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Authorship Pattern and Degree of Collaboration in Artificial Sintelligence Literature: A Study Based on Indian Contribution

M. Kumaran[1]* and A. Manoharan[2]

[1]Research Scholar, PG and Research Department of Library and Information Science, Bishop Heber College (Autonamous), Trichy – 620017, Tamil Nadu, India; m.kumaran.m@gmail.com
[2]Associate Professor, PG and Research Department of Library and Information Science, Bishop Heber College (Autonamous), Trichy – 620017, Tamil Nadu, India

Abstract

An analysis of 2676 publications published by Indian scientists during 1986-2015 and indexed by Scopus online database indicates that the publication output in the Indian research publication. It is observed that the Indian contribution has collaborated research outputs with a maximum of 12 authors. It further reveals that single authored contributions were accounted for 6.17% and similarly two authored publications for 44.81% and three authored publications for 30.08% of the total publications. Also, the maximum of 12 authors have been contributed one article. India has contributed 2676 (2.82%) to the Global Artificial Intelligence literature during the study period (1986-2015). The analysis has been limited to publications indexed in Scopus database only. India is ranked 4th among the major contributors in Artificial Intelligence literature. This work is to provide a profile of research in Indian research publication in India.

Keywords: Authorship Pattern, Artificial Intelligence, India, Scientometrics

1. Introduction

India is leading in the field of engineering and technology. In this direction, the growing field of Artificial Intelligence (AI) is no exception. From this study, it is understood that there are considerably contributed to the global level as 2676 by Indian contribution against 66858 global. The authorship pattern has been studied using simple collaboration. Further, the top ten authors production, and their various indices were calculated and presented.

1.1 Concept of Artificial Intelligence

The field of AI research was founded at a conference on the campus of Dartmouth College in the summer of 1956. Those who attended would become the leaders of AI research for decades. Many of them predicted that a machine as intelligent as a human being would exist in no more than a generation and they were given millions of dollars to make this vision come true. The idea of inanimate objects coming to life as intelligent beings has been around for a long time. The ancient Greeks had myths about robots, and Chinese and Egyptian engineers built automatons.

2. Objectives

The main objective of this study was to use Scientometric analyze the key features of Artificial Intelligence and research activities at India level particularly to authorship pattern.

- To identify and analyse the rate of growth of research productivity on Artificial Intelligence.

*Author for correspondence

- To note the document wise distribution of publications.
- To analyse the authorship pattern and examine the extent of research collaboration.
- To identify the ranking of authors based on publications.

3. Methodology

The study is on Indian contribution to Artificial Intelligence as case study encompassing records output on Scopus online database. The growth rate of output in terms of both at absolute level and relative level are analysed from 1986 to 2015. The authorship pattern and author productivity are examined to identify the pattern of research contribution in the field of Artificial Intelligence. Further, an attempt is made to measure the performance of researchers and their research concentration in the field of Artificial Intelligence.

3.1 Scope and Limitations

- Only the articles indexed and abstracted in the Scopus database has been taken for the study.
- The search term on Artificial Intelligence has been used for getting results.
- As some of the Indian author articles have the international collaboration, no efforts were made to exclude the international authors to analysis author productivity and collaboration.

4. Data Analysis

4.1 Yearly Distribution of Indian Contribution to Artificial Intelligence Literature

The yearly distribution of publications were analyzed with Ratio of Growth (RoG) and CAGR (Compound Annual Growth Rate) and are listed in Table 1.

From the above Table it seems that the productivity of literature on one to two digits during the initial periods with some ups and downs and the first three digit publications reported in the year 2010 with 225 (8.41%) research outputs. The publication trend dips in the next two years again shows some decreases in the 2011 and 2012 with 111 and 114 (4.15% and4.26%) publications. From there on publication trend seen with some ups and downs till the year 2012. Thereafter the trend shows some positive signs and the annual productivity touched 10% contributed publications in the year 2013, publications with 263 (9.83%), in the year 2014, publications with 467 (17.45%) and the productivity in the year 2015 907 publications with (33.89%). The publication trend was positive till the end of the study period. Figure 1 illustrate the cumula-

Table 1. Yearly distribution of Indian contribution to artificial intelligence literature

