the most frequently cited author with 491 citations. It should be noted that Flory was also listed in the earlier 100 top contributors to rubber literature.

In 1969, McGavack, using the 'Bibliography of Rubber Literature' as the source of information, found that 53% of the references were patents. On the other hand, Jones (1969), examined the citation sources of published papers appearing in MRPRA (Malaysian Rubber Producers' Research Association) Annual Reports 1960-1969. The study was conducted to forecast future journal purchasing policy. He found about 4406 journal citations gleaned from 349 journals. He found that 26% produced 91% of the citations, 8% produced 75% and 2.3% produced 50% of the citations. The most cited rubber journal was *Journal of Applied Polymer Science* with a total of 494 citations. On the other hand, a Malaysian journal, *Journal of Rubber Research Institute of Malaya* was cited only 34 times and ranked 29.

In 1972, McGavack presented yet another list of current top contributors to the rubber literature 1932-1970. Again, J. R. Scott ranked the highest and topped the list with a rating of 135.0. He contributed a total of 191 publications comprising 5 patents and 185 articles. Over the years, Scott was rated number one in three lists through his renowned scientific activities in rubber research. This new list of 1970 contained 52 contributors who were in first list published in 1958. Of the remaining 48 contributors, 19 have passed away and 29 others had to give way to younger rubber scientists.

In 1983, Kanesan Solomalai of Rubber Research Institute of Malaysia analysed a total of 1931 rubber physics references published between 1940 and 1981 to study the growth, funding, scatter, productivity and citation pattern of authors. It was found that the cumulative growth of rubber physics literature showed a tendency towards exponential growth especially from 1955 to 1981, with a doubling time of eleven years and an annual growth rate of 6.2%. The study found that the years between 1962 and 1967, the growth of rubber physics literature peaked, contributing 19% of the total literature. MRPRA contributed 28% of the total rubber physics. However, from 1968, the rest of the world, and not MRPRA, dominated the growth of the literature. The contribution by educational institutions to rubber physics literature registered a much steeper growth rate compared to other research and development centres. Malaysia, on the other hand, led the world in the funding of rubber physics research from 1946 to 1970, whereas before and after that period USA was the leader. The main research language used in rubber physics is English, which contributed 75% of the total literature. On the whole, the scatter of literature did approximate to a Bradford-Zipf distribution and the presence of a Groos' effect revealed an incomplete search of the literature. There was a scatter of 5.6 papers per journal and the core journals of rubber physics were common to that of rubber chemistry and technology. The study also found that *Journal of Polymer Science* was the most popular journal, which contributed 10% of the journal articles. Author productivity did not conform to Lotka's law as the mean value of the exponent of P was –2.5 and 72% of the authors produced one paper only. In term of research collaboration, it indicated an average of 1.8 authors per paper. Finally, rubber physicists contributed to a large proportion of the world's rubber literature and self-citation was prevalent among rubber physicists.

Tiew (1998), on the other hand, analysed a Malaysian rubber journal, *Journal of Natural Rubber Research* 1987-1996, published by the world-renowned Rubber Research Institute of Malaysia. He examined the authorship pattern, the range and frequency of references cited, the extent of acknowledgement and appendices included in research articles, the types of collaborative research and international collaboration. He found that the trend is towards multi-authorship and a high degree of collaboration between natural rubber researchers.

In 1999, Tiew and Sen studied the acknowledgements included in the research articles published in *Journal of Natural Rubber Research* 1986-1997 to analyse the types, frequency of occurrence, individuals acknowledged, etc. They found that 74% items contain acknowledgements; average acknowledgements per item is 2.2; the most common type of acknowledgement

relates to technical support; peer interactive communication account for 44% of the total; the most highly acknowledged individual is A. Subramaniam. The findings are in agreement with other studies conducted earlier which indicated a very small number of individuals being acknowledged several times.

Tiew (2000) analysed the extent of journal self-citation and author self-citation in the research articles published in *Journal of Natural Rubber Research* 1988-1997. The results show that 53% of rubber articles contained journal self-citations ranging from 1 to 12; a high percentage of authors cite themselves (61.4%); and a tendency for authors affiliated to the institution publishing the journal to cite the journal.

