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Trend Analysis on Bioelectronics Research output Indexed in Scopus Database

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Abstract: - *Bioelectronics is a subject that is emerged out of the fusion of the subjects like biology and electronics. This newly emerged subject plays a vital role in the health care and forensic science. As such, no steps have been taken so far to picturise the trend in the subject growth. Thus, this paper attempts study the trend in the growth by applying least square method and Price's fundamental law.*

Keywords: Bioelectronics research output – trend, Price's fundamental law of science, Trend analysis – research productivity on bioelectronics.

1. Introduction

Scientometric applications are growing at present to cope up with the ever growing nature of subjects. Though, this discipline is originated from bibliometrics, it applies some of the demographical and institutional aspects of the researcher or the producers of the knowledge in disciplines. The Bioelectronics is a subject of new origin. The literature available on the subject in Scopus reveals that the literature growth of the subject starts in the early nineties. In this context, this paper intended to apply few of the scientometric applications along with the picturising the trend of the growth of the subject.

Bioelectronics is a subject that is emerged out of the fusion of the subjects like biology and electronics. This newly emerged subject plays a vital role in the health care and forensic science. As such, no steps have been taken so far to picturise the trend in the subject growth. Thus, this paper attempts study the trend in the growth of research productivity of the subject over pa period of 26 years.

2. Review of Literature

Gupta et al. (2014) analysed scientometric indicators on Indian publications output in glaucoma research during 2002-11. The Scopus citation database has used to retrieve the data for 10 years (2002-11). John Jeyasekar Jesubright and Saravanan (2014) Carried out a study on forensic science literature from the year 1975 to 2011 to find out the growth in forensic science literature, authors' productivity, the top ranking source journal and the country-wise productivity. Hu et al. (2014) applied a scientometric analysis evaluate the status and trends of electric vehicle papers published between 1993 and 2012 in any journal of all the subject categories of the Web of Science. Dutta et al. (2013) reported the scientometric study of 834 articles downloaded from Web of Science on Carbon nanotube research in India that spanned from 1999 to 2012. The study analysed literature growth trends, which showed an initiation of potential growth of research in this subject since 2008. Kaliyaperumal and Natarajan (2009) studied the growth pattern as well as overall trend in literature output on retina during 2002-2007. Secondary data collection from a set of retrieved bibliographic records from the literature output in the field of retina from the CD-ROM sources of MEDLINE were used. Sangam et al. (2008) analyzed the growth pattern of Chemical Science literature in India in eighty subfields. SCI Finder Scholar - Chemical Abstract Online has been used for the period 1980-2005 to collect data.

3. Objectives of the study

The objectives of the study are as follows:

- To identify the year wise distribution of the literature on bioelectronics over a period of 26 years
- An Application of time-series analysis to picturise the trend on the growth of the literature output.
- Applications of Price's Fundamental Law of Science for the identification of trend in bioelectronics research output

4. Research methodology

For the purpose of this research, a total no..of 56561 records on bioelectronics are down loaded from Scopus database over a period of 26 years starting form 1989 – 2014. The bibliographical elements that are suitable for trend analysis and applications of Price's fundamental law are taken in to account for the analysis. Thus, the analysis and the results are presented a s follows:

Table 1 Year wise growth of Bioelectronics output

S.No.	Year	Publications	%
1	1989	122	0.22
2	1990	154	0.27
3	1991	365	0.65
4	1992	398	0.70
5	1993	534	0.94
6	1994	609	1.08

7	1995	772	1.36
8	1996	870	1.54
9	1997	945	1.67
10	1998	1088	1.92
11	1999	1145	2.02
12	2000	1348	2.38
13	2001	1408	2.49
14	2002	1566	2.77
15	2003	1735	3.07
16	2004	1949	3.45
17	2005	2301	4.07
18	2006	2670	4.72
19	2007	3143	5.56
20	2008	3558	6.29
21	2009	4080	7.21
22	2010	4030	7.13
23	2011	5221	9.23
24	2012	5042	8.91
25	2013	5648	9.99
26	2014	5860	10.36
Total		56561	100.00

Table 1 shows the growth of bioelectronics research for a period of 26 years from 1989 to 2014. It is seen from the table that the research productivity is grown 50 times under the study period. It is found that throughout the study period, there is gradual growth except a slow decline in the years 2010 and 2012.

