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Assessment of Mechanical Engineering Research Output using Scientometric Indicators: A Comparative Study of India and South Korea

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Abstract

The study examines Indian and South Korean mechanical engineering research output on several parameters including growth, research communication in core journals, and geographical distribution of publications, share of international collaborative publications at the national level as well as across subjects and characteristics of high productivity institutions, authors and cited papers. The study focuses on the articles published by India and South Korea, and indexed in Science Citation Index – Web of Science for the period 2011 to 2015. India has produced 11,041 papers in the mechanical engineering field, and received 44,307 citations and South Korea produced 8,585 papers and received 34,437 citations in the field during the period 2011 to 2015. The study suggests the need to increase the pace of Indian and South Korean scientific research and improve their quality. It also suggests to build competence and knowledge base to help bridge the scientific and technological gap with leading countries.

Keywords: Activity Index, Doubling Time, Growth Rate for Scientific Publication, Mechanical Engineering, Relative Growth Rate, Scientometrics

1. Introduction

Scientometric analysis is a well-established tool in information research. Monitoring and evaluating the various facets of the scientific enterprise is a necessary and integral part of science policy. Eugene Garfield pioneered several citation indices as measures of research output which are being widely used by the research community. The development of Science, Technology and Innovation (STI) indicators has grown substantially in recent decades.

Bibliometrics has established itself as a viable and distinctive research technique for studying the science of science based on bibliographic and citation data[1]. There has been an increasing interest in using scientometric data for assessing and monitoring research activities. The discipline devoted to the quantitative study and evaluation of scientific literature is called scientometrics. It has been applied to the evaluation of scientific disciplines, national scientific output, and bibliographic databases, and it provides valuable tools to describe scientific activity in the past and to orient future research[2]. The aim of scientometrics is to provide quantitative characterizations of scientific activity. Because of the particular importance of publication in scientific communities, it largely overlaps with bibliometrics, which is quantitative analysis of media in any written form.

The present study is aimed at finding out the growth of research publications in mechanical engineering from India and South Korea, including collaboration, annual growth rate, doubling time and activity index.

2. Review of Literature

There are not many bibliometric studies in engineering. Kim[3] compared the citation patterns of researchers in physics and mechanical engineering in Korea and found that type of publication, source and type of authorship influence the choice of sources cited by them. Noteworthy is that articles in physics journals from Japan are more frequently cited in papers written by purely Korean

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authorship than those with international co-authorship. In addition, articles of Korean journals are more highly cited in nationally authored papers than in internationally co-authored papers, in both fields. Ravichandra Rao and Suma[4] analysed Indian engineering literature and found that engineers in India publish in a select few journals and engineering research is concentrated in a few institutions in. They observed that research output in applied physics, light and optics, bioengineering and information science are increasing both at the world and India levels. Karamourzov[5] assessed the results of independent development of the CIS countries in the field of science over the period 1990–2009.

Jain[6], Tsay[7], Arunachalam[8], Kostoff[9], Sangam[10], Biradar[11], Sangam[12], Gupta[13], Bhattacharya[14] carried out similar scientometric studies to assess scientific research outcome such as output, comparative studies between countries, collaboration patterns studies, growth pattern, etc., in various topics.

3. Methodology

The data for this study was collected from the Science Citation Index- Expanded (SCI-E) of Web of Science, a comprehensive and exhaustive database enveloping almost all subjects of Science and Technology. Its coverage of engineering field is quite comprehensive. The distribution of publications, source wise distribution, most prolific institutions, leading research areas, prolific authors, highly cited papers, and international collaborators can be retrieved from the database. The database was searched for collecting documents in the areas of *Mechanical Engineering, Thermodynamics, Metallurgical Engineering, Materials Science, Manufacturing Engineering and Mechanics* published between 2011 and 2015. The researchers included metallurgical engineering and materials science as these are closely related to developments in mechanical engineering.

