

SCIENTOMETRIC ANALYSIS OF RESEARCH OUTPUT ON NEUTRINO IN INDIA

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Abstract

This paper describes the results of a Scientometric study of literature on Neutrino research published in India. The main objectives of this study are to examine Relative Growth Rate (RGR), Doubling Time (DT), Time series, the authorship pattern, degree of collaboration and core journals. The article in the SCOPUS database covering the period 1966-2011 have been considered for this study. The results of the study indicate that there is an increasing trend towards collaborative research in India.

1 Introduction

Quantitative measurement of publications, citations and other parameters have been largely applied and used in evaluating scientific research. Scientometric analyses of literature in various disciplines have been carried out by using primary journals or secondary sources to examine the quantitative aspects of literature growth in a particular field of knowledge.

Scientometric analysis of Scientometric publications is an important aspect of research endeavour in information science. It could be attributed to the fact that Scientometric studies are used to identify the pattern of publications, authorship, citations, secondary journal coverage and so on. These factors can give an insight into the dynamics which consequently lead to better information handling and management.

2 Concept of Neutrino

A neutrino is an electrically neutral, weakly interacting elementary subatomic particle with half-integer spin. The neutrino (meaning "small neutral one" in Italian) is denoted by the Greek letter ν (nu). All evidence suggests that neutrinos have mass but that their mass is tiny even by the standards of subatomic particles. Their mass has never been measured accurately.

Neutrinos do not carry electric charge, which means that they are not affected by the electromagnetic forces that act on charged particles such as electrons and protons. Neutrinos are affected only by the weak sub-atomic force, of much shorter range than electromagnetism, and gravity, which is relatively weak on the subatomic scale. They are therefore able to travel great distances through matter without being affected by it. Neutrinos are created as a result of certain types of radioactive decay, or nuclear reactions such as those that take place in the Sun, in nuclear reactors, or when cosmic rays hit atoms.

3 Objectives of the Study

The study has been designed with the following objectives:

- i) To examine the growth of literature on Neutrino published during 1966-2011 in India.
- ii) To study the authorship pattern and the extent of collaborative research.
- iii) To determine the degree of collaboration and
- iv) To identify the core journals on the subject of neutrino.

4 Methodology

A sum of **1322** records in Neutrino research covered a period from 1966 to 2011 in India. The data was downloaded from the SCOPUS which is the most comprehensive and leading bibliographic database providing access to the world's scientific and technical literature in physical sciences. In all 1322 records were obtained for the period of study. MS Excel 2007 was used for analyzing the data. The investigation being fairly analytical, data have been divided into specific subdivisions and discussed in the light of the objectives identified in this study. The design of the analysis includes the following categories like Relative growth rate, doubling time, authorship pattern, forms of publications, core journals and so on.

5 Scientometric indicators used

The following Scientometric indicators have been used in the study:

5.1 Relative Growth Rate and Doubling Time

The changes in the size of literature over specific period may be termed as growth of literature. Gupta and Karisidappa¹ suggested approaches in understanding knowledge growth, which are Qualitative and Quantitative. The qualitative approach suggests structural or descriptive models of knowledge growth and a quantitative approach is relied on

summarization statistics to describe observed behaviour and use of the Bibliometric / Scientometric techniques. In this section the study focused on the growth pattern of articles in MAP from 1991-2006. The relative growth rate was calculated for the articles and the doubling time (Dt) against each year study was also determined. The values of relative growth rate (RGR) and Dt for publication are represented in Table 2.

Doubling time is the time required for each doubling of a Quantity in exponential growth. It has been directly related to Relative Growth Rate. It is the time required for articles to become double of the existing amount.

Calculations for the doubling time:

New value=initial value* $2^{t/T}$ double where

T double=doubling time

t=time elapsed since the initial value at time t=0.

5.2 Time Series analysis

Social and economic research data is obtained relating to a phenomenon over a time period. Such data are called time series. Here the time series is a set of ordered observations of a quantitative variable taken at successive points in terms of years. Time series analysis on neutrino literature has been calculated to measure the trend of the neutrino growth and to predict the feature patterns. A straight-line equation is adopted as statistical measure to fore cast the trend pattern studied by Daya Sridhar².

