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Application of Lotka's Law Price's Square Root and Pareto Principle on Research Publications of Manonmaniam Sundaranar University - A Scientometric Analysis

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APPLICATION OF LOTKA'S LAW PRICE'S SQUARE ROOT AND PARETO PRINCIPLE ON RESEARCH PUBLICATIONS OF MANONMANIAM SUNDARANAR UNIVERSITY - A SCIENTOMETRIC ANALYSIS

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Abstract

This study analyzes the application of lotka's law, Price's square root law, Pareto principle and collaborative measures on Manonmaniam Sundaranar University research publications. The data retrieved and downloaded from Web of Science database from the year 1992 to 2020. The findings of the study revealed that the highest number of publications is in the year 2018 with 200 records. Multi authored contributed 97.80% of research publications whereas single authored contributed only 2.20% of total contribution. Padiyan DP is the most prolific author with 94 records during the study period. Mohanraj K and Sivakumar G is collaborated highest number of research publications with 56 records in the dataset. The highest number of publications collaborated between India and USA with 89 records. Collaborative measures such as degree of collaboration (0.99), collaborative index (9.26%), collaborative coefficient (0.67) and modified collaborative coefficient (0.66) for the study period. The study also applied statistical tool such as Kolmolgorov-Smirnov goodness of fit test to verify Lotka's law.

Keywords: *Lotka's law, Price's square root law, Pareto principle, Collaborative measures, Manonmaniam Sundaranar University, Bibexcel.*

Introduction

Scientometrics is the branch of information science which measured the quality and quantity of the research publications in the field of science related topics. The analysis of the scientific publications in the institution is an important aspect for research activities. The effectiveness of research publications can be measured through various bibliometrics laws. It is tool for the scientific communities to find the growth of particular topics in the globe. It can also measure the research publications which collaborated with other countries, universities, authors etc. It helps to evaluate the quality of research publications, performance, and the growth of literature in the science disciplines. In the academic institution, the study of scientometrics carried out for the analysis of research output in various aspects.

ManonmaniamSundaranar University was established on 7th September 1990 for the benefits of Tirunelveli, Tuticorin, Tenkasi and Kanyakumari district students. The name of the University in the name of Prof. P.Sundaram Pillai. He is very good poet. His "Tamil ThaaiVazhthu" is the official invocation song in Tamilnadu.

This paper deals with the application of Lotka's law, Price's square root law, Pareto principle and collaborative measure of research publications on Manonmaniam Sundaranar University from 1992 to 2020.

Review of Literature

Rathika, Thansukodi and Sudhakar (2020) studied the pattern of scientific productivity in the marine pollution literature. They also verified Lotka's law, Bradford's law and Price's square root law to the dataset which downloaded from Scopus database during 1989 to 2018.

Thamaraiselvi, Lakshmi and Manthiramoorthi (2020) have attempted a scientometric study to verify the applicability of Lotka's law in current science journal using general power method and inverse square method. Data downloaded from web of science database from 2014 to 2018. Statistical tool such as K-S test and Chi-Square test used to verify the fitness of Lotka's law to the dataset. They concluded that the dataset doesn't confirm the applicability of Lotka's law in both statistical methods.

Kumar and Pandey (2017) conducted a study to find the authorship pattern and collaborative measures on research work of Kumaun University. A total of 320 articles downloaded from the online databases such as SodhSindhu, Google Scholar and Research Gate for the period of 2010 to 2014. They revealed that multi authored papers dominant than

the single authored paper so the degree of collaboration is 0.95. The highest value of collaborative index is 4.94 in the year 2014 and collaborative coefficient is 0.99 in 2013.

Senthilkumar and Ulaganathan (2017) applied statistical tool such as K-S test, Lotka's law, Price's square root law and Pareto principle on Astrophysics research output in India using web of science database from the year 1998 to 2014. They concluded that the dataset doesn't fit to the laws.

Objectives

1. To find out year wise distribution of research publications.
2. To analyse the authorship pattern.
3. To find the most prolific authors.
4. To find the author collaboration.
5. To identify the country collaboration.
6. To find out the degree of collaboration, collaborative index, collaborative coefficient and modified collaborative coefficient.
7. To examine the fitness of Lotka's law, Price square root law and Pareto principle.
8. To analysis Kolmolgorov-Smirnov (K-S) Test.

