



Citation Analysis of Doctoral theses of Mathematics, Tripura

University: a Scientometric study

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Abstract

Mapping of Scientific literature by quantitative analysis provides better understanding of characteristics of a particular discipline. It provides insights for policy making in terms of journal and publisher selection; renewal of subscriptions and helps in understanding user needs and utilization of materials. The current study attempts to investigate citation pattern of Mathematics theses submitted to Tripura University. The study considered only those theses which were submitted to Shodhganga. Hence data were collected from 6 theses constituting 377 citations. The references were analysed with respect to authorship pattern wise, year wise, country wise, publisher wise and type of document used. Bardford's law was used to find out the core journals in the field of Mathematics which showed that Fuzzy Sets and Systems is one of the most impactful journals in the field of Mathematics. Half life of Mathematical journals is found to be 22 years from the Obsolescence rate of Mathematical journals. Degree of collaboration in the discipline was found out to be 0.58. An average citation per thesis in Mathematics is 62.83 as revealed by the study. The results found from the study will help mathematical researchers in understanding the characteristics of the field as well as librarians in policy making in terms of collection development.

Keywords: Scientometrics, Citation analysis, PhD thesis, Mathematical literature, Tripura University



1. Introduction

The exponential expansion of scientific literature, interdisciplinary nature of research and trend towards specialization has posed many problems both to the scientists and librarians. The extensive investigations and the abundance of literature being published and contributed to immense escalation of cost for the libraries, as the acquisition of published literature became an increasingly difficult task. To maintain a reasonable collection of periodicals, at least in broad fields, it is necessary for the librarians to know the characteristics of subject literature used by the users. Information is not only increasing exponentially but the growth rates also differ from one discipline to another.

The multiplicity of journals, the constraints of limited financial resources and the ever increasing needs of user community necessitated the librarians to develop need based information resources and services to meet the literature requirements of Scientist. Thus, a clear understanding of the characteristics of subject literature used by scientists is important for planning and designing of information system relating to a particular field (Zafrunnisha, 2012).

Citation is special reference works that is used to categorize as many published works on a given subject as possible, and serve as compilations for other authors or researchers (Gohain & Saikia, 2014). The tradition of providing Citations at the end of technical writing is an age old phenomenon (White, 1985).

2. Significance of the study

The study of Citation Analysis is one of the best techniques for analyzing the different attributes of Resources. The limited financial resources have caused a lot of problems to the librarian; so they are forced to look for an alternative system for collection development and provide quality document to the user community. That's where Citation Analysis proves to be one of the most essential and needful Study. This type of study is helpful to mathematics researchers and University librarians for subject wise source identification and maintains the library collection development policy. The analysis of this research work carried out between the particular periods is helpful to compare the research work carried out under Mathematics discipline. This study recalls the nature of information used by the researchers and enables the librarian to plan to provide better information services and better Collection development.



3. Review of Literature

The review of literature provides a direction to the proposed study. It helps to identify previous conclusions drawn in different studies in the area of interest of the researcher.

Becker & Chiware, 2015 examined the citation patterns of masters' theses and doctoral dissertations between 2005 and 2014 in the Faculty of Engineering at the Cape Peninsula University of Technology (CPUT). The conclusion of the study showed that both masters' and doctoral students are utilizing resources provided by the library and that the most used resources were journals, followed by books. The study concluded that citation analysis is still one of the most important tools to assess the usefulness of library holdings for postgraduate students' research activities. (Kumar & Dora, 2011) scrutinized the citations of the 49 doctoral dissertations submitted at the Indian Institute of Management, Ahmedabad, during the period 2004 to 2009. The study applied Bradford's law to recognize the groups of journals differentiated by their use. Results indicated that the top 48 journals that were ranked among the 30 most used journals contributed to more than 55% of the journal citations. (Sheshrao & Khaparde, 2011) analysed Ph.D. theses submitted to Dr. Babasaheb Ambedkar Marathwada University Library as a way of determining the use of information sources made by the scholars of the university. In the present study, 30 Ph.D. theses of Physics were chosen as a sample from the year January 2004-December 2008. There are 5726 citations in 30 theses. Citation analysis was carried out to find the types of cited documents, the chronological distribution of cited documents, to find out the authorship pattern of cited documents. The ranked list of cited journals and books, to find out the language-wise distribution, geographical distribution of cited documents, the ranked list of cited web - sources and the cited authors were studied. Gao, Yu & Luo, 2009 analyzed citations of 56 PhD theses submitted in 2005 at Wuhan University in China. The authors analyzed 10,222 citations in theses in Library and Information Science, Biology, Photogrammetry and Remote Sensing, and Stomatology and reviewed and compared the characteristics of the literature cited in the four disciplines. The results revealed that in Biology and Stomatology, mainly English language publications were cited whereas in the field of Library and Information Science, the cited literature came primarily from Chinese sources. In Photogrammetry and Remote Sensing, citations were almost evenly split between English and Chinese sources. Kuruppu & Moore, 2008 reported the findings of a study conducted to examine the types of information used by graduate students in the fields of biological and agricultural sciences at Iowa State University