4. Results and Discussion

4.1 Growth of Publications

One of the obvious features of scientific literature in recent years has been its rate of growth. A number of growth models have been proposed in this regard. In 1963 Price[15] proposed an exponential rate of growth of scientific literature. He predicted a regular exponential growth with doubling period of ten to fifteen years. In the topics considered in this study it was found that the articles from India doubled in 7 years, 1985 articles in 2001 to 4429 in 2008. Similarly for South Korea the doubling period is 9 years, with 2647 articles in 2001 to 5619 in 2010. The data is tabulated in Table 1.

Table 2. Growth of publications

Publication Year	South Korea	India
2014	8395	7265
2013	7599	6826
2012	7024	5756
2011	6727	5458
2010	5619	5215
2009	5188	4830
2008	4558	4429
2007	3999	3791
2006	4099	3131
2005	4042	2804
2004	3800	2509
2003	3066	2325
2002	2877	2002
2001	2647	1985

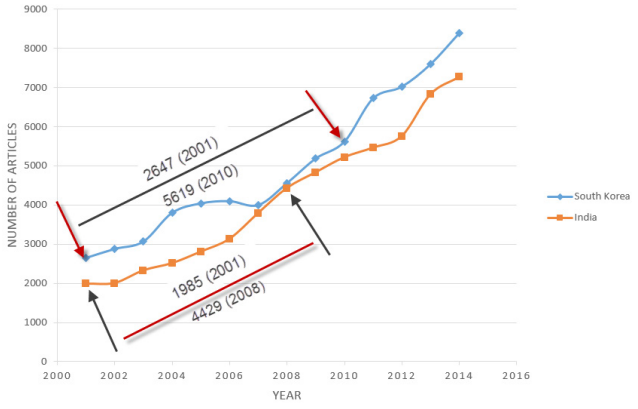

Figure 1. Doubling time of mechanical engineering publications from India and South Korea.

Mechanical engineering research output of India and South Korea in terms of total number of publications and citations, citations per papers have been illustrated in Table 2. India has produced 11,041 papers, and received 44,307 citations during the period 2011-2015, Citations per Paper is 4.01. As per the Web of Science data, cumulative publications growth, the cumulative output of India had increased from 1,900 articles in 2011 to 2,485 articles in 2015. The data collected for this study shows a gradual growth over the years. South Korea produced 8,585 articles, and received 34,437 citations during the period 2011-2015 with an average citation per article being 4.01. South Korea has published 1,566 articles in 2011and 1826 publications in 2015. Figure 1 shows the annual growth

and the citations received by both the countries.

The publications from both the countries have increased year by year. One important factor to note is that earlier articles still carry much relevance as older publications are quite heavily cited (Figure 2).

4.1.1 Prolific Research Institutions

Table 3 displays top institutions and comparison between India and South Korea based on number of publications. Indian Institute of Technology (IIT), Mumbai contributed the highest number of articles, i.e. 2,378 articles with 21.54%. Indian Institute of Science, Bangalore with 659 articles (5.97%) is a distant second followed by National Institute of Technology, Rourkela with 574 articles (5.20%). IIT Bombay offers wide variety of courses when compared to the other institutions in the areas under study. Metallurgical department has 34 Professors with over 80 doctoral students and many PG and UG students. Mechanical department too offers a wide variety of courses with over 60 faculty members and over 120 doctoral research students. It may be inferred that the strength of the department appears to be proportionate to the number of publications. With regard to South Korea the Hanyang University, Seoul, has published the highest articles i.e. 561 (6.53%), followed by Seoul National University, Seoul, with 551 articles (6.42%), Pusan National University, Busan, with 525 articles (6.12%), Pohang University of Science and Technology, Pohang, with 501 articles (5.84%), Yonsei University, Seoul, with 498 articles(5.80%), Korea Institute of Materials Science, Changwon, with 406 articles (4.73%), Korea University, Seoul, with 398 articles(4.64%) and Chonbuk National University, Jeonju, with 271 articles (3.16%).

