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Artificial Intelligence Research output in India from Scopus Database (2011-2020): A Scientometric Analysis

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ABSTRACT

In the ten years from 2011 to 2020, the global research output in artificial intelligence has a total of 223538 publications. The annual global output increased from 15892 publications in 2011 to 33192 publications in 2020. The world's five-year artificial intelligence research output increased by 39.61 percent from 88533 publications in 2011-2015 to 135005 publications in 2016-2020. Growth was relatively faster in the second half of the study period 2011-2020. From 2011 to 2020, in the field of artificial intelligence India's research output amounted to 18371 publications. The United States topped the list in collaboration with India, accounting for (37.52%) of the share. In the last ten years, China has accounted for the highest global publication share (25.58%). With 6982 (38.01%) publications, most of the publications in this research work were two authorship. The average collaborative degree is 0.95, and the average CC value is 0.60. The average value of the CI is 2.90, and the average value of MCC is 2.90. From 2011-15 to 2016-20, the activity index in Earth and Planetary Sciences fell from 110.72 to 94.72, and in Arts and Humanities fell from 84.84 to 107.47. Amity University, Noida, 462 (15.08%) research publications, Choudhury, T, 46 (13.77%) research publications Advances in Intelligent Systems and Computing appeared in the most number of journals in 2016 (36.23%). As a result, a careful examination revealed that the number of publications on artificial intelligence research is an increasing trend.

KEYWORDS: Scientometric, Authorship pattern, Degree of collaboration, Relative growth rate, and doubling time, Collaborative index CI, CC, MCC, Co-authorship index, Time series analysis**.**

INTRODUCTION

Artificial Intelligence (AI) is defined as "the science and engineering of creating intelligent machines, particularly intelligent computer programs by John McCarthy, the father of artificial intelligence. It is a method of instructing a computer or controlled software to think cleverly, in the same way, that brainy humans do. The primary goals of Artificial intelligence are too. I create expert systems – systems that exhibit intelligent behavior, learn, demonstrate,

explain, and advise their users; and (ii) implement the human brainpower in machines – systems that understand, think, learn, and behave like humans. Selecting science and technology based on disciplines such as computer science, biology, psychology, linguistics, mathematics, and engineering is what artificial intelligence is all about. AI is primarily concerned with the development of computer functions that are related to human intelligence, such as reasoning, learning, and problem-solving. Gaming, natural language processing, expert systems, vision systems, speech recognition, handwriting recognition, and intelligent robots are just a few of the fields where AI has dominated. Artificial intelligence is a vast field in terms of both breadth and depth. Expert systems, natural language processing, neural networks, fuzzy logic, and robotics are just a few examples of popular and thriving AI research areas[1].

Bibliometric Study

Some significant bibliometric studies based on Indian publications to various disciplines have been conducted. **Rajendran and Parihar (2007)**[2] conducted the analysis of Laser literature published between 1995 and 2005 in India. Ramakrishnan and Ramesh Babu (2007)[3] conducted a bibliometric analysis of Hepatitis literature from 1984 to 2003. The collaboration pattern in Indian contributions to Chemical Sciences research is described by **Sangam and Meera (2008**)[4]. In Human Nutrition, **Amudhavalli and Florence (2001)**[5] analyzed the profile of Indian productivity. **Senthilkumaran and Vadivel (2003)**[6] conducted a bibliometric analysis of Indian spices. **Amudhavalli and Senthilkumaran (2007)**[7] conducted a cross-national comparison of spice research in Asian countries from 1968 to 2002. According to **Sooryamorthy (2009)**[8], collaboration research in South Africa has been steadily increasing, and scientists are highly oriented toward collaborative research. **Manuelraj and Amudhavalli (2008)**[9] examined the literature on health science they found that the relationship between productivity and collaboration is low.

LITERATURE REVIEW

Ravichandran and Vivekanandhan (2021)[10] observed in a Scientometric analysis of wastewater management research publications from 2010 to 2019 from the Scopus database. According to the study, a total of 2842 (14.31%) publications with 19857 citations were contributed in 2019. A maximum of 101 (0.51%) research publications contributed by Ngo, H.H and joint authors contributed a maximum of 19355 articles, and 0.97 was the average degree of collaboration, Bioresource technology has contributed a maximum of 2102(10.58%) research publications, Ministry of Education, China has contributed a maximum of 863(22.32%) publications.

Srivastava and Mahajan (2016)[11] investigated artificial intelligence research in the Indian context by analyzing Scopus database publications from 1968 to 2014. The study detailed growth characteristics, citations, keywords, collaboration, organizational-level distributions, and so on. Some more bibliometric research was also conducted in India and covered various study aspects including Artificial Intelligence.

Niu2, et al. (2016)[12] conducted research productivity in the field of artificial research (AI) from 1990 to 2014. They analyzed the importance of publication patterns and provided a summary of the research directions.

Gunasegaram and Shanmugam (2016)[13] investigated artificial intelligence in global level research and published 10795 papers between 1981 and 2010, they analyzed the general characteristics of authorship patterns, collaborative patterns, and so on.

