A SCIENTOMETRIC STUDY ON AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME) DURING 2000 TO 2020

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ABSTRACT

The study deals with the analysis of scholarly communication published in the ASME Journal of Mechanics from 2000 to 2020. Various Scientomeric indicators like SCImago Journal Rank, Source Normalized Impact per Paper, Relative Growth Rate, Doubling Time, Domestic Collaboration Index, International Collaboration Index, Immediacy Index, are used.The Journal of Manufacturing Science and Engineering obtained the highest 1.36 SJR scores followed by The Journal of Turbomachinery with 0.972 SJR, Journal of Mechanical Design with 0.911 SJR scores.The highest immediacy index was found in 2019 with a 0.59 immediacy index score.Taiwan is the highest country in domestic collaboration 125.29 DCI.Scotlandhas found the highest international collaboration rate with a 220.66 ICI value.

Keyword: *Scientometrics indicators, Impact Factor, SCImago Journal Rank, Source Normalized Impact per Paper, Relative Growth Rate, Doubling Time, Domestic Collaboration Index, International Collaboration Index*

1. Introduction

Mechanical Engineering is the core branch of engineering and uses in almost every part of human life. The industrial development of any nation is based on the development of research in Mechanical Engineering. The growing nature of this branch create difficulties in understanding and handling literature to the professional like librarians, mechanical engineers, professors and students. According to the data indexed in the Web of Science, search literature grew from 1989 to 2020. It is found that during these 32 years, literature has grown tremendously.in 1989 Mechanical Engineering field produced only 5814 research articles throughout the World, increasing 134964 in 2020. Total 1289674 research articles were published in 32 years of span. It means the research literature in Mechanical Engineering was increased by 218.07 times in 32 years. Compared to the year 1989 and the year 2000, the annual growth of literature was approximately 22 times increased. The contribution of publications in 1982 was only 0.46% to the total, and it was increased by 10.46% in 2020. It was found that 57.41% growth to the complete publications was done during the last eight years. It indicated the enormous research work had been done in Mechanical Engineering. The number of publishers specialized in Mechanical Engineering was 285 in 1989 in the whole World. It increased up to 767 in 2013. The publisher, like Elsevier, has 224 journals and increased 988 journal titles contributed to Mechanical Engineering. Springer had 37 journal titles, and in 1989 which increased 817 journal titles in 2020. Wiley had 51 journal titles in 1989, which increased to 467 journal titles in 2020. Taylor and Fancies had 45 titles in 1989, which increased to 355 titles in 2020. IEEE had 31 titles in 1989 and increased to 134 journal titles in 2020. American Society of Mechanical Engineers (ASME) had ten journal titles in 1989 and increased by 25 in 2020. According to the data, there were 840 journals in 1989 in the World, which were increased 4819 journals in Mechanical Engineering.All this data indicated that the research publications increased enormously due to industrial evaluation and seven developmental waves in Mechanical Engineering. It created many problems to understand the nature of research and handling the data as per the requirement of researchers, Educationist, Engineers and students.So, to understand the nature and publication trends, The study was conducted.

2. Objective of the Study

1. To measure the year-wise distribution and growth of literature in 17 ASME journals
2. To understand the document type contribution of ASME Journals to the Mechanical Engineering.

3. To measure the journals-wise productivity, citation and different type on impact factor ranking found in ASME Journals.
4. To measure the relative growth rate and required doubling time for the publications of ASME Journals.
5. To understand the country-wise collaboration found in the publication of ASME Journals.

3. Review of Literature

Dixit, Swati, and karate, V.V. (2007)[1] studied pattern analysis related to authorship, Bibliographic forms, citations, contributing institutions in the field of the cotton research. The study indicates the growth in cotton field. It is found multi-authorship pattern. 'Crop Science' is the highest cited foreign journal (164) and the 'Journal of Indian Society of Cotton Improvement' is the highest cited Indian Journal (280).Vijay, K.R. and Raghavan, I (2007)[2]have published an article entitled " Journal of Food Science and Technology: A bibliometric study '. In the study, he found that the maximum number of contributions is done by a joint author. The contribution of Indian authors (82.72%) is more, only 17.28% of developed nations contributed to this journal. Karnataka (1241 articles) is the highest contributed state.Kademani, B. S. and et al., (2005)[3] published article' 'Publication productivity of the Bio-organic division at Bhabha atomic Research centre: A Scientometric Study. " 475 articles were published by Bio-organic division during 1972-2002. 'Synthesis' (202), and 'Bio-organic Chemistry' (100) are the highest contributed subjects. The highest collaboration co-efficient 1.0 was found in the year 1972, 1976-1977,1980-1985, 1987, 1989-90, and 1993.Baskaran, C., and Batcha, Sadik M. (2012)[4] published an article entitled "Publication pattern and authors collaboration of cardiology research" The data is retrieved from the MEDLINE database on cardiology during 1991-2010. 829 articles were analysed. The study measures countries' annual growth rate and collaboration index. The mean degree of collaboration is 0.70 and the highest score recorded is 0.88 in1991.
Batcha, Sadik M. and Chaturbhuj, S.B. (2019)[5] published an article entitled 'Analysis of scholarly communication on Phonology during 2000-2007: A Scientometric Study". The study found the degree of collaboration is 0.5 and the collaboration co-efficient and modified collaboration coefficient is 0.5. Goswami, U was the first rank author in phonology. 'Lingua' is the first rank journal; the USA was the highest contributed country. [6]Buriak, Jillian M. (2015)[6], in the Editorial entitled "Hot Topics in Materials Chemistry and the Immediacy Index long-term versus short-term impact" Using Web of Science data, the immediacy Chemistry of Material has gone up substantially, to a highly competitive 1.93 for 2014, from 1.27 for 2013.Aithal, P. S. (2017)[7], published an article entitled "Comparative study of various research indices used to measure the quality of research publication". In this paper, he explained the various indicators to access the impact authors based on citations such as h-index, g-index, and i10-index. In the paper, he suggested some of the new indicators like ARP-Index, RC-Index, Cost Index, etc.