Hypothesis

1. There is a steady growth of research publications during the study period.
2. The research publications fit to the Lotka's law, Price's square root law and Pareto principle.

Scope and Limitation

The study helps to evaluate the performance of faculty members in the research publications of Manonmaniam Sundaranar University. The faculty members individually or collectively contributed with other university faculties in same subject or relevant subject.For the present study, Manonmaniam Sundaranar University research productivity is considered from 1992 to 2020[accessed on 23rd March 2020]. It focussed on the research publications of various department faculty members and analysis was conducted using Bibexcel, Pajek and MS Excel software for tabulation and calculation.

Methodology

The main objectives of the study are to evaluate the quality of the research publications contributed by various department faculty members in Manonmaniam Sundaranar University, Tirunelveli, Tamilnadu, India. For the study, data retrieved and downloaded from Web of Science database from 1992 to 2020 [accessed on 23rd March

2020]. The bibliographic details such as year wise distribution, authorship pattern and collaborative measures etc analyzed using Bibexcel and MS Excel software packages.

Data Analysis and Interpretation

A total of 1546 records were published from Manonmaniam Sundaranar University during the study period. The research output analysed using various scientometric indicators.

Table 1: Year wise growth of research publications

Year	No. of Records	Percentage (%)
1992	2	0.13
1993	5	0.32
1994	4	0.26
1995	19	1.23
1996	11	0.71
1997	12	0.78
1998	15	0.97
1999	23	1.49
2000	21	1.36
2001	22	1.42
2002	16	1.03
2003	20	1.29
2004	24	1.55
2005	20	1.29
2006	14	0.91
2007	37	2.39
2008	37	2.39
2009	46	2.98
2010	59	3.82
2011	71	4.59
2012	80	5.17
2013	93	6.02
2014	91	5.89
2015	114	7.37
2016	157	10.16
2017	148	9.57
2018	200	12.94
2019	158	10.22
2020	27	1.75
Total	**1546**	**100.00**

Table 1 shows the year-wise distribution of Manonmaniam Sundaranar University research productivity from the year 1992 to 2020 March. A total of 1546 records published

during the given period. The highest number of publications is in the year 2018 with 200 records, followed by 2019 with 158 records, 157 records in 2016 and 148 records in the year 2017. The lowest number of publications is the year 1992 to 1994. It also observed that more than 110 publications recorded in the year 2015 to 2019 and there is some fluctuation in the growth of research productivity for the study period.

Hypothesis 1:

There is a steady growth of research publications during the study period.

The year-wise distribution of research publications explained that there is some fluctuation in the growth of research publications during the study period. Hence null hypothesis rejected for the above statement.

Table 2: Authorship pattern of research publications

Authorship pattern	Records	Percentage (%)
Single	34	2.20
Two	410	26.52
Three	388	25.10
Four	234	15.14
Five	174	11.25
Six	122	7.89
Seven	62	4.01
Eight	44	2.85
Nine	21	1.36
Ten	13	0.84
More than Ten Authors	44	2.85
Total	**1546**	**100.00**

Table 2 reveal the authorship pattern of research publications. Out of 1546 records, 26.52% of publications contributed by two authored followed by 25.10% by three authored and 15.14% by four authored whereas 2.20% of publications contributed by single authored. Hence it concluded that 97.80% of the research publications contributed by multi authored and single authored contribution is very low.

Table 3: Most Prolific Authors

Authors	No. of Records	Percentage (%)
Padiyan DP	94	6.08
Chandrasekar N	75	4.85
Senthil-Nathan S	70	4.53
Nair MS	67	4.33
Mohanraj K	58	3.75
Sivakumar G	57	3.68
Subramanian E	46	2.97
Palavesam A	43	2.78
Murugesan AG	43	2.78
Immanuel G	42	2.71
Arunachalam M	39	2.52
Magesh NS	38	2.45
Kumaresan S	37	2.39
Citarasu T	36	2.32
Henry J	33	2.13
Thanigaivel A	32	2.06
Rajasekaran TR	30	1.94
Sundarakannan B	29	1.87
Annadurai G	28	1.81
Kalaivani K	28	1.81
Vincent SGP	28	1.81
Vasantha-Srinivasan P	28	1.81
Baskar K	28	1.81
Veluraja K	27	1.74
Ponsankar A	26	1.68
Rajasekar S	26	1.68

