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

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ABSTRACT
This study examined the mechanical engineering research output from India, Japan, and South Korea on different parameters including growth, collaboration indices, and activity index. The purpose of the study is to understand the overall development of mechanical engineering through analytical approaches applied on the scholarly outcome of the countries considered for the study. The study focuses on analysing the articles published by India, Japan, and South Korea, and is restricted to articles indexed in the Science Citation Index – Web of Science for the period 2000 to 2014. The ratios of number of paper to citations for India, Japan, and Korea are 20,836: 1,97,679; 24,494: 2,04,393; and 30,578: 2,66,902 respectively for the period 2000-2014. The findings show that there is a decline in Japanese publications in mechanical engineering, whereas other two countries have recorded an increasing trend. While India has tripled its publications in a span of 15 years, South Korea, on the other hand, has doubled its publications in the same span of time. There has been an increasing trend towards collaboration in almost all fields of science and technology. However, the extent of collaboration and their rate of growth varied for one subject to another, one branch to another branch of the same subject, and from one country to another country. The present study analyses the growth of research publications of the mechanical engineering domain including authorship distribution, collaboration indices, prominent journals, and activity index.

Keywords: Scientometrics, Mechanical Engineering, Doubling Time, Activity Index, Growth Rate for Scientific Publication, India, Japan, South Korea, Authorship Distribution, Collaboration Indices, Bradford's Law

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1. INTRODUCTION

Mechanical engineering (UNESCO, 2010) emerged as a field during the industrial revolution in Europe in the 18th century; however, its development can be traced back several thousand years around the world. Mechanical engineering was driven forward by the successive waves of innovation and industrial revolutions. The literature on the subject recognizes seven waves in the growth and development of mechanical engineering starting from the 1750's (UNESCO, 2010). The last three waves have had significant impacts on carving the road map of the growth of mechanical engineering as a discipline and a profession. The fifth wave, based on information and telecommunications, was related to electrical and mechanical engineering. The sixth wave, beginning around 1980, was based on new knowledge production and application in such fields as IT, biotechnology, and materials. The seventh wave, beginning around 2005, and the current one, based on sustainable 'green' engineering and technology to promote sustainable development, climate change mitigation, and adaptation, will once again be focused particularly on a core of mechanical engineering.

The developments discussed above are significant in terms of total R&D expenditures at the global level which have been on the rise. The indicators published in 2016 by the National Science Foundation (2014, pp. 4-17) highlight that China, South Korea, and India are investing heavily in R&D and in developing a well-educated workforce skilled in science and engineering. The R&D expenditure in Asia is fast growing and the countries of India, China, South Korea, and Japan are the front runners, which was predicted many years ago. The high-technology manufacturing industries in China, Japan, and South Korea too have risen rapidly since 1998 (National Science Foundation, 2014, pp. 6-9).

Borrego (2007) studied the engineering research outcome to understand the role of engineering education coalitions in advancing the field of engineering education. Engineering research has grown into a large research community with an ever-increasing number of publications and scholars. Borrego, Froyd, and Hall (2010) and Wankat (2012) found that engineering education scholars are not well informed about research by other scholars and the research outcomes. For mechanical engineering, being among the oldest and greatly evolved disciplines, it remains unclear whether the mechanical engineering community is experiencing the same gap. This gap has high potential of bringing down the migration of research findings into practice.

Asia has a long history of engineering growth and this study plans to highlight the research growth with special reference to India, Japan, and South Korea. The research outcome from India, China, South, Korea and Japan have a high publication productivity compared to other countries of Asia in the area of mechanical engineering, according to data retrieved from the Science Citation Index for the period 2000-2014. Globally, the USA tops the list with 1,22,314 articles, followed by China with 69,515 articles, which is followed by England with 31,054 articles. While authors from India, Japan, and South Korea have published 20,850, 30,578 and 24,494 articles respectively, China has a larger number with 69,515 articles in Asia which is more than double the articles published by Japan, which is the highest among the three. The intention of this study is to have a comparison of the countries on an equal footing. Hence, the study revolves around the contributions of the three countries excluding China. Further, the first author of this paper, a mechanical engineer and also a library professional, has a natural flavour towards the discipline. These are the drivers which motivated the authors to take up a study which focuses on scientometric analysis of mechanical engineering.

