

A Quantitative Study on the Indo-Thai Collaborative Research Trend of 20 years (1999-2018)

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ABSTRACT: Being two prominent emerging economies of Asia, there have been some policy development from both Indian and Thailand government regarding research collaboration with the countries of South East Asian Nations. An evaluative study about the scientific collaboration between India and Thailand is essential to know the core strength and weaknesses of Indo-Thai collaborative research prospects. The current study makes a scientometrics assessment of Indo-Thai collaborative research from 1999 to 2018 and compares the collaboration growth with Indo-USA and Thai-USA collaboration of the same period based on Web of Science data. In the studied period, Indo-Thai collaboration has been growing at a greater rate than Indo-USA and Thai-USA collaboration, indicating the positive impact of Govt. policies. This trend is found to continue until 2030 with the forecasted data based on 20 years' records with the visible declining trend in Thai- USA collaboration scenario. Further top institutions from both countries in the high cited Indo- Thai collaborative research was listed out. The high cited articles often had multi-country collaboration where Indian and Thai institutions actively participated. USA is the top country that had a strong presence in the highly cited Indo-Thai collaborated papers. Keyword analysis of the high cited research articles reveals domains of health science, Physics, Particle property studies being prominent research areas of scientific collaboration between India and Thailand.

Keywords: Scientometrics, Scientific Collaboration, India, Thailand, Keyword Analysis

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1. Introduction

International collaboration is an essential part of Research and Development (R&D) policies of universities & research institutions in the 21st century knowledge creation process. Such international collaboration happens at various levels in various modes. It involves students and faculty exchange programs so that opinions and ideas can be shared & discussed. Collaboration in research might also happen for the development of new technologies. Sharing of scientific capabilities is another domain that leads to such international collaboration. India as a developing nation has been able to embark an important scientific point of view in the world for their cost-effective innovative technologies in the domains of space science, healthcare, renewable energy, etc. The Department of Science and Technology (DST) of Govt. of India mandates about the realization of international collabo

ration at two levels i) Bilateral Cooperation with developed and developing countries, (ii) Multilateral & Regional Cooperation (Department of Science and Technology, 2019). India is able to build significant col-laboration with Australia, Canada, EU, France, Germany, Israel, Japan, Russia, UK and USA via some program-oriented specific policies that gets budgetary provision in the annual union budget. Indo-French Centre for Promotion of Advanced Research (IFCPAR) is one such program financed by the Indian Govt. and France Govt. for collaborative scientific research programs in Artificial Intelligence, Big data, Quantum Materials, Biomedical Sciences and other allied subjects. Indo-US Science & Technology Forum (IUSSTF), Indo-German Science & Technology Centre (IGSTC) are another two major program for strategic collaboration building via joint workshops, fellowships, joint projects of mutual interest, virtual network clusters, laboratory sharing and many more. Moreover, with International Multilateral Regional Cooperation Division (IMRCD) of DST, Indian Govt. is making specific progress international, regional and multilateral S&T cooperation agreements/ frameworks with ASEAN, SAARC, ASEM, EAS countries.

With being a prominent member of associations like the BRICS, the G20, India not only being able to build strong economic and political relations with the developed and emerging economies of the world, but it is also helping to shape international collaboration of India in S&T domains. The University Grants Commission (UGC) of India has signed Memoranda of Understanding (MoUs) with countries like USA, UK, Germany, Norway, New Zealand for multiple joint research programs. The Ministry of Human Resource Development (MHRD) of Indian Govt. has embarked around 418 crores rupees for 2018-19 & 19-20 years under the Scheme for Promotion of Academic and Research Collaboration (SPARC) programs to facilitate the collaboration of Indian scholars with top-ranked institutions of the world (Press Information Bureau, 2018). Till the 2019-20 year, a total of 141 international collaborative projects are running, funded by the Department of Biotechnology under Indian Govt. (Department of Biotechnology, 2019).