Straight line equation is: $Y = a + bX$

$$\sum Y = Na + b \sum X$$

$$\sum XY = a \sum X + b \sum X^2$$

5.3 Co-Authorship Index (CAI)

Co-Authorship Index (CAI) is obtained by calculating proportionately the Publication by single, two and multi authored papers. To study how the CAI pattern changed during the period 1999-2003 by using CAI suggested by Garg and Padhi³.

$$N_{ij}/N_{i0}$$

$$CAI = \text{-----} * 100$$

$$N_{oj}/N_{oo}$$

Where,

N_{ij} = Number of papers having authors in block i

N_{io} = Total output of block i

N_{oj} = Number of papers having j authors for all blocks.

N_{oo} = Total number of papers for all authors and all blocks

CAI=100 indicates that a countries co-authorships effort for a particular type of Authorship corresponds to the world average. CAI>100 reflects higher than Average co-authorship effort and CAI <100 shows lower than average Co-authorship effort by that country for a given type of authorship pattern.

5.4 Degree of Collaboration

The Degree of Collaboration of authors by year wise is shown in Table 7. Extent or degree of collaboration can be ascertained by the formula by K.Subramanian⁴. His mathematical formula ascertained in calculating author's degree of collaboration in a discipline. The degree of collaboration among authors is the ratio of the number of collaborative publications to the total number of publication published in a discipline during certain period of time.

The degree of collaboration (collaboration coefficient) among authors is measured mathematically as;

$$C = \frac{Nm}{Nm + Ns}$$

Where,

C= degree of collaboration

Nm= number of multi authored papers

Ns= number of single authored papers

6 Analysis and Discussion

6.1 Growth of Neutrino research output

Table 1 reveals the frequency distribution in Neutrino research Output in India. A total of 1322 research papers were published during the period before 1966-2011. The

analysis shows the increasing trend in 1966 -2011. More number of papers published after 2007.

Table 1 Year-Wise Frequency Distribution in Neutrino Research Output

Sl. No	Year	No. of Research Output	Per cent
1	before1966	19	1.44
2	1967 - 1971	29	2.19
3	1972 - 1976	43	3.25
4	1977 - 1981	64	4.84
5	1982 - 1986	76	5.75
6	1987 - 1991	59	4.46
7	1992 - 1996	100	7.56
8	1997 - 2001	262	19.82
9	2002 - 2006	252	19.06
10	after 2007	418	31.62
Total		1322	100

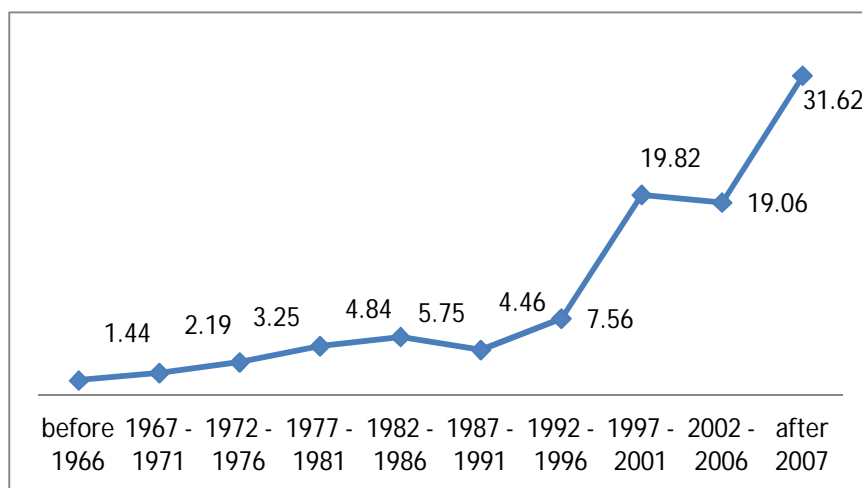


Fig-1 Distribution in Neutrino Research Output

6.2 Relative Growth Rate and Doubling Time

The table 2 and figure 2 and 3 shows the Average Growth Rate and the doubling time (DT) of neutrino research literature in India. The growth rate is found to be at a maximum during the year 1967-1971 and the minimum during the period1987-1991. The average growth rate works out to be 7.09. And also it is found that the average doubling time is 15.79 years. This is an indication that research on neutrino will double once in every 10 years.

