IN PURSUIT OF ELECTRONICS LITERATURE AND BRADFORD'S LAW OF SCATTERING & LEIMKUHLER MODEL: A STUDY BASED ON WEB OF SCIENCE DATABASE

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ABSTRACT -

The application of Bradford's law of scattering to electronic publications is the subject of this research article. The data for the study came from the Web of Science core collection, which is free to the public. 741 journals' five-year data sets produced 10387 English-language publications relating to electronics themes in general and physics studies in particular over the study period (2016-2020). The theoretical components of Bradford's law, as well as the rank list of journals created from the database, were tested. The Publication of Instrumentation emerged as the most desired journal, with 641 articles. The Bradford Multiplier (k) was found to be 10.451 in the database, and it was determined to be genuine because the percentage error of the distribution is - 0.02658, which is extremely small. The Bradford law is also graphically tested by creating a graph, which shows that it supports all three criteria.

Keywords - Bradford's Law of Scattering, Citation Dispersion, Leimkuhler model, Rank list of Journals, Web of Science

INTRODUCTION

A wealth of information is available on the internet and in libraries.When it comes to reading the articles, the majority of pupils and readers find them to be tedious.Researchers and librarians have the responsibility of making information retrieval as simple as possible.Primary data can be retrieved from a variety of sources, including books, periodicals, journals, conference proceedings, theses, and other similar publications.Journal literature will be considered not only important but also an emerging source of information among all of these sources.

Journal literature will be considered not only important but also an emerging source of information among all of these sources.Journals in any discipline typically present fresh ideas, concepts, formulas, and novel research discoveries.Micro-thoughts, subject comparisons, in-depth studies, and new developments in subjects, among other things, may be covered in the journal.Some of these publications are regularly referred to by students or researchers because they discovered a very strong relationship between their subjects, associations of ideas, and areas of study activity.This knowledge is focused in a few core journals.These highly referenced journals are designated as the subject's core journals.

S.C. Bradford, who popularised the Bradford Law of Scattering, was the first to propose the concept of core journals in 1934. The numerous approaches to identify the core journals in a field from a huge number of journals include citation indexing techniques, impact factor values of journals, and so on. Bradford's technique is the most widely used and well-known in bibliometric investigations including the appropriate and effective application of science through mathematical evidence.

Bradford Law of Scattering states that, ‘‘If scientific journals are arranged in order of decreasing productivity of articles on a given subject, they may be divided into a nucleus of periodicals more particularly devoted to the subject and several groups or zones containing the same articles as the nucleus, when the number of periodicals in the nucleus and succeeding zones will be as 1: n: n^2, where ‘n’ is a multiplier."

The current research investigates the application of Bradford's law to the field of electronics in order to identify the field's core journals. The paper also discusses the Leimkuhler model, as well as year-by-year and document-by-document analysis.

Electronics

Electronics have had a significant impact on the evolution of modern society. Electronics is the study of the emission, flow, and control of electrons in a vacuum and matter. It includes physics, engineering, technology, and applications. It differs from classical electrical engineering in that it employs active devices to control electron flow via amplification and rectification, as opposed to passive effects such as resistance, capacitance, and inductance.

Information processing, telecommunication, and signal processing are all areas where electronics is used. Digital information processing is made possible by electronic devices' ability to act as switches. Circuit boards, electronics packaging technology, and other various forms of communication infrastructure complete circuit functionality and transform the mixed electronic components into a regular working system known as an electronic system. An electronic system can be a subsystem of another engineered system or a stand-alone device.

REVIEW OF LITERATURE

Bibliometrics studies have been published in a variety of journals across a variety of fields. Initially, literature on bibliometrics and related aspects by Bellis, Diodatoand, and Borgman was used to clarify concepts. The studies on

bibliometrics by Garg and Tripathi and Tanuscodi were reviewed, but none of them addressed Bradford Law and the Leimkuhler Model.