Ravichandran and Vivekanandhan (2021)[14] examined wireless sensor network research output in India for the period 2010 to 2019 using the SCOPUS database. According to this study, in the year the, 2019 maximum number of publications were contributed with 2058 (17.48 percent), with a compound annual growth rate of 5.44. According to this study, decreasing in relative growth rate and an increased doubling. The degree of collaboration was 0.96 on average, and CAI decreased from the first block year (106.71) to the second block year (106.72). (97.39) for more than three authors.

Gupta B.M. and Dhawan S.M (2018)[15] investigated Artificial Intelligence Research in India: A Scientometric Assessment of Publication Output from the period 2007 to 2016. The paper observes the global research output in artificial intelligence, a total of 1, and 52,655 publications as seen in the Scopus database from 2007 to 2016. In artificial intelligence research, the top ten countries accounted for 74.32 percent of the global publication share. Their global publication share varied from 3.68 percent to 19.46 percent, with China accounting for 19.46%. In addition, the paper examines Indian publications in the field of artificial intelligence research between the period 2007 and 2016, India published 9730 papers, with an annual average growth rate of 27.45%, an average citation impact of 2.76 citations per paper, and a contribution of 10.34% of its total country output as international collaborative publications. The field of computer science had the most publications (86.99%).

Rishabh Shrivastava and Preeti Mahajan (2016)[16] A Scientific Analysis of Artificial Intelligence Research in India, at the end of July 2015, the data was manually collected using the Scopus database. From 1968 to 2014, publications in the field of artificial intelligence research in India were retrieved. 6,529 papers were published during this period in India. In this data set, the average number of citations per paper is 3.06. An average of three authors for each paper. The most popular keyword was discovered to be "Artificial Intelligence," followed by "Algorithms." 12.64% are published with International collaboration. Anna University was discovered to be the research productivity leader. The IITs were discovered to play a significant role in this field.

Scientometric Analysis of the Application of Artificial Intelligence in Agriculture by Juan Pablo Garcia Vazquez et al (2021)[17] shows that Artificial intelligence (AI) is regarded as a critical component in addressing the current challenges confronting the agricultural sector, such as food production and climate change. Since AI is successfully assisting in the optimization of human processes or tasks in a variety of industries. China, the United States, India, and Australia have more publications in the document type. The United States has more authors and institutions working together than any other country. China Agricultural University had the most papers published, and Gerrit Hoogenboom of the University of Florida has the most publications. Finally, we discovered that precision agriculture, smart farming, and smart sustainable agriculture are all terms that refer to the use of artificial intelligence and information technologies in agriculture.

Ignacio Rodríguez-Rodríguez et al (2021)[18] investigated the COVID-19 Pandemic they conduct a scientometric analysis of this area supported by text mining. They used VOS viewer software developed by researchers at Leiden University in the Netherlands for this purpose. They also identified the most relevant journals in terms of the COVID-19 pandemic, demonstrated the increasing value of open-access publishing, and highlighted the most influential authors through citation and co-citation analysis.

Praveena K. et al (2021)[19] investigated the Mapping of Artificial Intelligence Research Output: A Scientometric Study. The current study examines the current state of artificial intelligence research. At the end of November 2020,

the data will be collected from the Web of Science. The study's time frame ranges from 1999 to 2019. During this time period, a total of 21643 papers on the subject of artificial intelligence were published. The collection is exported to HistCite, which returns a long list of 20743 articles and 341247 times cited references, as well as their local and global citation scores (LCS and GCS). The Degree of Collaboration is found to be 0.83.

Chatterjee, J., & Dethlefs, N. (2021)[20] examined the Scientometric review of artificial intelligence for wind turbine operations and maintenance: The Past, Present, and Future. Wind energy has recently emerged as a highly promising renewable energy source. They provide a future perspective as well as current key challenges in data availability and quality, lack of transparency in black box-natured AI models, and prevailing issues in deploying models for real-time decision support, as well as potential solutions to these issues.

OBJECTIVES

- To study the global output in the top 10 most productive countries
- To study the growth of global share and its impact on citation
- To study the international collaboration of Indian publications and partner countries.
- To study the Relative growth rate, Authorship pattern
- Degree of collaboration, CI, CC, MCC, and Co-author Index
- To study the output of Indian research by broad subject areas and its growth and decline
- To study the most productive Indian organizations and authors
- To study the time series analysis

RESEARCH METHODOLOGY

Scopus database (http://www.scopus.com) was used to retrieve and download the 10-year publications data for artificial intelligence research at the global level for the period 2011-2020. Your query: (TITLE-ABS-KEY ("Artificial Intelligence") AND PUBYEAR > 2010 AND PUBYEAR < 2021 AND (LIMIT-TO (AFFILCOUNTRY, "India”))) Data was collected on 29.03.2021 the file download excel sheet.