As seen from the above, bibliometric studies on rubber journals are neither popular nor gaining ground among bibliometricians. Hence, this study on a Malaysian rubber journal is yet another attempt to add to the world's rubber literature coming especially from Malaysia, one of the world-leading producers of rubber. Apart from that, this study intends to generate interest to carry out such studies especially in Malaysia.

OBJECTIVES

The present study analyses the citations appended to the References Section of 250 research articles and 8 short communications published in the source journal "*Journal of Natural Rubber Research*" during 1988-1997. Rubber Research Institute of Malaysia publishes this quarterly international rubber journal. Among the objectives of the study are to find out:

(a) volume-wise distribution of citations;
(b) distribution of citations according to bibliographic forms;
(c) authorship pattern of citations;
(d) chronological distribution of citations ;
(e) ranked list of most cited journals/serial publications; and
(f) frequency distribution of journals/serial citations.

METHODOLOGY AND SAMPLE

The sample for this study comprises citations appended to References Section of the 250 research articles and 8 short communications in *Journal of Natural Rubber Research.* A total of 4181 citations were obtained from these ten volumes of journals published from 1988-1997, inclusive for the present study. All the citations appended in the articles were collected, examined and tabulated. For each citation, name of author, number of authors, type of documents cited, title of cited journal, and year of publication is noted. Use of different abbreviations in journal titles was recognized and identified. The abbreviations were checked using the Library of Congress's web site by

means of a title search, as well as *Ulrich's International Periodicals Directory*. Similar journals were grouped together for data tabulation purposes.

The database was created using Microsoft Access 97. A main Table was created consisting of six fields namely item id (table to uniquely identify each record in the database), type of publication (bibliographic form), number of authors, year of publication (publication year of each citation), journal/serial title of the citation and year of the source journal to accommodate the 4181 records of data.

Only titles of serial publications were recorded for the purpose of analysis. Other types of publications were ignored. A number of queries were generated to provide the following data: total number of citations per volume, total number of citations by type of document, authorship pattern of citations, count of citations by year of publications, count of citations by title of journals/serials, count of publications per author, a chronological listing of citations, ranked list of journals/serial publications and frequency distribution of journals/serial citations. Finally, these data were subjected to quantitative analysis.

FINDINGS AND DISCUSSION

Volume-wise Distribution of Citations

The source journal "*Journal of Natural Rubber Research*" 1988-1997 (vols. 3 to 12) were scanned, and altogether, 4181 citations were noted. Table 1 presents the volume-wise distribution of citations.

Table 1: Volume Wise Distribution of Citations

Volume Number	Number of Articles	Number of Citations	Average Citations Per Article
3/1988	27	466	17.3
4/1989	27	359	13.3
5/1990	27	401	14.8
6/1991	26	447	17.2
7/1992	24	481	20.0
8/1993	29	402	13.9
9/1994	28	429	15.3
10/1995	23	475	20.6
11/1996	23	425	18.5
12/1997	24	296	12.3
Total	258	4181	16.2

Forty issues, published in ten volumes of *Journal of Natural Rubber Research*, contained a total of 4181 citations in 258 articles. This means that every issue published an average of six articles with 16.2 citations per article.

Distribution of Citations According to Bibliographic Forms

Table 2 shows the analysis of citations according to bibliographic forms. Of the 4181 citations, as many as 3002 (71.80%) are from journals/serial publications, followed by monographs/books 548 (13.11%), conference proceedings 170 (4.07%), others (such as meetings reports and laboratory manuals) 113 (2.70%), reports 94 (2.25%), dissertations 79 (1.89%), unpublished data 60 (1.44%), patents 47 (1.12%), standards 23 (0.55%), private communications 22 (0.53%), incomplete citations 15 (0.36%) and data publication 8 (0.19%).