Table 2. Growth of publications

	India				South Korea			
Years	**TNP**	**TNC**	**CPP**	**RCI**	**TNP**	**TNC**	**CPP**	**RCI**
2011	1900	15178	7.99	1.99	1566	11760	7.51	1.87
2012	1941	11938	6.15	1.53	1616	9434	5.84	1.46
2013	2316	10046	4.34	1.08	1715	7902	4.61	1.15
2014	2399	5744	2.39	0.60	1862	4378	2.35	0.59
2015	2485	1401	0.56	0.14	1826	963	0.53	0.13
Total	**11041**	**44307**	**4.01**	**1**	**8585**	**34437**	**4.01**	**1**

TNP, total number of publications; TNC, total number of citations; CPP, citations per paper; RCI, relative citation impact forms.
(The citation impact is basically the number of citations per paper that that group has received over a certain time period, in the Table 2 the RCI is calculated as CPP divided by average CPP)

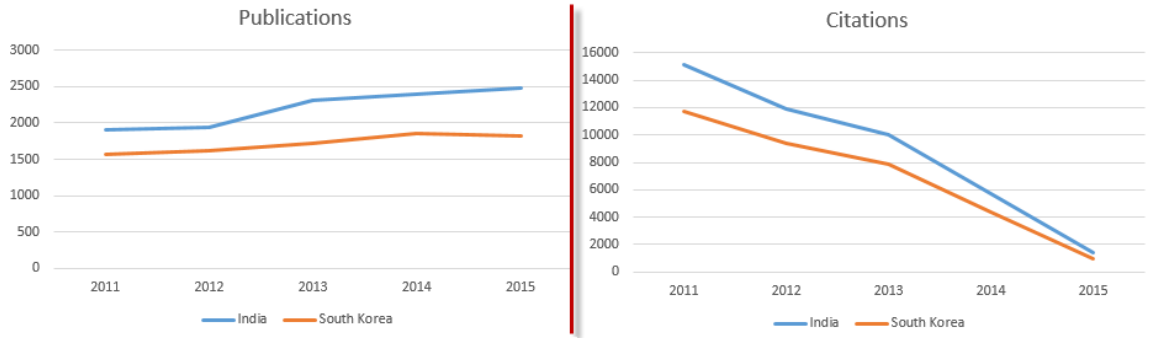

Figure 2. Pattern of growth of publications in mechanical engineering in India and South Korea (2011–2015).

Table 3. Prolific research institutions

	India			South Korea		
Sl. No.	Organizations	TP	% of 11041	Organizations	TP	% of 8580
1	Indian Institute of Technology, Mumbai	2378	21.54	Hanyang University, Seoul	561	6.53
2	Indian Institute of Science, Bangalore	659	5.97	Seoul National University, Seoul	551	6.42
3	National Institute of Technology, Rourkela	574	5.20	Pusan National University, Busan	525	6.12
4	Bhabha Atomic Research Centre, Mumbai	405	3.67	Pohang University of Science and Technology, Pohang	520	6.06
5	Indira Gandhi Centre for Atomic Research, Tamil Nadu	336	3.04	Korea Advanced Institute of Science & Technology, Daejeon	501	5.84
6	Council of Scientific and Industrial Research (CSIR) New Delhi	310	2.81	Yonsei University, Seoul	498	5.80
7	Jadavpur University, Kolkata	289	2.62	Korea Institute of Materials Science, Changwon	406	4.73
8	Anna University, Chennai	248	2.25	Korea University, Seoul	398	4.64
9	Banaras Hindu University, Varanasi	213	1.93	Chonbuk National University, Jeonju	348	4.05
10	Defence Metallurgical Research Laboratory, Hyderabad	203	1.84	Inha University, Incheon	271	3.16
11	Indian Institute of Technology, Delhi	152	1.38	POSCO, Pohang	250	2.91
12	Indian Institute of Technology, Roorkee	141	1.28	Korea Institute of Industrial Technology	250	2.91
13	Indian Institute of Technology, Guwahati	128	1.16	Sungkyunkwan University, Seoul	249	2.90
14	Indian Institute of Technology Madras	120	1.09	Korea Atomic Energy Research Institute, Daejeon	249	2.90
15	Annamalai University	111	1.01	Korea Institute of Science and Technology, Seoul	242	2.82
16	Indian School of Mines, Dhanbad	100	0.91	Chonnam National University, Gwangju	228	2.66
17	Kurukshetra University	98	0.89	Yeungnam University, North Gyeongsang	183	2.13
18	VIT University, Chennai	91	0.82	Pohang University of Science and Technology, Pohang	170	1.98
19	Indian Institute of Engineering Science and Technology, Shibpur	91	0.82	POSTECH, Pohang	169	1.97
20	Tata Steel, Mumbai	81	0.73	Chungnam National University, Daejeon	167	1.95