Table 2 Relative Growth Rate and Doubling Time

Sl. No	Year	No. of Records	Cumulative	RGR	Doubling Time
1	before 1966	19	19	2.94	0.24
2	1967 - 1971	29	48	0.93	0.75
3	1972 - 1976	43	91	0.64	1.08
4	1977 - 1981	64	155	0.53	1.30
5	1982 - 1986	76	231	0.40	1.74
6	1987 - 1991	59	290	0.23	3.05
7	1992 - 1996	100	390	0.30	2.34
8	1997 - 2001	262	652	0.51	1.35
9	2002 - 2006	252	904	0.33	2.12
10	after 2007	418	1322	0.38	1.82
Total		1322	4102	7.09	15.79

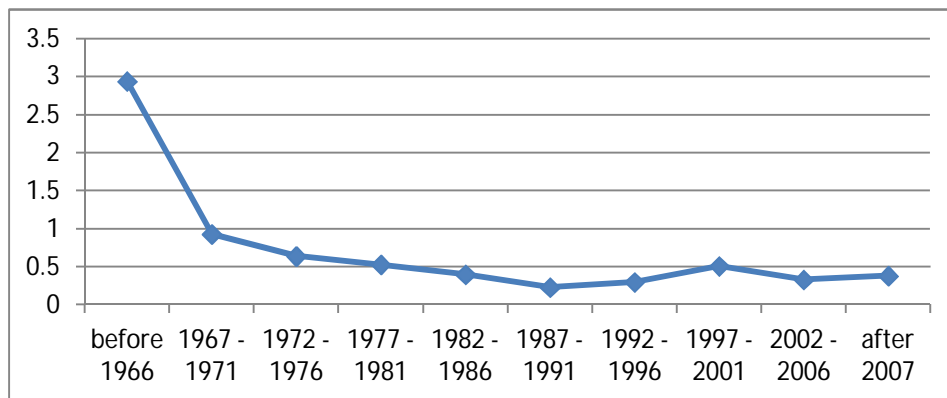


Fig-2 Relative Growth Rate of Neutrino Research in India

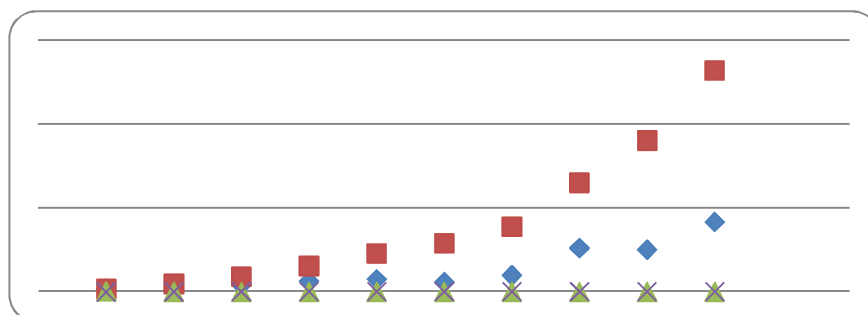


Figure-3 Doubling Time

6.3 Time Series Analysis

Social and economic research data is obtained relating to a phenomenon over a time period. Such data are called time series. Here the time series is a set of ordered observations

of a quantitative variable taken at successive points in terms of years. Time series analysis on Neutrino literature has been calculated to measure the trend of the Neutrino growth and to predict the future patterns.

Table 3 Research Output Trend: Time Series Analysis

Sl. No	Year	Count(Y)	X	X ²	XY
1	before 1966	19	0	0	0
2	1967 - 1971	29	1	1	29
3	1972 - 1976	43	2	4	86
4	1977 - 1981	64	3	9	192
5	1982 - 1986	76	4	16	304
6	1987 - 1991	59	5	25	295
7	1992 - 1996	100	6	36	600
8	1997 - 2001	262	7	49	1834
9	2002 - 2006	252	8	64	2016
10	after 2007	418	9	81	3762
Total		1322	45	285	9118

Table 3 reveals the estimated growth and the dip of the output. A straight-line equation is adopted as statistical measure to forecast the trend pattern suggested by Daya Sridhar.

