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Authorship Dynamics and Lotka's Law Applicability in the Realm of Archaeology

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ABSTRACT

This research seeks to explore authorship trends, author productivity, and the applicability of Lotka's law within the Archaeology discipline from 2018 to 2022. The primary goal of this research is to determine author productivity and evaluate the application of Lotka's law, including goodness-of-fit, using the Kolmogorov-Smirnov (K-S) and Chi-Square tests. Utilising the various quantitative methodologies (like- The K-S test and Chi-Square test), this study fulfils its objectives by analysing global research output in the field of Archaeology. The extraction of data is facilitated through advanced search techniques within the Web of Science Core Collection Database. 8980 authors contributed 3742 research articles of which 7095 (79.01 %) authors contributed only one research article, 1207 (13.44 %) authored two articles, and so on. The study's outcomes revealed the exponent 'n' (-3.337), constant 'c' (0.873), and critical value 'cv' (0.035) as significant metrics within the examined context. The observed number of authors is 8,980, while the expected number is 11,212. The Dmax value is 15.73 noted in the cumulative frequency comparison between the observed and expected values and the chi-square (X2) value in this dataset is 1434.302. The Kolmogorov-Smirnov (K-S) and Chi-Square tests were used to validate the applicability of Lotka's Law to the dataset. However, both goodness-of-fit tests rejected the hypothesis, after applying Lotka's law in the selected data set.

Keywords: Scientometrics; Authors' productivity; Authorship pattern; Lotka's law; K-S test; Chi-Square test; Archaeology; Web of science (WoS)

1. INTRODUCTION

Archaeology, the study of past human societies, offers a unique insight into what it means to be human. As the only discipline that encompasses the entire human past across all time and space, it provides essential perspectives on how we can shape our future. Archaeologists use a diverse array of evidence, including ancient tools, buildings, human remains, and environmental traces. Being truly interdisciplinary, archaeology incorporates methods from the arts, humanities, social sciences, and sciences to gather, analyse, and interpret evidence, revealing the rich history of human life. This positions archaeology to offer long-term perspectives on major 21st century challenges, such as cultural diversity, health, identity, climate change and equality[1].

Archaeology is a varied field, with most archaeologists concentrating on a specific region or topic. Specialization enables archaeologists to gain expertise in particular areas. For instance, some focus on human remains (bioarchaeology), animals (zooarchaeology), ancient plants (paleoethnobotany), or stone tools (lithics). Others specialise in technologies for locating, mapping or analysing archaeological sites. Additionally, underwater archaeologists examine remnants of human activity found beneath water surfaces or along coasts[2].

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This study involves the assessment of global literature and research in the field of Archaeology, as evidenced by the significant trends in publication activity, collaboration rates, and author contributions revealed through comprehensive data analysis aiming to illustrate authorship patterns and the application of Lotka's Law, one of the key bibliometric laws, to provide insights into the distribution of scholarly contributions within the discipline. The relevance of bibliometric laws to authorship productivity elucidates how principles such as Lotka's Law and others like- Price's Law and Bradford's Law provide critical insights into the distribution patterns and underlying factors that influence scholarly output, thereby informing more strategic research planning and resource management.

2. LITERATURE REVIEW

This segment provides an overview of papers and articles that have applicability to scientometric techniques and Lotka's Law to evaluate the patterns and expansion of various research areas and subject domains. Some studies investigated the relevance of Lotka's Law across various disciplines.

Applicability of Lotka's Law examined by Narendra Kumar[3] The applicability of Lotka's Law, both as a general inverse power ($a \neq 2$) and as an inverse square power relationship ($a=2$), was examined for research

productivity in the Council of Scientific and Industrial Research (CSIR), India. Two datasets, consisting of 6,076 and 17,681 research papers contributed by CSIR scientists between 1988-1992 and 2004-2008, were sourced from SCI-CD-ROM and Web of Science, respectively. The K-S Test was employed to assess the alignment between the observed data distribution, the inverse general power relationship, and the theoretical value of a=2. Results indicated that Lotka's inverse square law did not apply.

Authorship distribution in physics literature was analysed by Sudhier[4] to assess the validity of Lotka's law concerning scientific publication productivity, researchers compiled a list of journal articles covering various aspects of physics research cited in doctoral theses from the University of Kerala, Thiruvananthapuram, South India. They identified 1,665 authors using a straight count method and 3,367 authors using a complete count method. Results indicated that Lotka's law did not fit the productivity distribution for either author group, suggesting it does not apply to authors in the field of physics literature as examined in this study.