(ISU). The citations of doctoral dissertations submitted in nine agriculture and biological science subject fields (crop production and physiology; molecular, cellular, and developmental biology; entomology; genetics; microbiology; plant breeding; plant pathology; plant physiology; and soil science) at ISU from 1997–2006 were analyzed. The article discussed the types and ages of resources cited in the different subject fields studied. David Bunton, 2005 considered the generic structure of Conclusion chapters in PhD theses or dissertations. From a corpus of 45 PhD theses covering a range of disciplines, chapters playing a concluding role were identified and analysed for their functional moves and steps. Most Conclusions were found to restate purpose, consolidate research space with a varied array of steps, recommend future research and cover practical applications, implications or recommendations. It showed that a minority were found to focus more on the field than on the thesis itself. These field-oriented Conclusions tended to adopt a problem–solution text structure, or in one case, an argument structure. Variations in focus and structure between disciplines were also found. (Narang, Asha and Kumar, Anil, 2010) analysed 4798 citations from 400 articles of the Indian Journal of Pure and Applied Mathematics. Results showed that a decrease in the number of contributions in successive volumes. Research journal articles are the most cited forms of documents. Foreign publications were more cited than Indian publications. Growth and popularity of the journal showed a mixed trend of upward and downward progress. Maranna O, 2016 did the Bibliometric study of Mathematics PhD output of RCU University, Belagavi, between 1962 and 1972. He found that journal articles are most cited; English is the main language of References; Indian publications are most cited ; single authorship was found to be very high.

4. Objectives

The main objectives of the study are to:

- i. identify the authorship pattern of the citations;
- ii. rank the journals and finding the core journals in the field of Mathematics;
- iii. ascertain whether distribution of citations among the periodicals conform to the Bradford's law of distribution;
- iv. find out the Year wise distribution of citations;
- v. find out Rate of obsolescence hence half life of journals; and
- vi. find out most prolific countries and publishers

5. Research Methodology

The fundamental work is collecting the details of the published research papers from university subscribed databases. The original articles were referred to have clear understanding of the various procedure followed by earlier researchers in the field of study. The research study process to 2 levels the first level is determining the data and procedure followed for analyzing the data.

6. Data Collection

Data were collected from Shodhganga by downloading theses chapter wise from Tripura University's collection. Some of the theses contained the citation at the end of each chapter and in some others the citations were appended separately at the end of the theses in the form of bibliography. Total 377 citations were collected from 6 theses from department of Mathematics.

Table 1

Details of Theses submitted at Tripura University

Sl. No.	Title	Keywords	Completed Date	Pagination	Chapters
1	On fuzzy rough oscillatory region and its applications on data mining	Fuzzy Mathematics	2012	169p.	7
2	Some near fuzzy almost continuous mappings: their generalizations and applications	Fuzzy Mathematics	2012	82p.	7
3	Some fuzzy functions in fuzzy bitopological spaces and separation axioms in completely induced fuzzy bitopological spaces	Fuzzy Mathematics	2012	83p.	6
4	Study of some weakly fuzzy semi precontinuous mappings, their generalizations and applications	Fuzzy Mathematics	2012	80p.	6
5	Study of separation and covering axioms in the intuitionistic fuzzy topological spaces	Fuzzy Mathematics	2012	140p	9
6	Study of different structures in terms of ij-semi open sets in bitopological spaces and its applications	Fuzzy Mathematics	2012	94p.	7

Table 1 shows that total 6 theses were considered from the Department of Mathematics for the study. All the 6 theses are from the area of Fuzzy Mathematics and completed in the year 2012. Data were collected in December, 2017 and analysed in January to February 2018.