4.1.2 International Collaboration

Table 4 depicts the international collaborative papers of India and South Korea with top 20 countries during 2011 to 2015. The share of International collaborative publications in the mechanical engineering research output South Korea achieved the higher degree of international collaboration with i.e. 31.51% (of their total output) than India (18.96%) during the period. The largest number of collaborative publications (462) of India was with United States with 4.18% share, followed by South Korea with 302 publications (2.74%) share, Germany with 225 publications (2.04%) share and Japan with 144 publications (1.30%) share. With regard to South Korea the highest collaborating partner is United States with 869 publications (10.13%) share, followed by China with 427 publications (4.98%) share, India with 302 publications (3.52%) share, Japan with 292 publications (3.40%) share and Australia with 104 publications (1.21%) share. Interesting to observe that the top collaborator for both the countries is United States of America, and there is a strong collaboration between India and South Korea with both the countries in top 3. Interestingly when we take into account the global output in the research areas during the same period, both the countries have stronger collaboration with USA, Japan and Germany.

Table 4. International collaborating partners

India				South Korea		
Sl. No.	Countries/ Territories	TP	% of 11041	Countries/ Territories	TP	% of 8580
1	USA	462	4.18	USA	869	10.128
2	South Korea	302	2.74	China	427	4.977
3	Germany	225	2.04	India	302	3.52
4	Japan	144	1.30	Japan	292	3.403
5	Canada	119	1.08	Germany	147	1.713
6	England	114	1.03	England	132	1.538
7	China	113	1.02	Australia	104	1.212
8	Saudi Arabia	104	0.94	Iran	77	0.897
9	Australia	99	0.90	Saudi Arabia	67	0.781
10	France	94	0.85	France	66	0.769
11	Malaysia	83	0.75	Canada	58	0.676
12	Singapore	64	0.58	Vietnam	55	0.641
13	South Africa	63	0.57	Russia	42	0.49
14	Italy	57	0.52	Singapore	37	0.431
15	Slovakia	50	0.45	Pakistan	30	0.35

4.1.3 Source-wise Distribution of Research Output

The sources of Mechanical Engineering research include articles published in journals, reviews, conference and seminars proceedings, editorials, corrections and book chapters (Table 5). A total of 19,626 articles in mechanical engineering were published from India and South Korea from 2011 to 2015. Out of them, journal articles accounted for 18,900, (96.30%) from both countries. The comparative analysis indicates journal articles accounted for 96.97% of India's output and 95.45% of South Korea's output.

4.2 Activity Index

In the present study, the Activity Index (AI) has been calculated for different years to see how India's and South Korea's performance gradually changed during different years. Activity Index was first suggested by Frame[16] and used among others by Schubert and Braun[17]; Nagpaul[18]; Karki and Garg[19]; Garg and Padhi[20]; Kumari[21]; Chetri et. al.[22]; Sagar and Kademani[23].

AI characterizes the relative research effort of a country for a given subject. It is defined as;

$$AI=\frac{\text{given field's share in the country's publication output}}{\text{given field's share in the world's publication output}}$$

$$\text{Mathematically } AI=\frac{nij/nio}{noj/noo}*100$$

Where:

nij - Indian/South Korea output of papers in particular field

nio - Total Indian/South Korean output on all subjects

noj - World output of papers in particular field

noo - Total World output on all subjects

The calculations are provided in the Table 6 and 7. The Activity Index for India was highest for the following subject categories: Metallurgy Metallurgical