S. No.	Year	TP	%	Cum	cum %	RoG	CAGR
1	1986	8	0.30	8	0.30		0.16
2	1987	8	0.30	16	0.60	1.00	0.16
3	1988	23	0.86	39	1.46	2.88	0.13
4	1989	19	0.71	58	2.17	0.83	0.14
5	1990	11	0.41	69	2.58	0.58	0.16
6	1991	5	0.19	74	2.77	0.45	0.20
7	1992	4	0.15	78	2.91	0.80	0.21
8	1993	9	0.34	87	3.25	2.25	0.19
9	1994	6	0.22	93	3.48	0.67	0.21
10	1995	14	0.52	107	4.00	2.33	0.18
11	1996	25	0.93	132	4.93	1.79	0.17
12	1997	14	0.52	146	5.46	0.56	0.20
13	1998	7	0.26	153	5.72	0.50	0.24
14	1999	14	0.52	167	6.24	2.00	0.21
15	2000	14	0.52	181	6.76	1.00	0.22
16	2001	13	0.49	194	7.25	0.93	0.24
17	2002	12	0.45	206	7.70	0.92	0.25
18	2003	20	0.75	226	8.45	1.67	0.24
19	2004	43	1.61	269	10.05	2.15	0.21
20	2005	54	2.02	323	12.07	1.26	0.20
21	2006	67	2.50	390	14.57	1.24	0.20
22	2007	63	2.35	453	16.93	0.94	0.22
23	2008	75	2.80	528	19.73	1.19	0.22
24	2009	61	2.28	589	22.01	0.81	0.25
25	2010	225	8.41	814	30.42	3.69	0.17
26	2011	111	4.15	925	34.57	0.49	0.24
27	2012	114	4.26	1039	38.83	1.03	0.25
28	2013	263	9.83	1302	48.65	2.31	0.20
29	2014	467	17.45	1769	66.11	1.78	0.16
30	2015	907	33.89	2676	100.00	1.94	0.10
		2676	100.00				

(RoG- Ratio of Growth, CAGR – compound Annual Growth Rate)

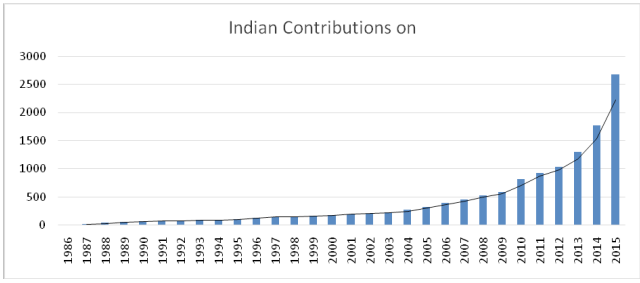

Figure 1. Yearly distribution of Indian contribution to artificial intelligence.

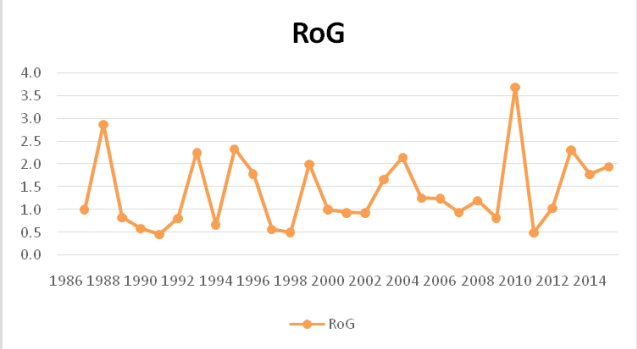

Figure 2. Indian contribution ratio of growth.

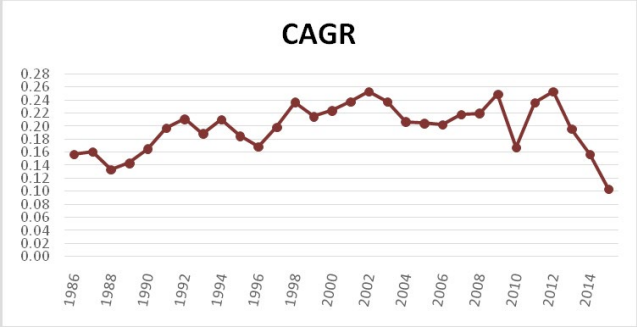

Figure 3. Indian contribution compound annual growth rate.

tive publications of the literature and shows linear growth during the study period. The Ratio of Growth of publications (RoG) ranged between 0.45 and 3.69 during the study period and reported very low in the year 1991 with 0.45 and high in the year 2010 with 3.69. The Ratio of Growth is above 1 in recent years of study. The Figure 2 shows the Ratio of Growth of literature for the study period which shows an exponential growth rate. The Compound Annual Growth Rate (CAGR) lies between 0.13 and 0.25. The Figure 3 shows the CAGR on yearly distribution and shows a parabolic trend over the period.