6.1. Procedure

The bibliographical records of the selected theses submitted to the departments of Mathematics were collected as the principal step. Further the copies of the theses were traced and the relevant parts for the study especially the bibliography and references part were copied and pasted in Microsoft Excel 2010 from the electronic versions of the theses for the detailed analytical study. Here, the study was restricted to the Citation Analysis of the doctoral theses submitted to the particular department. The doctoral theses uploaded in Shodhganga were first covered. All together 6 theses were traced and collected the data for the detailed analytical study. The details thus obtained has lead to the study of year wise thesis submitted details, subject, Place of Publications , year of publications , bibliographic forms, rate of Obsolescence, Language, author characteristics, Citation age, publisher name, and other such document characteristics.

7. Data analysis and interpretation

The basic purpose of the section is to analyze collected data. The total citations collected formed the basis of the citation analysis and interpretation for the study. The characteristics of any subject literature include not only the basic publishing pattern but that of authors themselves so the authors were analyzed to determine the percentage of single, two, three, four and more than four authors.

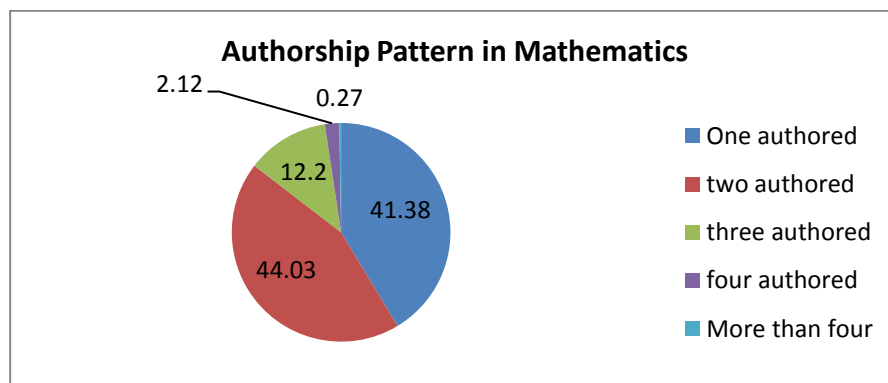


Figure 1. Authorship Pattern in Mathematics

It is seen from the figure 1 that out of total number of 377 citations are two authored 166 (44.03 %) followed by 156(41.38%) are by one author , 46(12.2 %) have 3 authors, 8(2.12%) have 4 authors and the least citation are by More than four authors i.e. 1(0.27). This indicates that double authored papers are predominant in the field of Mathematics.

Table 2
Degree of Collaboration

Sl.No.	Authorship	Number	Percentage
1	One authored	156	41.38
2	Multi authored	221	58.62
Total		377	100.00

Subramanyam's formula is used to determine the extent of research collaboration in the study (Sivasubramanyam, 1983).The formula is $C = Nm/Nm+Ns$, where

C = Degree of collaboration in a discipline

Nm = Number of multiple authored papers = 221

Ns = Number of the single authored papers = 156

$C = 221/221+156 = 0.58$

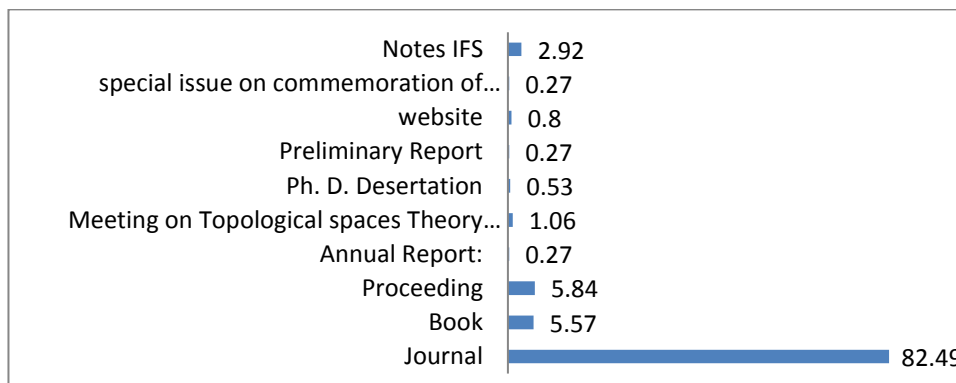


Figure 2: Type of document wise distribution of Citations in Mathematics

The researchers in Mathematical Science heavily depend on periodical sources than books for their studies. It was found that the Journals are the major form of media used with citation count,

