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Abstract

The popular quoted statement of Lotka's law is attempted to apply in the domain of DESIDOC Journal of Library & Information Technology. The authors contributed their views in the journal published since its first volume up to its 38th volume is considered in the study. The attempt has been made to test the mathematical formula i.e. a(n) = a(1)/n^2 with the dataset developed during the study. Moreover, most productive authors who have contributed their views in the DESIDOC Journal of Library & Information Technology are also identified.

Keywords : K-S Test, Lotka's Law, Scientific Productivity

Introduction

Alfred Lotka is the pioneer for making the study of 'Scientific Productivity'. The scientific productivity of authors is first calculated by him in 1926. It is very difficult task to measure the scientific productivity of any individual. However, it can strongly be measured by considering the number of publication on his/her credit during certain period. Comparatively it is easy to collect the publications of individuals and count it for measuring his scientific output. In view of this Alfred Lotka presented an analysis of the number of publications listed in Chemical Abstracts from 1907 to 1916 with the frequency of publications by particular authors. In analysis he exclude the names of corporate authors but only considered the name of author whose name is begin with A and B as listed in the Index. On the same line Lotka made a similar study in the field of Physics. On the basis of these two data sets he quoted following statement popularly known as Lotka's Inverse Square Law of Scientific Productivity.

'The number of authors making 'n' contribution is about $1/n^2$ of those making one contribution, and the proportion of all contributors who make a single contribution is about 60 percent.'

Mathematically, the first part of this law i.e. 'the number of authors making 'n' contributions is about $1/n^2$ of those making one contribution' can be stated as.

$$a(n) = a(1)/n^2$$

Where, a(1) is the number of authors contributing one article

a(n) is the number of authors contributing 'n' number of articles

'n' is number of articles

Review of Literature

Many studies are noted in which the Loka's law is trying to apply by taking different datasets of various subject domains. Kalyane and Sen[1] studied to find out author productivity. While testing Lotka's law they considered first author as well as all authors of the articles published in Journal of Oilseeds Research during 1984 to 1992. The result came out as the expected values are quite close to observed values as long as the number of paper does not exceed 5. Further the Lotka's law does not hold good beyond this number. Shukala, Sakensena, and Riswadakar[2] examined the applicability of Lotka's distribution to the research productivity of bio-energy researchers. The result showed that Lotka's distribution holds good for bio-energy literature and the value of n is ranges between 2.9 and 4.5. Kherde and Chore[3] attempted to verify the Law in the field of Library & Information Science and concluded that the law does not fit to the selected dataset. Pillai Sudhier[4] examined the validity of Lotka's law using total counting and straight counting of authors in the physics and applied K-S test as well as Chi-Square test on the data. Finally, found that the Lotka's generalised law is not applicable. Aswathy and Gopikutta[5] examined the fitness of Lotka's Inverse Square law for the journal publications of the faculty members belong to science departments of the universities in Kerala during 2005 to 2009. During the study it was

found that the data does not follow the law. Suresh Kumar[6] in his study examined the validity of Lotka's Law in the field of Library and Information Science. He considered 556 articles and found that the law is applicable to Library and Information studies publications. Kumar and Senthilkumar[7] verified the Lotka's Law in its generalized form as well as in inverse square form in the field of Astronomy & Astrophysics. The required data retrieved from Web of Science contained 6363 papers published by 2,719 authors during 2013-2017. While verifying the law the statistical tests - K-S and Chi-square test were applied. However, the study showed that law doesn't fit to the data.

Besides, many more authors had examined the applicability of Lotka's law in different fields. In the present article the attempt has been made to apply the Law in the domain of DESIDOC Journal of Library & Information Technology.

Objectives

The present study is carried out with the following prime objectives

- To identify the most productive authors in DESIDOC Journal of Library & Information Technology.
- To test the applicability of Lotka's Inverse Square Law of Scientific Productivity, in the entire period of publication of the DESIDOC Journal of Library & Information Technology.

While achieving the above set objectives, in the present article the dataset - the scientific productivity of authors identified through the articles published by them in the DESIDOC Journal of Library & Information Technology Volume 1 to Volume 38 is considered.

DESIDOC Journal of Library & Information Technology is publishing bimonthly since 1981. It's a peer-reviewed and reputed journal in the field of Library and Information Science. Articles related to library science, application of Information Technology in library activities, services, and products etc. are published in the journal. Besides, its main focus is also on the various facets of library and information science such as information systems, library management, knowledge management, collection development, bibliometrics and so on. The journal is indexed in Scopus**,** LISA, LISTA, EBSCO, Proquest, Library Literature and Information Science Index/Full-text, The Informed Librarian Online, Open J-Gate, Indian Science Abstracts, Indian Citation Index, WorldCat, Google Scholar, etc.[8]

Methodology

The data required for the present study was collected in two parts. In first part the data was collected from volume 1 to volume 30 of DESIDOC Journal of Library & Information Technology. This data was taken from the 'Cumulative Author Index Vol. 1-30' published in DESIDOC Journal of Library & Information Technology in volume 30, issue no. 6 in the year 2010 on page nos. 75 to 80. In second part, the required data was collected from remaining volumes i.e. volume 31 to volume 38. For this each issue published during the period of 2011 to 2018 were browsed. For verifying Lotka's Inverse Square Law of Scientific Productivity, the list of all authors who have contributed the articles in source journal was prepared.