DATA ANALYSIS

Global and India’s Output in Artificial Intelligence Research

Table 1 Global and India’s Output in Artificial Intelligence Research

	World		India							
Year	Publications	%	Publications	%	Citations	%	CPP	h-index	ICP	%
2011	15892	7.11	887	4.83	7171	0.81	8.08	36	138	3.75
2012	17027	7.62	896	4.88	6868	0.78	7.67	37	161	4.38
2013	16298	7.29	1022	5.56	8839	1.00	8.65	40	200	5.44
2014	18429	8.24	1242	6.76	10659	1.21	8.58	40	189	5.14
2015	20887	9.34	1987	10.82	16530	1.87	8.32	50	276	7.50
2016	22610	10.11	2254	12.27	48892	5.54	21.69	51	340	9.24

2017	22943	10.26	2386	12.99	110626	12.53	46.36	84	306	8.32
2018	27484	12.30	2448	13.33	196264	22.22	80.17	130	466	12.67
2019	28776	12.87	2503	13.62	214417	24.28	85.66	144	586	15.93
2020	33192	14.85	2746	14.95	262938	29.77	95.75	163	1017	27.64
2011-15	88533	39.61	6034	32.85	50067	5.67	8.30	203	964	26.20
2016-20	135005	60.39	12337	67.15	833137	94.33	67.53	572	2715	73.80
2011-20	223538	100.00	18371	100.00	883204	100.00	48.08	1550	3679	100.00

Table 1 shows the global research output in the field of artificial intelligence cumulated to a total of 223538 publications in 10 years from 2011to 2020. The annual global output increased from 15892 in 2011 to 33192 publications in 2020. The 5 years research output of the global level in artificial intelligence was 88533 (39.61%) in 2011-2015 and increased to 135005 publications in 2016-2020. The growth in the second half of the study period 2011-2020 was comparatively faster. India's research output in the field of artificial intelligence cumulated to a total of 18371 publications in 10 years from 2011 to 2020. Its annual output increased in volume from 887 in 2011 to 2746 publications in 2020. The five-year research output of the country jumped by 32.85%, from 6034 in 2011-15 to 12337 publications in 2016-2020. India's global share in artificial intelligence research from 2011-to 2020; its five-year global share increased substantially from 32.85% in 2011to 2015 to 67.15% from 2015 to 2020. The citation impact of India's publications output in artificial intelligence research averaged 48.08 citations per paper in 10 years from 2011to 2020. Its five-year citation impact declined from 8.30 in 2011-15 to 67.53 CPP in 20162-2020 as shown in Table 1.

International Collaboration

Table 2 India's internationally collaborative research output with leading countries and their share in artificial intelligence

Collaborative country	**Number of a collaborative paper**			**Share of a collaborative paper**		
	2011-2015	**2016-2020**	**2011-2020**	**2011-2015**	**2016-2020**	**2011-2020**
United States	247	494	741	12.51	25.01	37.52
United Kingdom	68	189	257	3.44	9.57	13.01
Australia	39	123	162	1.97	6.23	8.20
China	19	133	152	0.96	6.73	7.70
Singapore	50	96	146	2.53	4.86	7.39
Canada	44	76	120	2.23	3.85	6.08
Malaysia	23	87	110	1.16	4.41	5.57
France	50	50	100	2.53	2.53	5.06
Germany	29	66	95	1.47	3.34	4.81
Saudi Arabia	22	70	92	1.11	3.54	4.66
Indian total	591	1384	1975	29.92	70.08	100.00

In Table-2 shows that the USA is listed in the top accounting for (37.52%) share among the leading countries that collaborated with India, followed by the U.K. (13.01 %), Singapore (7.39 %), France and Canada (5.06 %, and 6.08 %), Australia, Germany, and Malaysia (from 8.20 % to 5.57 %), Saudi Arabia and China (4.66% and 7.70%) during 2011- 2020. The top countries whose share in India's international collaborative publications increased were the USA, the U.K, Australia, China, and Singapore, whereas decreases in the collaborative output by Canada, Malaysia, France, Germany, Saudi Arabia from 2011 to 2015 to 2016-202016 were shown in Table 2.

Top 10 Most Productive Countries in Artificial Intelligence Research

Table 3 Global Publication Share of Top 10 Most Productive Countries in Artificial Intelligence Research

Name of the country	Number of paper			Share of the paper		
	2011-2015	2016-2020	2011-2020	2011-2015	2016-2020	2011-2020
China	15374	29129	44503	22.48	27.59	25.58
United States	16665	25178	41843	24.37	23.85	24.05
India	6031	12324	18355	8.82	11.67	10.55
United Kingdom	6032	8541	14573	8.82	8.09	8.38
Germany	5253	6563	11816	7.68	6.22	6.79
France	4374	4713	9087	6.40	4.46	5.22
Italy	3689	5141	8830	5.40	4.87	5.08
Spain	4250	4463	8713	6.22	4.23	5.01
Japan	3364	5071	8435	4.92	4.80	4.85
Canada	3343	4456	7799	4.89	4.22	4.48
Total	68375	105579	173954	100.00	100.00	100.00
world	109459	171252	280711	38.99	61.01	100.00
Share of 10 countries in world total	39.31	60.69	100.00			

As from the publications data from 2011 to 2020 the Artificial intelligence research is spread across more than 100 countries. Table-, shows the top 10 most productive countries that accounted for 38.99% of global publication share in artificial intelligence research in 10 years. Their cumulated research output ranged between 7799 and 44503 publications and their global publications share ranged between 39.31% and 60.69% during 2011 to 2020. Their five-year global publication share increased marginally from 38.99% in 2011-2015 to 61.01% in 2016-2020. China accounted for the largest global publication share (25.58%) in 10 years, followed by the USA (24.05%), India and U.K. (10.55 % and 8.38 %), Germany (6.79 %), France and Italy (5.22% and 5.08%), Spain, Japan, and Canada (from 5.01% to 4.48%) during 2011-2020. as shown in Table 3.