Table 2: Distribution of Citations According to Bibliographic Forms

Ranking	Bibliographic form	Number of Citations	Percentage
1	Journal/Serial Publication	3002	71.80
2	Monograph/Book	548	13.11
3	Conference/Proceeding	170	4.07
4	Others	113	2.70
5	Report	94	2.25
6	Dissertation	79	1.89
7	Unpublished Data	60	1.44
8	Patent	47	1.12
9	Standard	23	0.55
10	Private Communication	22	0.53
11	Incomplete	15	0.36
12	Data Publication	8	0.19
	Total	4181	100

Authorship Pattern of Citations

Table 3 shows the authorship pattern of citations as appended to the References Section of 250 research articles and 8 short communications in *Journal of Natural Rubber Research*, the source journal. The table indicates that out of the total of 4181 citations, 1607 (38.44%) are single-authored, followed by two-authored contributions totaling 1307 (31.26%), and three-authored contributions totaling 641 (15.33%). Four or more authors contributed the remaining articles. However, there are 192 (4.59%) citations with incomplete details on the authorship. Nevertheless, it is noticed from the cited documents that one paper was co-authored by as many as sixteen authors.

Table 3: Authorship Pattern of Citations

No. of authors	No. of citations	Percentage
One	1607	38.44
Two	1307	31.26
Three	641	15.33
Four	266	6.36
Five	96	2.30
Six	23	0.55
Seven	28	0.67
Eight	12	0.29
Nine	3	0.07
Ten	3	0.07
Twelve	1	0.02
Thirteen	1	0.02
Sixteen	1	0.02
Incomplete	192	4.59
Total	4181	99.99

Chronological Distribution of Citations

Table 4 gives the chronological distribution of citations. The citations are divided into 10 periods of ten years each. The citations before 1917 are included in the group 1917. The result indicates that the period 1978-1987 received the most citations, 1279 or 31.03% of the total citations in term of chronological distribution of citations. It is noticed, however, that of the 4181 citations counted, 59 (1.41 %) citations had incomplete data pertaining to year of publication.

Table 4: Chronological Distribution of Citations

Span of period	No. of citations	Percentage
Till 1917	16	0.39
1918-1927	36	0.87
1928-1937	37	0.90
1938-1947	95	2.30
1948-1957	221	5.36
1958-1967	488	11.84
1968-1977	922	22.37
1978-1987	1279	31.03
1988-1997	1028	24.94
Total	4122	100

Ranked list of most cited journals/serial publications

Ranked list of cited serials assists libraries and researchers to select the serials of maximum utility in relation to their coverage of new and important literature in a particular subject area. The ranked list of journals/serials in the field of rubber research, based on the study, is presented in Table 5.

Table 5: Ranked List of Most Cited Journals/Serial Publications

Sl. No.	Rank	Title of Serial	No.of citations	Percentage	Cumulative no.	
					Citation	Percentage
1	1	Rubb. Chem. Technol.	198	6.60	198	6.60
2	2	J. nat. Rubb. Res.	173	5.76	371	12.36
3	3	J. Rubb. Res. Inst. Malaya	104	3.46	475	15.82
4	4	Proc. Int. Rubb. Conf	89	2.96	564	18.79
5	5	J. Rubb. Res. Inst. Malaysia	75	2.50	639	21.29
6	6	J. appl. Polym. Sci.	62	2.07	701	23.35
7	7	J. Polym. Sci.	56	1.87	757	25.22
8	8	Polymer	48	1.60	805	26.82
9	9	Nature	43	1.43	848	28.25
10	10	Contact Dermatitis	40	1.33	888	29.58
11	11	Wear	33	1.10	921	30.68
12	12	Proc. Rubb. Res. Inst. Malaya Plrs' Conf	30	1.00	951	31.68
13	13	J. Allergy Clin. Immunol.	27	0.90	978	32.58
14	14	Pl. Soil	26	0.87	1004	33.44
15	15	Indian J. Agric. Econ.	22	0.73	1026	34.18
16	15	Trans. Instn. Rubb. Ind.	22	0.73	1048	34.91
17	15	J. Am Chem. Soc.	22	0.73	1070	35.64
18	16	NR Technol.	21	0.70	1091	36.34
19	16	Trans Faraday Soc.	21	0.70	1112	37.04
20	17	Eur. Polym. J.	20	0.67	1132	37.71
21	17	Arch. Rubbercult.	20	0.67	1152	38.37
22	18	Proc. R. Soc.	19	0.63	1171	39.01
23	19	J. Chem. Phys.	18	0.60	1189	39.61
24	20	J. Phys. D.: Appl. Phys.	17	0.57	1206	40.17
25	20	Phytopathology	17	0.57	1223	40.74
26	20	SMR Bull.	17	0.57	1240	41.31
27	21	Proc. Int. Rubb. Conf.	16	0.53	1256	41.84
28	21	Analyt. Chem.	16	0.53	1272	42.37
29	22	J. appl. Phys.	15	0.50	1287	42.87
30	22	Macromolecules	15	0.50	1302	43.37