Table 2. Activity index of the Indian contributions

S.No.	Year	TP	World	Activity Index
1	1986	8	2246	008.90
2	1987	8	2353	008.49
3	1988	23	2230	025.77
4	1989	19	2352	020.18
5	1990	11	1219	022.55
6	1991	5	918	013.61
7	1992	4	905	011.04
8	1993	9	1085	020.72
9	1994	6	1252	011.97
10	1995	14	1082	032.33
11	1996	25	1092	057.20
12	1997	14	1204	029.05
13	1998	7	1130	015.48
14	1999	14	1150	030.42
15	2000	14	1193	029.32
16	2001	13	1040	031.23
17	2002	12	1023	029.31
18	2003	20	1305	038.29
19	2004	43	2699	039.80
20	2005	54	2824	047.77
21	2006	67	3283	050.99
22	2007	63	3877	040.60
23	2008	75	5198	036.05
24	2009	61	2227	068.43
25	2010	225	2786	201.78
26	2011	111	2452	113.10
27	2012	114	3330	85.53
28	2013	263	3294	199.48
29	2014	467	4368	267.12
30	2015	907	5741	394.72
	Total	2676	66858	100.00

4.2 Activity Index of Indian Contributions

The study has been carried out further to calculate the Activity Index (AI) of the Indian Publications and the results were presented in Table 2

From the above Table it is observed that Activity Index (AI) of Indian contribution were ranged between 8.90 and 394.72 between the study period. When the

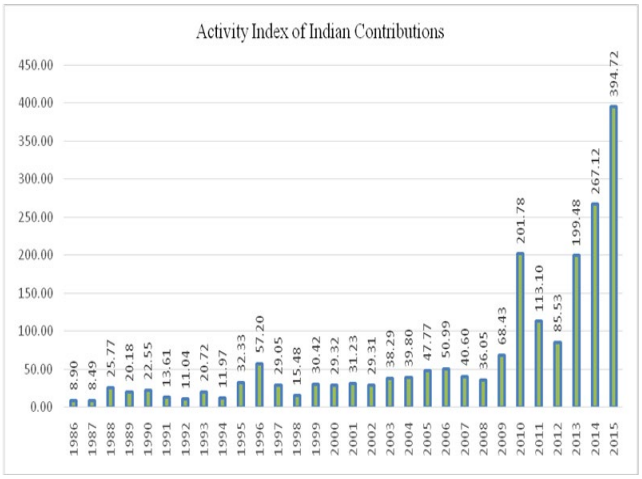

Figure 4. Activity index of Indian contributions.

performance of Indian contribution compared with the World's literature, AI reported less than 100 until the year 2009. It shows an increasing trend from 2010 onwards till the end of the study period because of various research and development activities has been carried out by the Indian scientists in recent years. The Figure 4 shows the Activity Index (AI) on the yearly distribution of Indian Contributions.

4.3 Author Productivity in Indian Contribution

The author productivity on Artificial Intelligence Literature in the Indian Contributions has been analyzed and presented in Table 3.

It is observed from above table that the Indian Contribution has collaborated research outputs with a maximum of 12 authors. It further reveals that single authored contributions were accounted for 6.17% and similarly two authored publications for 44.81% and three authored publications for 30.08% of the total publications. Also, the maximum of 12 authors have been contributed one article.