Kalmogorov-Smirnov test i.e. K-S test is applied for the verification of the dataset. While applying the Lotka's law, the number of contributors who had contributed single article is identified. In the same way the numbers of contributors who had contributed two, three, four and so on articles are also being identified. These numbers of contributors are named as 'Observed number of authors'. The 'Expected number of authors' against each Observed number of authors are calculated with the help of Lotka's formula given above. The deviation between these observed and expected number of authors are examined through K-S test.

Hypothesis

The following hypothesis was set for the present study.
Lotka's Inverse Square Law of Scientific Productivity is fit for the selected dataset of the DESIDOC Journal of Library & Information Technology.

Analysis

Considering the objectives of the present study the Lotka's Inverse Square Law of Scientific Productivity is tried to apply to the dataset on following both the conditions given in the law.

- The proportion of all contributors who make a single contribution is about 60 percent.
- The number of authors making 'n' contribution is about $1/n^2$ of those making one contribution.

Taking in to consideration above points the collected data is analyzed and presented in the tables.

Table: 1 Number of Articles wise Authors

Sr.No.	No. of articles	No. of authors
1	1	**839**
2	2	126
3	3	44
4	4	24
5	5	9
6	6	11
7	7	5
8	8	5
9	9	2
10	10	1
11	11	3
12	15	1
13	19	1
14	20	1
15	39	1
		1073

From table 1 it is observed that in 38 volumes of DESIDOC Journal of Library & Information Technology, 1073 authors were contributed their views in the form of articles. Out of them, 839 authors have contributed single article each in these volumes. The percentage of these authors is 78.19%. Further, 126 authors contributed two articles each in these volumes. During the study some authors are identified who have contributed 10 and more than 10 articles in 38 volumes of DESIDOC Journal of Library & Information Technology. These names are displayed in table 2. It is found that B.M.Gupta is the most productive author who has contributed 39 articles in these volumes and secured first rank in total 1073 authors. After B.M.Gupta, C.K.Ramaiah is the most prolific author. He has contributed 20 articles. If we see the others productivity in terms of publication of articles it is observed from table 2 that S.M.Dhawan has published 19 articles. Fifteen articles are on the name of Ashok Kumar. Three authors i.e. Alka Bansal, B.S.Kademani and Mohinder Sing have published 11 articles each. M.P.Satija put his views by contributing 10 articles. Amongst female authors Alka Bansal is the most productive author having 11 articles on her credit

Second objective of the present study is to test the applicability of Lotka's Inverse Square Law of Scientific Productivity. It has been attempted by collecting required data from the DESIDOC Journal of Library & Information Technology. The collected data is displayed in table 3 as observed number of authors. Observed number of authors means actually collected and classified according to their productivity in terms of number of articles they have contributed. Here, one article each is contributed by 839 authors. To test the applicability of Lotka's law to this observed number of authors, it is needed to calculate the expected number of authors for each

number of articles given in table 3. For going through this process at first step 839 which is a observed number of authors for single contribution is also considered as a expected number of authors for single article. Further, on the basis of this figure other figures are calculated by following Lotka's formula.

Table: 2 Most Productive Authors

Sr.No.	Rank	Name of authors	No. of articles contributed
1	1	B.M.Gupta	39
2	2	C.K.Ramaiah	20
3	3	S.M.Dhawan	19
4	4	Ashok Kumar	15
5	5	Alka Bansal	11
6	5	B.S.Kademani	11
7	5	Mohinder Singh	11
8	6	M.P.Satija	10

$a(n) = a(1)/n^2$

Where, a(1) is the number of authors contributing one article
a(n) is the number of authors contributing 'n' number of articles
'n' is number of articles
Here first expected number of authors is considered as 839 and therefore a(1) is 839. Now for 2 articles expected number of authors can be calculated by following way.

n = 2, and therefore a(n) = a(2)
a(1) = 839

If we put these values in the above mathematical formula, we will get expected number of authors who have contributed 2 articles.

$a(2) = 839/(2)^2$
$= 839/4 = 209.75$ i.e. 210
Further, for 3 articles expected number of authors will be

$a(3) = 839/(3)^2$
$= 839/9 = 93.22$ i.e. 93

In this way other expected values are calculated and displayed in table 3. The percentages given in this table are calculated considering the respective total of observed and expected number of authors. It reveals from table 3 that total of observed number of author is 1073 and that of expected number of author is 1315.

The first condition of Lotka's inverse square law is the proportion of all contributors who make a single contribution should be about 60 percent. However in our study it comes 78.19%. Therefore here is scope to say that this condition is not satisfied in our data set.