With the Association of South-East Asian Nations (ASEAN), India started a specific ASEAN -India Science & Technology Collaboration in 1996, with the creation of ASEAN India S&T working group (AIWGST) with direct financial support from ASEAN-India fund which was later supported by a dedicated ASEAN India S&T Development Fund (AISTDF) financed by India. Later in 2015, the fund was increased to \$5 million every year. Under such process, India is increasing institutional collaboration with various Thai Universities in recent time. Moreover, strong collaboration between Indian pharmaceutical companies and Thai health business organizations is regularly observed. Such collaborations are actually helping institutions of both countries to have fair brownie points in various university ranking schemes at world level as well as national levels. Regular announcement of bilateral research funding schemes from DST of Govt. of India & Ministry of Science and Technology of Kingdom of Thailand is observed in recent years (Department of Science and Technology, 2018). With such growing trend of funding scenarios from Govt. of both India and Thailand, an assessment of collaborative research projects that have been able to trend among world scientific community may further help to shape the policy of funding process in coming times.

2. Review of Literature

Assessment of scientific collaboration among authors, institutions, countries is a broader domain of research under evaluative bibliometric practices. The issue of Thai University and institutions perspective about collaborative research is widely discussed by Numprasertchai & Igel (2005) using practical examples of different Thai universities. The study elaborated about “not so good” quality of university-industry linkage of Thai universities and probable possibilities for a better scenario in that perspective with the establishment of various Govt. funded research institutions. Worasinchai & Ribiere (2008) proposed a Government, University, Industry and Networks (G-U-I-N) framework for Thai university and industry collaboration perspectives for facilitating better knowledge management. Singh & Hasan (2015) made an assessment of the research collaboration and scientific output of BRICS countries. Analyzing the internal network of the BRICS countries the study finds, India having a strong collaboration with China and Russia reflecting the result of international collaboration policy of Indian Govt. The study also reflected the USA as the top country that maintained the highest collaboration with every other BRICS country. Gupta, Lal, & Zainab (2002) studied about the bilateral and multilateral collaboration of India with the south-east Asian countries and finds India-Malaysia collaboration to be at the top and India-Thailand Collaboration in 4th position among the Southeast Asian countries. Measuring collaboration in a size-independent Probabilistic Affinity Index (PAI), Finardi (2015) listed out collaboration among BRICS countries within scientific sub-areas and at country level. The study finds a stable trend of the international collaboration of BRICS countries in PAI scale. Jhamb, Meera, & Singh (2019) made an elaborative quantitative study of scientific collaboration in Indian Geology research using different collaboration metrics scales. The study finds strong Indo-US collaboration followed by Indo-UK and Indo-Germany collaboration in the studied period in Geology research of India.

3. Objectives of the Current Study

Observing the growing active trend of India's funding approach towards collaborative research projects with ASEAN countries, the current study was undertaken to understand the collaborative research trend of India and Thailand in quality scientific publications from 1999-2018. This study was undertaken to fulfill some dimensions of Indo-Thai collaborative research as mentioned in the following objectives-

- To study the growth trend of Indo-Thai collaborative research papers of the last twenty years (1999-2018) and compare it with the USA, the collaboration of both the countries forecasting the future growth trend until 2030.
- To list out the highly cited Indo-Thai collaborated research papers and find out the top institutions from India and Thailand that have been able to produce those highly cited collaborative research in the studied period.
- To find out the top journals where Indo-Thai collaborated highly cited research papers have been published most.
- To find out the core subject areas of research for the highly cited papers using keyword analysis of title and abstract of the research articles.

4. Methodology

4.1. Data Source and Data Collection

Web of Science (WoS) core collection was used as a data source for collecting the highly cited articles having "India AND Thailand" in the address field. The time limit applied to the collection of data was 1999 -2018. It retrieved all total of 3185 articles. The collected data were then downloaded in txt format. The citation count limit was chosen until the date of data collection. The individual country output for the same period was also collected from WoS.