4.4 Authorship Pattern in Indian Contributions

The Authorship Pattern in Indian Contribution has been analyzed and the same has been presented in the Table 4

The above table shows that Single authored contributions occupy 6.17 of the total publications and the remaining 93.83% were produced from collaborated works. It shows that the Indian researchers are more

Table 3. Author productivity on indian contributions

S.No.	No. of Authors	TP	%	Cum.	Cum. %
1	1	165	6.17	1070	039.99
2	2	1199	44.81	3511	131.20
3	3	805	30.08	6015	224.78
4	4	330	12.33	7537	281.65
5	5	119	4.45	8348	311.96
6	6	40	1.49	8807	329.11
7	7	12	0.45	9020	337.07
8	8	4	0.15	9142	341.63
9	10	1	0.04	9197	343.68
10	12	1	0.04	9234	345.07
	Total	2676	100.00		

(TP-Total Publications, Cum- Cumulative)

Table 4. Authorship pattern in Indian contributions

S.No.	Authors collaboration	Frequency	%	Number of Authors
1	Single	165	6.17	165
2	Double	1199	44.81	2398
3	Three	805	30.08	2415
4	Four	330	12.33	1320
5	>4	177	06.61	885
	Total	2676	100.00	7183
Average Authors per article = 2.68				
Degrees of Collaboration = 0.938341				

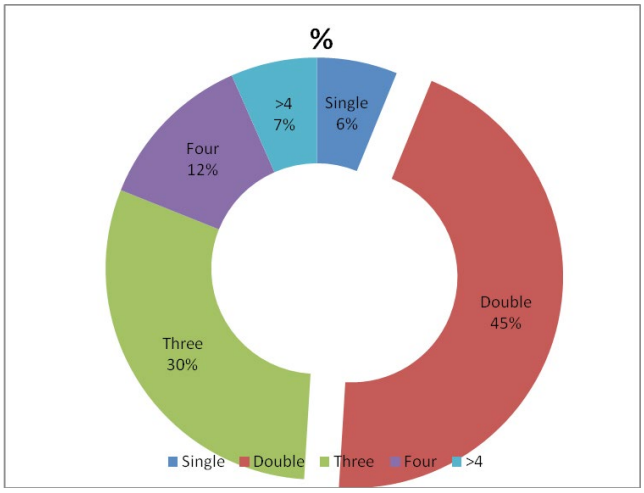

Figure 5. Share of authorship pattern.

interested in collaborative work rather than opting for an individual one. There are 7183 authors were involved in 2376 Indian contributions with an average of 2.68 authors per output. The Degree of Collaboration is 0.938341. From the analysis it is clear that the Indian contribution to the Artificial Intelligence literature is of collaborative nature. The Figure 5 shows the share of Authorship collaboration in Indian contribution.

4.5 Authorship Pattern versus Year in Indian Contributions

The yearly distribution of publications with number of authors contributed is examined along with the other authorship indices Degrees of Collaboration (DC), Collaborative Index (CI), Collaborative Coefficient (CC), and Modified Collaborative Coefficient (MCC) are presented in Table 5.

Table 5. Authorship pattern versus year in Indian contribution

S.No.	Year	Single	Double	Three	Four	Five and Above	Total	DC	CI	CC	MCC
1	1986	2	3	2	0	1	8	0.75	2.38	0.45	0.47
2	1987	0	4	4	0	0	8	1.00	2.50	0.58	0.61
3	1988	8	7	6	1	1	23	0.65	2.13	0.39	0.41
4	1989	1	8	5	2	3	19	0.95	2.89	0.59	0.62
5	1990	1	3	3	0	4	11	0.91	3.27	0.61	0.63
6	1991	2	1	2	0	0	5	0.60	2.00	0.37	0.38
7	1992	1	3	0	0	0	4	0.75	1.75	0.38	0.39
8	1993	0	5	4	0	0	9	1.00	2.44	0.57	0.60
9	1994	1	3	2	0	0	6	0.83	2.17	0.47	0.49
10	1995	1	9	2	2	0	14	0.93	2.36	0.52	0.55
11	1996	5	12	7	1	0	25	0.80	2.16	0.46	0.48
12	1997	1	8	2	3	0	14	0.93	2.50	0.54	0.56
13	1998	1	3	2	1	0	7	0.86	2.43	0.51	0.53
14	1999	1	5	6	2	0	14	0.93	2.64	0.57	0.60
15	2000	1	6	4	2	1	14	0.00	0.00	0.00	0.00
16	2001	2	5	5	1	0	13	0.85	2.38	0.51	0.53
17	2002	0	8	2	2	0	12	1.00	2.50	0.57	0.59
18	2003	2	5	12	0	1	20	0.90	2.65	0.57	0.59
19	2004	5	20	15	1	2	43	0.88	2.42	0.52	0.54
20	2005	5	19	17	9	4	54	0.91	2.78	0.57	0.59
21	2006	2	28	24	10	3	67	0.97	2.76	0.60	0.62
22	2007	4	27	22	6	4	63	0.94	2.67	0.57	0.59
23	2008	6	25	37	3	4	75	0.00	0.00	0.00	0.00
24	2009	3	26	21	10	1	61	0.95	2.67	0.58	0.60
25	2010	13	102	60	29	21	225	0.94	2.75	0.58	0.60
26	2011	12	34	46	11	8	111	0.89	2.72	0.56	0.58
27	2012	10	43	35	17	9	114	0.91	2.75	0.57	0.59
28	2013	13	112	71	50	17	263	0.95	2.79	0.59	0.61
29	2014	25	204	135	62	41	467	0.95	2.76	0.58	0.61
30	2015	37	461	252	105	52	907	0.96	2.64	0.57	0.60
	Total	165	1199	805	330	177	2676	0.94	2.68	0.57	0.59