Table 5. Source-wise Distribution Of Research Output of India and South Korea

India			South Korea		
Document Types	Publications	%	Document Types	Publications	%
Journal Articles	10706	97.91	Journal Articles	8194	96.65
Conference paper	142	1.30	Conference paper	218	2.57
Review	81	0.74	Review	66	0.78
Letter	5	0.05	**Total**	**8478**	**100**
Total	**10934**	**100**			

Table 6. Activity index of various subjects

	India					
	Metallurgy Metallurgical Engineering	Materials Science	Thermodynamics	Mechanics	Robotics	Energy Fuels
2011	130.53	115.88	169.09	105.84	31.15	99.71
2012	121.77	101.58	174.56	119.92	16.92	88.57
2013	127.87	116.32	174.99	113.57	36.62	99.40
2014	130.69	120.59	168.60	114.99	35.59	106.77
2015	146.16	121.31	159.97	97.53	50.01	110.67

Table 7. Activity index of various subjects

	South Korea					
	Metallurgy Metallurgical Engineering	Materials Science	Thermodynamics	Mechanics	Robotics	Energy Fuels
2011	170.46	165.54	98.48	71.44	145.29	73.42
2012	177.34	160.06	91.87	57.51	219.01	87.11
2013	177.17	178.32	95.59	60.97	180.74	100.30
2014	174.43	173.25	108.16	56.70	177.40	104.43
2015	168.26	161.59	117.67	73.49	160.17	119.18

Engineering (146.16) in 2015, Materials Science (121.31) in 2015, Thermodynamics (174.99) in 2013, Mechanics (119.92) in 2012, Robotics (50.01) in 2015 and Energy Fuels (110.67) in 2015 (Table 5). With regard to South Korea the Activity Index was highest for the following subject categories: Metallurgy Metallurgical Engineering (177.34) in 2012, Materials Science (178.32) in 2013, Thermodynamics (117.67) in 2015, Mechanics (73.49) in 2015, Robotics (219.01) in 2012, and Energy Fuels (119.18) in 2015 in 2011 (Table 6).

It is observed from the data that India has stronger research output in Thermodynamics and Mechanics than South Korea. The average Activity Index for Robotics, Materials Science, Mechanics and Energy Fuels for Korea is higher for all years (from 2011–2015) and is high compared to other subjects and India's average. The average Activity Index for Robotics is 176.52, which clearly indicates that there is a significant contribution of scientists from South Korea in this subject compared to their Indian counterparts. Among the mechanical engineering subject categories considered in this study, the Activity Index is lowest for Robotics in India. Similarly the average Activity Index for South Korea is lowest for Mechanics. The research on robotics in South Korea began in late 1980's and for India in early 1990's. There is a significant rise in terms of articles published by South Korea when compared to India in Robotics over the years.

5. Conclusion

The present study provides a scientometric analysis of mechanical engineering research in India and South Korea. Both of the countries are strong in mechanical engineering, with a diversified focus. India is strong in thermodynamics and mechanics, while South Korea scores high in the other four fields considered for the study. The study of collaboration infers that both the countries have collaborated with countries with high contribution in the field.