4.2. Analysis Process

For filtering the highly cited articles, it was necessary to set the minimum criteria of the citation number. As in 20 years period, the number of collaborated articles were only 3185, a minimum citation value of 50 citations were set as a threshold for an article to be considered as highly cited. With this criterion set, a total of 474 articles was got that had a minimum of 50 citations. Further analysis was done on this dataset of 474 articles. Bibexcel (Pearson, R Danell, & Wiborg, 2009) tool was used as a tool for processing the collected data as per the objectives of the study. MS-Excel was also used for further in-depth analysis of those data.

5. Findings and Discussion

5.1. Findings Against Objective 1

The growth trend of overall Indo-Thai collaborated research articles were studied and the growth trend was compared from both Indian perspectives (i.e. comparing it with total Indian research output) and Thai perspectives (i.e. comparing with total Thai research output). As both countries have a strong tendency to collaborate with well -established laboratories, facilities and institutions of USA, the Indo- USA collaboration and Thai-USA collaboration for the same period was also studied to make a comparison of the growth trend of Indo-Thai collaboration with Indo-USA collaboration and Thai- USA collaboration. In the twenty years' period from 1999-2018, yearly on an average 159 Indo -Thai collaborative research articles have been published that formed 0.272% of total Indian output and 2.280% of total Thai output. The average share of Indo -USA collaborative articles for the same period was 7.37% of total Indian while the same for Thai-USA collaborated articles were 19.665% of total Thai output.

In the studied period, Combined Annual Growth Rate (CAGR) of Indo-Thai collaborated articles were 137%. From Indian perspectives the growth is 57% over the period when it is compared with total Indian output. From Thailand's perspectives the growth is 36% over the period when compared with total Thai output. The growth trend is checked in MS-Excel in a multi axis graph, plotting the yearly collaborative output as bar diagram in left X-axis and cumulative of yearly collaborative output in right X- axis as a function of Time (i.e. Year) as shown in fig 1. When a regression line is drawn by comparing this two data points for the already available article output and the forecasted trend, the resultant R2 value obtained is 0.967, falling in the much significant range of 0.9 to 1.0, proving the exponential growth trend of Indo-Thai collaborative research. Average Yearly Growth Rate (AYGR) as compared to total Indian output over the years is 15.39% while the same as compared to total Thailand's output is 11.51%. Over the same period, the AYGR for Indo- USA collaboration is 2.28 in comparison to total Indian output and the

AYGR for Thai-USA collaboration growth is 0.06% with a visible declining trend. The higher growth rate from both Indian and Thai perspective proves the increasing trend of Indo-Thai collaborative research domains in the last 20 years. Table 1 shows the detailed findings.

The following formulas were used to calculate the Yearly Growth Rate and Combined Annual Growth Rate in Table 1 and Table 2. Growth rate was calculated based on percentage growth to make the result more normalized without any presence of bias effect.

$$\text{Yearly Growth Rate} = (\text{Data of year 2} - \text{Data of year 1}) / \text{Data of year 1} \times 100$$

$$\text{Combined Annual Growth Rate} = \left[\frac{\text{Value at the end of the period}}{\text{Value at the beginning of the period}} \right]^{1/\text{No of years-1}} \times 100$$

Forecasting of the future Indo-Thai collaboration trend until 2030, based on the 20 years' data, it was found that the fore-casted AYGR until 2030 for Indo -Thai collaborated articles is 6.04% from Indian perspective while the same is 6.15% from the Thai perspective. This AYGR is far higher than the forecasted collaboration growth of Indo-USA and Thai-USA till 2030. In fact, a negative growth trend will be observed in the Thai-USA collaboration until 2030. Table 2 represents the detailed findings.