The present study aims at finding out the growth of research publications of the mechanical engineering domain from India, Japan, and South Korea, including authorship distribution, collaboration indices, and activity index.

2. REVIEW OF LITERATURE

This study describes and explores the factual picture of research interests within mechanical engineering by analyzing the literature.

Bibliometrics has established itself as a viable and distinctive research technique for studying the science of science based on bibliographical and citation data (Gupta & Gupta, 2004). There has been an increasing interest in using scientometric information for assessing or monitoring research activities for the past few decades. The discipline devoted to the quantitative study and

evaluation of the scientific literature is called scientometrics or bibliometrics. Bibliometrics has been applied to the evaluation of scientific disciplines, national scientific production, and bibliographic databases, and it provides valuable tools to describe scientific activity in the past and to orient future research (Schoepflin & Glanzel, 2001). The aim of scientometrics is to provide quantitative characterizations of scientific activity. Because of the particular importance of publications in scientific communities, it largely overlaps with bibliometrics, which is quantitative analysis of media in any written form.

Bibliometric studies on engineering are rather scantly found. Kim (2002) compared the citation patterns of researchers from physics and mechanical engineering domains in Korea and found that the type of publication source and type of authorship were found to influence the choice of sources cited by them. Noteworthy is that articles in physics journals from Japan are more frequently cited in papers written with purely Korean authorship than those with international co-authorship. In addition, articles in Korean journals are more highly cited in nationally authored papers than in internationally co-authored papers, in both fields. Ravichandra Rao and Suma (1999) analysed the Indian engineering literature and found that the engineers in India publish in a few selected journals and only a few of the institutions are concentrated in engineering research. They observed that research output in applied physics, light and optics, bioengineering, and information science are increasing both at the world and India level. Kaur and Gupta (2009) examined India's performance based on its publication output in immunology and microbiology during 1999-2008, based on several parameters including the country's annual average growth rate, global publications share and rank, institutional profile of top 15 institutions, international collaboration profiles and major collaborative partners, patterns of communication in national and international journals, and characteristics of its top 15 most productive authors. Karamourzov (2012) assessed the results of the independent development of the Commonwealth of Independent States (CIS) countries in the field of science over the period 1990-2009. Jesiek et al. (2011) studied the global trends in engineering education with the help of scientometric indicators and recommended ways to build global capacities in engineering education, and suggested steps to grow cross-national collaboration. In a similar study comparing the outputs of India and China in the fields of sciences and engineering, Panat (2014) found that Chinese research output is increasing compared to India's. In a recent study, Banshal, Muhuri, Singh, and Basu (2017) analyse the research output of 16 (out of 23) of the most prestigious engineering and technology institutions of India (Indian Institute of Technology), comparing with the likes of MIT-USA and NTU-Singapore. In the engineering disciplines, mechanical engineering stands in the top 5, inviting policy makers/funding agencies to make strategic decisions in terms of the allocation of funds and resources toward upliftment of the discipline. In a recent similar cross national comparitive assessment on endocrinology and metabolism, Lyu, Pu, and Zhang (2017) compare the research output of China, Japan, and South Korea. The research articles from China and South Korea increased in a span of 10 years from 2005-2014, but for Japan there wasn't significant increase.

Sangam, Keshava, and Agadi (2010), Gupta, Kshitij, and Verma (2011), Bhattacharya, Shilpa, and Bhati (2012), Elango and Rajendran (2015), Hadagali and Anandhalli (2015), Singh, Banshal, Singhal, and Uddin (2015), Liu, Lin, Wang, Peng, and Hong (2016), Barrot (2017), Zou and Laubichler (2017), and Nobre and Tavares (2017) are studies assessing scientific research output in the last ten years, to mention a few. There has been an increasing trend towards collaboration between countries and institutions in almost all fields of science and technology. However, the extent of collaboration and their rate of growth varies from one subject to another, one branch to another branch of the same subject, and from one country to another country. The present study aims at finding the growth of research publications of the mechanical engineering domain from India, Japan, and South Korea.

