



## Contribution of BRICS nations in Physics: application of Bradford law

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### Abstract

Present paper attempts to verify applicability of Bradford's Law of scattering to the cotemporary physics literature. The data for the study was sourced from Web of Science Core Collection database; it comprises a large number of 2,06,383 research articles published across BRICS nations in various sub-streams areas of physics covering 6-year period i.e. 2007-12. The study reports that there is a deviation in the distribution of journals in the 2<sup>nd</sup> and 3<sup>rd</sup> zones from the normal Bradford distribution. Concludes that current research publication trends in research communication in physics literature are moving towards a new direction, quite different from the past trends.

**Keywords:** BRICS ; Bradford's law of scattering; Physics literature; Physics Core Journals

### 1 Introduction

Bradford formulated the law of scattering across journals in 1948 and claimed that for a given subject area "there are a few very productive periodicals, a larger number of more moderate producers, and a still larger number with constantly diminishing productivity" Bradford (1953). He observed that information on a given subject is dispersed in a certain pattern, which is known as Bradford distribution, or Bradford's law of scattering. Bradford originally developed his findings on the basis of studying the distribution of articles in journals in the fields of electrical engineering, applied geophysics and lubrication."The law of distribution of papers on a given subject in scientific periodicals may thus be stated: 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 number of articles as the nucleus, when the numbers of periodicals in the nucleus and succeeding zones will be as 1: n: n<sup>2</sup>”. The journals in the first segment are characterized as core journals that of highest importance to researchers, those in the 2<sup>nd</sup> segment are of moderate importance, and those in the third and the last segment comprises long tail of journals and are of marginal importance to the researchers in the discipline.”, (Xu, 2011).

## **2 Literature Review**

A number of studies have been conducted on the subject in particular to test the applicability of Bradford’s law of scattering. Nash-Stewart, Kruesi & Mar (2012) studied the application of Bradford Law in Cochrane Reviews literature and found that Bradford's law was not useful for predicting the size of the literature on a subject from the number of articles appearing in core journals. Wardikar & Gudadhe (2013) explored Bradford's Law of Scattering to the Literature of Library & Information Science. In a study of doctoral theses citations submitted to the Universities of Maharashtra, they found that journal distribution pattern in library and information science theses does not fit into Bradford distribution pattern. A study conducted by Tripathi and Sen (2016) examined the application of Bradford law in crop science literature, and concluded that the distribution of journals does not fit into the Bradford's distribution pattern..

## **3 Objectives of the study**

- To verify applicability of Bradford law of scattering to contemporary physics literature as contributed by BRICs nations during 2007-12
- To bring out a list of most productive journals in the field of Physics literature.

## **4 Methodology**

The study sourced data on research publications in physics contributed by BRICS nations (Brazil, Russia, India, China, and South Africa) from the international database Web of Science covering the period 2007-12. The gathered data was cleaned and analyzed for ranking the source journals as per the productivity of articles they published. The Bradford law was tested both empirically and graphically using BRICS publications data in the subject for the purpose.

## **5 Data Analysis**

BRICS nations jointly have published a total of 253001 publications in physics stream during the period 2007-12. Their research output appeared across several different types of publication sources like journals, conference proceedings, books, and reports. The study finds that journal type publication sources accounted for the largest share of BRICS nations output. In all, a total of 206383 articles (81.57%) had appeared across 1558 source journals (Table 1). All of 1558 source journals were ranked according to the decreasing order of the productivity (from 1 to 5452 articles) they covered during the period (Table 2, Appendix A).

The BRICS nation output of 206383 articles across 1558 journals was sorted into three zones, each zone to comprise 68794 articles, amounting to  $1/3^{\text{rd}}$  of the total output. Whereas, this study finds that referenced productivity figure of 68794 articles and actual productivity data figures as available in Table 2 do not match zone-wise exactly. Therefore, such productivity figures as available in Table 1 (comprising 68670, 69007, and 68706 articles zone-wise respectively) as being the closest match to the referenced figure of 68794 articles (the  $1/3^{\text{rd}}$  of total output), have been considered for verification of Bradford law of scattering (Table 2).