Dhoble & Sudhir Kumar[5] Conducted a study on 3,588 papers sourced from CAB Direct, and examined the authorship patterns and the applicability of Lotka's Law by tallying the number of publications per author. The chi-square test was applied to test the hypothesis, and the law was still applicable to this research.

Naqvi & Fatima[6] discussed the applicability of Lotka's law to International Business literature was examined using data from 11,202 references in research articles published in the Journal of World Business between 2012 and 2014. The study found that Lotka's distribution applies to this literature, a conclusion further supported by Chi-Square and K-S statistical tests.

A scientometric analysis was carried out by Radhakrishnan & Baskaran[7] In the field of Phytochemistry, 13,215 records from 2014 to 2018 were analysed. The data were sourced through the SCOPUS online database. The Chi-square value for Lotka's Law analysis was 225.65, which exceeds the table value. According to Price's Square Root Law, the square root of the total number of authors, who contributed 7.94 % of the total work, is 255.52. Pareto's 80/20 rule findings revealed that 20 % of the authors accounted for only 46.60 % of the total contributions.

Kherde[8] examined the applicability of Lotka's law in the DESIDOC Journal of Library & Information Technology. The study included contributions from authors in all volumes, from the first to the 38th. The mathematical formula a(n) = a(1)/n2 was tested using the dataset compiled during the research. Additionally, the study identified the most prolific authors who have contributed to the journal.

Explored authorship distribution by Patel and Verma[9] in Congestive Heart Failure research from 1989 to 2023 using Web of Science data. 2565 documents were analysed with Histcite and Bibexcel, and visualized with Excel. Results show increasing publications, with 2021 seeing the most. Journal articles have the highest impact, notably in European Journal of Heart Failure and International Journal of Cardiology. Top authors include Kumar A. and Yusuf S. Lotka's law applies, confirmed by the Dmax value.

Conducted a detailed bibliometric analysis of fused deposition modelling to uncover trends and research areas by Parvanda, Kala and Sharma[10]. Utilising the Web of Science database, 2793 documents were examined using keywords. The analysis highlighted key authors, countries, and sources, which were visualized using a three-field plot. Author productivity was examined using Lotka's law and validated with the K–S test, while Bradford's law identified core sources in FDM research. Trend topic analysis showed a shift from error reduction to optimising printing parameters, materials, and applications. The study's findings inform current research trends and suggest future areas for exploration.

Gunaseelan and Ranganathan[11] evaluated Global Limnology Research publications from 1989 to 2020 using Web of Science data. Out of 1499 papers from 402 journals, 'Hydrobiologia' emerged on top. However, Bradford's law didn't apply, and Lotka's law was invalidated. John P. Simol stands out as a prolific author. The study identified 'Lake' and 'Lakes' as significant keywords, fitting into Zipf's law. Additionally, Price's square root law and the Pareto Principle were applied. This research sheds light on limnology's research dynamics, aiding scientists and information professionals in the field.

Carried out a study by Fallah[12], *et al*. aimed to compare Lotka's law of author productivity with Google Scholar's i10-Index by analysing Chemistry Publications of Iran in the Web of Science Database from 2000-2020. Using scientometric methods, the study found notable Iranian authors like Mohamadreza Ganjali, Majid Heravi, and Mojtaba Shamsipur. However, Lotka's law's validity in measuring author productivity in Iranian chemistry wasn't confirmed. While cautioning against drawing definitive conclusions from a single study, it noted that 85 % of Iranian authors with multiple publications had an i10-index. Consequently, Lotka's law's validity in Iranian chemistry papers was uncertain, while the i10-index showed promise as a credible metric in this field.

Devi, Kutty and Vani[13] investigated the author productivity pattern in animal breeding research, specifically concerning the use of random regression models (RRMs), aligns with Lotka's inverse square law of scientific productivity. Analysing data from 236 animal breeding research publications obtained from the PubMed database, the research assessed various bibliometric indicators, including publication and citation growth, co-authorship patterns, and prolific authors. While Ignacy Misztal emerged as the most prolific author in RRM usage in animal breeding research, the study found that the observed author's productivity pattern did not conform to Lotka's law, as indicated by the K-S test. Research offers valuable insights into authorship patterns and productivity trends in animal breeding research, challenging the application of Lotka's law in this specific context.