Straight line equation is: $Y = a + bX$

$$\sum Y = Na + b \sum X$$

$$\sum XY = a \sum X + b \sum X^2$$

$$1322 = 10a + 45b$$

$$38367 = 9706a + 285b$$

$$a = 3.11 \quad b = 28.69$$

Estimated literature in 2015 is when $X = 2015 - 1966 = 49$

$$= 3.11 + 28.69 * 49 = 1405.92$$

Estimated Literature in 2020 is when $X = 2020 - 1966 =$

$$3.11 + 28.69 * 54 = 1552.37$$

From the above projections, it can be inferred that the future trend on Neutrino will have an increasing trend in the year 2015 and may gain to an increasing trend in 2020. The pattern of growth of Neutrino output also show similar differences in the calculation and the estimated trend.

6.4 Types of Documents

Table 4 displays the type of documents found in the collected records. It is evident that the journal is the most preferred medium of all the forms. The largest number of the journal used indicates a continued trend of relying primarily on this form of publications. Of the total research literature output in Neutrino, 90.32 per cent is in the form of articles followed by 7.34 per cent in the form of reviews article while other types perform a poor show with negligible numbers.

Table 4 Form -wise distribution

Sl. No	Year	Articles	Conference Papers	Erratums	Letters	Notes	Reviews	Short Surveys	Total
1	1966 and Before	19	0	0	0	0	0	0	19
2	1967 - 1971	29	0	0	0	0	0	0	29
3	1972 - 1976	39	0	0	1	0	2	1	43
4	1977 - 1981	62	0	0	0	0	2	0	64
5	1982 - 1986	72	0	0	1	1	2	0	76
6	1987 - 1991	59	0	0	0	0	0	0	59
7	1992 - 1996	99	0	0	1	0	0	0	100
8	1997 - 2001	253	4	1	0	0	4	0	262
9	2002 - 2006	215	31	0	0	0	3	3	252
10	2007 and After	347	62	0	2	1	5	0	418
Total		1194 (90.32 %)	97 (7.34%)	1 (0.08%)	5 (0.38%)	2 (0.15%)	18 (1.36%)	4 (0.30%)	1322 (100%)

6.5 Authorship pattern

The literature of any subject reflects not only basic publishing pattern but also the characteristics of the author themselves. Authorship pattern can be deciphered in areas like Author productivity, collaborative or multiple authorship, author choice in the form of publications. An analysis of literature output from Table 6 Indicates the authorship pattern.

To find the authorship pattern, the entire data was divided into seven blocks as single, two, three, four, five, six, seven, eight, nine, ten and more than ten authored publications as shown in Table 5. The results presented in Table 5 show that two authored publications were highest with 31.69%. and three authored publications were second highest with 22.92%. Nine and ten authored papers at 0.23% were the lowest.

Table 5 Authorship Pattern

Authors	Before 1966	1967-1971	1972-1976	1977-1981	1982-1986	1987-1991	1992-1996	1997-2001	2002-2006	After 2007	Total
1	11	14	13	20	23	11	15	62	42	71	282 (21.33%)
2	2	12	18	33	36	27	41	77	70	103	419 (31.69%)
3	2	2	2	5	12	9	18	64	75	108	303 (22.92%)
4	3	0	0	5	2	4	9	26	30	67	148 (11.20%)
5	0	0	2	1	0	0	1	4	15	21	42 (3.18%)
6	0	0	0	0	0	0	2	0	4	5	13 (0.98%)
7	0	0	0	0	0	0	0	0	2	2	4 (0.3%)
8	0	0	0	0	0	0	0	0	0	0	0 (0%)
9	0	0	0	0	2	0	0	0	0	1	3 (0.23%)
10	0	1	0	0	0	0	0	1	0	1	3 (0.23%)
More than 10	1	0	0	0	1	8	14	28	14	39	105 (7.94%)
Total	19	29	43	64	76	59	100	262	252	418	1322(100%)

6.6 Pattern of Co-Authorship Index (CAI)

For calculating the co-authorship index for authors, countries have been replaced with block. For this study, the authors have been classified into ten blocks. Vs. Single, Two, and multiple authors and period of the study has been divided into 10 blocks as 1966-2011.