4. Methodology

4.1 Ranking by Impact Factor

Eugene Garfield firstly coined the term impact factor, which is abbreviated as IF. According to Garfield[8], " the ratio of the number of the papers published over a period of time". The journal Impact Factor (IF) is regularly produced by the Institute for Scientific Information. It is published in the Journal Citation Reports (JCR). JCR impact factor mathematically represented as below:$IF(Ay) = \frac{X_1+X_2}{Y_1+Y_2}$

Where, IF (Ay) = impact factored of the journal 'a' for the year 'y'
X_1 = number of citations received by X_1 source item in the year y
X_2 = number of citations received by X_2 source item in the year y
Y_1 = number of source items published in the journal 'a' in the year Y_1
Y_2 = number of source item published in the journal 'a' in the year Y_2
For example., Impact Factor for the Current Science in 2016 can be calculated as follow:

$$IF(Ay) = \frac{X_1 + X_2}{Y_1 + Y_2}$$

$$IF(\text{Current Ccience 2016}) = \frac{\text{Total citations received in 2016 for 2014 + 2015}}{Total\ No\ of\ Articles\ publishe\ in\ 2014 + 2015}$$

$$IF(\text{Current Ccience 2016}) = \frac{632}{671 + 804}$$

$$IF(\text{Current Ccience 2016}) = \frac{632}{1475}$$

$$IF(\text{Current Ccience 2016}) = 0.428$$

Therefore, the impact of current science for the year 2016 is 0.428

The impact factor indirectly measures the quality and impact of articles published in journals. The article published in the journals received a high impact factor that has prestige in scholarly communication. It has considered a high-quality article. Thus, the impact factor offset the effect of age, size, and frequency of a journal's publications on the frequency of citations. However, the value of the impact factor is affected by different factors such as subject area, type of documents or length of the citation measurements windows. It is generally found that the higher impact factor received by the reviews type of documents than for other documents types. Similarly, basic research received a higher impact factor than applied research. The newly evolving and slowly growing disciplines have been affected by the short citation window of the JCR IF-that is two years. That is why the impact factor can not be compared with the journals of different disciplines. To come out with such limitations of impact factor now two years and five years impact factors are introduced. The formula of these impact factors is the same only citation windows and document years are two years in 2 years impact factor and five years in 5 years impact factor.

Elsevier Scopus introduced two types of journal impact factor, which are-

(a) SCImago Journal Rank (SJR)

(b) Source Normalized Impact per Paper (SNIP)

(a) SCImago Journal Rank (SJR)

Elsevier's Scopus think about the qualitative aspect of citation and, with the help of SCImago Research Group and CWTS, developed SCImago Journal Rank that is the SJR impact factor. These metrics are calculated by the bibliometric team externally for Elsevier using Scopus index journal as its raw data, and it is available to all in Scopus and other locations.

Generally, the impact factor considers all citation values as equal. However, in the SJR, a widely read multidisciplinary journal citation counts as intensely as one from a more focused or local interest source. The SJR is a prestige metric inspired by Google's PageRank, whereby a journal's subject fields, quality, and reputation directly affect the value of citations it gives to other journals.

The SJR is a prestige journal metric rather than a popularity metric. It means if articles from A journal received 100 citations and articles from B journal also received 100 citations. However, journal 'A' received citations from more prestigious journals, and journal B received citations from less prestigious journals. Then the SJR impact factor of A journal is higher than B though both journals have the same citations.

(b) Source Normalized Impact per Paper (SNIP)

The SNIP indicator is based on two other indicators: the journal raw impact per Pape (RIP) divided by the relative database citation potential (RDCP) in the journals subfield. In this impact factor, both the numerator and the denominator are quotients. The numerator is similar to three years impact factor. The denominator is citation potential which depends on the topicality of the subject field. It measures the citation characteristic of the field the journal cited. It is determined by how often and how rapidly authors cite other works and how well the database, i.e., Scopus, cover their field.