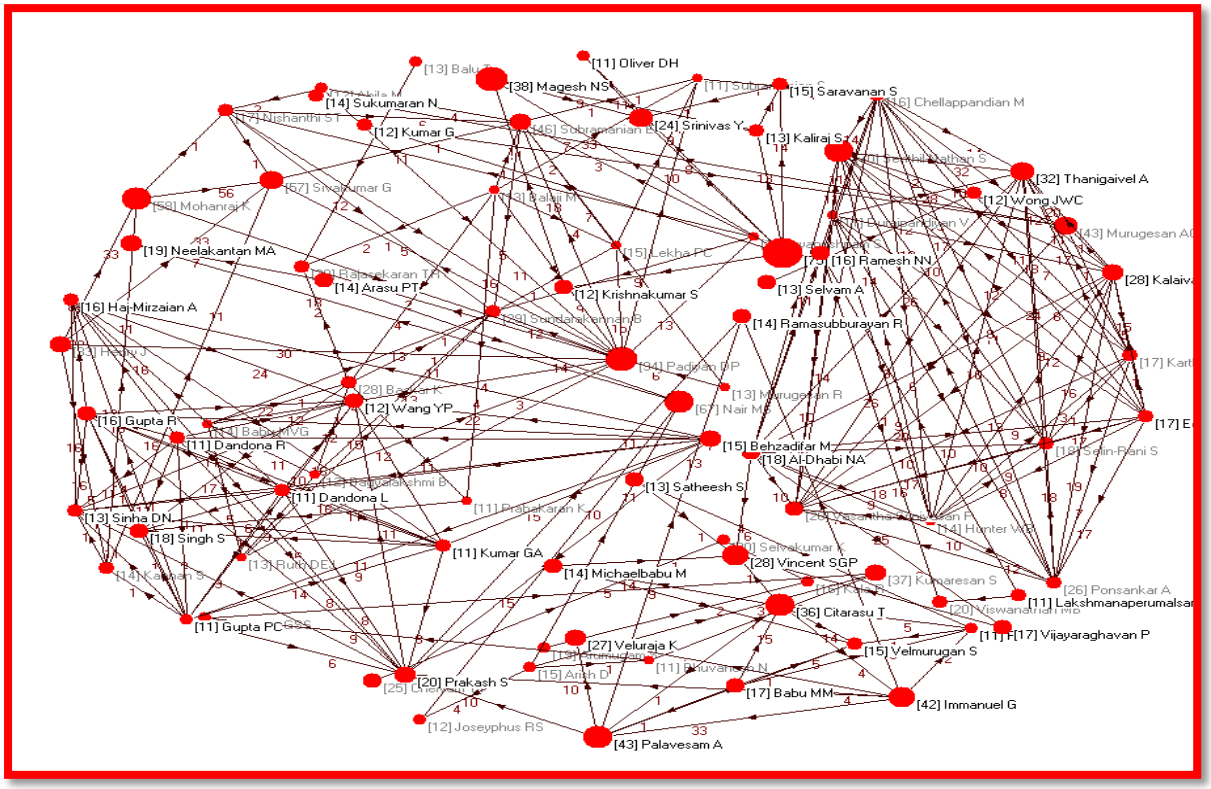
Table 3 shows the most prolific authors contributed on Manonmaiam Sundaranar University. The highest number of research publications contributed by Padiyan DP (94) followed by Chandrasekar N with 75 research publications, Sentil-Nathan S with 70, Nair MS with 67 and Mohanraj N with 58 research publications. Hence it concluded that top five prolific authors contributed 23.54% of total research publications.