Relative Growth Rate (RGR)

The rate of growth has been calculated as the most important feature of science and technology in recent years. Scientific progress has necessitated an increase in both manpower and financial investment. The increase in the number of publications per unit of time indicates the relative growth rate. **Mahapatra (1985)**[21] developed the following formula to calculate the mean relative growth rate over the specific period of the interval.

$$R(a) = \frac{(W_2 - W_1)}{(T_2 - T_1)}$$

Where,

R (a) = RGR = the mean relative growth rate over the specific period of interval

W_1 = the logarithm of the beginning number of publications/pages

W_2= the logarithm of the ending number of publications/pages after a specific period of interval

$T_2 - T_1$ = the unit difference between the beginning time and the ending time.

The doubling time is the time required to double the number of records actually published in a given period. The doubling time is calculated from the relative growth rate and the natural logarithm number is used, the difference has a value of 0.693. The following formula can be used to calculate the corresponding doubling time:

$$Dt = \frac{0.693}{R(a)}$$

Relative Growth Rate (RGR) in artificial Intelligence Research Publications

Table 4 Relative Growth Rate (RGR) in artificial Intelligence Research Publications

S. No	Year	Publications	Cum	W1	W2	RGR=(W2-W1)	Dt=(0.693/RGR
1	2011	887	887		6.79		
2	2012	896	1783	6.79	7.49	0.70	0.99
3	2013	1022	2805	7.49	7.94	0.45	1.53
4	2014	1242	4047	7.94	8.31	0.37	1.89
5	2015	1987	6034	8.31	8.71	0.40	1.73
6	2016	2254	8288	8.71	9.02	0.32	2.18
7	2017	2386	10674	9.02	9.28	0.25	2.74
8	2018	2448	13122	9.28	9.48	0.21	3.36
9	2019	2503	15625	9.48	9.66	0.17	3.97
10	2020	2746	18371	9.66	9.82	0.16	4.28
	Total	18371					

Table 4 shows the results of calculating the relative growth rate and the doubling time (Dt) in artificial intelligence research output in India. According to the research, the relative growth rate in 2012 is 0.70, and in 2020 the relative growth rate is 0.16. According to this study, the relative growth rate is decreasing from 2011 to 2020. At the same time, the doubling time is found to be 0.99 in 2012 and 4.28 in 2020. During the study period, it was confirmed that the doubling time was increasing.

Authorship Pattern in artificial Intelligence Research Publications

Table 5 Authorship Pattern in artificial Intelligence Research Publications

Authorship Pattern							
Year	**1**	**2**	**3**	**4**	**5**	**>5**	**Total**
2011	54	374	267	125	42	25	887
2012	48	342	270	153	59	24	896
2013	52	395	298	164	71	42	1022
2014	73	512	358	190	69	40	1242
2015	88	883	554	286	104	72	1987
2016	108	1012	761	313	112	80	2386
2017	115	918	668	332	140	81	2254
2018	126	946	698	424	177	132	2503
2019	135	801	716	412	228	156	2448
2020	164	799	789	473	235	286	2746
Total	963	6982	5379	2872	1237	938	18371
%	5.24	38.01	29.28	15.63	6.73	5.11	100.00

Table 5 shows the authorship pattern in the field of artificial intelligence research output in India for a ten-year study period. From the study it was identified in table-5, that the majority of the authors in the field are preferred to publish their research works in two authorship modes with 6982(38.01%) publications. Followed by three authors with 5379(29.28%) publications, four authorship modes with 2872(15.63%) publications, and five authorship modes with 1237(6.735). Single authors have contributed 963(5.24%) publications, and more than five authors have contributed 938(5.11%) publications. It is confirmed that more than 94.76% of publications are contributed by multiple authors in this study.

Degree of Collaboration

The degree of collaboration is the relationship between the single author and multi-author contributions. The degree of collaboration is used by the **Subramaniyam** formula (1983)[22], used by **Vivekanandhan (2016)[23] Sivasamy (2020)[24] Ravichandran (2021)**[25]

$$DC = \frac{Nm}{(Nm + Ns)}$$

Where DC = Degree of Collaboration

N_m = Number of multi-authored publications

N_s = Number of single-authored publications

In the present study, Nm = 18371, Ns= 963

So that, the degree of collaboration is =18371/ (963+18371) = 0.95

Degree of Collaboration in artificial Intelligence Research Publications

Table 6 Degree of Collaboration in artificial Intelligence Research Publications

Year	Single author publications NS	Multi authors publications NM	Total authors publications NM+NS	Degree of collaborations DC= NM/(NM+NS)
2011	54	833	887	0.94
2012	48	848	896	0.95
2013	52	970	1022	0.95
2014	73	1169	1242	0.94
2015	88	1899	1987	0.96
2016	108	2278	2386	0.95
2017	115	2139	2254	0.95
2018	126	2377	2503	0.95
2019	135	2313	2448	0.94
2020	164	2582	2746	0.94
Total	963	17408	18371	

Table 6 examines the degree of collaboration of India in artificial intelligence research publications for the period of ten years. From this study, it is identified that the degree of collaboration is between 0.94 in the year 2011 and 0.94 in the year 2020. The average degree of collaboration is 0.95. The majority of artificial intelligence research publications contributed by collaborative authors were identified in this study.