Mathematically, SNIP[9] is represented as:$SNIP = \frac{RIP}{RDCP}$

For a given year of analysis, the RIP value of a journal equals the average number of times the journal's publications in the three preceding years was cited in the year of analysis. e.g., if 100 publications appeared in a journal from 2008-2010 and were cited 200 times in 2011, then the RIP value of the journal for 2011 equals 200/100=2. It is just like the Impact factor for three years citation window. The only difference is that in calculating RIP values, citing and cited publications are

included on the Scoups document types- article, conference paper, or review.

The calculation of RDCP is getting by the following formula: $RDCP = \frac{DCP}{median\ (DCP)}$

In the formula, DCP denotes a journal's database citation potential, and median (DCP) denotes the median DCP value of all journals in the database. It follows from the above formula that the median RDCP value of all journals in the database equals one. Consequently, half of the journals in the database have a SNIP value higher than their RIP value, and half of the journals in the database have a SNIP value that is lower than their RIP value. Hence, within a given year of analysis, the division by median (DCP) does not affect how journals compare with each other.

Since the step from a journal's DCP value to its RDCP value boils down to a division by a fixed value, it is essential to understand the calculations of the DCP value of a journal. This calculation starts by delineating a journal subject field. The subject field of a journal is defined as a set of all publications in the year of analysis with at least one reference to the journal. The DCP value of a journal equals the average number of references in the publications that appeared in the three preceding years in journals covered by the database. The calculation of a journal's DCP value only considers citing and cited publications of the Scoups document type- articles, conference papers and reviews. Mathematically, the DCP value of a journal can be expressed as: $DCP = \frac{r_1+r_2+r_{...}+r_n}{n}$

Where, n = the number of publications in the subject field of the journal.

r_1=The number of references in the ith publication to publications that appeared in the three preceding years in journals covered by the database.

4.2 Ranking by Immediacy Index

Immediacy Index is the reshow of the citations received to the articles in the published year and the number of articles in that year of the particular journal.

Mathematically, the Immediacy index is expressed as: $Ii(Jy) = \frac{C}{X}$

Where, Ii(Jy)= Immediacy Index of the journal J for the year Y

C= number of citations received by X source items published in journal J in the year Y

X= Number of source items published in journal J in the year Y

This index expressed how quickly the published articles get visible by others in the published year itself. It shows the quality of research impact of an author or journal in that field. However, the length of journals and time of publication affect this index. As the number of papers is more in a particular journal, getting more citations increases. In the same way, the more frequency of publication (i.e., Quarterly monthly) has a chance to get more citations rather than a low frequency of publication (half-yearly and yearly).

4.3. Relative Growth Rate

The growth of publications in any specific field or journal can be calculated with the help of two indicators- one is the relative growth rate, which calculates the increase in the number of publications per unit of time. The second indicator is doubling time which predicts the time required for publication to become double the existing amount.

Mahapatra developed a model for finding the relative growth rate in publication. The mean relative growth rate R (P) over a specific interval period can be calculated mathematically.

$$\bar{R}_{(P)} = \frac{w_2 - w_1}{T_2 - T_1}$$

Where, R (P)=Mean relative growth rate over the specific period interval

W1=log w1(natural log of the initial number of publications)

W2=log w2 (Natural log of the final number of publications)

T2-T1=the unit difference between the initial time and final time

The same formula is used to find out the relative growth rate for citations. The mean relative growth rate of citations over the specific period is calculated mathematically, as follow:

$$\bar{R}_{(C)} = \frac{C_2 - C_1}{T_2 - T_1}$$

Where, C2 and C1 are the cumulative numbers of citations in the year T2 and T1

R(C) =Mean relative growth rate of citations over a specified period interval
C1 =log C1 (natural log of the initial number of citations)
C2 =log C2 (natural log of the final number of citations)
T2-T1 =The unit difference between the initial time and final time.

4.4. Doubling time

Doubling time means the time required for published literature to become double the quantity of the existing amount. It is directly related to the relative growth rate. Suppose the number of articles in a subject double during a given period. In that case, the difference between logarithms of number at the beginning and end of this period must be the logarithm of the number 2. As per the Napier logarithm, the value of log 2 is 0.693. Therefore, once the relative growth rate is found, it is calculated what interval the Napier logarithm of number increases by 0.693 to achieve the doubling time of literature.
The doubling time is calculated from the following mathematical formula
for Publications, it is represented as:

$$Dt(p) = \frac{0.693}{\bar{R}\,(p)}$$

for Citations, it is represented as:

$$Dt(c) = \frac{0.693}{\bar{R}\,(c)}$$

4.5. Domestic Collaborative Index

Collaboration can be classified as Local, Domestic, and international collaboration. In the present study, domestic and international collaboration are considered. If the affiliation of the authors of an article belongs to one country, then that published paper is called a domestically collaborated paper. Generally, any institute starts its research publications with domestic collaboration, and gradually international collaboration increases. Garg and Padhi[10] (2001) and Dutt, Garg, and Bali[11] (2003) suggested the Domestic collaborative index (DCI) and the International Collaborative Index (ICI) for examining the pattern of collaboration. To calculate the degree of domestic collaboration, DCI (Domestic Collaborative Index) is used. It is calculated by the following formula.