In the 1<sup>st</sup> zone, 32 journals accounted for 68670 articles, and in the 2<sup>nd</sup> zone, 103 journals accounted for 69007 articles. The Bradford multiplier 'n' was derived by dividing number of journals in the 2<sup>nd</sup> zone (103) by the number of journals in the 1<sup>st</sup> zone (32) *i.e.*  $103/32 = 3.21$ . Since Bradford multiplier has to be an integer, the resultant figure of 3.21 has been rounded off to integer 3.

Table 1

Distribution of Source Journals by Bradford Zones

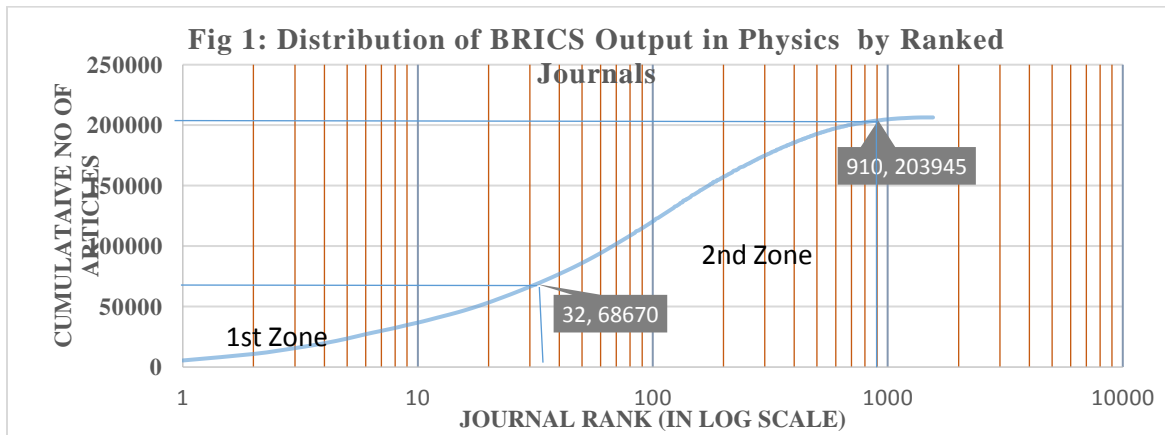
Bradford Journal Zones	Actual # of Articles that Journals published	Actual # of Journals by Zones which Account for ( $1/3^{\text{rd}}$ of Total Articles)	Bradford Ratio of Journals by Zones	# of Journals Derived according to Bradford Journal Ratio	Difference in # of Journals between Actual and Derived figures by Zones (3 & 5)
1	2	3	4	5	6
1 <sup>st</sup> Zone	68670	32	1	32	0
2 <sup>nd</sup> Zone	69007	103	3	96	-7
3 <sup>rd</sup> Zone	68706	1423	9	288	-1135
Total	206383	1558	Ratio= 1:3:3 <sup>2</sup>	416	-1142



Using 3 as the Bradford multiplier, the distribution of journals across three zones was determined in line with Bradford ratio  $1:3:3^2$ . Accordingly, the first zone is deemed to have 32 journals, the middle zone to have 96 journals ( $32 \times 3 = 96$ ), and the third zone to have 288 journals ( $32 \times 3 \times 3 = 288$ ).

Comparing the empirically derived journal distribution (32:103:1423) and the journal distribution derived by using Bradford ratio (32:96:288), it is to be seen that they differ marginally in 2<sup>nd</sup> zone but in the 3<sup>rd</sup> zone they differ even more significantly. The 2<sup>nd</sup> zone comprises 103 journals (based on  $1/3^{\text{rd}}$  output), compared to 96 derived using Bradford ratio of  $1:3:3^2$ . The 3<sup>rd</sup> zone comprises 1423 journals (based on  $1/3^{\text{rd}}$  output), compared to 288 journals derived using Bradford ratio (see columns 3 – column 5). The wide deviation in the journal distribution derived using  $1/3^{\text{rd}}$  output data (32:103:1423), and the distribution derived using Bradford ratio (32:96:288), in particular the deviation in the 3<sup>rd</sup> zone, confirms that Bradford law of scattering is not applicable to contemporary research communication trends in physics research.