3. METHODOLOGY

The data for this study were 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 in the engineering field is quite comprehensive and well acknowledged. The database

was searched for collecting documents pertaining to the areas related to mechanical engineering published between 2000 and 2014.

The query used to search documents from South Korea is:

CU = South Korea AND WC= (Mechanics OR Engineering Mechanical OR Thermodynamics OR Engineering, Aerospace OR Engineering Manufacturing OR Engineering Industrial OR Robotics). The search results were restricted to Science Citation Index Expanded with the time span 2000-2014. Indian and Japanese publications were retrieved by changing CU=India and CU=Japan in the query respectively.

The data set was collected in the month of April 2016. Articles, conference proceedings, and review articles are considered for the present study. The data were then analysed with the help of Microsoft Excel, and formulae related to scientometric analysis have been used to calculate the desired results. Scientometric indicators like collaboration indices and activity index have been calculated in addition to publications growth and author productivity, and the most prominent journals are calculated.

The collaboration indices have been calculated, and the formulae to calculate the various indices are stated here:

$$C1 = \frac{\sum_j^k j \times f_j}{N}, DC = 1 - \frac{f_1}{N}, CC = 1 - \left\{ \sum_{j=1}^{n} (1/j) f_j / N \right\}$$

Where f_i is the total number of articles with i authors published during a certain period of time,

N is the total number of articles published during the same time period,

k is the number of authors per article in each discipline,

f_1 is the number of single authored papers,

f_j is the number of articles with a single author published during a certain period of time.

The Activity Index (AI) is also calculated, which characterizes the relative research effort of a country for a given subjects. AI is defined as

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

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

Where:

nij - Indian / South Korean 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

4. RESULTS AND DISCUSSION

This section provides the results after application of scientometric tools to analyse the outcome.

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 regarding the rate of growth. Way back in 1963 Price (1963) proposed an exponential rate of growth of scientific literature. He predicted a regular exponential growth with a doubling period of ten to fifteen years. For testing the fitness of the Price model, it's found that the articles doubled in the topic considered here from India in the span of seven years, from 660 articles in 2,000 to 1,332 articles in 2008. Similarly, for South Korea the doubling period is 12 years with 1,004 articles in 2000 to 2,113 articles in 2013. Table 1 provides the temporal development of research publications, and related references and citations for the articles published in the time span studied. As far as Japan is considered, there was a thin change both upwards and downwards for the period studied. Figure 1 puts the data into a pictorial representation with the publications and citations data. Interestingly the research publications' slope for Japan is downward from 2,115 articles in 2000 to 1,737 articles in 2014. Further analysis showed that out of the top 10 Japanese journals which were indexed in Web of Science in 2000, only one continues to be indexed in 2014, and nine of them were discontinued over the years. The number of journals indexed dropped to 137 in 2014 from 215 in 2000, accounting for a drop-percentage of 36.27; while for India, although there is a drop in the number of indexed journals between 2000 and 2014, the drop percentage is not as significant as in Japan's case. 42 out of 50 (in 2000) Indian journals continue to be indexed in 2014 with a drop-percentage of 16. Indi-

an authors published their articles in 286 journals. The drop-percentage for South Korean journals is 21.08 with 131 out of 166 (2000) journals continuing to be indexed in 2014. South Korean authors published their articles in 268 journals in 2014.

India is slightly ahead in publications compared to South Korea and Japan in 2014, even though the research publications were less compared to both countries. A total of 2,66,902 articles cited 30,578 articles published by Japan, likewise for South Korea 2,04,393 articles cite 24,494 articles, and 20,836 articles published by India received 1,97,679 citations. The citations per paper rate is highest for India with 9.5 followed by 8.7 for Japan and 8.3 for South Korea. Gross drop can be identified for South Korea beginning in 2005 when there was a drastic increase in publications in 2006, and similarly for India during the same time frame. But interestingly there was a drop in publications beginning in 2006 in South Korea and it took five years to regain numbers.