$$\text{DCI} = \frac{\text{D}i/\text{D}io}{\text{D}o/\text{D}oo}\ X\ 100$$

Where, Di= number of domestically co-authored paper for block 'i'
Dio = number of domestically co-authored paper for all the blocks
Do= Total number of co-authored papers
Doo= Total output

4.6. International Collaborative Index

If the affiliation of at least one author of an article belongs to a foreign country, then that published paper is called an internationally collaborated paper. The degree of international collaboration is calculated by ICI (International Collaboration Index) by the following formula

$$\text{ICI} = \frac{\text{I}i/\text{I}io}{\text{I}o/\text{I}oo}\ X\ 100$$

Where, Ii= number of internationally co-authored papers for block 'i'
Iio = number of internationally co-authored paper for all the blocks
Io = Total number of co-authored papers for block
Ioo= Total output
If the value of DCI or ICI is equal to 100, it means a given country's collaborative efforts correspond to the world average. If DCI or ICI >100 indicates collaboration efforts higher than the world's average, and if DCI or ICI<100 means less than average collaboration.

5. Analysis of Data

5.1. Document-wise distribution of Publications

ASME published 12 document types, including Articles, Conference proceedings, Editorial Materials, Reviews, Corrections, New Items, Biographical- Items, Reprints, Retracted Publications, Book Reviews, and Bibliography in the study years. From table No. 1, it is clear that the most prominent form of document type used by scientists or research scholars is articles. Out of 42596 published documents, 36604 documents are articles that cover 85.93% of the total. The articles received 511736 citations within 21 years of citation window. Every journal has contributed articles as the most prominent document type. The Conference proceeding papers are found 4438 in the credit of ASME with 10.42% to the total. Conference proceedings are also a form of

articles. In the present study, this type of document receives 91075 citations. The citations received by conference proceedings are 14.73% of the total citations. The Editorial materials have 824 records with 1.93 % documents and 1236 citations with 0.20% to the total. The Review is generally considered an essential form of scholarly communication. In the study year, ASME found 332 records as review articles which are 0.78% of the total. The citations received by Review articles are 13522, which shows the importance of this. The citations received by Review articles are 2.19 % of the total. The Other form of document types published by ASME are less in number in that form; Corrections are 209 (0.49%), News items are 102 (0.24 %), Bibliographical items are 65 (0.15%), Reprints is 13 (0.03%) Articles retracted publications are 3 (0.01%,) Book reviews are 2 (0.00%), and only one document is published as Bibliography form.

Table No.1 Document-wise distribution of Publications of ASME Journals

Sr. No	Document Type	Records	% of 42596	Citations	% of 618187
1	Article	36604	85.93	511736	82.78
2	Proceedings Paper	4438	10.42	91075	14.73
3	Editorial Material	824	1.93	1236	0.20
4	Review	332	0.78	13522	2.19
5	Correction	209	0.49	168	0.03
6	News Item	102	0.24	167	0.03
7	Biographical-Item	65	0.15	33	0.01
8	Reprint	13	0.03	230	0.04
9	Retracted Publication	3	0.01	14	0.00
10	Letter	3	0.01	6	0.00
11	Book Review	2	0.00	0	0.00
12	Bibliography	1	0.00	0	0.00
Total		**42596**	**100.00**	**618187**	**100**

5.2 Document-wise distribution over the years

Table Number 2 represents the year-wise distribution of document types publications published by 17 ASME journals from 2000 to 2020. Total 4438 records are found as conference proceeding articles. It shows that the number of publications is consistently increasing over the years. Its coefficient variations for the publications are 0.18, which shows the consistent pattern in publications. The mean of the publications is 2028.38. It means the average number of publications is 2028.38. The value or the number of documents published each year has a deviation of 355.41. Table Number 2 represents that the publications of articles observed continuous growth except the fluctuation found in 2015, 2016 and 2020. Total 36604 articles were published during 21 years, and it is the most prominent document type of published materials by ASME Journals. The standard deviation of the article's publications is 466.56, and the mean value of the range of article publication is 1743.05, and the standard deviation value is much higher (466.56), which means each year's publications have much deviated from the mean value or the average. However, the coefficient value of the article is 0.268, which show consistency in publications. Compared to other forms of documents, the highest publications in the form of articles are found in 2019, with 2499 articles.