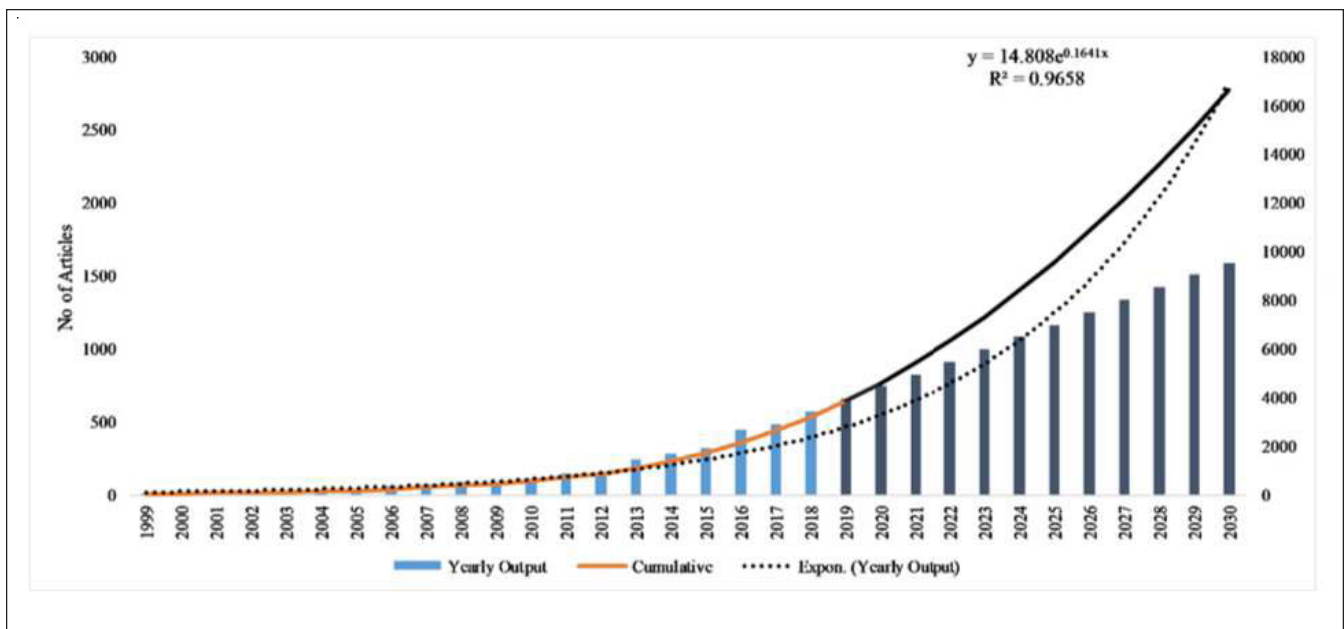


Figure 1. Indo-Thai Collaborated article growth 1999-2018 and forecasted growth 2018-2030

5.2. Findings against Objective 2

The highly cited Indo-Thai collaborated articles from 1999 to 2018 were chosen with a minimum citation criterion of 50 citations till the day of data collection. 474 articles i.e. 14.88% of total 3185 articles got minimum of 50 citations in the studied period. Table 3 gives an overview of the highly cited Indo-Thai collaborated papers. 2014 is the year with highest 86 papers with minimum of 50 citations, followed by 2015 and 2013. The top cited paper was published in the year 2012 with alone 5435 citations. Actually this top cited paper entitled “*Observation of a new boson at a mass of 125 GeV with the CMS experiment at the LHC*” is a large collaborative paper with more than 2000 authors. From India 6 institutes viz. Punjab University, Delhi University, Bhaba Atomic Research Centre, Tata Institute of Fundamental Research, Saha Institute of Nuclear Physics, Vishwa Bharati University participated in it and from Thailand, Chulalongkorn University participated. The second most cited of the period is “*Prevention of HIV-1 Infection with Early Antiretroviral Therapy*” is also multi country collaborative paper where YR Gaitonade Center for AIDS Res & Edu, National AIDS Research Institute from India and Research Institute of Health Science of Chiang Mai University from Thailand participated. The highly cited publications of Indo-Thai collaboration often had multi country collaboration.