4.2. Authorship Distribution

Due to the advent of technology in the last few decades, the collaboration between researchers has increased, and multiple-authorship has been a characteristic feature of modern science (Balog, 1980). The literature on any subject reflects not only the basic publishing pattern but also the characteristics of the authors themselves. Collaboration in research is said to have taken place when two or more scientists work together on a scientific problem or project and contribute their physical and mental efforts. Price (1963) was

Table 1. Growth of Publications and Citations

Published Year	India			Japan			South Korea		
	Cited References	Publications	Citations	Cited References	Publications	Citations	Cited References	Publications	Citations
2000	12713	660	10840	28548	2115	22913	15847	1004	12933
2001	11358	609	8392	30220	2153	24318	18899	1183	15748
2002	13755	703	10442	34436	2294	29922	20064	1264	17915
2003	15039	757	13970	33767	2222	25483	22221	1335	17424
2004	18106	838	12514	36048	2336	23948	23781	1440	15721
2005	20525	927	13236	38486	2281	24724	25711	1580	16882
2006	26338	1125	16796	37713	2230	21868	28437	1773	15227
2007	31900	1332	17608	35671	1972	21153	27255	1459	16520
2008	39016	1619	19166	36883	1932	18285	31583	1571	14793
2009	45017	1765	18402	34770	1839	13806	35042	1721	13878
2010	51006	1855	16340	41246	2024	13627	38716	1753	13697
2011	51265	1851	13324	39827	1753	10286	41255	1790	11668
2012	60100	2020	11549	41649	1863	7857	49765	2113	10225
2013	71218	2371	9698	45472	1827	5640	54967	2166	7422
2014	77583	2404	5402	45551	1737	3072	60035	2342	4340
Total	5,44,939	20,836	1,97,679	5,60,287	30,578	2,66,902	4,93,578	24,494	2,04,393