Many articles in the LIS literature have focused on Bradford's Law of scattering. Several different versions of the law have been proposed. Vickery's (1948) paper was the first notable paper on law, followed by Kendall's (1949) paper (1960). Later, Wilkinson (1972) discussed the law's bipolar nature, proposing that the law's verbal formulation expresses Bradford's theory while its graphical formulation expresses his observation. Vickery and Leimkuhler (1967) initiated the search for an exact formulation of Bradford's law, which was later followed by many other authors.Despite the fact that several research have meticulously evaluated the law's reasonableness, they frequently discover that the Bradford multiplier's value differs among subject groups. The investigations of Sengupta (1990) and Goffman and Morris (1970) are remarkable in terms of application.

Gunasekaran, S. and et.al.(2006) used bibliometric analytic methodologies to conduct a study on Chemical Science. The information was gathered from the Chemistry Citation Index CD-ROM, which was released in 2002.

Sudhier, K.G (2010) used Bradford's law of scattering to the literature of physics. The Indian Institute of Science doctorate theses were cited in the report. The Bradford multipliers were computed, and the law was shown to be applicable with K equal to 1.2. This modification satisfies the Bradford law for the data set when the multiplier for the first two zones was calculated using n=5. However, when the multiplier's mean (13.4) is taken into account, the law does not suit the journal distribution, and the percentage of error is found to be 68.66. Bradford's law was validated using the Leimkuhler model, according to the study. Only 0.072% of the total was discovered, which is insignificant.

Amsaveni, N. (2016) Assessing Bradford's Law of Scattering in Neural Network Literature. It is discovered that, while this law does not fit theoretically, the alternative, such as the Leimkuhler model, is applicable to neural network literature.

Neelamma, G. (2016) used Bradford's law in Botany literature from 2005 to 2014. There are a total of 12051 references in 1183 publications, with 572 journals cited. The investigation indicated that Bradford's law matches the data well, with a 1.5% margin of error.

Pattanashetti, D.M., and Harinarayana N.S. (2017) conducted research on 'Assessment of Medical Engineering Research Output Using Scientometrics Indicators from Japan and South Korea.' The results suggest that Japanese publications in Mechanical Engineering are declining while those in the other two countries are increasing. During the study period, South Korea doubled its publications.

OBJECTIVES OF THE STUDY

The following are the primary objectives of the current study:

1) To comprehend the year-wise types of documents.
2) To prepare a rank list of the most cited journals on the electronics topic.

3) To study the phenomenon of article scattering.
4) To examine the appropriateness of verbal and graphical formulations of Bradford's Law of Scattering.
5) To validate the Leimkuhler model in the field of electronics.

METHODOLOGY

The current study focuses on the application of the Leimkuhler model to the research outcomes of electronic subjects in general, and the physics research area in particular, published in journals between 2016 and 2020, in order to verify Bradford's law of scattering. The Web of Science core journal open access database was used to acquire information about the journals publication years, document type, subject, research field, database, language of publishing, and other specified bibliographic parameters. Following that, a data sheet with various properties was developed. The application of Bradford's Law of Scattering and the Leimkuhler Model were carried out and evaluated using these parameters, and the procedure and results were discussed as conclusions. Articles were classified as items, and journals as sources, in the study. In descending order of productivity, 741 journals containing 10387 articles were arranged from electronics. The identified journals and their accompanying frequency of articles were analysed for the verification of Bradford's law of scattering proposed by Bradford and Leimkuhler's model. For assessing the adequacy of the graphical formulation, the natural log value of the cumulative number of journals was generated for producing the graph, whereas the verbal formulation was examined using three separate parameters for carrying the diverse number of periodicals.