of 311 (82.49 %) of total literature used, where as the proceedings used in 22(5.84%) followed by Books is used in 21 (5.57%).

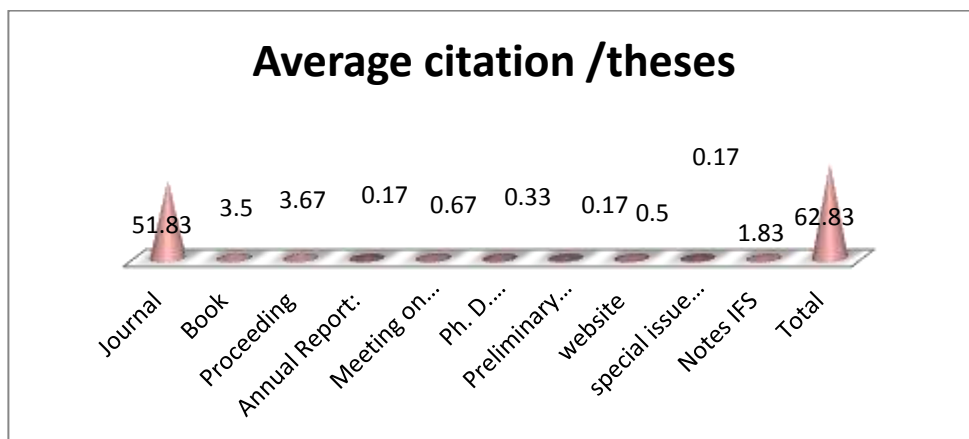


Figure 3: Average Citations/ theses in Mathematics

Figure 3 shows that average citation per thesis in Mathematical science for 6 theses and 377 citations is 62.83.

Table 3.

Year wise distribution of Citations in Mathematics

Sl.No.	Year	Number	Percentage
1	1937	1	0.27
2	1960-1970	19	5.04
3	1971-1980	31	8.22
4	1981-1990	74	19.63
5	1991-2000	129	34.22
6	2001-2010	111	29.44
7	2011-2014	12	3.18
Total		377	100.00

The period-wise distribution of citations was measured by number of year which elapsed between the publications of a cited document. With this purpose the whole time span of the documents used was divided into period groups, each of 10 years duration.