Conducted a study by Tunga and Biswas[14] that delved into the citation patterns of the journal Economica, aiming to scrutinise the applicability of Lotka's law & productivity of authors in the given dataset. Analysing 9527 citations across 330 articles spanning from 2011 to 2020, the research revealed that journal articles accounted for the majority of cited literature, followed by books. Notably, a significant portion of journal citations were from multi-authored articles. However, the study concluded that the economic literature within Economica doesn't align well with Lotka's law. These findings offer valuable insights into citation trends within economic literature and suggest nuances in author productivity distribution within this field.

3. PROBLEM IDENTIFICATION

The present study is accompanied by a set of research questions and a hypothesis, which play a pivotal role in delineating the research problem. These research questions guide the investigation by identifying specific areas of inquiry, while the hypothesis propose potential conclusions, offering a structured framework for empirical testing and analysis. The following research questions and hypotheses are pertinent to the present study:

3.1 Research Questions

- What is the year-wise distribution of the research output?
- Which authors are the most prolific?
- What is the research output's authorship pattern and degree of collaboration?
- Is Lotka's Law applying to the research output in the realm of Archaeology?
- Does Lotka's Law meet the criteria of the Chi-Square and K-S goodness-of-fit tests?

3.2 Hypothesis

In the present study, the following hypothesis was established:

Lotka's Law of Scientific Productivity accurately applies to the dataset chosen within the realm of Archaeology.

4. OBJECTIVES

The present study has the following major objectives:

- To find out the distribution of literature output across different years
- To investigate the patterns of authorship and the extent of collaboration within the literature output.
- To identify the top authors with the highest publication rates in the realm of Archaeology
- To assess the applicability of Lotka's law in the output of literature patterns in Archaeology
- Employing the K-S and Chi-Square goodness-of-fit tests to evaluate the applicability of Lotka's law for the output of research (in the field of Archaeology)

5. METHODOLOGY

This study employs a quantitative approach to analyse worldwide research output within the Archaeology field. The investigation leverages the Web of Science Core Collection Database and utilises an advanced search technique for data extraction. The necessary data for the study was obtained using the search query: (TS='Archaeology' or TS='Archeology') AND WC='Archaeology', covering the timeframe from 2018 to 2022, and focusing exclusively on research articles as the document type.

The data extraction was conducted on December 24, 2022. Utilising the export function, the data was obtained in the chosen text format (e.g., Excel, Plain text file) to facilitate diverse analytical endeavours aimed at accomplishing the study's objectives. After being exported, the data underwent essential editing and filtering processes with the help of MS Excel before being organised into tabulated form for subsequent data analysis and interpretation. The conformity of Lotka's law applicability in the current dataset was assessed through the K-S and Chi-Square tests.

5.1 Lotka's Law

Lotka's Law stands as a fundamental principle in bibliometrics given by Alfred J. Lotka in 1926[15], addressing the occurrence of author publication frequencies within a specific field in his publication featured in the JWAS. Lotka was a pioneer in observing and analysing author productivity patterns using sample data from Chemical Abstracts spanning from 1907 to 1916. His findings suggested that the number of authors making 'n' contributions is approximately inversely proportional to n^2 compared to those contributing only one, and approximately 60 % of all contributors produce just a single contribution. Lotka's empirical law of scientific productivity defines the number of authors as 'y', and the number of papers as 'x', with 'n' and 'c' as constants. This formulation is recognised as the inverse square law within Lotka's Law. The expanded version of Lotka's Law can be expressed as follows:

$\mathbf{x^n\ y = c}$ where c & n are constant

X is the number of article contributions [like 1,2,3,4……..] and y is the number of authors.

5.2 Lotka's Law Verification

K-S and Chi-Square (X^2) tests are utilised to validate datasets. When applying Lotka's law, we tally the number of individuals who have contributed a single article, as well as those who have contributed two, three, four, or more articles. These contributor counts are designated as the Observed number of authors. The K-S and Chi-Square tests hold central importance in evaluating the extent to which Lotka's Law conforms and fits the data concerning both goodness-of-fit and conformity.