DISCUSSION

Bradford's Law of Scattering

Bradford's Law of Scattering establishes a quantifiable relationship between journals and the papers that appear in them. The Current Bibliography of Applied Geophysics (1928-1931) and the Quarterly Bibliography of Lubrication were statistically analysed by Samuel Clement Bradford, Chief Librarian of the London Science Museum (1931-1933). He examined journals that contained references to these topics in descending order of productivity, then separated the articles into three zones that were roughly similar in size. He referred to the first as the nuclear zone, which is highly productive; the second as a moderately productive zone; and the third as a low-productive zone. Bradford observed consistency while estimating the number of titles in each of the three zones. Bradford determined that the ratio of journal titles in consecutive zones followed a consistent pattern based on his findings. Bradford's initial formulation was that if scientific journals were sorted in order of decreasing production of articles on a given subject, they might be classified into a nucleus of periodicals more specifically devoted to the subject and many groups or zones containing the same articles as the nucleus, with the number of periodicals in the nucleus and subsequent zones being 1: n: n^2, where 'n' is a multiplier.

Bradford's law was depicted graphically. Vickery (1948), Leimkuhler (1967), Brookes (1969a, 1969b), Wilkinson (1972), Egghe (1985, 1986, 1990a, 1990b), Basu (1992), and Ravichandra

Rao (1992) proposed the mathematical models afterwards (1998). These researchers provided mathematical models for the dispersion of journal articles.

A. Brooke's Model (1969)

$F(x) = a + b \log x$----------(1)

where $F(x)$ is the cumulative number of references contained in the first x most productive journals, and a and b are constants.Bradford's Law is most commonly expressed in this manner.

The verbal formulation was developed by Vickery (1948) to show that it may be applied to any number of zones with equal yield.

B. Leimkulher's (1967) Model

$R(r) = a \log(1 + br)$ ----------(2)

where $R(r)$ is the cumulative number of articles contributed by journals ranked 1 through r, and a and b are parameters. Where r = 1, 2, 3 ….

C. Egghe's model

Bradford's Multiplier has been modified using Leimkuhler's Model as

$k = (e^{\gamma} \times y_m)^{1/p}$----------(3)
Where γ is Euler's number($e^{\gamma} = 1.781$),

p = Number of zones i.e. 3.

y_m =Number of items in the most productivity sources.

$Y_0 = {}^{A}/_{P}$

Where A denotes the total number of articles.

Let T denote the total number of journals in Bradford group

r_0= Number of journals in the nucleus zone of Bradford is calculated as:

$r_{0} = \frac{T(k-1)}{(k^{p}-1)}$ ----------(4)

$r_1 = r_0 \times k$

$r_2 = r_0 \times k^2$

Brooke asserts that in order to evaluate the applicability of Bradford's Law, the following three implicit requirements must be satisfied:

i. The number of articles in each zone must remain constant when the journals are divided into zones.
ii. The Bradford multiplier, k, must be greater than 1.
iii. The Bradford multiplier must remain approximately constant.

Type of Documents Cited

Table - 1: Year wise Types of Documents cited

Publication Year	Books	Conference proceedings	Journals	Scientific reports	Article Total
2016	1	229	1470	2	1702
2017		367	1854	3	2224
2018		261	2064	2	2327
2019		318	2422	1	2741

2020		207	2577		2784
	1	1382	10387	8	11778

The frequency of Conference proceedings and J citations is higher than other B and S categories of documents in the year-by-year trend of types of documents referenced from 2016 to 2020. The table contains information about the frequency and type of documents cited. It demonstrates that journals take up the majority of this five-year distribution, followed by Conference proceedings. Scientific reports& Books are insignificant.

Rank list of journals

Ranking journals are those that have achieved recognition in their respective fields. In descending order, the table 2 shows the frequency rankings of core journals.