Collaborative Coefficient, Collaboration Index, Modified Collaboration Coefficient

Collaborative Coefficient (CC)

The following formula proposed by **Ajiferuke et al**. can be used to measure the pattern of co-authorship collaboration among the authors (1988)[26]

$$CC = 1 - \left[\sum_{j=0}^{k}\left(\frac{1}{j}\right) \times Fj/N\right]$$

Whereas,

Fj = Number of publications with j author papers

N = Total number of research publications and

k = the greatest number of authors/papers in the given field.

Collaboration Index (CI)

The simple indicator is currently used in the publications to the collaboration index, which is roughly equivalent to the mean number of authors per paper as proposed by **Ajiferuke et al (1988)[26]**

$$CI = \frac{\sum_{j=1}^{k} jfj}{N}$$

Here

J - The number of co-authored papers appearing in a discipline

N - The total number of publications in the field over the same time period of interval and

k - The highest number of authors per paper in the same time field.

Modified Collaboration Coefficient

The modified collaboration coefficient (MCC) counted by the formula which is suggested by **Savanur and Srikanth**, (2010)[27]

Which is given below:

Where,

$$MCC = \frac{N}{N-1}\left[1 - \frac{\sum_{j=1}^{k} jfj}{N}\right]$$

j = the number authors in an article i.e. 1, 2, 3.....

Fj = the number of j authored articles

N = the total number of articles published in a year, and

A = the total number of authors per article

Collaborative Coefficient, Collaboration Index, Modified Collaboration Coefficient

Table 7 Collaborative Coefficient, Collaboration Index, Modified Collaboration Coefficient

Authorship Pattern									
Year	**1**	**2**	**3**	**4**	**5**	**>5**	**CC**	**CI**	**MCC**
2011	54	374	267	125	42	25	0.58	2.78	2.78
2012	48	342	270	153	59	24	0.59	2.89	2.90
2013	52	395	298	164	71	42	0.60	2.93	2.94
2014	73	512	358	190	69	40	0.58	2.83	2.83
2015	88	883	554	286	104	72	0.59	2.82	2.83
2016	108	1012	761	313	112	80	0.59	2.81	2.81
2017	115	918	668	332	140	81	0.59	2.87	2.87
2018	126	946	698	424	177	132	0.60	2.99	2.99
2019	135	801	716	412	228	156	0.61	3.11	3.11
2020	164	799	789	473	235	286	0.62	3.25	3.25
Total	963	6982	5379	2872	1237	938			

Table 7 explains the collaborative measures of artificial intelligence research publications in India for the period of ten years from 2011 to 2020. From the study, it is identified that the maximum collaboration coefficient value is 0.62 in the year 2020, and the minimum CC value is 0.58 in the year 2011 and 2014. The average collaborative coefficient value is 0.60. The collaboration index values are identified in the above-mentioned table, the maximum

collaboration index value is 3.25 in the year 2020 and the minimum collaboration index value is 2.78 in the year 2011, the average collaboration index value is 2.90. The modified collaborative coefficient is the maximum value of 3.25, and the minimum value is 2.78. The average value of MCC is 2.90, during this period of study.

Co-authorship Index (CAI)

To investigate how the pattern of co-authorship and the use of the co-authorship index proposed by **Garg and Padhi (2001)**[28] has been explained by the following formula. To calculate the co-authorship index (CAI), the entire set of data is divided into two block years.

$$CAI = \left[\frac{(Nij/Nio)}{(Noj/Noo)}\right] \times 100$$

Whereas,

Nij - Number of publications having j authors in I block

Nio - Total publications of I block

Noj - Number of publications having j authors for all blocks

Noo-: Total number of publications for all authors and all blocks

Here CAI=100 implies that a country's co-authorship effort for particular authorship corresponds to the world average

CAI > 100 reflects a higher than average co-authorship effort

CAI < 100 reflects lower than average co-authorship effort by the given type of authorship pattern.

For calculating the co-authorship index for authors, years have been replaced with block years. For this study, the authors have been classified into two blocks (ie.2011-2015 and 2016-2020) Vs**.** Single, Two, Three authors, and More than three authors.

Co-authorship Index (CAI) in artificial Intelligence Research Publications

Table 8 Co-authorship Index (CAI) in artificial Intelligence Research Publications

5 year Block	Single Author	CAI	Two Authors	CAI	Three Authors	CAI	More than three Author	CAI	Total
2011-2015	315	99.59	2506	109.28	1747	98.88	1466	88.44	6034
2016-2020	648	100.20	4476	95.46	3632	100.55	3581	105.66	12337
Total	963		6982		5379		5047		18371

From table-8, we can find that the Co-Authorship Index values are calculated by the block year period for artificial intelligence research publications in India for the period of ten years as mentioned. According to the findings of the study, CAI for single, three authors, and more than three authorship contributions is increasing from the first to the second block year. Simultaneously, CAI is decreasing for two authors, from the first to the second block year. 1st block (109.28) to 2nd block (95.46).