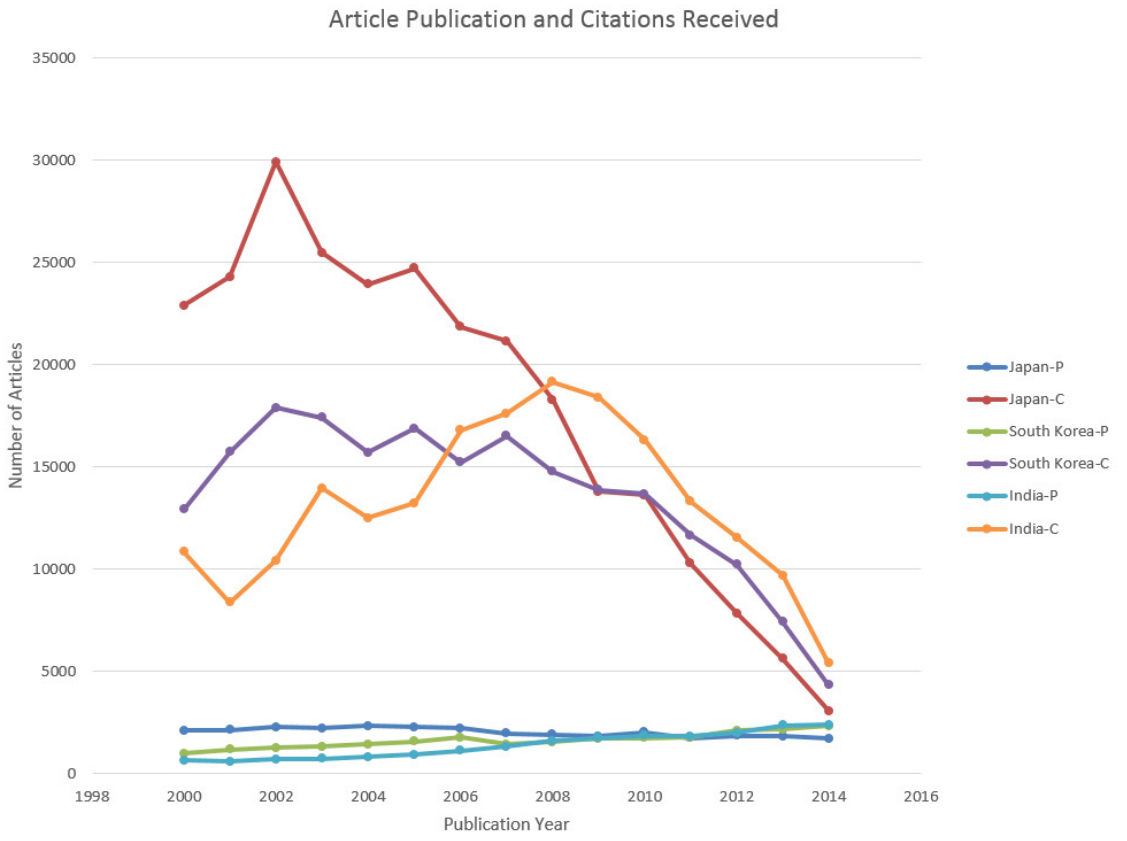

Fig. 1 Article publications (P) and citations (C) received by the articles published in respective years in all the three countries

among the first to observe that multi-authored papers are steadily increasing with a simultaneous reduction in single authored papers. His observations were based on sampling of Chemical Abstracts for the period of 1910-1960.

The pattern of co-authorship was studied by distributing the output of publications with respect to number of authors. The distribution was done as single author, two authors, up to four authors, and the rest were clubbed into one group named *five and above group.* Table 2 clearly shows that articles with three authors in both Japan and South Korea are on top when compared to the other set of articles. Researchers publishing articles in Japan and South Korea preferred to work in large groups. In India, researchers are becoming more and more aware of the importance of collaboration where articles with two authors are in higher numbers compared to the other sets of articles. Overall, 29% of the total number of articles (for all three countries) have been authored by three authors, followed by 28% with two authors. Interestingly 18% of the total number of articles are authored by four authors, and only 8% of the articles are authored by a single author. This reveals that collaboration has gained momentum and the trend is towards two-authored and three-authored publications. It would be pertinent to mention here that single author does not necessarily mean no collaboration. The majority of single authors were found to have multiple addresses thereby meaning that they were utilizing the facilities of other institutions within the country and thus are considered as domestic collaboration. Collaboration between authors in

Table 2. Authorship Pattern

Authorship Pattern						
	India (20,836)		Japan (30,578)		South Korea (24,494)	
No. of Authors	No. of Publications	Percentage	No. of Publications	Percentage	No. of Publications	Percentage
1	1496	7.2	3400	11.1	1533	6.3
2	**7746**	**37.2**	6233	20.4	6543	26.7
3	6815	32.7	**7993**	**26.1**	**7213**	**29.4**
4	3002	14.4	6261	20.5	4757	19.4
5 & above	1791	8.6	6691	21.9	4448	18.2

Japan and South Korea is slightly better than compared to India, as a larger percentage of articles in Japan and South Korea are authored by three authors.

4.3. Collaboration Indices

Collaboration is an intense form of interaction that allows for effective communication as well as the sharing of competence and other resources (Melin & Persson, 1996). To compare the extent of collaboration in two fields (or subfields) or to show the trend towards multiple authorships in a discipline, many studies have used either the mean number of authors per paper, termed the Collaborative Index (CI) by Lawani (1980), and/or the proportion of multiple-authored papers, called Degree of Collaboration (DC) by Subramanyam (1983) as a measure of the strength of collaboration in a discipline. These two measures are shown to be inadequate by Ajiferuke, Burell, and Tague (1988) and they derived a single measure called Collaborative Coefficient (CC) that incorporates some of the merits of both of the above. The Collaboration Coefficient as defined by Ajiferuke, Burell, and Tague lies between 0 and 1, with 0 corresponding to single authored papers. However it is not 1 for the case where all papers are maximally authored, i.e. every publication in the collection has all authors in the collection as co-authors. The research output indicators revealed the stable growth and increased cooperation in terms of the number of articles, the average number of references, and the collaboration index.