6. References

1. Gupta, B.M. and Gupta, P. Analysis of India's S&T Research Capabilities and International Collaborative Strength Particularly in Context of Indo-German Collaboration, 2004-09. New Delhi; DFG India, German Research Foundation. 2011 Oct. p. 27.
2. Schoepflin, U. and Glanzel, W. (2001). Two Decades of "Scientometrics": An Interdisciplinary Field Represented by its Leading Journal. *Scientometrics*, 50:301-12. https://doi.org/10.1023/A:1010577824449.
3. Kim, M.J. (2002), Citation Patterns of Korean Physicists and Mechanical Engineers: Differences by Type of Publication Source and Type of Authorship. *Scientometrics*, 55(3):421–36. https://doi.org/10.1023/A:1020418930669.
4. Ravichandra Rao, I.K. and Suma, P. (1999). A Quantitative Study of Indian Engineering Literature. *Scientometrics*, 46(3):605-19. https://doi.org/10.1007/BF02459615.
5. Karamourzov, R. (2012). The Development Trends of Science in the CIS Countries on the Basis of some Scientometric Indicators. *Scientometrics*, 91(1):1-14. https://doi.org/10.1007/s11192-011-0592-6.
6. Jain, A. and Garg, K.C. (1992). Laser Research in India: Scientometric Study and Model Projections. *Scientometrics*, 23(3):395-415. https://doi.org/10.1007/BF02029806.
7. Tsay, M.T.; Jou, S.J. and Ma, S.S. (2000). A Bibliometric Study of Semiconductor Literature, 1978-1997. *Scientometrics*, 49(3):491-509. https://doi.org/10.1023/A:1010593824716.
8. Arunachalam, S. and Rino, S.I. (2003). Mapping New Biology Research in India and China: an Analysis of Publication, Citation and International Collaboration. 9th International Conference on Scientometrics and Informetrics, Dalian, China, August 2003, 1-9. PMid:12713134.
9. Kostoff Bhattacharya, RNK, Sujit, M. Pecht Assessment of China's and India's Science and Technology Literature – Introduction, Background, and Approach, Technological Forecasting and Social Change, 9, 2007, p. 1519–38.
10. Sangam, S.L. and Meera. (2009). Research Collobration Pattern in Indian Contribution to Chemical Sciences. *Collenet Journal of Scientometrics and Information Management*, 3(1):39-45. https://doi.org/10.1080/09737766.2009.10700863.
11. Biradar, B.S. and Rajashekhar, G.R. (2010, December). Scientometric Analysis of Biotechnology Literature. In: Sangam and Others (Eds.). Proceedings of National Seminar on

Webometrics, Informetrics and Scientometrics, DLISc, K.U. Dharwad. p. 134-45. PMCid:PMC2974139.
12. Sangam, S.L.; Keshava and Agadi A.B. (2010). Growth Pattern of Marine Engineering Literature. *Information Studies*, 16(2):113-20.
13. Gupta, B.M.; Kshitij, A. and Verma C. (2011). Mapping of Indian Computer Science Research Output, 1999–2008. *Scientometrics*, 86:261–83. https://doi.org/10.1007/s11192-010-0272-y.
14. Bhattacharya and Sujit Shilpa. Bhati China and India: The Two New Players in the Nanotechnology Race. *Scientometrics*, 2012. https://doi.org/10.1007/s11192-012-0651-7.
15. Price, D.J. (1963). Little Science, Big Science, Columbia University Press, New York, 119.
16. Frame, J.D. (1977). Mainstream Research in Latin America and the Caribbean. Interciencia, 2:143.
17. Schubert, A. and Bruan, T. (1986). Relative indicators and Relational Charts for Comparative Assessment of Publication Output and Citation Impact. *Scientometrics*, 9:281. https://doi.org/10.1007/BF02017249.
18. Nagpaul, P.S. (1995). Contribution of Indian Universities to the Main-Stream Scientific Literature: A Bibliometric Assessment. *Scientometrics*, 32(1):11-36. https://doi.org/10.1007/BF02020186.
19. Karki, M.M.S. and Garg, K.C. (1997). Alkaloid Chemistry Research in India. *Journal of Chemical Information and Computer Science*, 37:157. https://doi.org/10.1021/ci960032z.
20. Garg, K.C. and Padhi, P. (1999). Scientometrics of Laser Research Literature as Viewed through the Journal of Current Laser Abstracts. *Scientometrics*, 45:251. https://doi.org/10.1007/BF02458436.
21. Kumari, L. (2006). Trends in Synthetic Organic Chemistry Research: Cross-Country Comparison of Activity Index. *Scientometrics*, 67(3):467-76. https://doi.org/10.1556/Scient.67.2006.3.8.
22. Chetri, I.S.; Saini, A.K. and Luthra, R. (2009). CSIR-UGC National Eligibility Test: A Performance Indicator of Basic Science Education in Indian Universities. *Current Science*, 97(4):490-99.
23. Sagar, A. and Kademani, B.S. (2011). Growth and Impact of S&T in Madhya Pradesh during 2000-2009. DESIDOC *Journal of Library and Information Technology*, 31(1):3-18. https://doi.org/10.14429/djlit.31.1.757.