Activity Index (AI)

The Activity Index (AI) characterizes a country's relative research efforts on a given subject. The Activity Index was calculated for each year in the current study to show the performance of artificial intelligence over time. Frame proposed the Activity Index, which is now used by many organizations **Schubert & Braun, (1986)[29], De Solla Price, (1981)[30], Karki & Garg, (1997)**[31]. It is defined as:

$$A = \left[\frac{\text{Given field's share of the countries publications}}{\text{Given field's share of the world publications}}\right] \times 100$$

The method used for calculating AI has been explained below for research output by different nations in different blocks.

$$AI = \left[\frac{[N_{ij} / Nio]}{[Noj / Noo]}\right] \times 100$$

Where

N_{ij} = Number of publications in theme I and block A

N_{io} = Number of publications in theme I for all blocks

N_{oj} = Number of publications in all fields block A

N_{oo} = Number of publications for all fields and all blocks

AI = 100 indicates that the country's research effort in the given field is corresponds

Precisely to the world's average

AI > 100 reflects higher activity than the world's average, and

AI < 100 indicates lower than average effort dedicated to the field under study.

The subject wise breakup of publications output of India in artificial intelligence research

Table 9 The subject wise breakup of publications output of India in artificial intelligence research

Subject	Number of publications			% TP	Activity Index		Total Citations	%	CPP
	2011-2015	2016-2020	2011-2020		2011-2015	2016-2020	2011-2020		2011-2020
Agricultural and Biological Sciences	45	129	174	0.95	78.37	110.66	2601	2.66	14.95
Arts and Humanities	21	54	75	0.41	84.84	107.47	854	0.87	11.39
Biochemistry, Genetics and Molecular Biology	402	247	649	3.53	187.69	56.81	4653	4.75	7.17
Business, Management and Accounting	93	353	446	2.42	63.18	118.13	3141	3.21	7.04
Chemical Engineering	67	185	252	1.37	80.56	109.57	1412	1.44	5.60
Chemistry	37	103	140	0.76	80.08	109.81	1027	1.05	7.34
Computer Science	5064	10181	15245	82.80	100.65	99.68	76843	78.46	5.04

Decision Sciences	271	937	1208	6.56	67.98	115.77	5070	5.18	4.20
Dentistry	0	14	14	0.08	0.00	149.26	37	0.04	2.64
Earth and Planetary Sciences	76	132	208	1.13	110.72	94.72	2306	2.35	11.09
Total Indian output	6076	12335	18411	100.00					

The artificial intelligence research output by India published during 2011-2020 is distributed across ten sub-fields (as identified in the Scopus database classification), with computer science accounting for the highest publications share 15245(82.80 %), followed by Decision Sciences 1208(6.56%), biochemistry, genetics & molecular biology 649(3.53 %), Business, Management and Accounting 446(2.42%), Chemical Engineering 252(1.37%), Earth and Planetary Sciences 208(1.13%) and Agricultural and Biological Sciences 174(0.95%) during 2011-2020. The activity index, which computes the change in research activity in a discipline from time 2011-15 to 2016- 20 (the world average activity index of a given subject is taken as 100), witnessed

Increase in computer science (from 99.68 to 100.65), Decision Sciences (from 67.98 to 115.77), Biochemistry, Genetics and Molecular Biology (from 187.69 to 56.81), Business, Management and Accounting (from 63.18 to 118.13), and Chemical Engineering (from 80.56 to 109.57), Agricultural and Biological Sciences decision science (from 78.37 to 110.66), whereas activity index declined in Earth and Planetary Sciences (from 110.72 to 94.72) and Arts and Humanities (from 84.84 to 107.47) from 2011-15 to 2016-20. They registered the highest citation of Computer Science 76843(78.46%), CPP is 5.04, followed by Decision Sciences 5070(5.18%) citations, CPP is 4.20, Biochemistry, Genetics, and Molecular Biology 4653(4.75%) citations, CPP is 7.17. during 2011-2020 as shown in Table 9.

Profile of Top 10 Most Productive Organizations from India

Table 10 Top 10 most productive organizations in artificial intelligence research in India

Organizations	**TP**	**%**	**TC**	**%**	**CPP**	**h-index**	**ICP**	**%**	**RCI**
Amity University, Noida	462	15.08	1244	5.49	2.69	13	282	10.65	0.36
Vellore Institute of Technology, Vellore	442	14.43	3847	16.98	8.70	28	258	9.74	1.18
Jadavpur University	402	13.12	2569	11.34	6.39	26	427	16.13	0.86
Anna University	368	12.01	2045	9.03	5.56	20	370	13.97	0.75
Indian Institute of Technology Kharagpur	287	9.37	2206	9.74	7.69	23	229	8.65	1.04
Indian Institute of Technology Delhi	274	8.94	3727	16.45	13.60	30	250	9.44	1.84
Amrita Vishwa Vidyapeetham	248	8.09	1358	5.99	5.48	18	245	9.25	0.74
Indian Statistical Institute, Kolkata	199	6.49	1830	8.08	9.20	24	226	8.53	1.24
Indian Institute of Science, Bengaluru	197	6.43	2250	9.93	11.42	18	231	8.72	1.54
Birla Institute of Technology and Science, Pilani	185	6.04	1583	6.99	8.56	19	130	4.91	1.16
Total of 10 organizations	3064	100.00	22659	100.00	7.40	219	2648	100.00	1.00
Total of India	11198								
Share of 10 organizations in India's total output	27.36								