To find out the top institutions most featured in the high cited Indo-Thai collaborative papers, the C1 field from the Web of Science metadata were extracted using Bibexcel. These data were then further analyzed by creating a pivot table in MS-Excel. From Table 4, 7 institutions from India featured in the top 5 list, out of which 3 were fundamental research centers and other four

Year	Total Pubs From India	Total Pubs From Thailand	Total Indo-Thai Collab Pubs	Indo-Thai Collab Pubs				Total Indo-USA Collab Pubs	% of Indo-USA Pubs Compared to total Indian	Yearly growth rate based on %	% of Thai-USA Pubs to total Thai	Yearly growth rate based on %
				% as compared to total Indian Pubs	Yearly growth rate based on %	% as compared to total Thai Pubs	Yearly growth rate based on %					
1999	18202	1162	13	0.071	--	1.119	--	1113	6.115	--	19.621	--
2000	18184	1375	21	0.115	62	1.527	36.46	1294	7.116	16.37	19.927	1.56
2001	19234	1574	28	0.146	27	1.779	16.50	1376	7.154	0.53	20.902	4.89
2002	20757	1918	20	0.096	-34.2	1.043	-41.37	1437	6.923	-3.23	21.741	4.01
2003	22930	2359	22	0.096	0	0.933	-10.55	1607	7.008	1.23	21.789	0.22
2004	24940	2513	25	0.1	4.2	0.995	6.65	1796	7.201	2.75	23.12	6.11
2005	27799	3035	41	0.147	47	1.351	35.78	1941	6.982	-3.04	22.867	-1.09
2006	31150	3769	61	0.196	33.3	1.618	19.76	2189	7.027	0.64	21.146	-7.53
2007	36429	4370	67	0.184	-6.1	1.533	-5.25	2466	6.769	-3.67	20.847	-1.41
2008	42690	5205	86	0.201	9.2	1.652	7.76	2764	6.475	-4.34	19.404	-6.92
2009	44037	6113	69	0.157	-21.9	1.129	-31.66	2873	6.524	0.76	17.029	-12.24
2010	47430	6418	109	0.23	46.5	1.698	50.40	3372	7.109	8.97	15.986	-6.12
2011	51754	6850	141	0.272	18.3	2.058	21.20	3795	7.333	3.15	15.942	-0.28
2012	54921	7514	143	0.26	-4.4	1.903	-7.53	4197	7.642	4.21	16.569	3.93
2013	61365	7699	239	0.389	49.6	3.104	63.11	4638	7.558	-1.10	18.392	11.00
2014	66908	8024	281	0.42	8	3.502	12.82	5170	7.727	2.24	18.881	2.66
2015	69545	8346	321	0.462	10	3.846	9.82	5609	8.065	4.37	19.998	5.92
2016	75056	9467	448	0.597	29.2	4.732	23.04	6555	8.733	8.28	19.901	-0.49
2017	77610	10003	480	0.618	3.5	4.799	1.42	6808	8.772	0.45	19.954	0.27
2018	82848	10760	570	0.688	11.3	5.297	10.38	7614	9.19	4.77	19.303	-3.26
Avg.	44689	5424	159	0.272	15.39	2.280	11.51	3431	7.371	2.28	19.665	0.06
CAGR for 20 years			137%	57%		36%		*	8%		0.3%	

Table 1. Indo-Thai Collaborative research growth from 1999-2018 and comparison of it to USA collaboration