In the last section we discussed authorship patterns and saw that Japan and South Korea have published more articles with three authors when compared to India, where two authored publications are more numerous. After necessary computations, the indices data are published in Table 3. Japan scores high in terms of collaboration with the maximum CI being 3.82 and minimum being 3.27, followed by South Korea with a maximum of 3.52 CI. India has been a bit more consistent in terms of growth in CI compared with Japan and South Korea.

The degree of collaboration (DC) for India on the other hand indicates a steep curve beginning in 2003 with an indication of collaborative research being on the rise, compared to Japan and South Korea where at times in the middle the trend is downwards. All the three indices indicate that collaboration is on the upward trend, with yellow occupying the last part of the table. The collaboration coefficients for India, Japan, and South Korea are 0.6, 0.66, and 0.65 respectively which infers that the collaborative pattern is dominant over the single authored papers in this study. This trend, of course, is similar to the trends found in other disciplines as in laser science (Garg & Padhi, 2001), social media (Coursaris & Van Osch, 2014), cloud computing (Heilig & Vob, 2014), computer science (Singhal, Sumit Kumar Banshal, Uddin, & Singh, 2015), etc.

Table 3. Collaboration Indices

Published Year	CI			DC			CC		
	India	Japan	South Korea	India	Japan	South Korea	India	Japan	South Korea
2000	2.67	3.32	2.71	0.89	0.86	0.90	0.54	0.58	0.55
2001	2.72	3.32	2.95	0.90	0.85	0.93	0.55	0.58	0.59
2002	2.65	3.41	3.00	0.89	0.88	0.93	0.54	0.60	0.60
2003	2.75	3.27	3.03	0.88	0.87	0.92	0.55	0.59	0.60
2004	2.87	3.43	3.12	0.91	0.88	0.93	0.57	0.60	0.61
2005	2.76	3.45	3.22	0.91	0.90	0.94	0.56	0.62	0.62
2006	2.78	3.57	3.42	0.92	0.88	0.95	0.57	0.61	0.64
2007	2.79	3.41	3.37	0.92	0.88	0.94	0.57	0.61	0.63
2008	2.86	3.55	3.36	0.93	0.89	0.94	0.59	0.62	0.63
2009	2.87	3.54	3.38	0.93	0.90	0.93	0.59	0.62	0.63
2010	2.95	3.61	3.44	0.94	0.90	0.94	0.59	0.63	0.64
2011	2.92	3.61	3.47	0.94	0.90	0.94	0.59	0.62	0.64
2012	2.96	3.57	3.51	0.94	0.88	0.95	0.60	0.62	0.65
2013	2.95	3.74	3.51	0.94	0.93	0.95	0.59	0.65	0.65
2014	2.93	3.82	3.52	0.95	0.93	0.94	0.60	0.66	0.64

4.4. Activity Index

In the present study, the Activity Index (AI) has been calculated for different years to see how India, Japan, and South Korea's performance gradually changed during different years. Activity Index has been used to calculate the same. The Activity Index was first suggested by Frame (1977) and used among others by Schubert and Braun (1986), Nagpaul (1995), Karki and Garg (1997), Garg and Padhi (1999), Kumari (2006), Chetri, Saini, and Luthra (2009), and Sagar and Kademani (2011).

The activity index in Table 4 clearly shows that research in Japan was high in 2000 and decreased gradually, and it is a downward trend altogether. On the other hand South Korea's research can be compared to a sine wave as in 2001 it was in peak and reached a high in 2005 and took a downward trend from then onwards. On the other hand, India's research is on the upward trend beginning in 2000, with a minimal downtrend in the middle. Overall there is a significant rise in terms of articles published by India when compared to Japan and South Korea. A graph (Figure 2) has been plotted to display the activity index of all the three countries.