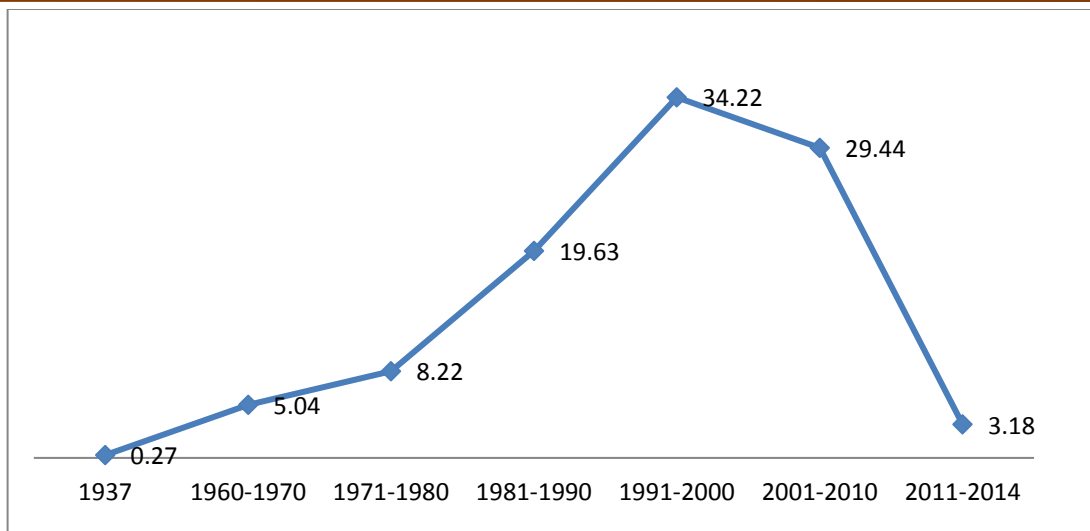


Figure 4: Year wise distribution of Citations in Mathematics

It is found from figure 4 that a citation in Mathematics lies in between 1937 to 2014. Highest number citations 129 (34.22) fall between 1991-2000 followed by 2001-2010 i.e. 111 (29.44) and 1981-1990 i.e. 74(19.63%)

Table 4

Ranking of Journals in Mathematical Sciences

Sl. No.	Rank	Name of journal	No. of citations	Percentage
1	1	Fuzzy Sets and Sytems	96	30.87
2	2	Journal of mathematical analysis and applications	40	12.86
3	3	Journal of Tripura Mathematical Society	24	7.72
4	4	The Journal of Fuzzy Mathematics	19	6.11
5	5	Acta Ciencia Indica	8	2.57
6	5	Bull. Calcutta. Math. Soc	8	2.57

The ranking list of journals is essentially a practical tool designed to help the librarian and research scientist to select the journals of maximum utility in relation to their coverage of new and important literature in particular subject area.

Thus it is noted that a few journals yielded more citations and more journals yielded a few citations. A high concentration in a few journals is evident. Therefore “core” or productive journals can be identified on the basis of ranked list. Table 4 showed that Fuzzy Sets and Systems contains highest number of citations i.e. 96 (30.87%) followed by Journal of Mathematical Analysis and Applications 40 (12.86%); Journal of Tripura Mathematical Society 24 (7.72%); The Journal of Fuzzy Mathematics 19 (6.11%) and Acta Ciencia Indica and Bull. Calcutta. Math. Soc both having 8 (2.57%) each. It also found that 61(19.61%) journals are cited only once.

7.1 Bradford’s Law of Scattering

Bradford’s law states that “If scientific journals are arranged in decreasing productivity of articles on a given subject, they may be divided into a nucleus of periodicals more particularly devoted to subject and several zones of groups containing the same number of articles as the nucleus, then the zone will be as **1:n:n²** which basically states that most articles are produced by few sources and the rest are made up of many separate sources (Bradford, S.C. 1934).

Table 5
Bradford’s Law of Scattering in Mathematics

Sl. No	Zone	No of Articles	No of journals
1	1	96	1 Journal
2	2	105	6 Journal
3	3	110	79 Journal
Total		311	86 Journals

In the present set of data numbers of journals have been arranged in order of decreasing productivity of articles (Table No. 5). They were divided in a nucleus of 3 equal zones. Numbers of articles in each zone were more or less equal.

The attempt was made to test applicability of Bradford’s Law of scattering, as shown in Table No.6. The total numbers of journal articles were divided into 3 almost equal zones, i.e. 96 to 110 articles in each zone. It was observed that, numbers of articles in each zone are in approximately same range but numbers of journals in each zone are 1: 6: 79. Even though data does not fit Bradford’s Law of scattering mathematically but verbally it fits in to it that only a few journal



contain more productive articles and more number of journals contain less productive articles.

The one journal coming under the 1st zone is the Core journal.

Table 6

Rate of Obsolence in Mathematical Sciences

Sl. No.	Age of Citation	No of citations	Cumulative Citations	Percentage
1	0 year old	0	0	0
2	1	0	0	0
3	2	0	0	0
4	3	0	0	0
5	4	0	0	0
6	5	0	0	0
7	6	7	7	2.25
8	7	8	15	2.57
9	8	4	19	1.29
10	9	11	30	3.54
11	10	9	39	2.89
12	11	15	54	4.82
13	12	8	62	2.57
14	13	9	71	2.89
15	14	6	77	1.93
16	15	12	89	3.86
17	16	9	98	2.89
18	17	9	107	2.89
19	18	8	115	2.57
20	19	13	128	4.18
21	20	11	139	3.54
22	21	6	145	1.93
23	22	6	151	1.93
24	23	18	169	5.79
25	24	6	175	1.93
26	25	13	188	4.18
27	26	15	203	4.82
28	27	14	217	4.50
29	28	11	228	3.54
30	29	8	236	2.57
31	30	13	249	4.18
32	31	7	256	2.25