Table 2: Rank list of journals

Rank	Article Title	Frequency	Percentage
1	Journal of instrumentation	641	6.1712%
2	Electronics	506	4.8715%
3	Nuclear instruments & methods in physics research section a-accelerators spectrometers detectors and associated equipment	446	4.2938%
4	Advanced materials	285	2.7438%
5	Nature communications	272	2.6187%
6	Applied sciences-basel	263	2.5320%
7	Scientific reports	248	2.3876%
8	Ieee transactions on nuclear science	221	2.1277%
9	Advanced functional materials	218	2.0988%
10	Micromachines	216	2.0795%
11	Nanomaterials	187	1.8003%
12	AIP advances	182	1.7522%
13	Applied physics letters	179	1.7233%
	Acs applied materials & interfaces	179	1.7233%
14	Materials	176	1.6944%
15	Physical review B	151	1.4537%
16	Nano letters	146	1.4056%
17	Advanced science	145	1.3960%
18	Advanced electronic materials	135	1.2997%
19	IEEE transactions on electron devices	133	1.2804%
20	ACS Nano	121	1.1649%
21	Advanced materials technologies	118	1.1360%
22	Nanoscale	114	1.0975%
23	Review of scientific instruments	101	0.9724%
24	Sensors	98	0.9435%
25	Optics express	88	0.8472%
26	Journal of materials chemistry c	85	0.8183%

	Journal of applied physics	85	0.8183%
27	Ieee sensors journal	83	0.7991%
28	Nanotechnology	80	0.7702%
29	Physical review applied	77	0.7413%
30	Small	76	0.7317%
	Total	**6055**	58.2940%

The table 2 shows that thirty (30) journals accounted for 6055 (58.2940 percent) of all journal citations. The table 2 also shows that the Journal of instrumentation is the most mentioned journal by authors of publications in the topic of electronics, having been cited 641 times, accounting for around 6.1712% of the journals cited. Nuclear instruments & methods in physics research section a-accelerators spectrometers, detectors, and associated equipment were rated third with a frequency of 446 times (4.8715%). The frequency and percentage for the remaining first thirty journals are indicated in the table above.

Number of Journals in Each Rank

All 10387 journal articles are organised in decreasing order and assigned a rank to determine the number of journals that occupy specific ranks.

The frequency of citations below 30 is provided in the following table 3, along with the rank from the previous table 2 for convenience. The rankings, on the other hand, are given as the number of journals in a certain group with a total number of articles.

Table 3: Number (Frequency) of Journals in Each Rank with no of articles

Sr No	Rank	No. of Journals	No. of Articles
01.	32 - 35, 37, 39 - 41, 42, 46, 48 -49, 56	1 each	599
02.	31, 36, 38, 43-45, 47, 53	2 each	694
03.	52,54,57,59,64	3 each	315
04.	5-51, 60,65,68	4 each	392
05.	55, 61-62	5 each	280
06.	67	6	66
07.	58, 63	9 each	315
08.	69	11	99
09.	66	12	144
10.	70-71	15 each	225
11.	72-73	33 each	363
12.	74	44	176
13.	75	58	174
14.	76	105	210
15.	77	280	280
	Total		**4332**

The total of 10387 articles is derived from 741 journals. The journals are classified into 77 distinct ranks based on the frequency with which they appear in the media. In the top three positions, 15.34% of journals are found. Within the first 30 ranks, the table 3 lists 6055, or 58.2940 percent, and 4332, or 41.71 percent. There are only a couple of journals. However, when compared to a specific rank, the number of journals ranges from 1 to 293 journals. There were 280 journals in the last rank, which was 77. It showed that the lower-ranking journals have a higher number of publications than the middle-ranking journals. The table 4 shows the number of journals that are available for each rank. Thus, the top 30 journals accounted for more than 58 percent (58.2940 percent) of all journal citations, while 741 journals accounted for the remaining 42 percent. As a result, a huge number of citations are concentrated in a few journals.

Bradford's Law: Its Implementation

The following explanation and data are offered to demonstrate the appropriateness of journal distribution using the verbal formulation of Bradford's law. The first section is concerned with the theory's linguistic form. The first section studies the geometric representation based on the same data, and the second half analyses the periodicals sorted by decreasing frequency of citations.