Table 4: Author Collaboration

Author	Collaborated Author	No. of Records	Percentage (%)
Mohanraj K	Sivakumar G	56	3.62
Henry J	Mohanraj K	33	2.13
Henry J	Sivakumar G	33	2.13
Immanuel G	Palavesam A	33	2.13
Chandrasekar N	Magesh NS	33	2.13
Senthil-Nathan S	Thanigaivel A	32	2.06
Behzadifar M	Haj-Mirzaian A	30	1.94
Senthil-Nathan S	Vasantha-Srinivasan P	28	1.81
Gupta R	Haj-Mirzaian A	28	1.81
Kalaivani K	Senthil-Nathan S	28	1.81
Ponsankar A	Senthil-Nathan S	26	1.68
Thanigaivel A	Vasantha-Srinivasan P	26	1.68
Behzadifar M	Gupta R	26	1.68
Ponsankar A	Vasantha-Srinivasan P	25	1.61
Haj-Mirzaian A	Wang YP	24	1.55
Ponsankar A	Thanigaivel A	24	1.55
Gupta R	Wang YP	22	1.42
Behzadifar M	Wang YP	22	1.42
Kalaivani K	Vasantha-Srinivasan P	20	1.29
Kalaivani K	Thanigaivel A	20	1.29

From the above table it clearly indicates the author collaboration of research publications. Out of 1546 records, Mohanraj K and Sivakumar G collaborated highest number of research publications with 56 records followed by Henry J and Mohanraj K with 33 records, Henry J and Sivakumar G with 33 records, Immanuel collaborated with Palavesam A published 33 records, Chandrasekar N and Magesh NS with 33 records and so on.

Figure: 1: Network of Author Collaboration



Pajek software used to create the author collaborative network figure.

Table 5: Country Collaboration

Country	Collaborated country	No. of Records	Percentage (%)
India	USA	89	5.75
India	Saudi Arabia	61	3.94
India	South Korea	49	3.16
India	Peoples R China	42	2.71
India	Japan	33	2.13
Germany	India	22	1.42
India	Italy	21	1.35
India	UK	20	1.29
Australia	India	20	1.29
India	Mexico	19	1.22
Australia	USA	19	1.22
India	Malaysia	19	1.22
France	India	19	1.22
Egypt	India	19	1.22
India	Portugal	19	1.22

Table 5 explained the collaboration of countries in the research publications on Manonmaniam Sundaranar University. The highest number of publications collaborated between India and USA with 89 records followed by India and Saudi Arabia (61), India and South Korea with 49 records India and Peoples R China with 42 publications, India and Japan

with 33 records and so on. Hence it concluded that India is collaborated total of 23.99% of the research publications with other countries in the dataset.