Year	Total Indo-Thai Collab Pubs	% of Indo-Thai Collab compared to total Indian output	Yearly Growth rate	% of Indo-Thai Collab compared to total Thai output	Yearly Growth rate	% of Indo-USA Collab compared to total Indian output	Yearly Growth rate	% of Thai-USA Collab compared to total Thai output	Yearly Growth rate
2018	570	0.688	--	5.297	--	9.19	--	19.303	--
2019	655	0.745	8.28	5.757	8.68	9.521	3.60	18.632	-3.48
2020	740	0.803	7.79	6.218	8.01	9.852	3.48	18.486	-0.78
2021	825	0.862	7.35	6.679	7.41	10.184	3.37	18.34	-0.79
2022	909	0.92	6.73	7.14	6.90	10.515	3.25	18.194	-0.80
2023	994	0.979	6.41	7.601	6.46	10.847	3.16	18.048	-0.80
2024	1079	1.038	6.03	8.062	6.06	11.178	3.05	17.902	-0.81
2025	1164	1.096	5.59	8.523	5.72	11.509	2.96	17.756	-0.82
2026	1249	1.155	5.38	8.984	5.41	11.841	2.88	17.61	-0.82
2027	1334	1.213	5.02	9.445	5.13	12.172	2.80	17.464	-0.83
2028	1419	1.272	4.86	9.906	4.88	12.503	2.72	17.318	-0.84
2029	1504	1.331	4.64	10.367	4.65	12.835	2.66	17.172	-0.84
2030	1588	1.389	4.36	10.828	4.45	13.166	2.58	17.026	-0.85
Avg.	1079	1.04	6.04	8.06	6.15	11.18	3.04	17.94	-1.04

Collab= Collaboration; Pubs= Publications; Avg.= Average

Table 2. Collaboration Growth Forecast until 2030

were universities. The institutions from Thailand were purely universities. The institutions from Thailand were top institutions of their country based on Times Higher Education ranking of 2019. As most of the high cited Indo -Thai collaborated papers had multi -country collaboration, further analysis of the countries other than India and Thailand in the corpus of 474 high cited articles were made and the top 10 is listed in table 5. With India and Thailand, highly cited articles had the highest presence of institutions from USA (75.316%) followed by China (65.61 %).

Sl. No	Article Title	Citation Count
1	Observation of a new boson at a mass of 125 GeV with the CMS experiment at the LHC	5435
2	Prevention of HIV-1 Infection with Early Antiretroviral Therapy	4064
3	Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies	3929
4	Guidelines for the use and interpretation of assays for monitoring autophagy	2299
5	The map-based sequence of the rice genome	2247
6	Guidelines for the use and interpretation of assays for monitoring autophagy (3rd edition)	2028
7	Saxagliptin and Cardiovascular Outcomes in Patients with Type 2 Diabetes Mellitus	1771
8	Gefitinib plus best supportive care in previously treated patients with refractory advanced non-small-cell lung cancer: results from a randomised, placebo-controlled, multicentre study (Iressa Survival Evaluation in Lung Cancer)	1643
9	Antibiotic resistance-the need for global solutions	1222
10	Global Prevalence and Major Risk Factors of Diabetic Retinopathy	1185

Table 3. Top 10 most cited Indo-Thai collaborated articles

Rank	Top Institutions from India	No of Papers	% Share in highly cited	Rank	Top Institutions from Thailand	No of Papers	% Share in highly cited
1	Panjab University	159	33.54	1	Chulalongkorn University	168	35.44
1	Saha Institute Of Nuclear Physics	159	33.54	2	Mahidol University	97	20.46
2	National Institute Of Science Education Research	128	27.00	3	Suranaree University Of Technology	42	8.86
3	Bhabha Atomic Research Center	123	25.95	4	Chiang Mai University	35	7.38
4	Tata Institute Of Fundamental Research	121	25.53	5	Prince Of Songkla University	21	4.43
4	Delhi University	121	25.53				
5	VisvaBharati University	120	25.32				

Table 4. Top productive institutions from both countries in highly cited Indo-Thai collaborative publications

Sl no	Country	No of Article amongst high cited	Percentage Share
1	USA	357	75.316
2	China	311	65.612
3	England	273	57.595
4	Brazil	256	54.008
5	France	242	51.055
6	Germany	241	50.844
7	Italy	238	50.211
8	South Korea	238	50.211
9	Spain	230	48.523
10	Switzerland	228	48.101

Table 5. Top 10 countries in High cited Indo-Thai Collaborative Research other than India and Thailand