(DC-Degree of Collaboration, CI-Collaborative Index, CC-Collaborative Coefficient, MCC- Modified Collaborative Coefficient)

From the above Table, it seems that the value of DC ranged between 0.60 and 1.00 with an average of 0.89 during the study period. The value of CC ranged between 0.37 and 0.61 with an average of 0.51. The value of CC lied between 0.43 and 0.64 with an average value of 0.59. The MCC value ranged between 0.38 and 0.62 with an average value of 0.61. From the above analysis it is indicated that multi-authored collaborated works dominates over single authored works throughout the study period.

4.6 Application of Various Indices to Top Ten Indian Authors

The study has been analyzed to find out the top ten Indian authors to calculate the standard bibliometric indicators like total publications, cited total publications, total citations and Average Citations per Paper (ACPP) and other indices like 'h', 'g', 'hg', 'p', 'R', '$h_{(nom)}$', 'e', and 'a' and the results were presented in Table 6.

From the above Table it is observed that among the Indian authors Pal S.K., has contributed the highest number of 16 publications on Artificial Intelligence literature which yielded 746 citations with CPP of 49.73 citations per paper. Tiwari M.K., has published 16 papers and got the citations among the Indian authors with 222 citations with CPP of 14.80 citations per paper. Panigrahi B. K., has contributed 15 publications and received 195 citations with CPP of 21.67 citations per paper. The 'h' index value for Pal S.K is 11 and his 'g' index value is 16. The 'h' index value for Tiwari M.K., is 9 and his 'g' index is 15 and the

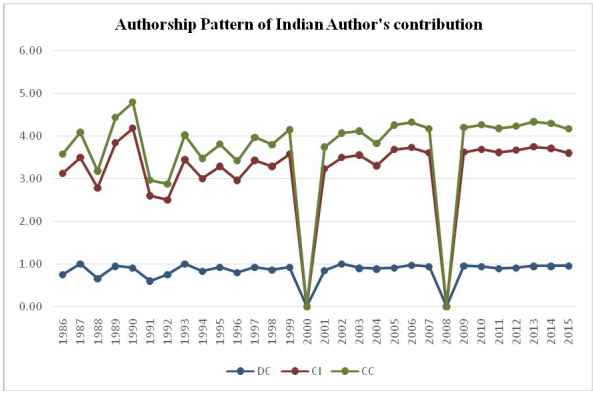

Figure 6. Authorship pattern of Indian author's contribution.

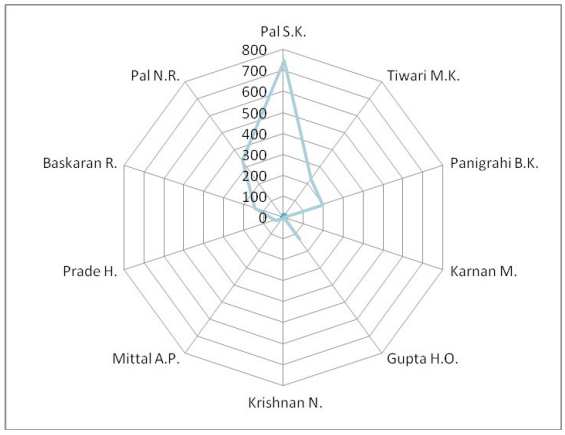

Figure 7. Various indices on top ten Indian authors publications.