Figure 2: Network of Country Collaboration

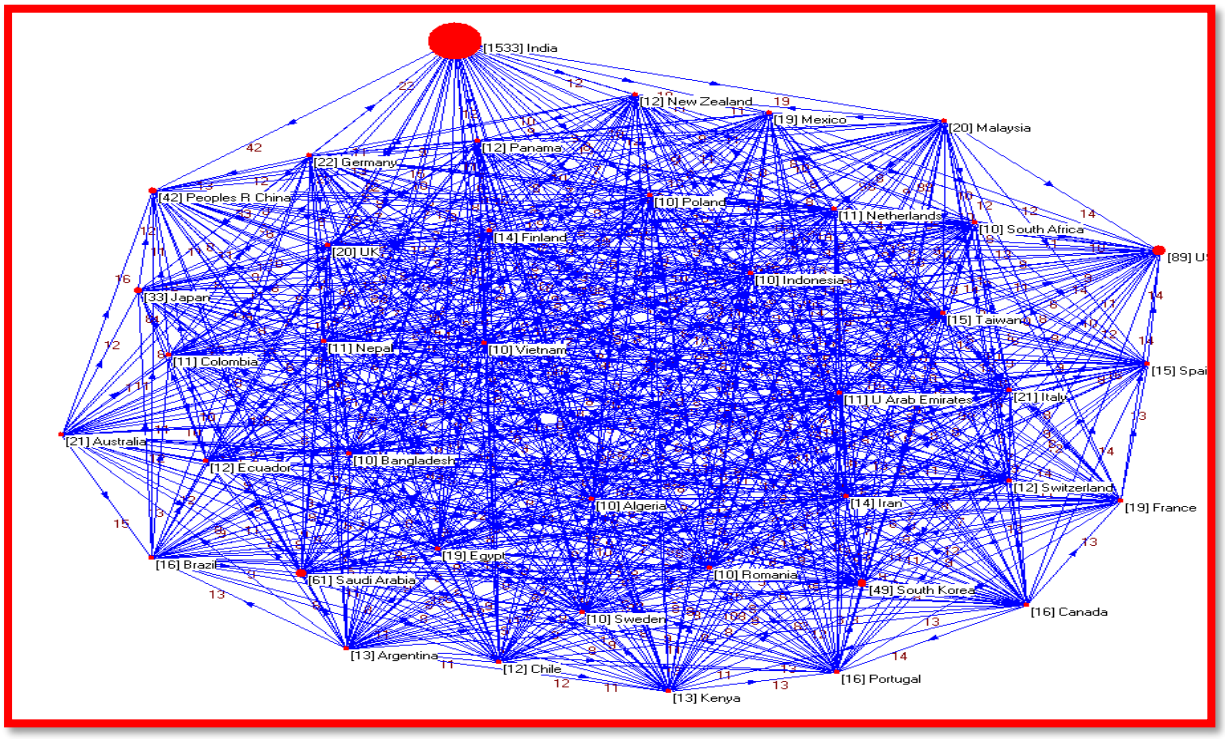


Table 6: Collaborative measures of research publications

Authorship pattern	Records	DC	CI	CC	MCC
Single	34	0.99	9.26	0.67	0.66
Two	410				
Three	388				
Four	234				
Five	174				
Six	122				
Seven	62				
Eight	44				
Nine	21				
Ten	13				
More than Ten Authors	44				
Total	**1546**				

Table 6 revealed the collaborative measures of research publications of Manonmaniam Sundaranar University. Collaborative measures such as degree of collaboration, collaborative

index, collaborative coefficient and modified collaborative index calculated using the formula derived by Subramanyam (DC), Lawani (CI), and Ajiferuke, Burell and Tague (CC & MCC). The analyze of the dataset shows that the degree of collaboration is 0.99, collaborative index is 9.26, collaborative coefficient is 0.67 and modified collaborative coefficient is 0.66. Hence it concluded that multi authored papers contributed more than the single authored papers. From the above discussion it also concluded that very high collaborative research activities found in Manonmaniam Sundaranar University research publications during the study period.

Application of Lotka's law

Alfred Lotka's explained the frequency of scientific productivity of authors in a given dataset. In this study straight count method and inverse square root method used to verify the Lotka's law. Below table determined the calculated value of n, c and c.v.

Table 7: Determining the Value of n, c and c.v.

No. of Publications (x)	No. of Authors (y)	X (Log x)	Y (Log y)	X^2	X*Y	x^n	$1/x^n$
1	1211	0.0000	7.0992	0.0000	0.0000	1.0000	1.0000
1	1159	0.0000	7.0553	0.0000	0.0000	1.0000	1.0000
1	1042	0.0000	6.9489	0.0000	0.0000	1.0000	1.0000
1	1021	0.0000	6.9285	0.0000	0.0000	1.0000	1.0000
2	988	0.6931	6.8957	0.4805	4.7797	1.0317	0.9693
1	979	0.0000	6.8865	0.0000	0.0000	1.0000	1.0000
1	374	0.0000	5.9243	0.0000	0.0000	1.0000	1.0000
1	167	0.0000	5.1180	0.0000	0.0000	1.0000	1.0000
1	81	0.0000	4.3944	0.0000	0.0000	1.0000	1.0000
1	67	0.0000	4.2047	0.0000	0.0000	1.0000	1.0000
1	53	0.0000	3.9703	0.0000	0.0000	1.0000	1.0000
1	35	0.0000	3.5553	0.0000	0.0000	1.0000	1.0000
1	34	0.0000	3.5264	0.0000	0.0000	1.0000	1.0000
1	32	0.0000	3.4657	0.0000	0.0000	1.0000	1.0000
1	29	0.0000	3.3673	0.0000	0.0000	1.0000	1.0000
1	27	0.0000	3.2958	0.0000	0.0000	1.0000	1.0000
1	22	0.0000	3.0910	0.0000	0.0000	1.0000	1.0000
2	21	0.6931	3.0445	0.4805	2.1103	1.0317	0.9693