33	32	3	259	0.96
34	33	3	262	0.96
35	34	3	265	0.96
36	35	1	266	0.32
37	36	5	271	1.61
38	37	10	281	3.22
39	38	1	282	0.32
40	39	2	284	0.64
41	40	2	286	0.64
42	Older than 40 years	25	311	8.04
		311		100.00

Table 6 shows that researchers cite more than 40 years old documents. From the principle of obsolescence it is found that out of 311 citations 22 years old journal covers 151 citations with showing 48.55%. It indicates that Half life of journals = 22 years.

The journals are analyzed publisher wise and the result of the most productive publishers is shown in the Figure 5.

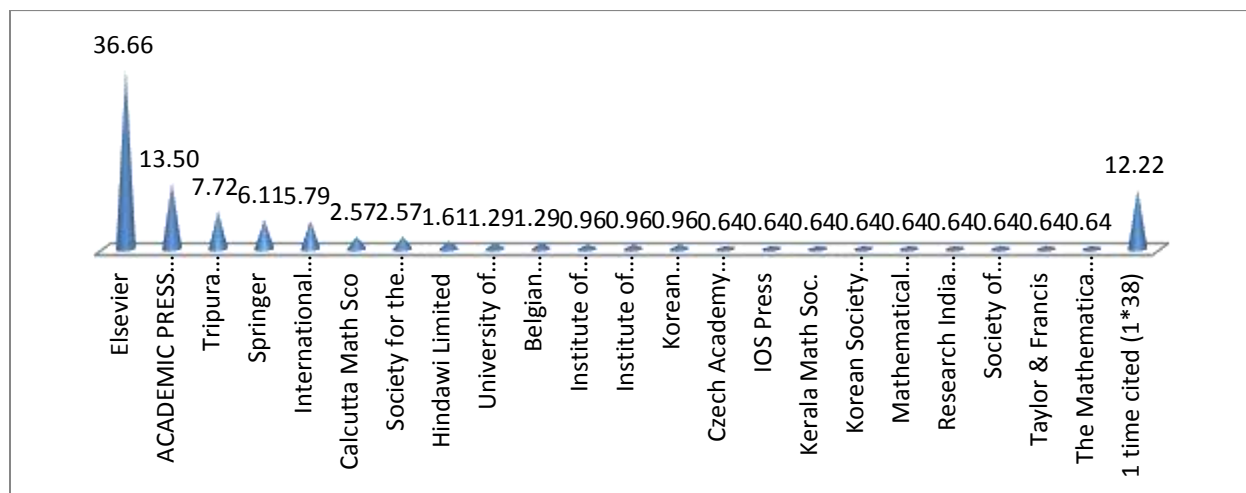


Figure 5: Publisher wise distribution of Journals: Mathematics

It is shown in figure 5 that Elsevier 114(36.66) is the most productive Publisher in the field of Mathematics followed by Academic Press 42(13.50%); Tripura Mathematical Society 24(7.72%); Springer 19 (6.11%) and International Fuzzy Mathematics Institute, USA 18 (5.79%).