5.2.1 K-S (Kolmogorov-Smirnov) Test

K-S test is suggested by Coile[16]. The procedure includes

generating the expected cumulative frequency distribution [F(x)] from the null hypothesis and comparing it with the observed cumulative frequency distribution [Sn(x)]. The point where the theoretical and observed distributions show the greatest difference is pinpointed. This point is denoted by D, which represents the maximum absolute difference between F(x) and Sn(x). The value of D is computed and then compared to a critical threshold. If the calculated D value exceeds this critical threshold, the null hypothesis is rejected; otherwise, the null hypothesis is accepted. It is defined as:

$$\mathbf{Dmax = |Fo(x)-Sn(x)|}$$

5.2.2 Chi-Square (X2) Test

When observations within a sample are categorized into specific classes, the question arises whether the observed frequencies significantly deviate from the expected frequencies based on certain hypotheses or theoretical frameworks. In this context, the chi-square (X^2) test proves valuable for determining the extent to which a theoretical distribution, such as Lotka's Law or others, aligns suitably with the provided observations. It is expressed as:

$$X^2 = (Fo - Fe)^2 / Fe$$

Where Fo is the Observed Frequency;
Fe is the Expected Frequency.

6. DATA ANALYSIS AND INTERPRETATION

6.1 Yearly Distribution of Publications

Table 1 presents a chronological overview of literature productivity in the Archaeology field spanning from 2018 to 2022. Noteworthy is the significant upsurge in publication numbers observed over this period. The table emphasises a consistent growth in article count between 2018 and 2022. Notably, the year 2021 records the highest publication count at 876 (23.41 %), while the lowest count is noted in 2022 with 602 publications (16.09 %). Additionally, the table underscores an upward trend in the Doubling Time (Dt.) for publications, illustrating a continuous increase from 2018 to 2022.

Table 1. Yearly distribution of publications

Year	Publications	%	Doubling time (Dt.)
2018	697	18.626	-
2019	774	20.684	0.94
2020	793	21.192	1.61
2021	876	23.41	2.10
2022	602	16.088	4.07
Total	**3742**	**100**	-

6.2 Patterns of Authorship and Degree of Collaboration

Table 2 illustrates how authors' publications are distributed across various authorship patterns within the selected field of study. It is evident that single-author papers account for 1212 (32.39 %), while two-author publications hold a share of 20.28 %, three-author works represent 14.27 %, and four-author contributions make up 9.65 %. Notably, the remaining 23.41 % of publications involve more than four authors. The table highlights the prevalence of multi-authored works compared to single-author ones. The Degree of Collaboration (DC), calculated between 2018 and 2022, ranges from 0.65 to 0.70, with a mean value of 0.68.

6.3 Authors with the Highest Productivity

Table 3 provides an overview of the most prolific authors, each contributing a minimum of 10 articles. Among them, Eren MI emerges as the foremost contributor, showcasing an impressive 23 (0.62 %) publications. Following closely are Buchanan B. with 17 (0.45 %) publications, Hofman CL with 16 (0.43 %) publications, O'Connor S. with 13 (0.35 %) publications, Bebber MR and Veth P. with 12 (0.32 %) publications each, and Ward I with 11 (0.29 %) publications. Notably, Blue L and Thompson VD also have 10 (0.27 %) publications each.

6.4 Authors' Article Productivity

Table 4 presents the global author productivity distribution in the field of Archaeology. Among 8980 authors contributing 3742 research articles, the distribution is as follows: 7095 (79.01 %) authors contributed one article, 1207 (13.44 %) authored two articles, 389 (4.33 %) contributed three articles, and so forth. Notably, Table 3 highlights that the count of authors producing more than ten articles remains notably low.

6.5 Author Productivity (Lotka's Law)

Lotka's Law exposes the distribution of author productivity frequency within a specific subject or discipline. This study

Table 2. Patterns of authorship and degree of collaboration

Authorship	Years					Total	%
	2018	2019	2020	2021	2022		
Single	241	262	240	272	197	**1212**	32.39
Two	157	149	189	166	98	**759**	20.28
Three	91	118	116	120	89	**534**	14.27
Four	65	72	67	96	61	**361**	9.65
More than four	143	173	181	222	157	**876**	23.41
Total	**697**	**774**	**793**	**876**	**602**	**3742**	**100**
Degree of Collaboration (DC)	**0.65**	**0.66**	**0.70**	**0.69**	**0.67**	**0.68 (mean/avg.)**	**-**

Table 3. Authors with the highest productivity

Authors	Publications	%	Rank
Eren MI	23	0.62	1
Buchanan B	17	0.45	2
Hofman CL	16	0.43	3
O'Connor S	13	0.35	4
Bebber MR	12	0.32	5
Veth P	12	0.32	5
Ward I	11	0.29	6
Blue L	10	0.27	7
Thompson VD	10	0.27	7

seeks to investigate the suitability of the law concerning global publications in the realm of Archaeology. For evaluating its applicability, the values of 'n', 'c', and the 'Critical value' for the dataset are computed, as detailed in the calculations presented in Table 5.