A scientometric analysis of the top 10 most productive organizations from India in artificial intelligence revealed that their productivity varied from 185 to 462 publications shown in the table - 10; together they accounted for 3064(27.36%) national publications share during 2011-2020. Their scientometric profile is presented in Table 10. Four organizations registered productivity rates above the group average of 23.94. Amity University, Noida, 462(15.08%) research publications, 1224(5.49%) citations, CPP is 2.69, h- index is 13, and RCI is 0.36, Vellore Institute of Technology, Vellore 442(14.43%) research publications, 3847(16.98%) citations, CPP is 8.70, h-index is 28, RCI is 1.18. Jadavpur University 402(13.12%) research publications, 2569(11.34%) citations, CPP is 6.39, h-index is 26, and RCI is 0.86. And Anna University, Chennai, 368(12.01%) research publications, 2045(9.03%) citations, CPP is 5.56, h-index is 20, and RCI is 0.75.

Profile of Top 10 Most Productive Indian Authors

Table 11 Top 10 most productive authors in artificial intelligence research in India

Authors	Publications	%	Citations	%	CPP	h-index	ICP	%	RCI
Choudhury, T.	46	13.77	122	3.92	2.65	7	1	0.72	0.28
Soman, K.P.	39	11.68	272	8.73	6.97	8	1	0.72	0.75
Konar, A.	35	10.48	186	5.97	5.31	7	18	12.95	0.57
Malhotra, R.	34	10.18	526	16.89	15.47	11	4	2.88	1.66
Panigrahi, B.K.	32	9.58	736	23.64	23.00	15	11	7.91	2.47
Tripathy, B.K.	32	9.58	113	3.63	3.53	6	4	2.88	0.38
Dey, N.	30	8.98	402	12.91	13.40	11	51	36.69	1.44
Chaudhury, S.	29	8.68	50	1.61	1.72	4	1	0.72	0.18
Khatri, S.K.	29	8.68	52	1.67	1.79	4	0	0.00	0.19
Sangaiah, A.K.	28	8.38	655	21.03	23.39	13	48	34.53	2.51
Total of 10 authors	334	100.00	3114	100.00	97.25	86	139	100.00	
Total of Indian authors	2299								
Share of the 10 authors in India's total output		14.53							

A scientometric analysis of the top 10 most productive authors from India in artificial intelligence revealed that their productivity varied from 28 to 46 publications. Together they contributed 2299(14.53%) shares to national publications output from 2011to 2020. Their scientometric profile is presented in Table 11. Their scientometric profile is presented in Table 11. Four authors registered productivity rates above the group average of 64.11. Choudhury, T. 46(13.77%) research publications, 122(3.92%) citations, CPP is 2.65, h- index is 7, and RCI is 0.28, Soman, K.P.39(11.68%) research publications, 272(8.73%) citations, CPP is 6.97, h-index is 8, RCI is 0.75. Konar. A, .35 (10.48%) research publications, 186(5.97%) citations, CPP is 5.31, h-index is 7, and RCI is 0.57. And Malhotra, R, 34(10.18%) research publications, 2526(16.89%) citations, CPP is 15.47, h-index is 11, and RCI is 1.66.

Top 15 most productive journals in artificial research in India

Table 12 Top 15 most productive journals in artificial research in India

Journals	Number of paper			
	2011-2015	2016-2020	2011-2020	TP %
Advances In Intelligent Systems And Computing	337	1679	2016	36.23
Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics	611	522	1133	20.36
Communications In Computer And Information Science	254	296	550	9.88
Procedia Computer Science	74	420	494	8.88
ACM International Conference Proceeding Series	106	174	280	5.03
2014 IEEE International Conference On Computational Intelligence And Computing Research IEEE Iccic 2014	273	0	273	4.91
Smart Innovation Systems And Technologies	184	44	228	4.10
2016 IEEE International Conference On Computational Intelligence And Computing Research Iccic 2016	0	203	203	3.65
Proceedings 2015 International Conference On Computational Intelligence And Communication Networks Cicn 2015	0	203	203	3.65
Proceedings 2014 6th International Conference On Computational Intelligence And Communication Networks Cicn 2014	185	0	185	3.32
Total of 10 journals	2024	3541	5565	100.00
Total of Indian journals	4542	7911	12453	
Share of the 10 journals in India's total output	44.56	44.76	44.69	

Of the total publications output by India in artificial intelligence research, 2016(36.23%) appeared as Advances In Intelligent Systems And Computing, 1133(20.36%) in Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics 550(9.88%) in Communications In Computer And Information Science, and the rest as Procedia Computer Science 494(8.88%) and ACM International Conference Proceeding Series 280(5.03%). The top 10 journals accounted for a 44.56 % share (2024 papers) of total country output appearing in journal medium during 2011- 2020. The publication output in these 10 journals varied between 185 and 2016 papers per journal; the five-year output by India in these 10 journals increased marginally from 44.56 % in 2011-2016 to 44.76% in 2017-2020. During the study period 2011-2020 as shown in Table 12.