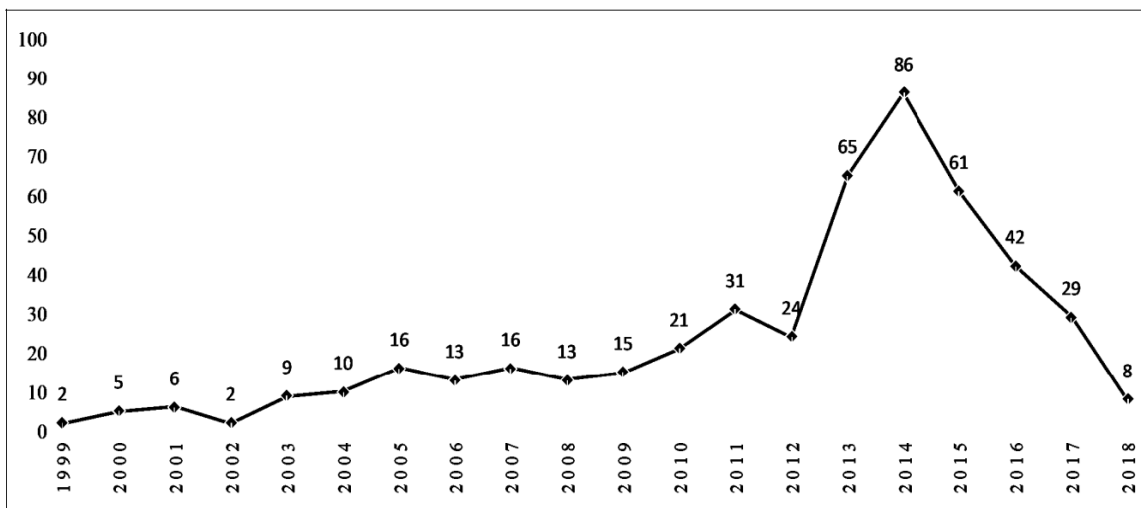


Figure 2. Distribution of highly cited articles based on publication years

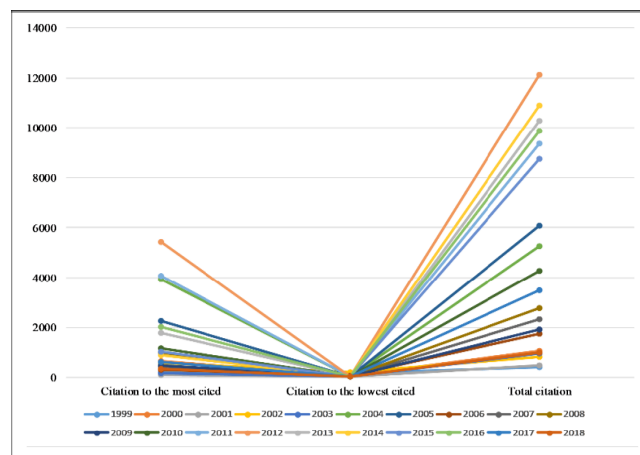


Figure 3. Citation distribution to the most cited and lowest cited with total citation of each year amongst the highly cited

5.3. Findings against Objective 3

The journal details where the highly cited articles were published were pulled out using the “SO “metadata field of WoS through Bibexcel. The respective Impact Factor (IF) of the journals were collected from Journal Citation Reports of 2018. *Physics Letters B* is the journals where most no of highly cited articles were published. In the top 10 (Table 6), highest IF journal was *New England Journal of Medicine* with IF of 70 as per JCR 2018.

5.4. Findings Against Objective 4

Keywords appearing in the abstract and title of articles are very much useful to determine the core subject areas of research in articles. The macro-level categorization of articles (like the WoS subject areas) might give the overhaul subject of re-search, but keyword-based analysis of papers gives a more specific thorough idea of the subject trend of research. Subject experts shall always be able to relate with the macro- level subjects of research by just looking at the trend of the keyword. For this purpose, an analysis of the keywords appearing in the abstract and title of highly cited research articles were done using the VOSviewer (Van Eck & Waltman, 2010) tool. The result with a minimum co -occurrence threshold limit of 3 occurrences is shown in fig 4. From Fig 4, the presence of keywords in 7 different clusters is visible. Keywords from the domain of physics, particle property studies and from health sciences is found prominent in the highly cited Indo-Thai articles of last twenty years’ period.