6.5.1 Calculations of the Values of 'n', 'c' and 'cv'

Calculations were carried out to evaluate how suitable Lotka's law is for estimating the values of n, c, and cv.

(a) Calculation of Exponent 'n'

To apply Lotka's Law, the initial step involves calculating the exponent 'n.' This value is determined

Table 4. Authors' article productivity

S. No.	Number of articles	Observed authors (in numbers)	Total contributions	Observed authors (%)
1	1	7095	7095	79.01
2	2	1207	2414	13.44
3	3	389	1167	4.33
4	4	146	584	1.63
5	5	68	340	0.76
6	6	36	216	0.41
7	7	15	105	0.16
8	8	10	80	0.11
9	9	5	45	0.06
10	10	2	20	0.02
11	11	1	11	0.01
12	12	2	24	0.02
13	13	1	13	0.01
14	16	1	16	0.01
15	17	1	17	0.01
16	23	1	23	0.01
Total		**8980**		**100**

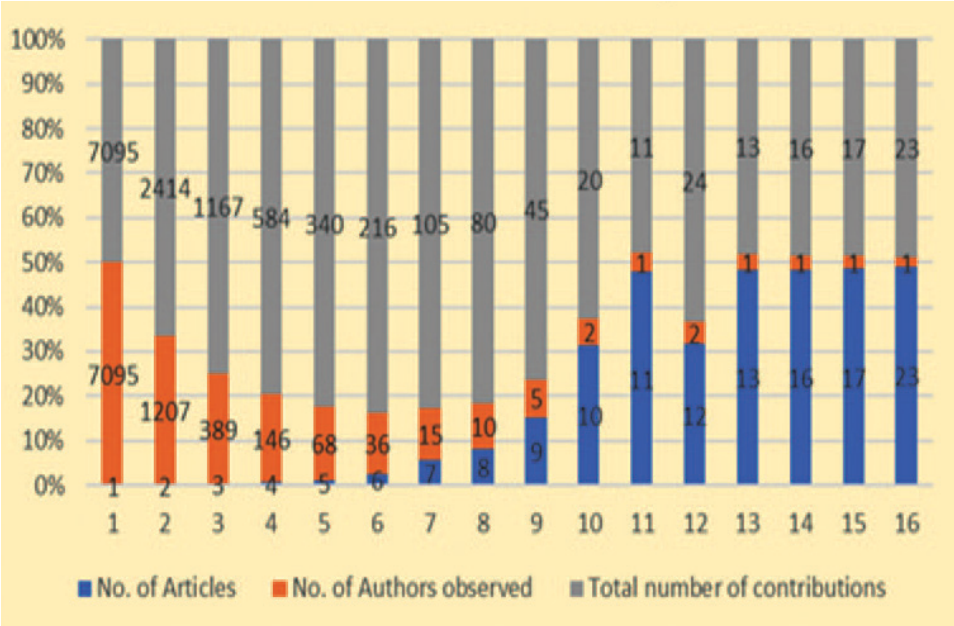

Figure 1. Authors' article productivity.

Table 5. Author productivity (Lotka's Law)

S. No.	Articles (x) (in numbers)	Observed authors (y)	X (log x)	Y (log y)	X^2	XY	x^n	$1/x^n$
1	1	7095	0	3.851	0	0	1	1
2	2	1207	0.301	3.082	0.090601	0.927682	10.105	0.099
3	3	389	0.477	2.590	0.227529	1.23543	39.098	0.026
4	4	146	0.602	2.164	0.362404	1.302728	102.111	0.009
5	5	68	0.699	1.833	0.488601	1.281267	215.012	0.005
6	6	36	0.778	1.556	0.605284	1.210568	395.085	0.003
7	7	15	0.845	1.176	0.714025	0.99372	660.834	0.002
8	8	10	0.903	1	0.815409	0.903	1031.837	0.001
9	9	5	0.954	0.699	0.910116	0.666846	1528.647	0.001
10	10	2	1	0.301	1	0.301	2172.701	0.000
11	11	1	1.041	0	1.083681	0	2986.258	0.000
12	12	2	1.079	0.301	1.164241	0.324779	3992.343	0.000
13	13	1	1.114	0	1.240996	0	5214.696	0.000
14	16	1	1.204	0	1.449616	0	10426.736	0.000
15	17	1	1.230	0	1.5129	0	12764.625	0.000
16	23	1	1.362	0	1.855044	0	35001.430	0.000
	Total	**8980**	**13.589**	**18.553**	**13.52196544**	**9.14725235**	**76542.518**	**1.146**