Table 6. Various indices on top ten Indian authors publications

S. No	Authors	No. of Publications	cited TP	No. of Citations	CPP	CPP Rank	Avg. citations per paper (ACPP)	Bibliometric/Scientometric Indices								
								h-index	g-index	hg-index	p-index	r-index	Normalised "h" index - hnom	e-index	a-index	Rank
1	Pal S.K.	16	15	746	49.73	1	49.73	11	16	13.3	32.6	27.31	0.6875	25	67.82	1
2	Tiwari M.K.	16	15	222	14.80	7	14.80	9	15	11.6	14.5	14.9	0.5625	11.87	24.67	1
3	Panigrahi B.K.	15	9	195	21.67	4	21.67	6	14	9.17	13.6	13.96	0.4	12.61	32.5	3
4	Karnan M.	10	3	3	1.00	9	1.00	1	1	1	0.97	1.732	0.1	1.414	3	4
5	Gupta H.O.	9	8	126	15.75	6	15.75	4	1	2	12.1	11.22	0.444444	10.49	31.5	5
6	Krishnan N.	9	2	2	1.00	9	1.00	1	1	1	0.76	1.414	0.111111	1	2	5
7	Mittal A.P.	9	3	8	2.67	8	2.67	2	3	2.45	1.92	2.828	0.222222	2	4	5
8	Prade H.	9	2	41	20.50	5	20.50	2	6	3.46	5.72	6.403	0.222222	6.083	20.5	5
9	Baskaran R.	8	5	147	29.40	3	29.40	3	8	4.9	13.9	12.12	0.375	11.75	49	9
10	Pal N.R.	8	8	336	42.00	2	42.00	7	3	4.58	24.2	18.33	0.875	16.94	48	9

(TP-Total Publications, CTP- Cited Total Publications, TC-Total Citations, ACPP-Average Citations per Paper)

Table 7. Ranking of Indian authors based on indices

S.No	Author	based on citations	based on ACPP	h	g	hg	p	r	hnom	e	A
1	Pal S.K.	1	1	1	1	1	1	1	2	1	1
2	Tiwari M.K.	3	5	2	2	2	3	3	3	4	6
3	Panigrahi B.K.	4	6	4	3	3	5	4	5	3	4
4	Karnan M.	8	8	8	7	8	8	8	9	8	8
5	Gupta H.O.	6	4	5	8	8	6	6	4	6	5
6	Krishnan N.	10	10	9	8	9	10	10	9	10	10
7	Mittal A.P.	8	8	7	6	7	8	8	7	8	8
8	Prade H.	7	7	7	5	6	7	7	7	7	7
9	Baskaran R.	5	3	6	4	4	4	5	6	5	2
10	Pal N.R.	2	2	3	6	5	2	2	1	2	3

(TP-Total Publications, TC-Total Citations, ACPP-Average Citations per Paper)

'h' index value for Panigrahi B. K is 6 and his 'g' index is 14. All the calculated values of the indices for the top ten authors were indicated in the Table 6.

The Indian Authors were ranked based on the score obtained with various indices and the same has been presented in Table 7.

The top rank in terms of publications goes to Pal S.K., followed by Tiwari M.K., and Panigrahi B.K., In the total citations category the first rank goes to Pal S.K.,. Followed by Pal N.R., and Tiwari M.K., in terms of ACPP the first rank goes to Pal S.K followed by Pal N.R. and Baskaran R. In the other indices category, Pal N.R secured first rank in $h_{(nom)}$ indices and secured second rank in ACPP, 'P' ,'r' and 'e' index and secured third rank in 'h' index.

5. Findings and Conclusion

The findings of the year wise distribution of research output on Artificial Intelligence bring out the fact that the highest number of publication is 907 in 2015 followed by 467 papers in 2014 and 263 papers in 2013. From 1986 to 2009 the number of publications is less than 100. The finding of the ranking of authors based on their publications brings out the fact that pal S K has published 16 papers with 746 Citation Scores (h-index 11) ranked first based on number of publications in the field of Artificial Intelligence. It is to conclude that the sum of citations of the Artificial Intelligence research publications and the h index scored is good. Since, the database found contributions only from 1986, that the research begins during the period.

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