Source Title	No of Articles	Impact Factor as per JCR 2018
Physics Letters B	45	4.162
Journal Of High Energy Physics	36	5.883
Lancet	31	59.102
European Physical Journal C	24	4.843
Physical Review Letters	21	9.227
Fungal Diversity	18	15.596
Physical Review D	11	4.368
New England Journal Of Medicine	10	70.67
Journal Of Instrumentation	9	1.366
Clinical Infectious Diseases	8	9.055
Physical Review C	8	3.132

Table 6. Top 10 Journals where most no of highly cited articles were published

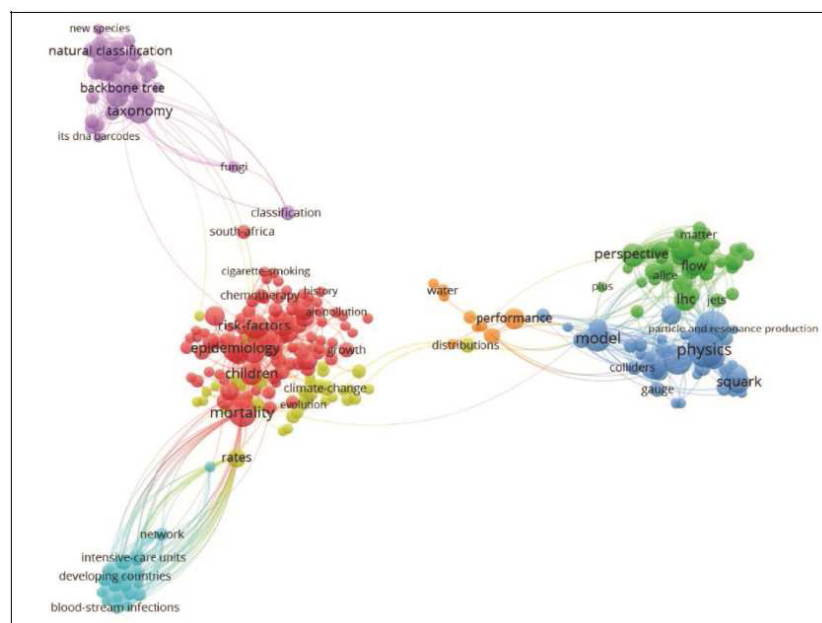


Figure 4. Keywords co-occurrence map for highly cited Indo-Thai collaborative research papers

6. Conclusion

Being two prominent economies of South-East Asia, collaborative science is mutually beneficial for both India and Thailand. With a large time-span of twenty years, the actual growth of collaboration for the longer period between the countries could be realized in the study. The exponential growth of collaboration between the two countries can be relatable with central sponsored policies from the Govt. of the two countries, even though the further study in this regard is necessary to be more conclusive. Both countries have strong scientific collaboration with the USA, but the annual growth of Indo-Thai collaboration of the last twenty years is found greater than the Indo-USA and Thai-USA collaboration from the perspectives of both countries. This trend is forecasted to continue until 2030. Analyzing the Indian and Thai institutions in the highly cited Indo-Thai collaborated articles, Punjab University and Saha Institute of Nuclear Physics are the top Indian institutions featuring in 159 of 474 highly cited articles, while Chulalongkorn University and Mahidol University are the top two Thai institutions featuring in 168 and 97 highly cited articles respectively. The highly cited Indo-Thai collaborated articles had strong USA collaboration as 75% of articles had the presence of institutions from the USA followed by institutions from China. Keywords analysis of highly cited research articles revealed health sciences, physics and particle property studies as key areas of research in impactful Indo-Thai collaborated research.

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