Table No.2 Year-wise distribution of ASME publication along with citation details

Sr. No.	Year	Publications	% of 42596	Citations	% of 618187	ACPI	ACPY	h-index	ACPCY
1	2000	1477	3.47	38898	6.29	26.34	1852.29	87	1852.29
2	2001	1583	3.72	42938	6.95	27.12	2044.67	85	2146.90
3	2002	1588	3.73	**47654**	**7.71**	**30.01**	**2269.24**	96	2508.11
4	2003	1632	3.83	44029	7.12	26.98	2096.62	83	2446.06
5	2004	1658	3.89	42739	6.91	25.78	2035.19	87	2514.06
6	2005	1705	4.00	43458	7.03	25.49	2069.43	85	2716.13
7	2006	1811	4.25	44048	7.13	24.32	2097.52	81	2936.53
8	2007	1881	4.42	40129	6.49	21.33	1910.90	77	2866.36
9	2008	1892	4.44	32418	5.24	17.13	1543.71	65	2493.69
10	2009	1959	4.60	31399	5.08	16.03	1495.19	63	2616.58
11	2010	2006	4.71	30636	4.96	15.27	1458.86	65	2785.09
12	2011	2073	4.87	29249	4.73	14.11	1392.81	59	2924.90
13	2012	2155	5.06	27546	4.46	12.78	1311.71	56	3060.67
14	2013	2256	5.30	26278	4.25	11.65	1251.33	49	3284.75
15	2014	2309	5.42	25355	4.10	10.98	1207.38	50	3622.14
16	2015	2245	5.27	22125	3.58	9.86	1053.57	45	3687.50
17	2016	2228	5.23	16255	2.63	7.30	774.05	33	3251.00
18	2017	2464	5.78	14947	2.42	6.07	711.76	31	**3736.75**
19	2018	2601	6.11	10896	1.76	4.19	518.86	22	3632.00
20	2019	**2722**	**6.39**	6088	0.98	2.24	289.90	15	3044.00
21	2020	2351	5.52	1102	0.18	0.47	52.48	9	1102.00
Total		**42596**	**100**	**618187**	**100**	**14.51**	**29437.48**	**NIL**	**NIL**

ACPI=Average Citations per Items/Article, **ACPY**= Average Citations Per Year, **ACPCY**= Average Citations Per Citable Year

The citations depend on the citeable year; that is why one cannot realise the accurate quality of the documents published in the year. The table represents that if the publications' citable span draws average citations, we get average citation per citable year (ACPCY). According to that highest value was received in the year 2017 with a 3736.75 ACPCY value. It means that 2464 documents have consistently got much higher citations in the citable year. As the average number of citations per citable years decreases, the citations increase continuously with a slight fluctuation in 2016, 2018, 2019 2020. It means that as the citable years' increase, the average citation count decreases. In other words, the utilisation of older documents is increasing slowly. It is the absolute value of the documents published each year.

The table also represents the h-index value received by each year. Through the h-index, the publication impact created by the published documents in a particular year is represented. As per table number 3, the highest h-index impact was found in 2002 with a 96 h-index score. It means that there are at least 96 documents within 1588 documents that received at least 96 or greater than 96 citations. The remaining documents have less than 96 citations. Similarly, the second-highest h-index was found in 2000 and 2004 with 87 h-index scores. The lowest h index score was found in 2020 with nine scores.

5.3Source wise distributions of ASME Journals along with journal Impact Factor

The journals published by the American Society of Mechanical Engineers (ASME) are taken in the present study. Seventeen source titles are taken with the publication duration from 2000 to 2020. Table Number 3 represents these journal-wise data along with Total Citations (TC), average citation per item (ACPI), average citations per year (ACPY), and different forms of journal impact factors. According to table number 4, 17 journals published 42596 articles from 2000 to 2020. In all the journals, the Journal of Heat Transfer published the highest number of articles that is 4320, with 10.14 % publications. The second and third highest publications were found by the Journal of Engineering and Gas Turbines and Power and the Journal of Fluid Engineering with 1475 and 3333 documents, respectively with 9.80 % and 7.82 %. The lowest productivity was found by the Journal

of Offshore Mechanics and Arctic Engineering with 1207 contributions which are 2.83 % of the total. It is found that the journals devoted to the core subject have high productivity while the journals which deal with the interdisciplinary obtain a significantly less number of published articles. The Journal of Offshore Mechanics and Arctic Engineering deals with analysis design and technology development in Ocean, Offshore Arctic and related field. As this journal is very specialised in the subject area, the productivity is less than other core subjects (1207 articles, 2.83 % of the total).

The ASME journal received 618231 citations to 42596 published articles within the study duration. The citation data was collected on 24th April 2021. It is found that the Journal of Heat and Transfer received 77848 citations for 4320 published articles with the rank first. It contributed 12.59% to the total received citations. This journal received 18.02 average citations per article (ACPI) and have 3707.05 average citations per year (ACPY). The second-ranked journal was the Journal of Biochemical Engineering received 68379 citations for 3057 published articles and received 11.06% citations. The journal obtained 22.37 average citations per article (ACPI) and received 3256.14 average citations per year (ACPY).