Applicability of Bradford law of scattering to contemporary physics literature has also been examined graphically by using sample data of journals (Table 2 Appendix A). Journals rank data (on a log scale) was plotted along x-axis against cumulative number of articles along y-axis (Figure 1). The study finds that the curve in the figure does not mirror a classical Bradford distribution. The middle zone depicts nearly a straight line, depicting moderate productivity type journals starting from position 33 to 910 in the journals ranking list. The 2<sup>nd</sup> zone as per illustration comprises approximately 878 journals, and 3<sup>rd</sup> zone comprises 648 journals. The journal distribution of 32:878:648 as determined graphically across three zones does not seem to conform to Bradford ratio of  $1:3:3^2$ . Given this observation, it is certain that Bradford law of scattering and distribution does not stand valid in the case of contemporary physics literature as published by BRICS nations during 2007-12.



## 6 Conclusion

The study finds that both empirically and graphically Bradford law of scattering and distribution are not applicable to contemporary literature in physics research. This deviation in the distribution of journals in the 2<sup>nd</sup> and 3<sup>rd</sup> zones from the normal Bradford distribution reflects that current research publication trends in research communication in physics literature are moving towards a new direction, quite different from the past trends.

A list of core journals describing 1<sup>st</sup> zone of Bradford law of scattering in physics literature is provided in Appendix B

## References

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## Appendix - A

Table 2

## BRICS Source Journals Ranked in the Descending Order of Productivity

Journal Rank	No of Journals	Articles	Articles Cumulative
1	1	5452	5452
2	1	5385	10837
3	1	4815	15652
4	1	4064	19716
5	1	3819	23535
6	1	3634	27169
7	1	2771	29940
8	1	2418	32358
9	1	2387	34745
10	1	1990	36735
11	1	1962	38697
12	1	1952	40649
13	1	1728	42377
14	1	1629	44006
15	1	1604	45610
16	1	1587	47197
17	1	1569	48766
18	1	1565	50331
19	1	1538	51869
20	1	1483	53352
21	1	1476	54828
22	1	1475	56303
23	1	1382	57685
24	1	1347	59032
25	1	1301	60333
26	1	1286	61619
27	1	1263	62882
28	1	1231	64113
29	1	1182	65295
30	1	1175	66470
31	1	1111	67581
32	1	1089	68670
33	1	1088	69758
34	1	1086	70844
35	1	1063	71907
36	1	1032	72939
37	1	1024	73963
38	1	1014	74977
39	1	1006	75983

Journal Rank	No of Journals	Articles	Articles Cumulative
40	1	960	76943
41	1	954	77897
42	1	941	78838
43	1	921	79759
44	1	918	80677
45	1	917	81594
46	1	907	82501
47	1	886	83387
48	1	882	84269
49	1	879	85148
50	1	866	86014
51	1	861	86875
52	1	858	87733
53	1	845	88578
54	1	841	89419
55	1	831	90250
56	1	822	91072
57	1	814	91886
58	1	801	92687
59	1	795	93482
60	1	794	94276
61	1	786	95062
62	1	784	95846
63	1	782	96628
64	1	774	97402
65	1	769	98171
66	1	760	98931
67	1	756	99687
68	1	743	100430
69	1	733	101163
70	1	731	101894
71	1	720	102614
72	1	690	103304
73	1	686	103990
74	1	679	104669
75	1	675	105344
76	1	673	106017
77	1	666	106683
78	1	652	107335