4.5. Bradford's Law of Scattering

Bradford (1934), a British mathematician, librarian, and documenter at the Science Museum in London revealed a pattern of how literature in a subject is distributed in journals.

Table 5 provides the journal distribution during the study period, and each of the zones covers one third of the articles. The core journals in zone 1 for each country are listed in Table 5a. The analysis of journals shall help scholars in getting an overview of prominent journals. The *Journal of Materials Processing Technology* and *International Journal of Heat and Mass Transfer* top the list from all countries. They are the prominent journals in the mechanical engineering research community.

Table 4. Activity Index

Published Year	World Publications	Publications			Activity Index		
		India	Japan	South Korea	India	Japan	South Korea
2000	5441	660	2115	1004	0.85	2.71	1.29
2001	5691	609	2153	1183	0.75	2.64	1.45
2002	6441	703	2294	1264	0.76	2.49	1.37
2003	6540	757	2222	1335	0.81	2.37	1.42
2004	7668	838	2336	1440	0.76	2.13	1.31
2005	7619	927	2281	1580	0.85	2.09	1.45
2006	8794	1125	2230	1773	0.89	1.77	1.41
2007	8522	1332	1972	1459	1.09	1.62	1.19
2008	9288	1619	1932	1571	1.22	1.45	1.18
2009	10370	1765	1839	1721	1.19	1.24	1.16
2010	11281	1855	2024	1753	1.15	1.25	1.08
2011	11338	1851	1753	1790	1.14	1.08	1.1
2012	13432	2020	1863	2113	1.05	0.97	1.1
2013	15536	2371	1827	2166	1.07	0.82	0.97
2014	17462	2404	1737	2342	0.96	0.69	0.94
Total	**145423**	**20836**	**30578**	**24494**			

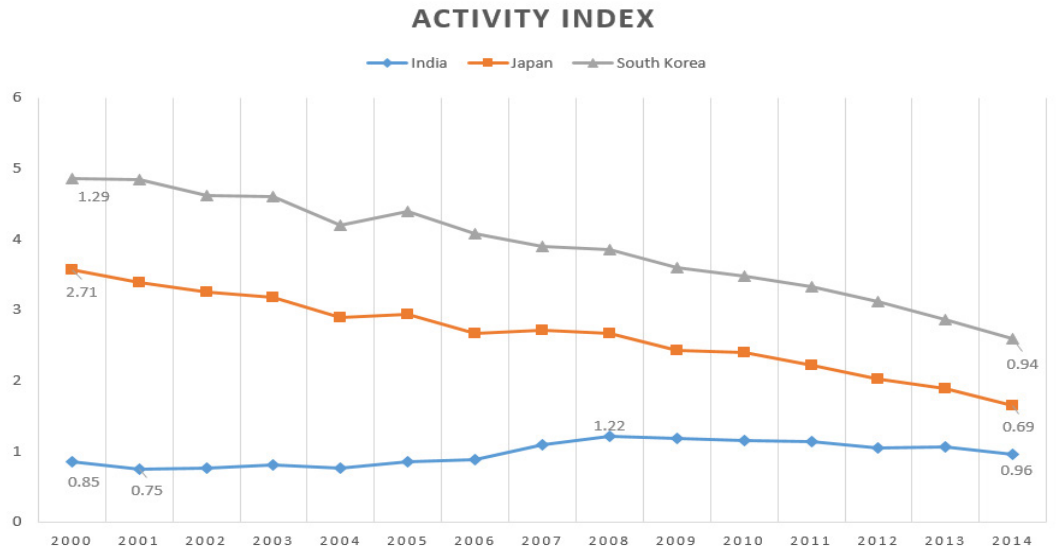

Fig. 2 Activity index of India, Japan, and South Korea

Table 5. Zone-Wise Distribution of Articles and Journals from all Three Countries