However, the second condition is 'the number of authors making 'n' contribution is about $1/n^2$ of those making one contribution'. For attempting to satisfy this condition and test the formulated hypothesis of the study i.e. 'Lotka's Inverse Square Law of Scientific Productivity is fit for the selected dataset of the DESIDOC Journal of Library & Information Technology', as stated earlier the K-S statistical test is to be applied.

For the application of K-S test, the deviation between the observed and expected number of authors is to be calculated. For that the frequencies of the observed and expected number of authors are find out. These frequencies and its cumulative frequencies are displayed in table 4.

Table: 3 Number of Articles wise Expected Authors Calculated on the basis of Lotka's Equation

Sr.No.	No. of articles	No. of authors			
		Observed	%	Expected	%
1	1	**839**	**78.19**	839	63.80
2	2	126	11.74	210	15.97
3	3	44	4.10	93	7.07
4	4	24	2.24	52	3.95
5	5	9	0.84	34	2.59
6	6	11	1.03	23	1.75
7	7	5	0.47	17	1.29
8	8	5	0.47	13	0.99
9	9	2	0.19	10	0.76
10	10	1	0.09	8	0.62
11	11	3	0.28	7	0.53
12	15	1	0.09	4	0.30
13	19	1	0.09	2	0.15
14	20	1	0.09	2	0.15
15	39	1	0.09	1	0.08
Total		**1073**	**100**	**1315**	**100.0**

The maximum deviation between the cumulative frequencies of the observed and expected value is determined by the following formula

$$D = \text{Max} \mid Fo(X) - Sn(X) \mid$$

Where Fo(X) is the cumulative frequency of expected value
Sn(X) is the cumulative frequency of observed value

If we check the statistical table it will be observed that at 0.01 level of significance, K-S

Statistics = $\frac{1.63}{\sqrt{n}}$

Where ‘n‘ is total number of authors identified during the period.

From table 4 it is observed that the maximum deviation between the cumulative frequencies of the observed and expected value is 0.1439.

It means D = Max | Fo(X) - Sn(X) | = 0.1439

At the 0.01 level of significance,

K-S Statistics = $\frac{1.63}{\sqrt{n}}$

Here n is number of authors observed during the study which is 1073 (Refer Table 3)

$$\text{K-S Statistics} = \frac{1.63}{\sqrt{1073}}$$

$$= \frac{1.63}{32.76} = 0.0498$$

As D i.e. 0.1439 is greater than K-S Statistics i.e. 0.0498, the given data does not fit for Lotka’s law. Further, from the analysis it seems that the proportion of all contributors who make a single contribution is about 78.19 percent (please refer table 3). It means in the study both the conditions of Lotka's law are not being satisfied. Therefore our set hypothesis i.e. 'Lotka’s Inverse Square Law of Scientific Productivity is fit for the selected dataset of the DESIDOC Journal of Library & Information Technology' is not accepted.

Table: 4 Number of Articles wise Frequency of Authors

Sr. No.	No. of articles	Frequency of Authors		Cumulative Frequency		D= |Fo(x)-Sn(x)|
		Observed	Expected	Observed Sn(x)	Expected Fo(x)	
1	1	0.7819	0.6380	0.7819	0.6380	**0.1439**
2	2	0.1174	0.1597	0.8993	0.7977	0.1016
3	3	0.0410	0.0707	0.9403	0.8684	0.0719
4	4	0.0224	0.0395	0.9627	0.9079	0.0548
5	5	0.0084	0.0259	0.9711	0.9338	0.0373
6	6	0.0103	0.0175	0.9814	0.9513	0.0301
7	7	0.0047	0.0129	0.9861	0.9642	0.0219
8	8	0.0047	0.0099	0.9908	0.9741	0.0167
9	9	0.0019	0.0076	0.9927	0.9817	0.011
10	10	0.0009	0.0062	0.9936	0.9879	0.0057
11	11	0.0028	0.0053	0.9964	0.9932	0.0032
12	15	0.0009	0.0030	0.9973	0.9962	0.0011
13	19	0.0009	0.0015	0.9982	0.9977	0.0005
14	20	0.0009	0.0015	0.9991	0.9992	0.0001
15	39	0.0009	0.0008	1.0000	1.0000	0.0000

Conclusion

In 1926 Alfred Lotka had put the law regarding the scientific productivity on the basis of the datasets taken from Chemical Abstract as well as Auerbach's Geschichstafel der Physic. Mathematically, this law can be expressed as $a(n) = a(1)/n^2$. In the present study the attempt has been made to apply the Lotka's law in the domain of DESIDOC Journal of Library & Information Technology. If we consider both the conditions given in law, it is observed that in the present study out of 1073 identified authors, 839 have contributed single article in 38 volumes of the source journal. The share of it is 78.19%. It means the first condition is not satisfied. So far as second condition is concerned the mathematical expression is also not satisfied when test through K-S statistical test. Therefore the law does not fit to the collected dataset. Considering the first objective of the study, Dr.B.M.Gupta is found most productive contributor having 39 articles on his credit.

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