Verbal Formation

In the table 4, a total of 10387 cited journals are listed in order of decreasing number of citations. A table 4 is generated with the information of journals with their rank, total number of journals in each rank, cumulative number of journals, number of articles received by each journal, cumulative articles, log of cumulative journals of each rank to test the verbal construction of Bradford's law. This data is required to put Bradford's law to the test verbally. The 10387 journals were separated into three zones in order to test the algebraic interpretation of the law. The Bradford multiplier factor was calculated by dividing a zone's journals by the previous zone's journals. The three zones were chosen with the goal of minimizing the percentage error in citation distribution throughout the three zones.

Table 4: Journal and Citation Dispersion in Bradford Zones

Rank	N0. of Journals	Cumulative no. of Journals	No. of Articles/Frequency	Cumulative No. of Articles/Frequency	Log(n)	Zone
1	1	1	641	641	0	
2	1	2	506	1147	0.69	
3	1	3	446	1593	1.10	
4	1	4	285	1878	1.39	
5	1	5	272	2150	1.61	**First**
6	1	6	263	2413	1.79	
7	**1**	**7**	**248**	**2661**	**1.95****	
8	1	8	221	2882	2.08	
9	1	9	218	3100	2.20	

Rank	N0. of Journals	Cumulative no. of Journals	No. of Articles/Frequency	Cumulative No. of Articles/Frequency	Log(n)	Zone
10	1	10	216	3316	2.30	
11	1	11	187	3503	2.40*	
12	1	12	182	3685	2.48	
13	2	14	358	4043	2.64	
14	1	15	176	4219	2.71	
15	1	16	151	4370	2.77	
16	1	17	146	4516	2.83	
17	1	18	145	4661	2.89	
18	1	19	135	4796	2.94	
19	1	20	133	4929	3.00	
20	1	21	121	5050	3.04	
21	1	22	118	5168	3.09	
22	1	23	114	5282	3.14	
23	1	24	101	5383	3.18	
24	1	25	98	5481	3.22	
25	1	26	88	5569	3.26	
26	2	28	170	5739	3.33	
27	1	29	83	5822	3.37	
28	1	30	80	5902	3.40	
29	1	31	77	5979	3.43	
30	1	32	76	6055	3.47	
31	2	34	146	6201	3.53	
32	1	35	72	6273	3.56	
33	1	36	67	6340	3.58	
34	1	37	61	6401	3.61	
35	1	38	58	6459	3.64	
36	2	40	112	6571	3.69	
37	1	41	51	6622	3.71	
38	2	43	100	6722	3.76	
39	1	44	48	6770	3.78	
40	1	45	46	6816	3.81	
41	1	46	40	6856	3.83	
42	1	47	39	6895	3.85	
43	**2**	**49**	**76**	**6971**	**3.89***	**Second**
44	2	51	74	7045	3.93	
45	2	53	72	7117	3.97	
46	1	54	34	7151	3.99	**Third**
47	2	56	64	7215	4.03	
48	1	57	31	7246	4.04	
49	1	58	30	7276	4.06	

Rank	N0. of Journals	Cumulative no. of Journals	No. of Articles/Frequency	Cumulative No. of Articles/Frequency	Log(n)	Zone
50	4	62	116	7392	4.13	
51	4	66	112	7504	4.19	
52	3	69	81	7585	4.23	
53	**2**	**71**	**50**	**7635**	**4.26****	
54	3	74	72	7707	4.30	
55	5	79	115	7822	4.37	
56	1	80	22	7844	4.38	
57	3	83	63	7907	4.42	
58	9	92	180	8087	4.52	
59	3	95	57	8144	4.55	
60	4	99	72	8216	4.60	
61	5	104	85	8301	4.64	
62	5	109	80	8381	4.69	
63	9	118	135	8516	4.77	
64	3	121	42	8558	4.80	
65	4	125	52	8610	4.83	
66	12	137	144	8754	4.92	
67	6	143	66	8820	4.96	
68	4	147	40	8860	4.99	
69	11	158	99	8959	5.06	
70	15	173	120	9079	5.15	
71	15	188	105	9184	5.24	
72	33	221	198	9382	5.40	
73	33	254	165	9547	5.54	
74	44	298	176	9723	5.70	
75	58	356	174	9897	5.87	
76	105	461	210	10107	6.13	
77	**280**	**741**	**280**	**10387**	**6.61***	
	741		10387			