through the Linear Least Square (LLS) method, utilising the provided formula given by Pao (1985)[17]:

$$n = \frac{N\Sigma XY - \Sigma X\,\Sigma Y}{N\,\Sigma X^2 - (\Sigma X)^2}$$

Where, N: number of data pairs considered
X: the log x (Number of publications)
Y: the log y (Number of authors)

Using data from Table 5, 'n' is calculated by substituting these values into the equation, resulting in the value of 'n' as follows:

$$n = \frac{16 * 9.14725235 - 13.589 * 18.553}{16 * 13.52196544 - (13.589)^2}$$

$$n = \frac{146.3560376 - 252.116717}{216.35144704 - 184.660921}$$

$$n = \frac{-105.7606794}{31.69052604}$$

$$n = -3.337$$

(b) Calculation of Constant 'c'

The determination of constant 'c' is accomplished through the utilisation of the subsequent formula:

$$c = \frac{1}{\Sigma\, 1/x^n}$$

$$c = \frac{1}{1.146}$$

$$c = 0.873$$

(c) Calculation of Critical Value "CV"

The calculated value was compared with the critical value (cv), using the formula:

$$cv = \frac{n}{\sqrt{\Sigma y}}$$

$$cv = \frac{3.337}{\sqrt{8980}}$$

$$cv = 0.035$$

The values for the exponent 'n' (-3.337), constant 'c' (0.873), and critical value 'cv' (0.035) are derived from the aforementioned calculations.

6.5.2 Goodness-of-Fit Tests

Multiple statistical methods exist for conducting goodness-of-fit tests. Among these techniques, the K-S and Chi-square tests are widely applied to assess goodness-of-fit.

(a) K-S test

In the context of Table 6, the calculation for the expected author value can be derived from the observed

Table 6. Observed and expected frequency of authors

S. No.	Articles (in numbers)	Observed authors	Observed authors (%)	Cumulative % (observed authors) [Sn(x)]	Expected authors	Expected authors (%)	Cumulative % (expected authors) [Fo(x)]
1	1	7095	79.01	79.01	7095	63.28	63.28
2	2	1207	13.44	92.45	1774	15.82	79.10
3	3	389	4.33	96.78	788	7.03	86.13
4	4	146	1.63	98.41	443	3.95	90.08
5	5	68	0.76	99.17	284	2.53	92.61
6	6	36	0.41	99.58	197	1.76	94.37
7	7	15	0.16	99.74	145	1.29	95.66
8	8	10	0.11	99.85	111	0.99	96.65
9	9	5	0.06	99.91	88	0.79	97.44
10	10	2	0.02	99.93	71	0.63	98.07
11	11	1	0.01	99.94	59	0.53	98.60
12	12	2	0.02	99.96	49	0.44	99.04
13	13	1	0.01	99.97	42	0.37	99.41
14	16	1	0.01	99.98	28	0.25	99.66
15	17	1	0.01	99.99	25	0.22	99.88
16	23	1	0.01	100.00	13	0.12	100.00
	Total	**8980**	**100**		**11212**	**100**	