From table number 3, it is found that the Journal of Solar Energy Engineering, which deals with solar power generation Technology, has only 1685 research articles which are less in number as compared to the other core journals. It is significantly less in number, but still, this journal received 26678 citations during the study year. Articles from this journal received a 15.83 ACPI score which is nearest to the first rank journal. It means that solar power generation is an emerging field in Mechanical Engineering and significantly impacts research scholars. It is also found that the lowest number of citations received by the Journal of Offshore Mechanics and Arctic Engineering and is 9007 with 1.46 % citations to the total. These articles received a 7.46 score of average citation per article (ACPI) and 428.90 scores of average citations per year (ACPY). The table also depicts that only two journals, the Journal of Heat Transfer and the Journal of Biochemical Engineering, received more than 10% citations. It founds that the Journal of Mechanical Design, the Journal of Engineering for Gas Turbines and Power, the Journal of Fluid Engineering, the Journal of Turbomachinery and the journal of Applied Mechanics have received citations of more than 7% and less than 10%. These journals are devoted to the core subject of Mechanical Engineering.

Table No. 3 Source-wise distributions of ASME Journals along with journal Impact Factor

Sr. No.	Source Titles	Records	% of 42596	Citations	% of 618231	ACPI	ACPY	SJR Score	SCI JIF	IF (WOS)	5 Years IF
1	J1	4320	10.14	77848	12.59	18.02	3707.05	0.72	1.96	1.74	1.59
2	J2	4175	9.80	45748	7.40	10.96	2178.48	0.57	1.94	1.09	1.14
3	J3	3333	7.82	46162	7.47	13.85	2198.19	0.53	2.22	1.75	1.64
4	J4	3057	7.18	68379	11.06	22.37	3256.14	0.55	1.90	1.77	2.07
5	J5	3012	7.07	43673	7.06	14.50	2079.67	0.69	2.85	1.89	2.20
6	J6	2969	6.97	61715	9.98	20.79	2938.81	0.91	3.34	2.79	3.16
7	J7	2777	6.52	42098	6.81	15.16	2004.67	1.37	3.20	2.74	2.73
8	J8	2737	6.43	32234	5.21	11.78	1534.95	0.53	1.74	1.24	1.22
9	J9	2356	5.53	45216	7.31	19.19	2153.14	0.97	2.86	1.57	1.80
10	J10	2343	5.50	32538	5.26	13.89	1549.43	0.50	1.90	1.68	1.60
11	J11	2189	5.14	14077	2.28	6.43	670.33	0.41	1.08	0.90	0.86
12	J12	2111	4.96	27513	4.45	13.03	1310.14	0.61	2.52	1.44	1.65
13	J13	1774	4.16	14480	2.34	8.16	689.52	0.62	3.23	2.63	2.32
14	J14	1685	3.96	26678	4.32	15.83	1270.38	0.55	1.98	2.01	1.66
15	J15	1276	3.00	17308	2.80	13.56	824.19	0.37	1.14	1.22	1.14
16	J16	1275	2.99	13557	2.19	10.63	645.57	0.52	1.88	1.67	1.73
17	J17	1207	2.83	9007	1.46	7.46	428.90	0.56	1.35	1.22	1.22
Total		**42596**	**100**	**618231**	**100**	**14.51**	**29439.57**	**NIL**	**NIL**	**NIL**	**NIL**

J1=Journal of Heat Transfer, **J2**=Journal of Engineering for Gas Turbines and Power, **J3**=Journal of Fluids Engineering, **J4**= Journal of Biomechanical Engineering, **J5**=Journal of Applied Mechanics, **J6**=Journal of Mechanical Design, **J7**=Journal of Manufacturing Science and Engineering, **J8**=Journal of Dynamic Systems Measurement and Control, **J9**=Journal of Turbomachinery, **J10**=Journal of Tribology, **J11**=Journal of Pressure Vessel Technology, **J12**=Journal of Vibration and Acoustics, **J13**=Journal of Energy Resources Technology, **J14**=Journal of Solar Energy Engineering, **J15**=Journal of Engineering Materials and Technology, **J16**=Journal of Electronic Packaging, **J17**=Journal of Offshore Mechanics and Arctic Engineering. **ACPI**=Average Citations Per Item/Article, **ACPY**=Average Citation Per Year, **SJR**=SCImago Journal Rankings**, SCI JIF**= Science Journal Impact Factor **IF(WOS)**= Impact Factor from the citations data of WOS.

Table number 3 depicts the score obtained by ACP and ACP as per the table shown the highest ACP score obtained by the Journal of Biochemical Engineering with 22.37 ACPI score the second-ranked journal in ACPI score is the Journal of Mechanical Design with 20.79 ACPI score. From the ACPI score of these journals, it is found that interdisciplinary and core subjects have gotten weightage in Mechanical Engineering research. Apart from the above two journals, the Journal of Turbomachinery and the Journal of Heat Transfer received 19.19 and 18.02 ACPI scores, respectively. It is found that the highest average citation per year (ACPY) was received by the Journal of Heat Transfer with 3707.05 ACPY scores, followed by the Journal of Biomechanical Engineering with 3256.14 ACPY scores. The Journal of Offshore Mechanics and Arctic Engineering receives the lowest average citation per year with 428.90 ACPY scores.