Only journals/serials cited 15 times or more have been included in the table. On the whole, a total of 30 journals/serial titles made the list. *Rubber*

Chemistry and Technology tops the list with 198 citations (6.60%), followed by *Journal of Natural Rubber Research* with 173 citations (5.76%), *Journal of Rubber Research Institute Malaya* with 104 citations (3.46%), *Proceedings of the International Rubber Conference* with 89 citations (2.96%), and *Journal of Rubber Research Institute Malaysia* with 75 citations (2.50%).

Frequency Distribution of Journals/Serial Citations

Table 6 indicates the frequency distribution of journals/serial citations based on the study. A total of 893 journals/serial titles received 3002 citations. More than 849 journals/serial titles (95.07%) received between 1 to 10 citations while the rest, 44 journals/serial titles (4.93%) received more than 11 citations. The journal/serial title which received the most citations is *Rubber Chemistry and Technology* (198 citations).

Table 6: Frequency Distribution of Journals/Serial Citations

Frequency of citations	No. of serial titles	Cumulative total no. of serial titles	Percentage
1-10	849	849	95.07
11-20	25	874	2.80
21-30	8	882	0.90
31-40	2	884	0.22
41-50	2	886	0.22
51-60	1	887	0.11
61-70	1	888	0.11
71-80	1	889	0.11
81-90	1	890	0.11
91 & above	3	893	0.34
Total	893	893	99.99

SUMMARY AND CONCLUSION

Citation analysis reveals that between 1988-1997 every issue of *Journal of Natural Rubber Research* published an average of six articles with 16.2 citations per article. This figure, however, is slightly higher compared to McGavack's study (1968) of *Rubber Chemistry and Technology* where he found that the average rubber article contained 11.86 citations. On the whole, this finding is quite similar to some earlier bibliometric studies, which found that, on an average, a research article has an average of 15 citations.

The study confirms that journals/serial publications remain the most useful source of information for rubber scientists, with 3027 (72.40%) out of a total

4181 citations. This percentage is lower when compared to the studies by Solomai (1983) and Jones (1969) who found that rubber physics literature and journal citations for all rubber literature to be 86% and 78%, respectively. Hence, this conforms to earlier studies, which indicate that rubber scientists depend highly on journals/serial literature.

The authorship pattern of citations reveals very clearly that rubber scientists are moving towards collaborative research, as the majority of citations (61.56%) are two-authored or more. As early as 1963, Price relying on data obtained from *Chemical Abstracts* up to 1960, predicted that by 1980 the single-authored paper would be extinct, as the trend is moving towards collaborative research. Some probable factors leading to these collaborations are multidisciplinary research activities, multidisciplinary application of research results, resource sharing and information technology (Sen, 1997).

The chronological distribution of citations indicates that rubber scientists are quite up-to-date as references cited are fairly recent with 55.97% published between 1978-1997. In other words, rubber scientists are up-to-date in their coverage of the latest literature, so as not to lag behind.

The study found that *Rubber Chemistry and Technology* tops the list (6.60%) as the most cited journal/serial publication in the field of rubber research. However, Malaysian rubber journals, namely, *Journal of Natural Rubber Research*, *Journal of Rubber Research Institute Malaya*, and *Journal of Rubber Research Institute Malaysia* were among the top five cited serials indicating the prominent role played by the country in the field of rubber research.

In term of frequency distribution of journals/serial citations, most of the serial publications (95.07%) received between one to ten citations. *Rubber Chemistry and Technology* was the most cited journal/serial title with 198 citations.

It is hoped that the citation styles of *Journal of Natural Rubber Research* articles will adopt more standardised and uniform so as to ease analysis. During the study, there were twelve citations with incomplete details as to bibliographic form, and 192 citations had incomplete authorship details. Moreover, various authors adopted different referencing styles when citing journals/serial titles. This hinders the process of data analysis and may affects the accuracy of the study.

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