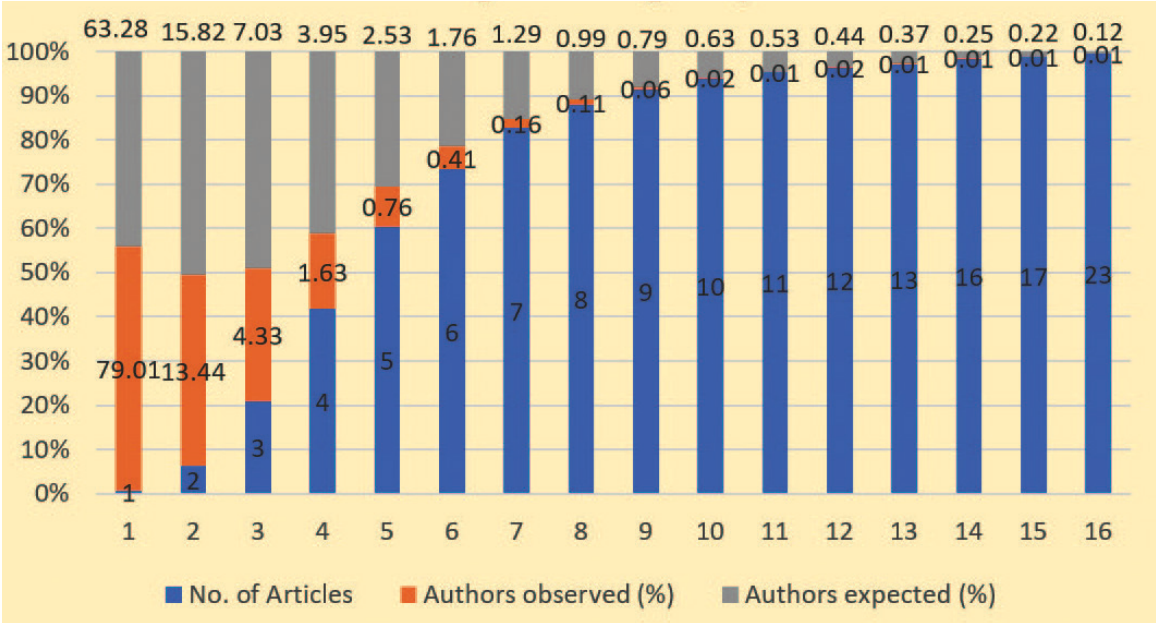

Figure 2. Observed and expected frequency of author.

author values using the subsequent formula:

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

Wherea(n): Number of authors contributing 'n' number of articles.

a(1): Number of authors contributing one article.

'n': Numberof articles. (i.e., 1, 2, 3,……..)

Initially, the expected number of authors is taken as 7095, resulting in a value of 7095 for a(1). Subsequently, the calculation for the expected number of authors for two articles can be carried out as follows:

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

and a(1) = 7095

Inserting these values into the formula gives the expected number of authors contributing two articles.

a(2) = 7095/22

a(2) = 1774

Moreover, in the case of 3 articles, the expected number of authors is as follows:

a(3) = 7095/32

a(3) = 788

Subsequently, for 4, 5, 6, and so on articles, the expected number of authors will be computed using the formula mentioned above.

6.6 Observed and Expected Frequency of Authors

This method determines the remaining expected values shown in Table 6. Percentages are based on observed and expected author totals. Analysis of Table 6 shows 8,980 observed authors and 11,212 expected authors.

6.7 K-S Test of Observed and Expected Authors' Frequency

To apply the K-S test, calculate the deviation between observed and expected author numbers. Determine the frequencies of these numbers, shown as cumulative frequencies in Table 7 maximum deviation of 15.73 (Dmax) is noted in the cumulative frequency comparison between the observed and expected values. The determination of the critical value takes place considering a significance level of 0.01, and it is computed as follows:

6.7.1 K-S Statistics

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

In this context, "n" represents the count of authors observed during the study, with a total of 8980 authors (see Table 6).

$$\boldsymbol{Statistics} = \frac{\mathbf{1.63}}{\sqrt{\mathbf{8980}}}$$

$$\boldsymbol{Statistics} = \mathbf{0.017}$$

The value of Dmax, which is 15.73 (See Table 7), Exceeding the K-S statistic of 0.017 indicates that the given data does not follow Lotka's law. This implies that within the scope of this study, Lotka's Law of Scientific Productivity does not apply to the dataset selected within the field of Archaeology. The calculated critical value (cv) for the selected dataset is 0.035, which is also lower than the Dmax value of 15.73. This suggests that Lotka's Law does not apply to this study.

6.8 Chi-Square (X^2) Test

Table 8 displays Chi-Square test results on author productivity according to Lotka's Law.