Table 2 Bioelectronics Research trend – Time Series Analysis

S.No.	Year	Publications (Y)	Deviation from 2001.5	Deviations multiplied by 2 (X)	XY	X^2
1	1989	122	-12.5	-25	-3050	625
2	1990	154	-11.5	-23	-3542	529
3	1991	365	-10.5	-21	-7665	441
4	1992	398	-9.5	-19	-7562	361
5	1993	534	-8.5	-17	-9078	289
6	1994	609	-7.5	-15	-9135	225
7	1995	772	-6.5	-13	-10036	169
8	1996	870	-5.5	-11	-9570	121
9	1997	945	-4.5	-9	-8505	81
10	1998	1088	-3.5	-7	-7616	49

11	1999	1145	-2.5	-5	-5725	25
12	2000	1348	-1.5	-3	-4044	9
13	2001	1408	-0.5	-1	-1408	1
14	2002	1566	0.5	1	1566	1
15	2003	1735	1.5	3	5205	9
16	2004	1949	2.5	5	9745	25
17	2005	2301	3.5	7	16107	49
18	2006	2670	4.5	9	24030	81
19	2007	3143	5.5	11	34573	121
20	2008	3558	6.5	13	46254	169
21	2009	4080	7.5	15	61200	225
22	2010	4030	8.5	17	68510	289
23	2011	5221	9.5	19	99199	361
24	2012	5042	10.5	21	105882	441
25	2013	5648	11.5	23	129904	529
26	2014	5860	12.5	25	146500	625
		56561	-2001.5	-4003	661739	5850

One of the best ways of obtaining trend values is the method of least square. It is a statistical procedure from which a straight line trend is obtained. This line is called the line of best fit. It is a line from which the sum of the deviations of various points on either side is equal to zero i.e $\sum(y-y_c)=0$ and the sum of the squares of these deviations of actual and computed value would be least as compared to other lines i.e $\sum(y-y_c)^2$ is least. For this reason that the sum of the squares of variations of various points from the line of the best fit is the least. This method is known as method of least square. The method is used to fit a straight line trend or a parabolic trend.

Straight Line equation $Y_c = a + bX$
Since $\sum x = 0$
$a = \sum Y/N = 56561/26 = 2175.42$ $b = \sum XY/\sum x^2 = 661739/5850 = 113.12$
Estimated literature in 2020 is when X = **37**
= 2175.42 + 113.12 *37 = 2175.42 + 4185.44 = 6360.86
Estimated literature in 2025 is when X = **47**
= 2175.42 + 113.12 *47 = 2175.42 + 5316.54 = 7492.06

Table 3 Trend in Authorship Pattern

S.No	Authorship	Anon		Single		Joint		Coll.		Total
	Year									
			%		%		%		%	
1	1989	0	0.00	34	27.87	37	30.33	51	41.80	122
2	1990	0	0.00	36	23.38	36	23.38	82	53.25	154
3	1991	0	0.00	97	26.58	67	18.36	201	55.07	365
4	1992	0	0.00	77	19.35	87	21.86	234	58.79	398
5	1993	0	0.00	97	18.16	119	22.28	318	59.55	534
6	1994	0	0.00	105	17.24	120	19.70	384	63.05	609
7	1995	0	0.00	90	11.66	161	20.85	521	67.49	772
8	1996	0	0.00	114	13.10	176	20.23	580	66.67	870
9	1997	0	0.00	107	11.32	169	17.88	669	70.79	945
10	1998	0	0.00	122	11.21	185	17.00	781	71.78	1088
11	1999	0	0.00	112	9.78	202	17.64	831	72.58	1145
12	2000	1	0.07	152	11.28	236	17.51	959	71.14	1348
13	2001	0	0.00	113	8.03	242	17.19	1053	74.79	1408
14	2002	0	0.00	124	7.92	275	17.56	1167	74.52	1566
15	2003	0	0.00	118	6.80	291	16.77	1326	76.43	1735
16	2004	0	0.00	140	7.18	325	16.68	1484	76.14	1949
17	2005	0	0.00	149	6.48	357	15.51	1795	78.01	2301
18	2006	0	0.00	165	6.18	386	14.46	2119	79.36	2670
19	2007	0	0.00	134	4.26	451	14.35	2558	81.39	3143
20	2008	0	0.00	149	4.19	448	12.59	2961	83.22	3558
21	2009	0	0.00	174	4.26	499	12.23	3407	83.50	4080
22	2010	2	0.05	165	4.09	482	11.96	3381	83.90	4030
23	2011	0	0.00	174	3.33	590	11.30	4457	85.37	5221
24	2012	0	0.00	189	3.75	545	10.81	4308	85.44	5042
25	2013	2	0.04	181	3.20	582	10.30	4883	86.46	5648
26	2014	0	0.00	142	2.42	559	9.54	5159	88.04	5860
		5	0.01	3260	5.76	7627	13.48	45669	80.74	56561

Table 3 shows the trend of authorship pattern during the study period 1989 to 2014. Single authored publications are maximum in the year 1989 with 27.87 percent of the total output while joint authored publications also shows a similar trend. Collaborative publications having more than two authors is in increasing trend having 41.80 per cent in the year 1989 and 88.04 per cent in the year 2014. That is, collaborative publications have doubled in the period of 26 years.