	Zone	1st	2nd	3rd
India	Articles	64028	64929	67748
	Journals	*9*	*26*	*343*
Japan	Articles	87789	86633	87072
	Journals	*18*	*37*	*332*
South Korea	Articles	66602	67591	68714
	Journals	*12*	*39*	*325*

5. CONCLUSION

The idea behind studying publication output is to understand the growth of mechanical engineering publications amongst the three countries which have a common footing. The publications in the field of mechanical engineering from India, Japan, and South Korea have been analysed. Price connected the size of science and time in terms of scientific growth. India and South Korea prove his model of doubling time, in fact with India being in the forefront, which has greatly increased its scientific activities in mechanical engineering. The study suggests the need to increase the pace of Japanese research in mechanical engineering as there is a decline in the number of publications. This may indicate that India can earn significant competitive advantages in the area of mechanical engineering. Japan's contributions were superior in the beginning, i.e., 2000, and there was a downtrend as the years passed by, with South Korea showing a rise and decline with the time. India's research was on the upward trend, with a small downtrend in the middle. Japan scores high in terms of collaborativeness amongst authors. Articles published by researchers in Japan and South Korea preferred to work in large groups. In India, researchers are becoming more and more aware of the importance of collaboration. The study did indicate that collaboration is on an upward trend with the time.

The analysis of most preferred publications may help, especially for new generations of scholars, to get an overview of important publications in the area of mechanical engineering. This study demonstrates the strength of a scientometric analysis to investigate a field of interest. As demonstrated, the results of the study are valuable for discussing and defining future research agendas in the area of mechanical engineering. As a continuation of this research work, the authors intend to do further analyses to identify the important stakeholders in the field of mechanical engineering. In a nutshell, the study shows that Japan's achievements are higher than the other two countries, i.e., India and South Korea, as far as mechanical engineering is concerned.

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Table 5a. Core Journals for each Country Grouped in Zone 1

Country	Journal	Articles	Citations Received
INDIA	International Journal of Heat and Mass Transfer	681	10974
	Journal of Materials Processing Technology	517	9658
	The International Journal of Advanced Manufacturing Technology	826	8644
	Journal of Sound and Vibration	441	6664
	Journal of Chemical & Engineering Data	513	6578
	Wear	339	6543
	Energy	283	5398
	The Journal of Thermal Analysis and Calorimetry	616	4788
	Energy Conversion and Management	276	4781
JAPAN	Journal of Materials Processing Technology	692	10160
	International Journal of Heat and Mass Transfer	534	9017
	Wear	365	6160
	CIRP Annals - Manufacturing Technology	390	5808
	Journal of Fluid Mechanics	278	5226
	Physics of Fluids	420	4898
	Journal of Micromechanics and Microengineering	360	4688
	Composites Part A:Applied Science and Manufacturing	208	4570
	Journal of Chemical & Engineering Data	308	4378
	Energy	225	4330
	Proceedings of the Combustion Institute	328	4172
	Journal of Sound and Vibration	329	3866
	International Journal of Fatigue	256	3659
	International Journal of Plasticity	91	3446
	International Journal of Refrigeration	231	3430
	Advanced Robotics	663	3426
	IEEE/ASME Transactions on Mechatronics	170	3352
	The International Journal of Robotics Research	91	3203
SOUTH KOREA	Journal of Materials Processing Technology	781	11124
	International Journal of Heat and Mass Transfer	577	10543
	Journal of Sound and Vibration	535	7246
	Journal of Micromechanics and Microengineering	467	6581
	Journal of Mechanical Science and Technology	2285	6295
	International Journal of Precision Engineering and Manufacturing	1071	4875
	International Journal of Refrigeration	249	3727
	The International Journal of Advanced Manufacturing Technology	459	3459
	Energy	265	3391
	International Journal of Plasticity	83	3187
	International Journal of Machine Tools and Manufacture	162	3088
	International Journal of Solids and Structures	197	3086

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