Time-series Analysis

Time series analysis reveals that the estimated growth values are identified based on previous data. A straight–line equation is adapted to measure the future values based on previous data. Time series analysis used by **Jeyshankar and Ramesh Babu B (2013)**[32]

Table 13 time series analysis

S. No	Year	Count (y)	X	Y	XY
1	2011	887	-5	25	-4435
2	2012	896	-4	16	-3584
3	2013	1022	-3	9	-3066
4	2014	1242	-2	4	-2484
5	2015	1987	-1	1	-1987
6	2016	2254	1	1	2254
7	2017	2386	2	4	4772
8	2018	2448	3	9	7344
9	2019	2503	4	16	10012
10	2020	2746	5	25	13730
		18371		110	22556

Table 15 shows that the time series analysis formula has been predicted for artificial intelligence research publications for the years 2025 and 2030

Straight Line Equation is

$Y = a + bx$

Here,

$\sum Y = 18371, \sum X^2 = 110, \sum XY = 22556$

$a = \sum Y/N = 18371/10 = 1837.1 = 1837$

$b = \sum XY/\sum X^2 = 22556/110 = 205.05 = 205$

Estimated publications in the year 2025 is when X=2025-2015=10

$Y = a + bx$

$= 1837 + (205*10) = 1837+2050 = 3887$

Estimated literature in 2030 is when X=2030-2015=15

$Y = a + bx$

$=1837 + (205*15) = 1837 + 3075= 4912$

The estimated growth based on a time series analysis statistical application will be expected in the artificial intelligence research publications in the year 2025 is around are equal to 3887 and in the year 2030 is around are equal to 4912. So that time serious analysis conformed that the publications on artificial intelligence research are increasing trend.

FINDING AND CONCLUSION

- The global research output in the field of artificial intelligence cumulated to a total of 223538 publications in 10 years from 2011to 2020. The annual world output increased in volume from 15892 in 2011 to 33192 publications in 2020. The five-year research output of the world in artificial intelligence jumped by 39.61% from 88533 in 2011-2015 to 135005 publications in 2016-2020. The growth in the latter half of the study period 2011-2020 was relatively faster. India's research output in the field of artificial intelligence cumulated to a total of 18371 publications in 10 years from 2011 to 2020.

- Among the leading countries that collaborated with India, the USA topped the list accounting for (37.52%) share, followed by the U.K. (13.01 %), Singapore (7.39 %), France, and Canada (5.06 % and 6.08 %).
- During the cumulated research output ranged between 7799 and 44503 publications and their global publications share ranged between 39.31% and 60.69% during 2011-2020. Their five-year global publication share increased marginally from 38.99% in 2011-2015 to 61.01% in 2016-2020. China accounted for the largest global publication share (25.58%) in 10 years,
- The study the relative growth rate is 0.70 in the year 2012 and 0.16 in the year 2020. This study confirmed that the relative growth rate is decreasing trend from 2011 to 2020. At the same time, doubling time is found that 0.99 in the year 2012 and 4.28 in the year 2020. It is confirmed that doubling time is an increasing trend during the study period.
- The study majority of the authorship pattern in the field are preferred to publish their research works in two authorship modes with 6982(38.01%) publications. Followed by three authorship modes with 5379(29.28%) publications, four authorship modes with 2872(15.63%) publications, and five authorship modes with 1237(6.735).
- The average degree of collaboration is 0.95. From this study, it is identified that the majority of artificial intelligence research publications are contributed by collaborative authors.
- During the maximum CC value is 0.62 in the year 2020, and the minimum CC value is 0.58 in the year 2011, and 2014. The average CC value is 0.60. The maximum CI value is 3.25 in the year 2020 and the minimum CI value is 2.78 in the year 2011, the average CI value is 2.90. The MCC is a maximum value of 3.25, and the minimum value is 2.78, the average value of MCC is 2.90.
- The study CAI for single authorship contributions is increasing trend from 1st block year to 2nd block year. At the same time, CAI is decreasing trend for two authors, single authors, three authors, and more than three authors increasing trend from 1st block year to 2nd block year.
- The activity index declined in Earth and Planetary Sciences (from 110.72 to 94.72) and Arts and Humanities (from 84.84 to 107.47) from 2011-15 to 2016-20. They registered the highest citation of Computer Science 76843(78.46%), CPP is 5.04,
- The study the Amity University, Noida, 462(15.08%) research publications, 1224(5.49%) citations, CPP is 2.69, h- index is 13, and RCI is 0.36, Vellore Institute of Technology, Vellore 442(14.43%) research publications, 3847(16.98%) citations, CPP is 8.70, h-index is 28, RCI is 1.18.
- During the Choudhury, T. 46(13.77%) research publications, 122(3.92%) citations, CPP is 2.65, h- index is 7, and RCI is 0.28, Soman, K.P.39(11.68%) research publications, 272(8.73%) citations, CPP is 6.97, h-index is 8, RCI is 0.75.
- During the journals of artificial intelligence research, 2016(36.23%) appeared as Advances In Intelligent Systems And Computing, 1133(20.36%) in Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics.
- The estimated growth based on a time series analysis statistical application will be expected in the artificial intelligence research publications in the year 2025 is around are equal to 3887 and in the year 2030 is around are equal to 4912. So that time serious analysis conformed that the publications on artificial intelligence research are increasing trend.

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