Through ACPI and ACPY indicators, it is clear that subjects like Biomechanical Mechanical Design, Turbomachinery, Heat Transfer, Solar Energy are the prominent subjects that received higher citations count per year and article. The demand for these subjects is much higher than the other subjects of Mechanical Engineering. It is also found that the articles of ASME have a 14.51 ACPI score in general, which is considered a good average. It is found that every year is ASME articles receive 29439.57 average citations to the total publications.

SJR score is also known as the SCImago Journal Rank. This indicator measures the influence of scientific journals by the number of citations received by a journal and the importance or prestige of the journal where citations come from. SJR is a Prestige Metric inspired by Google's page rank whereby journals subject field, quality, and reputation directly affect the value of citation it gives to other journals. Therefore, a journal SJR is a numeric value indicating the average number of weighted citations received during a selected year per document published in the journal during the previous three years. It is said that higher SJR values are meant to indicate greater journal prestige. Table number 4 indicate that the highest prestigious ASME journal is the Journal of Manufacturing Science and Engineering which obtained a 1.36 SJR score. It means that this journal received a higher number of citations and citations from higher prestigious SJR valued journals. The second and third-ranked prestigious journals are the Journal of Turbomachinery and the Journal of Mechanical Design, with 0.972 and 0.911 SJR scores. According to the data, the lowest SJR score is received by the Engineering Materials and Technology journal with 0.368. It means that though this journal received citations better than few other journals, the referenced citations do not belong from widely cited journals. It may be possible that the citations received by the journal are local influenced citations. They do not belong to reputed journals. The data also represent that though some journals have high citations but received low SJR scores, others have fewer citations but receive higher SJR scores. It means that ASME journals having more than 0.5 SJR scores are having more research impact in the field of mechanical engineering publications.

5.4 Immediacy index and Relative Citation Index of the year-wise publications of ASME Journals

The immediacy index is a measure of how quickly the average article in a particular journal is cited. It means that the articles published and get citations within the published year is measured by Immediacy Index. Table 5.15 expressed the year-wise distribution of immediacy index for articles published by ASME journals from 2000 to 2020. It is found that the highest immediacy

index was found in 2019 with a 0.59 immediacy index score. It is found that in 2019, 2722 articles were published, and in 2019 these articles got 1608 citations in the same year. These citations with the same year are highest among the study year. So that in 2019 immediacy index is highest. In other words, the visibility of the articles by other research scholars is highest compared to other years. The Immediacy index score continuously increased from 2000 to 2020, except the decline is found in 2008(0.7), 2009 (0.10) and 2013 (0.18). During the years 2014 to 2020, the Immediacy index continuously increases significantly. The data shows that the quality of ASME journals are improving as research scholars with increasing trends prefer it. The immediacy index started at 0.05, and it increased 0.59 within 21 years. It shows that research scholars give preference to the ASME journals recent articles. It proves the quality and upgraded information found in ASME journals.

This Scientometric indicator was developed by the Institute of Scientific Information (ISI) presently. Thomson Reuters, USA. This indicator measures the influence and visibility of the articles published during a particular year. According to the data expressed in table no. 5.16, the highest relative citation index found in 2002 with a 2.07 RCI value. It shows that articles published in 2002 have received citations higher than the citation rate to the total journal publications. The RCI value of 2002 also indicates that the citation rate to the article published is double the average citation rate of ASME journals. It means the quality, visibility, and acceptability of these articles were very high in 2002. The data show that from 2000 to 2010, the value of RCI indicators is more than 1, indicating that during these years, the year-wise articles have received the higher citation rate of the publications of the total journal. It also depicted that from 2011 to 2020, the RCI value continuously decreased, and it was less than 1, indicating that these years articles did not get citation rate which the complete publications of journals achieved. The Citable year is also essential and has an impact on RCI. It is found that the mean rate of RCI value is 1.10, which is more than one. It indicates that the articles published in ASME journals have received more citations than the total journals publication rate. The quality of articles and visibility of articles where both have found higher during the study period. The table shows the total number of citations and average citations per item already discussed in year-wise distribution of articles. (Table no. 2). Only one relation found between ACPI and RCI is that if ACPI increases, the value of RCI is also increased, and if ACPI value decreases, the value of RCI is also decreased. It means there is a positive correlation found between these two indicators.