Journal Rank	No of Journals	Articles	Articles Cumulative
79	1	647	107982
80	1	633	108615
81	1	628	109243
82	1	622	109865
83	1	616	110481
84	1	614	111095
85	2	1222	112317
87	1	609	112926
88	1	607	113533
89	1	601	114134
90	1	597	114731
91	1	593	115324
92	1	584	115908
93	1	577	116485
94	1	573	117058
95	1	571	117629
96	1	568	118197
97	1	560	118757
98	1	559	119316
99	1	556	119872
100	1	550	120422
101	1	544	120966
102	1	542	121508
103	2	1080	122588
105	1	538	123126
106	1	520	123646
107	1	518	124164
108	1	516	124680
109	1	512	125192
110	1	507	125699
111	1	490	126189
112	1	483	126672
113	1	482	127154
114	1	480	127634
115	1	477	128111
116	1	476	128587
117	1	468	129055
118	1	465	129520
119	1	463	129983
120	1	459	130442
121	1	458	130900
122	1	457	131357
123	1	444	131801
124	2	884	132685
126	1	438	133123
127	1	434	133557
128	1	431	133988

Journal Rank	No of Journals	Articles	Articles Cumulative
129	1	418	134406
130	1	414	134820
131	2	822	135642
133	1	409	136051
134	1	408	136459
135	3	1218	137677
138	1	404	138081
139	2	804	138885
141	1	395	139280
142	1	388	139668
143	1	387	140055
144	1	386	140441
145	1	384	140825
146	2	750	141575
148	2	740	142315
150	1	366	142681
151	1	364	143045
152	1	357	143402
153	1	352	143754
154	1	347	144101
155	1	343	144444
156	1	342	144786
157	1	338	145124
158	1	336	145460
159	2	666	146126
161	1	327	146453
162	1	322	146775
163	1	314	147089
164	1	312	147401
165	1	308	147709
166	1	307	148016
167	1	305	148321
168	1	304	148625
169	1	303	148928
170	1	301	149229
171	1	293	149522
172	1	288	149810
173	1	285	150095
174	1	279	150374
175	2	550	150924
177	2	548	151472
179	1	271	151743
180	1	267	152010
181	4	1064	153074
185	1	264	153338
186	1	257	153595
187	1	256	153851



Journal Rank	No of Journals	Articles	Articles Cumulative
188	3	765	154616
191	1	252	154868
192	1	251	155119
193	1	249	155368
194	1	248	155616
195	2	492	156108
197	1	244	156352
198	1	243	156595
199	2	484	157079
201	2	482	157561
203	1	240	157801
204	1	235	158036
205	1	231	158267
206	1	226	158493
207	1	224	158717
208	1	222	158939
209	1	215	159154
210	2	428	159582
212	1	212	159794
213	1	211	160005
214	1	210	160215
215	1	209	160424
216	1	208	160632
217	1	205	160837
218	1	204	161041
219	3	600	161641
222	4	788	162429
226	1	194	162623
227	2	386	163009
229	2	380	163389
231	2	378	163767
233	4	752	164519
237	4	748	165267
241	2	372	165639
243	1	185	165824
244	1	184	166008
245	2	366	166374
247	1	181	166555
248	2	358	166913
250	2	356	167269
252	2	350	167619
254	2	348	167967
256	1	173	168140
257	1	172	168312
258	2	342	168654
260	1	170	168824
261	2	336	169160

Journal Rank	No of Journals	Articles	Articles Cumulative
263	1	165	169325
264	1	163	169488
265	2	322	169810
267	2	320	170130
269	1	158	170288
270	2	314	170602
272	2	308	170910
274	2	306	171216
276	2	304	171520
278	1	148	171668
279	2	294	171962
281	3	435	172397
284	2	286	172683
286	3	423	173106
289	2	280	173386
291	3	417	173803
294	2	276	174079
296	3	411	174490
299	1	135	174625
300	3	402	175027
303	2	266	175293
305	2	262	175555
307	2	260	175815
309	3	387	176202
312	1	128	176330
313	1	127	176457
314	1	126	176583
315	2	250	176833
317	2	248	177081
319	1	122	177203
320	1	120	177323
321	4	476	177799
325	3	354	178153
328	2	234	178387
330	1	115	178502
331	2	228	178730
333	1	113	178843
334	2	222	179065
336	1	110	179175
337	5	545	179720
342	3	324	180044
345	3	321	180365
348	3	315	180680
351	1	104	180784
352	4	412	181196
356	4	408	181604
360	4	404	182008