Table 6 Co-Authorship Index

Sl. No	Year	Single Author	CAI	Two Authors	CAI	Three Authors	CAI	More than Three Authors	CAI	Total
1	before 1966	11	271.41	2	33.21	2	45.93	4	87.52	19
2	1967 - 1971	14	226.31	12	130.56	2	30.09	1	14.34	29
3	1972 - 1976	13	141.73	18	132.08	8	81.17	4	38.67	43
4	1977 - 1981	20	146.50	33	162.69	5	34.09	6	38.97	64
5	1982 - 1986	23	141.87	36	149.45	12	68.89	5	27.35	76
6	1987 - 1991	11	87.40	27	144.39	9	66.55	12	84.55	59
7	1992 - 1996	15	70.32	41	129.36	18	78.53	26	108.09	100
8	1997 - 2001	62	110.94	77	92.73	64	106.58	59	93.62	262
9	2002 - 2006	42	78.13	70	87.64	75	129.85	65	107.23	252
10	after 2007	71	79.63	103	77.75	108	112.73	136	135.26	418
Total		282		419		303		318		1322

Table 6 reveals that the result of co-authorship index and it is observed that the value of CAI for two authored papers is the highest and for single authored papers was lowest, which indicated that the collaborative research is increasing in the field of Neutrino research

in India. With regard to the multiple authored publications with more than single authors, the co-authorship has shown fluctuation trend.

6.7 Degree of Collaboration

The degree of collaboration for different years is calculated as per the equation proposed by Subramanian and is presented in Table 7. The degree of collaboration over the years varies from 0.42 to 0.85. And also it reveals that the degree of collaboration in authorship trend works out to be 0.42 and above. Thus the degree of collaboration gives a picture of extent of collaborations among the authors. The average has been arrived at 0.77.

Table 7 Degree of Collaboration

Sl. No.	Year	1 au	2 au	3 au	More than three	Degree of Collaboration	Total
1	1966 and Before	11	2	2	4	0.42	19
2	1967 - 1971	14	12	2	1	0.52	29
3	1972 - 1976	13	18	8	4	0.70	43
4	1977 - 1981	20	33	5	6	0.69	64
5	1982 - 1986	23	36	12	5	0.70	76
6	1987 - 1991	11	27	9	12	0.81	59
7	1992 - 1996	15	41	18	26	0.85	100
8	1997 - 2001	62	77	64	59	0.76	262
9	2002 - 2006	42	70	75	65	0.83	252
10	2007 and After	71	103	108	136	0.83	418
Total		282	419	303	318	0.77	1322

6.8 Preferred journals by the scientists of Neutrino Research

The concept of core journals has been derived from Bradford's Law. It describes how the literature on a particular subject is scattered in the journals. According to Garfield "Bradford's Law is one of several statistical expressions, which try to describe the workings of science by mathematical means". This law is considered as the best known of the entire Bibliometric concept.

The journals are ranked based on their frequency of occurrence along with comparatively higher productivity count. The ranked list of journal titles is provided in the following tables and consecutively for every unit of time period of the study.

The data in table 8 reveals the highly preferred journals by the scientists of Neutrino. Out of the 1322 articles, 376 articles have been published in "Physical Review D - Particles, Fields, Gravitation and Cosmology", 205 in "Physics Letters", and 66 in "Pramana - Journal

of Physics” and so on. The most of the Neutrino researcher preferred foreign journals to Indian journals.

Table 8 Core Journals in Neutrino Research

Sl. No.	Name of Journal	Total
1	Physical Review D - Particles, Fields, Gravitation Cosmology	376
2	Physics Letters	205
4	Pramana - Journal of Physics	66
5	Modern Physics Letters A	55
6	Physical Review Letters	50
7	AIP Conference Proceedings	47
9	Nuclear Physics B	32
10	Journal of High Energy Physics	25
11	Journal of Physics G: Nuclear and Particle Physics	24
12	International Journal of Modern Physics A	22
14	Astrophysics and Space Science	21
15	Physical Review C - Nuclear Physics	18

9. Conclusion

This study clearly indicates that there is an increasing trend towards collaborative research in the field of neutrino in India. The publications in journal articles (90.32 %) are high in this field when compared to the publications in the conferences. The study reveals the Indian scientist has strong base in neutrino research. The core journals indicate that researchers are selective in publishing their research results in highly specialized and high impact factor journals. However, majority researchers find Indian journals as an easier channel for publication of their research results.

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