* Bradford zone dispersion

** Bradford zone dispersion with application of Leimkuhler model

Table 5: Scatter of Journals and articles over Bradford's zone

Zone	No. of journals	No. of articles	Bradford Multiplier
1	11	3503	--
2	38	3468	3.45
3	692	3416	18.21
Total	741	10387	10.83

Application of Leimkuhler model

The 741 journals have been separated into three zones in order to test Bradford's law. Bradford assumes a minimum of three zones, i.e., p=3, hence the value of k i.e. Bradford's Multiplier can be computed using the formula.

$k= (1.781 \times Ym)^{1/p}$

Where Ym is the number of citations received to rank one journal = 641 (Please refer Table 4)

$k = (1.781 \times 641)^{1/3} = (1141.62)^{1/3} = 10.451$

$Y_0 = A/P$

Where P is number of zones = 3 (Please refer Table 5)

$Y_0= 10387 \div 3 = 3462.33$

$r_0= T (k-1) \div (k^p -1)$

$= 741 (10.451- 1) \div (10.451^3 -1)$

$= (741 \times 9.451) \div (1141.49 -1)$

$= 7003.19 \div 1140.49$

$r_0= 6.14$

$r_1 = r_0 \times k = 6.14 \times 10.451 = 64.174$

$r_2 = r_0 \times k^2 = 6.14 \times 10.451^2 = 670.69$

$a = Y_0 \div \log k = 3462.33 \div 1.019 = 3397.77$

$b = (k- 1) \div r_0 = (10.451-1) \div 6.14 = 9.451 \div 6.14 = 1.539$

Table 6 summarises the results of the calculation.

From table 6, the number of journals in nucleus is found to be 6.14 and k = 10.45 is a multiplier.

Therefore, the Bradford distribution is

$6.14: 6.14 \times 10.45: 6.14 \times 10.45^2 \approx 1: n: n^2$

$6.14 : 64.163 : 670.50 = 740.803$

Percentage of error = $[(740.803 – 741) \div 741] \times 100 = [(- 0.197) \div 741] \times 100 = - 0.0002658 \times 100$

Percentage of error = - 0.02658 %

The percentage error of the distribution is 0.02658%, and the number of journals sending articles to each zone multiplies by 10.451. The first zone, with 6.14 journals, contributes 2413 articles; the second zone, with 64.174 journals, contributes 4979 articles; and the third zone, with 670.69 journals, contributes 2995 articles.

Table 6: Application of Leimkuhler model

Zone	No. of journals	No. of articles	Bradford Multiplier
1	6.14	2413	--
2	64.174	4979	10.451
3	670.69	2995	10.451
Total	**741.004**	**10387**	**10.451**

Graphical Formulation

Brookes pioneered the graphical (formulation) method. It is only the experimental confirmation of Bradford's Law's verbal formulation that notices a certain regularity in the distribution of scientific publications.