1	18	0.0000	2.8904	0.0000	0.0000	1.0000	1.0000
1	16	0.0000	2.7726	0.0000	0.0000	1.0000	1.0000
2	15	0.6931	2.7081	0.4805	1.8771	1.0317	0.9693
1	14	0.0000	2.6391	0.0000	0.0000	1.0000	1.0000
7	13	1.9459	2.5649	3.7866	4.9912	1.0915	0.9162
4	12	1.3863	2.4849	1.9218	3.4448	1.0644	0.9395
8	11	2.0794	2.3979	4.3241	4.9863	1.0981	0.9107
13	10	2.5649	2.3026	6.5790	5.9060	1.1223	0.8910
21	9	3.0445	2.1972	9.2691	6.6895	1.1468	0.8720
44	8	3.7842	2.0794	14.3201	7.8690	1.1856	0.8434
62	7	4.1271	1.9459	17.0332	8.0310	1.2041	0.8305
122	6	4.8040	1.7918	23.0786	8.6077	1.2413	0.8056
174	5	5.1591	1.6094	26.6159	8.3032	1.2613	0.7928
234	4	5.4553	1.3863	29.7605	7.5627	1.2782	0.7823
388	3	5.9610	1.0986	35.5336	6.5488	1.3077	0.7647
410	2	6.0162	0.6931	36.1941	4.1701	1.3109	0.7628
34	1	3.5264	0.0000	12.4352	0.0000	1.1720	0.8533
1546	**7496**	**30.9750**	**119.1562**	**108.3697**	**67.5957**	**32.5106**	**29.7095**

n= 0.46., c = 0.0336., c.v = 0.018.

Table 8: Kolmolgorov-Smirnov (K-S) Test (n=0.46)

No. of Publications (x)	No. of Authors (y)	Observed Authors (Fo)		Expected Authors (Fe)		Deviation (Fo-Fe)
		%	Cumulative %	%	Cumulative %	
1	1211	0.162	0.162	0.034	0.034	0.128
1	1159	0.155	0.316	0.034	0.034	0.283
1	1042	0.139	0.455	0.034	0.034	0.422
1	1021	0.136	0.591	0.034	0.034	0.558
2	988	0.132	0.723	0.024	0.024	0.699
1	979	0.131	0.854	0.034	0.034	0.820
1	374	0.050	0.904	0.034	0.034	0.870
1	167	0.022	0.926	0.034	0.034	0.892
1	81	0.011	0.937	0.034	0.034	0.903

1	67	0.009	0.946	0.034	0.034	0.912
1	53	0.007	0.953	0.034	0.034	0.919
1	35	0.005	0.957	0.034	0.034	0.924
1	34	0.005	0.962	0.034	0.034	0.928
1	32	0.004	0.966	0.034	0.034	0.933
1	29	0.004	0.970	0.034	0.034	0.936
1	27	0.004	0.974	0.034	0.034	0.940
1	22	0.003	0.977	0.034	0.034	0.943
2	21	0.003	0.979	0.024	0.024	0.955
1	18	0.002	0.982	0.034	0.034	0.948
1	16	0.002	0.984	0.034	0.034	0.950
2	15	0.002	0.986	0.024	0.024	0.962
1	14	0.002	0.988	0.034	0.034	0.954
7	13	0.002	0.990	0.014	0.014	0.976
4	12	0.002	0.991	0.018	0.018	0.973
8	11	0.001	0.993	0.013	0.013	0.980
13	10	0.001	0.994	0.010	0.010	0.984
21	9	0.001	0.995	0.008	0.008	0.987
44	8	0.001	0.996	0.006	0.006	0.990
62	7	0.001	0.997	0.005	0.005	0.992
122	6	0.001	0.998	0.004	0.004	0.994
174	5	0.001	0.999	0.003	0.003	0.996
234	4	0.001	0.999	0.003	0.003	0.996
388	3	0.000	1.000	0.002	0.002	0.997
410	2	0.000	1.000	0.002	0.002	**0.998**
34	1	0.000	1.000	0.007	0.007	0.993

Table 8 shows the Kolmogorov – Smirnov goodness of fit test to verify the Lotka's law. It clearly explained that maximum difference between the observed and expected frequency of the author productivity at 5% level of significance. In the present study the critical value (0.018) which is less than that of maximum difference (0.998). Hence it concluded that the application of Lotka's law doesn't fit to the Manonmaniam Sundaranar University research publications.