Table 4 Research productivity of the countries

S.No	Country	Publications	%
1.	USA	21555	38.11
2.	England	14187	25.08
3.	Netherlands	6229	11.01
4	Switzerland	5113	9.04
5.	Germany	4077	7.21
6.	China	913	1.61
7.	Japan	855	1.51
8.	Austria	461	0.82
9.	South Korea	333	0.59
10	Serbia	286	0.51

Research productivity in the field of Bioelectronics are published in journals from 68 countries, and in the table no 4 only top ranking 10 countries are presented of which, USA has the highest productivity of 38.11 percent followed by England having 25.08 percent. The third ranked country in publication productivity is Netherlands (11.01%) followed by Switzerland (9.04%). China is in the 6th place while India is in the 12th position. A close look at the table reveals that productivity contribution in the field of Bioelectronics is by developed countries proving.

Table 5 Language wise distribution of the Publications

S.No	Language	Publications	%
1.	English	55395	97.94
2.	Chinese	644	1.14
3.	German	127	0.22
4.	Japanese	109	0.19
5.	French	61	0.11
6.	Portuguese	58	0.10
7.	Russian	55	0.10
8.	Czech	34	0.06
9.	Spanish	28	0.05
10.	Polish	15	0.03

Research publications in Bioelectronics are available in 19 languages of which English forms a major proportion of 97.94 percent. The second ranked language is Chinese (1.14%) followed by German (0.22%). Other languages like Japanese, French, Portuguese etc., have only limited number of papers as seen in the table 5 which presents only top ten languages.

Table 6. Price's Fundamental Law of Science for the trend in bioelectronics research output

S. No.	Year	No of Authors	Exponential Growth $b = y_{t1}/y_{t0}$
1	1989	217	
2	1990	307	1.41
3	1991	682	2.22
4	1992	753	1.10
5	1993	992	1.32
6	1994	1310	1.32
7	1995	1656	1.26
8	1996	1841	1.11
9	1997	2119	1.15
10	1998	2643	1.25
11	1999	2699	1.02
12	2000	3225	1.19
13	2001	3371	1.05
14	2002	3902	1.16
15	2003	4580	1.17
16	2004	5002	1.09
17	2005	6023	1.20
18	2006	7090	1.18
19	2007	8336	1.18
20	2008	9462	1.14
21	2009	9909	1.05
22	2010	10080	1.02
23	2011	13528	1.34
24	2012	14363	1.06
25	2013	16580	1.15
26	2014	16229	0.98

Price's[1] celebrated lectures on "Little Science and Big Science" reviewed some earlier works by Francis Galton, J.M.Cattell and A.J.Lotka and presented a notable "feeling that most of the great scientists are still with us, and that the greater part of scientific work has been produced within living memory, within the span of the present generation of scientists". He considers an exponential time trend as the appropriate model to fit for data on number of scientists. He calls this principle of exponential growth as the "fundamental law of any analysis of science".

Let y_t = number of scientists during a period t. (t may be just 1 year or a span of say, 30 or 45,years).

$y_t = e^{a'+b'}{}_t$

----------1

$\log y_t = a'+b'_t$

Let a' = log a and b' = log b.

Then $\log y_t = \log a + t \log b$

Or $y_t = a.* b_t$

----------2

In (2) if b>1 the exponential curve is rising over time (+ve growth) and if b<1, curve is falling down (-ve growth). (2) may also be written as

$y_t=y0*b_t$ (Since t=0, y0=a=number of scientists in the beginning).

or

$y_t=y_{t-1}*b$

Since b>1, obviously the number of scientists during any period t is greater than those existing during any particular period in the past.

From table 6 it is seen that the exponential growth rate is greater than 1 in all the years and hence proving Price's Fundamental law of science.

Summary and conclusion:

The research productivity is grown 50 times under the study period. It is found that throughout the study period, there is gradual growth except a slow decline in the years 2010 and 2012.The trend analysis reveals that the stady growth of the research productivity. Collaborative publications having more than two authors is in increasing trend having 41.80 per cent in the year 1989 and 88.04 per cent in the year 2014. That is, collaborative publications trend has doubled in the period of 26 years.

USA has the highest productivity of 38.11 percent followed by England having 25.08 percent. The third ranked country in publication productivity is Netherlands (11.01%) followed by Switzerland (9.04%). China is in the 6th place while India is in the 12th position. Research publications in Bioelectronics are available in 19 languages of which English forms a major proportion of 97.94 percent. The second ranked language is Chinese (1.14%) followed by German (0.22%). Other languages like Japanese, French, Portuguese etc., have only limited number of publications. The exponential growth rate is greater than 1 in all the years and hence proving Price's Fundamental law of science. But it is to state that India position in terms research productivity in the subject is negligible

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