The Chi-square goodness-of-fit test is used to validate if the author's productivity frequency follows Lotka's

Table 7. K-S Test of observed and expected authors' frequency

S. No.	Articles (in numbers)	Cumulative % Sn(x)	Cumulative % Fo(x)	Dmax = |Fo(x)-Sn(x)|
1	1	79.01	63.28	**15.73**
2	2	92.45	79.10	13.35
3	3	96.78	86.13	10.65
4	4	98.41	90.08	8.33
5	5	99.17	92.61	6.56
6	6	99.58	94.37	5.21
7	7	99.74	95.66	4.08
8	8	99.85	96.65	3.20
9	9	99.91	97.44	2.47
10	10	99.93	98.07	1.86
11	11	99.94	98.60	1.34
12	12	99.96	99.04	0.92
13	13	99.97	99.41	0.56
14	16	99.98	99.66	0.32
15	17	99.99	99.88	0.11
16	23	100.00	100.00	0.00

Table 8. Chi-Square (X2) test on productivity of authors

No. of articles	Observed authors (Fo)	Expected authors (Fe)	(Fo-Fe)	$(Fo-Fe)^2$	$(Fo-Fe)^2/Fe$
1	7095	7095	0	0	0
2	1207	1774	567	321489	181.223
3	389	788	399	159201	202.032
4	146	443	297	88209	199.117
5	68	284	216	46656	164.282
6	36	197	161	25921	131.579
7	15	145	130	16900	116.552
8	10	111	101	10201	91.901
9	5	88	83	6889	78.284
10	2	71	69	4761	67.056
11	1	59	58	3364	57.017
12	2	49	47	2209	45.082
13	1	42	41	1681	40.024
16	1	28	27	729	26.036
17	1	25	24	576	23.040
23	1	13	12	144	11.077
Total	**8980**				**X^2 = 1434.302**

law. Outcomes are structured and presented in Table 8. The computed chi-square value in this dataset is 1434.302, exceeding the theoretical critical value of Chi-Square at a significance level of 5 % or 0.05 for 15degrees of freedom, which is 24.996. Consequently, the obtained Chi-Square value (1434.302) surpasses the theoretical value (24.996). Thus, Lotka's law does not apply to the literature output in archaeology.

7. FINDINGS OF THE STUDY

In this section, we go through the findings obtained from our study, offering a comprehensive overview of the outcomes derived from our data analysis and exploration of the research questions posed earlier.

The year 2021 records the highest publication count at 876 (23.41 %), while the lowest count is noted in the year 2022. Doubling Time for publications is rising. Over 60 % of research works are multi-authored, with a collaboration degree of 0.68. The top 7 authors each have at least 10 articles, with Eren MI leading with 23 publications. 8980 authors contributed 3742 research articles, and the distribution is as follows 7095 (79.01 %) authors contributed only one research article, 1207 (13.44 %) authored two articles, and so on. The study's outcomes revealed the exponent 'n' (-3.337), constant 'c' (0.873), and critical value 'cv' (0.035) as significant metrics within the examined context. A total of 8980 authors were observed, compared to an expected total of 11212 authors. Dmax value is 15.73 noted in the cumulative frequency comparison between the observed and expected values and the chi-square (X2) value in this dataset is 1434.302. So, the null hypothesis can be rejected.

8. CONCLUSION

The above findings provide a valuable contribution to understanding research productivity and collaborative patterns in the examined field. After applying Lotka's Law and based on the comprehensive data analysis, the study revealed several significant findings. The year 2021 marked the peak of publication activity with 876 articles (23.41 %), while the lowest was recorded in 2022. An increasing trend in Doubling Time (Dt.) for publications was observed, indicating a growing pace of research output. Multi-authored publications dominate, with over 60 % of research involving multiple contributors, and a Degree of Collaboration of 0.68 was identified.

Among the authors, the top 7 contributed at least 10 articles each, with Eren MI being the most prolific with 23 publications. A total of 8980 authors produced 3742 research articles, with 7095 authors (79.01 %) contributing only one article, and 1207 (13.44 %) contributing two. The bibliometric analysis revealed significant metrics, including an exponent 'n' of -3.337, a constant 'c' of 0.873, and a critical value 'cv' of 0.035. The observed total number of authors (8980) was compared to the expected total (11212), with a Dmax value of 15.73, indicating a significant deviation. The K-S and Chi-Square tests both were employed to verify Lotka's Law applicability to the dataset. However, both goodness-of-fit tests rejected the hypothesis that Lotka's Law of Scientific Productivity accurately applies to the dataset chosen within the realm of Archaeology. Thus, the data indicates that Lotka's Law of Scientific Productivity does not apply to Archaeology's published literature.

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