Application of Price's Square Root and Pareto Principle

Table 9: Price's Square Root and Pareto Principle

No. of Publications (x)	No. of Authors (y)	%	Total Contribution	%
1	1211	16.155	1211	8.458
1	1159	15.462	1159	8.095
1	1042	13.901	1042	7.278
1	1021	13.621	1021	7.131
2	988	13.180	1976	13.802
1(1540)	**979(2075)**	**13.060(27.68)**	**979(7908)**	**6.838(55.24)**
1	374	4.989	374	2.612
1	167	2.228	167	1.166
1	81	1.081	81	0.566
1	67	0.894	67	0.468
1	53	0.707	53	0.370
1	35	0.467	35	0.244
1	34	0.454	34	0.237
1	32	0.427	32	0.224
1	29	0.387	29	0.203
1	27	0.360	27	0.189
1	22	0.293	22	0.154
2	21	0.280	42	0.293
1	18	0.240	18	0.126
1	16	0.213	16	0.112
2	15	0.200	30	0.210
1	14	0.187	14	0.098
7(1521)	**13 (91)**	**0.173(1.21)**	**91(5888)**	**0.635(41.13)**
4	12	0.160	48	0.335
8	11	0.147	88	0.615
13	10	0.133	130	0.908
21	9	0.120	189	1.320
44	8	0.107	352	2.459
62	7	0.093	434	3.031
122	6	0.080	732	5.113
174	5	0.067	870	6.077
234	4	0.053	936	6.538
388	3	0.040	1164	8.130
410	2	0.027	820	5.727
34	1	0.013	34	0.237
Total	7496	100	14317	100

Price's Square root law

Price's square root law used to validate the distribution status of authors who published research publications in Manonmaniam Sundaranar University during study period. The calculation of PSQ based on the below formula.

PSQ = $\sqrt{N}$

N = 7496

PSQ =$\sqrt{7496}$ = 86.57.

Based on the above calculation, PSQ law value located at 41.13% of total contribution which is less than 50% (half of the research publications). So this result is not fit to the Price's square root law. The second highlighted value in the above table shows the related result.

Pareto Principle (80/20 Rule)

Pareto principle used to validate whether of 80% of contributions does come from 20% of the contributors. The first highlighted value of above table denoted the analyzed value of Pareto principle for Manonmaniam Sundaranary University research publications. Since the total authors are 7496 that mean 20% of the total authors is 1499.2%.

Total number of authors =7496.

20% of authors from total authors = 1499.2.

Total number of publications = 1546.

80% of publications from total publications = 1236.8.

Based on the above calculated value 27.68% of authors contributed nearly 55.24% of the total contribution. According to the Pareto principle the value of the total contribution less than that of 80% so we can conclude that this result is not fit to the Pareto principle.

Hypothesis 2:

The research publications fit to the Lotka's law, Price's square root law and Pareto principle.

The maximum difference is less than that of critical value so the application of Lotka's law doesn't fit to the data set, Price's square root law less than that of 50% of the research publications and Pareto principle value is less than that of 80% of total contribution. Hence it concluded that null hypothesis rejected.

Conclusion

This study concluded that the highest number of publications is in the year 2018 with 200 records, followed by 2019 with 158 records, 157 records in 2016 and 148 records in the year 2017 whereas the lowest number of publications is the year 1992 to 1994. Out of 1546 records, 26.52% of publications contributed by two authored followed by 25.10% by three authored and 15.14% by four authored whereas 2.20% of publications contributed by single authored. Padiyan DP is the most prolific author with 94 records during the study period. Mohanraj K and Sivakumar G is collaborated highest number of research publications with

56 records in the dataset. The highest number of publications collaborated between India and USA with 89 records. The study also concluded the collaborative measures such as degree of collaboration (0.99), collaborative index (9.26), and collaborative coefficient (0.67) whereas modified collaborative coefficient (0.66). The application of Lotka's law using the statistical tool such as K-S test, Price's square root law and Pareto principle doesn't fit to the dataset.

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