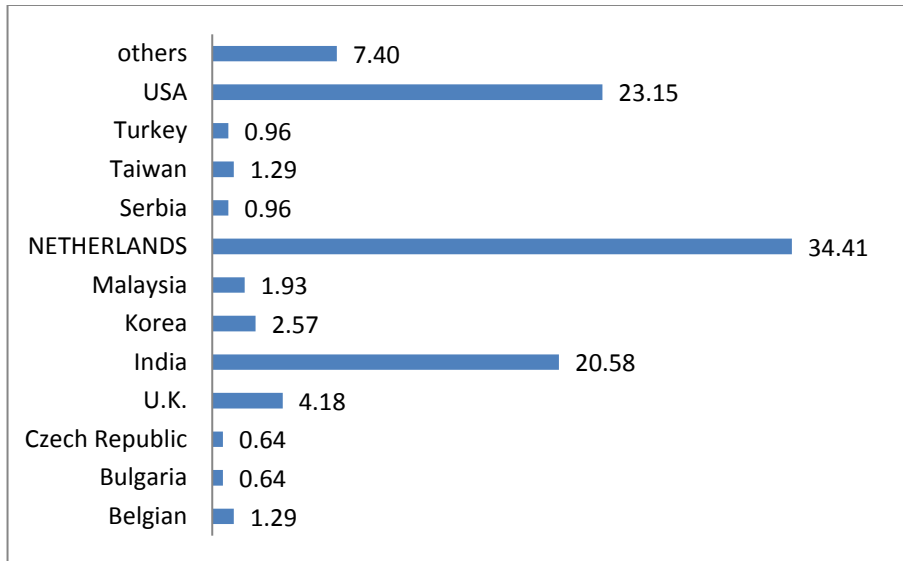


Figure 6: Country wise distribution of Journals: Mathematics

Figure 6 shows that Netherlands is the most productive country having 107(34.41%) citations out of 311 citations followed by USA 72(23.15%) and India 64(20.58%).

Table 7

Publisher wise distribution of books: Mathematics

Sl. No.	Name of Publisher	number	Percentage
1	Addison Wesley Publishing Company	1	4.76
2	American Elsevier Publ. Co	1	4.76
3	D. Reidel Publishing Company	1	4.76
4	Dover Publications	1	4.76
5	Kluwer Academic Publisher	6	28.57
6	Plenum Press	1	4.76
7	Prentice Hall	3	14.29
8	Springer-Verlag	2	9.52
9	Tata Mc.Graw Hill	1	4.76
10	Topology Atlas	1	4.76
11	University Book Stall	1	4.76
12	Unknown	2	9.52
Total		21	100.00

Table 7 explains that Kluwer Academic Publisher is having number citations for books 6(28.57%) followed by Prentice Hall 3 (14.29%) and Springer-Verlag 2(9.52%).

Table 8

Country wise distribution of books: Mathematics

Sl. No.	Country	No	Percentage
1	USA	7	33.33
2	India	4	19.05
3	others having 1	10	47.62
Total		21	100.00

It is evident from table 8 that USA 7(33.33%) is most productive country in terms of books in the field of Mathematics followed by India 4(19.05%).

Table 9

Language wise distribution of citations: Mathematics

Sl. No.	Language	Number	Percentage
1	English	375	99.46
2	Portugese	1	0.26
3	French	1	0.26
Total		377	100.00

It is clearly visible from table 9 that almost all the works cited are published in English language in the field of Mathematics.

Table 10: overall comparison

Sl. No	Department	Average citations	Average Page numbers	Average chapters
1	Mathematics	62.83	71	7

Average citation per thesis varies from discipline to discipline. (Maranna, 2016) found average number of References is 67.63 per thesis (11 theses constituted 744 citations). This study



found that an average number of citation per thesis is 62.83 (Table 10). The study also showed that average pagination of Mathematics theses is 71 pages and average is 7 (Table 10).

8 Conclusion

While analysing the data for the study it was observed that no uniformity was maintained in the citation styles. Citations within the same thesis were also not uniform. It is recommended that departments should take initiative to follow a particular style manual so that uniformity in citations can be achieved. The quantitative analysis of Mathematical literature has put forward some interesting facts. The study has tried to bring in to light some characteristics of Mathematical literature. It is found that Mathematical researchers depend on highly on journal articles for pursuing their research. The rank list of journals show that Fuzzy Sets and Systems a product of Elsevier BV from Netherlands is the most impactful journal in the field of Fuzzy Mathematics as all the 6 theses belong to the sub area of Fuzzy Mathematics. The data in this study do not fit Bradford's Law of scattering mathematically like previous studies such as (Ganesh & Viju, 2013) who mentioned in their study that Library and Information Science literature do not follow Bradford's law as well. The current study, however, verbally fits in to it that only a few journals contain more productive articles and more number of journals contain less productive articles. The one journal coming under the 1st zone is the Core journal. Most impactful research in Mathematics is published from the Netherlands followed by USA and India. Elsevier journals are found to be most effective preferred in the field.

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