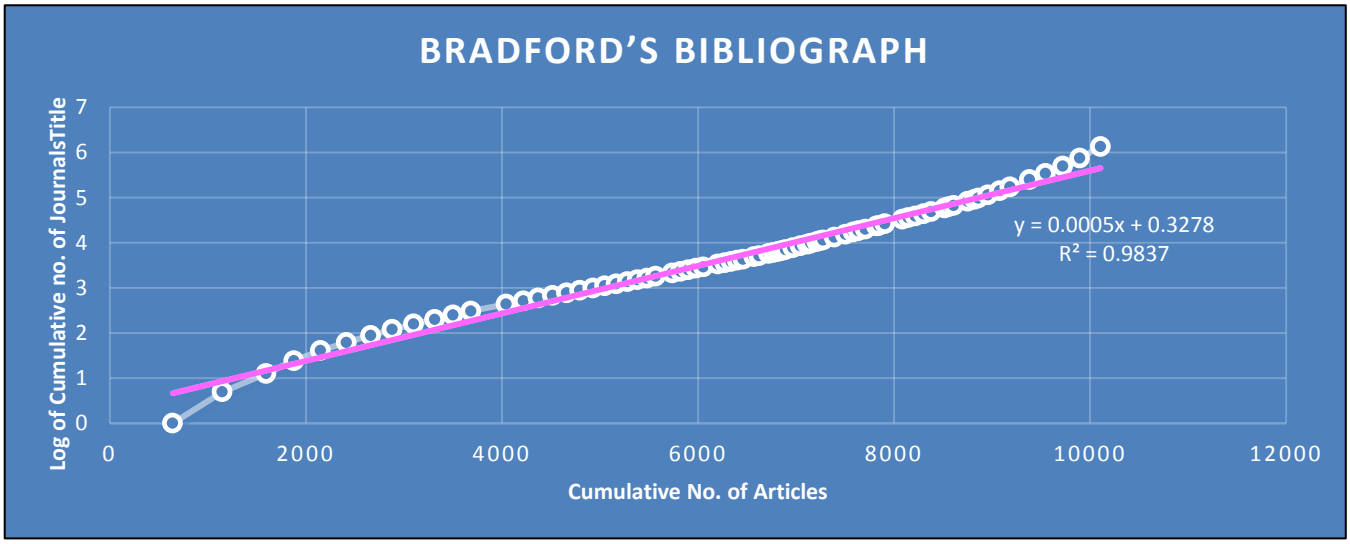
The graph shows the cumulative number of journal titles on the vertical (Y) axis and the cumulative number of articles on the horizontal (X) axis as a logarithmic plot.

If Bradford's law is confirmed, the distribution will display the following three characters.

i. A rapid rise for the first few points

ii. A major portion of linear relation between two variables and

iii. A 'droop' at the tail end of the distribution indicating the incompleteness of the bibliography.



FINDING

The following facts are revealed as a result of the many Scientometrics indicators and the application of Bradford's law of scattering:

1. According to document analysis, 19% are journals, 11.73% are Conference proceedings, barely 0.07% are Scientific reports, and a minuscule 0.01% are Books.

2. In terms of five-year dispersion, the year with the most publications 2784 (23.64%) was 2020, while the year with the fewest 1702 (14.45%) was 2016.

3. With 641 (6.1712%) articles, the 'Journal of Instrumentation' is the most preferred journal.As per the three zones of cited periodicals, equal articles have not been fit into Bradford'slaw of Scattering.

4. The study provided by Eggle'sLeimkuher model demonstrates that Bradford's law will suit the 14:64.174:670.69 geometric sequence of referenced journals with a constant Bradford Multiplier of 10.451.

5. After applying the Leimkuher model, the proportion of errors is found to be the most negligible (-0.02658%).

CONCLUSION

The current database included 11 journals that covered 3503 articles, 38 journals that covered 3468 articles, and 692 journals that covered 3416 articles. In other words, each journal group covered one-third of the total number of citations.

Bradford predicted that the detected zones would form an almost geometric series in the form of 1: n: n^2, but the relationship of each zone in the current investigation was determined to be

11:38:692. This is not consistent with the Bradford distribution.

As a result, the method based on the Leimkuhler model is used to verify Bradford's Law of scattering. Bradford's Law was found to be valid for the database using the Leimkuhler model. The percentage of errors discovered to be the least significant (-0.02658%). Bradford's Law of Scattering has received a great deal of attention. However, no one model has yet been developed that adequately matches the majority of the data.

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