Journal Rank	No of Journals	Articles	Articles Cumulative
364	4	400	182408
368	2	198	182606
370	1	98	182704
371	2	194	182898
373	6	576	183474
379	1	95	183569
380	2	188	183757
382	4	372	184129
386	3	276	184405
389	1	91	184496
390	4	360	184856
394	1	89	184945
395	1	88	185033
396	6	522	185555
402	3	258	185813
405	1	85	185898
406	1	84	185982
407	2	166	186148
409	3	243	186391
412	4	320	186711
416	4	316	187027
420	5	385	187412
425	4	304	187716
429	3	225	187941
432	2	148	188089
434	7	511	188600
441	1	72	188672
442	6	426	189098
448	4	280	189378
452	4	276	189654
456	6	408	190062
462	3	201	190263
465	4	264	190527
469	7	455	190982
476	2	128	191110
478	7	441	191551
485	4	248	191799
489	7	427	192226
496	7	420	192646
503	4	236	192882
507	5	290	193172
512	5	285	193457
517	3	168	193625
520	2	108	193733
522	8	424	194157
530	2	104	194261
532	2	102	194363

Journal Rank	No of Journals	Articles	Articles Cumulative
534	2	100	194463
536	5	245	194708
541	3	144	194852
544	3	141	194993
547	3	138	195131
550	5	225	195356
555	6	264	195620
561	3	129	195749
564	3	126	195875
567	5	205	196080
572	5	200	196280
577	9	351	196631
586	7	266	196897
593	8	296	197193
601	7	252	197445
608	9	315	197760
617	6	204	197964
623	5	165	198129
628	7	224	198353
635	9	279	198632
644	4	120	198752
648	6	174	198926
654	6	168	199094
660	10	270	199364
670	6	156	199520
676	20	500	200020
696	8	192	200212
704	14	322	200534
718	10	220	200754
728	17	357	201111
745	15	300	201411
760	13	247	201658
773	11	198	201856
784	17	289	202145
801	17	272	202417
818	20	300	202717
838	22	308	203025
860	23	299	203324
883	27	324	203648
910	27	297	203945
937	24	240	204185
961	38	342	204527
999	32	256	204783
1031	43	301	205084
1074	44	264	205348
1118	56	280	205628
1174	50	200	205828



Journal Rank	No of Journals	Articles	Articles Cumulative
1224	60	180	206008
1284	100	200	206208
1384	175	175	206383

Journal Rank	No of Journals	Articles	Articles Cumulative
1558	1558		



## Core Journals in Physics Research

Chinese Physics Letters
Applied Physics Letters
Chinese Physics B
Journal Of Applied Physics
Materials Letters
Applied Surface Science
Physical Review B
Communications In Theoretical Physics
Physical Review A
Physical Review B
Physics Of The Solid State
Physics Letters A
Technical Physics Letters
Physical Review D
Jetp Letters
Journal Of Physics D Applied Physics
Nanotechnology
Physical Review Letters
Physica B Condensed Matter
Physical Review Letters
Physical Review D
Technical Physics
Journal Of Chemical Physics
Journal Of Nanoscience And Nanotechnology
Physical Review E
Semiconductors
Journal Of Experimental And Theoretical Physics
Journal Of Applied Physics
Chinese Physics C
Chaos Solitons Fractals
Quantum Electronics
Solid State Communications

Note: These journals account for 1/3<sup>rd</sup> of the total productivity of articles contributed by BRICS nations during 2007-12