Table No. 4 Immediacy index and Relative Citation Index of the year-wise publications of ASME Journals

Sr. No	Year	Published Articles	Citation Given to the Articles in Published Year	Immediacy Index	TNC	RCI
1	2000	1477	72	0.05	38898	1.81
2	2001	1583	83	0.05	42938	1.87
3	2002	1588	126	0.08	**47654**	**2.07**
4	2003	1632	122	0.07	44029	1.86
5	2004	1658	119	0.07	42739	1.78
6	2005	1705	186	0.11	43458	1.76
7	2006	1811	186	0.10	44048	1.68
8	2007	1881	263	0.14	40129	1.47
9	2008	1892	132	0.07	32418	1.18
10	2009	1959	204	0.10	31399	1.10
11	2010	2006	369	0.18	30636	1.05
12	2011	2073	386	0.19	29249	0.97
13	2012	2155	561	0.26	27546	0.88
14	2013	2256	411	0.18	26278	0.80
15	2014	2309	808	0.35	25355	0.76

16	2015	2245	792	0.35	22125	0.68
17	2016	2228	873	0.39	16255	0.50
18	2017	2464	1090	0.44	14947	0.42
19	2018	2601	1213	0.47	10896	0.29
20	2019	2722	**1608**	**0.59**	6088	0.15
21	2020	2351	1086	0.46	1102	0.03
Total		**42596**	**NIL**	**NIL**	**618187**	**NIL**

5.5 Relative Growth Rate (RGR) and Doubling Time (DT) for the publications and citation received by ASME Journals:

According to the table No 5, the relative growth rate for the year 2000 was 0.659, and it continuously moved on and reached 2.897 in 2020. It is found that the relative growth rate of ASME journals increasing continuously through the study years. From 2000 to 2006 mean relative growth rate was 1.175, and from 2007 to 2014, the mean relative growth rate was found 2.231, and during the years 2015 to 2020, the mean relative growth rate was found 2.231. It shows that the literature published by ASME journals are continuously increasing their publications. The difference between the relative growth rate in 2000 and 2020 is 2.238 it means almost more than double the growth rate found in publications.

Table 5.5 Relative Growth Rate (RGR) and Doubling Time (DT) for the publications and citation received by ASME Journals

Year	Publications	Cum. Publications	W1	W2	RT (p)	Dt (p)	TNC	Cum. Citations	W3	W4	RT (c)	Dt (c)
	RGR(p) & Dt(p)						RGR(c) & Dt(c)					
2000	1477	1477	7.30	7.30	0.00		38898	38898	10.57	10.57	0.00	
2001	1583	3060	7.37	8.03	0.66	**1.05**	42938	81836	10.67	11.31	0.64	**1.07**
2002	1588	4648	7.37	8.44	1.07	0.65	**47654**	129490	10.77	11.77	1.00	0.69
2003	1632	6280	7.40	8.75	1.35	0.51	44029	173519	10.69	12.06	1.37	0.51
2004	1658	7938	7.41	8.98	1.57	0.44	42739	216258	10.66	12.28	1.62	0.43
2005	1705	9643	7.44	9.17	1.73	0.40	43458	259716	10.68	12.47	1.79	0.39
2006	1811	11454	7.50	9.35	1.84	0.38	44048	303764	10.69	12.62	1.93	0.36
2007	1881	13335	7.54	9.50	1.96	0.35	40129	343893	10.60	12.75	2.15	0.32
2008	1892	15227	7.55	9.63	2.09	0.33	32418	376311	10.39	12.84	2.45	0.28
2009	1959	17186	7.58	9.75	2.17	0.32	31399	407710	10.35	12.92	2.56	0.27
2010	2006	19192	7.60	9.86	2.26	0.31	30636	438346	10.33	12.99	2.66	0.26
2011	2073	21265	7.64	9.96	2.33	0.30	29249	467595	10.28	13.06	2.77	0.25
2012	2155	23420	7.68	10.06	2.39	0.29	27546	495141	10.22	13.11	2.89	0.24
2013	2256	25676	7.72	10.15	2.43	0.28	26278	521419	10.18	13.16	2.99	0.23
2014	2309	27985	7.74	10.24	2.49	0.28	25355	546774	10.14	13.21	3.07	0.23
2015	2245	30230	7.72	10.32	2.60	0.27	22125	568899	10.00	13.25	3.25	0.21
2016	2228	32458	7.71	10.39	2.68	0.26	16255	585154	9.70	13.28	3.58	0.19
2017	2464	34922	7.81	10.46	2.65	0.26	14947	600101	9.61	13.30	3.69	0.19
2018	2601	37523	7.86	10.53	2.67	0.26	10896	610997	9.30	13.32	4.03	0.17
2019	**2722**	40245	7.91	10.60	2.69	0.26	6088	617085	8.71	13.33	4.62	0.15
2020	2351	**42596**	7.76	10.66	**2.90**	**0.24**	1102	**618187**	7.00	13.33	**6.33**	**0.11**

W1=Natural Log of initial number of Publications, **W2=** Natural Log of Final Number of Publications, **RGR(p)=** Relative Growth rate of Publications, **DT(p)=** Doubling Time of Publication, **W3=** Natural Log of initial number of Citations, **W4=** Natural Log of final number of Citations, **RGR(c)=**Relative Growth of Citations, **Dt(c)=**Doubling Time of Citations.

Table no. 5 also provides how many years the publications required to be double in the quantity of ASME journals collectively by showing the doubling time required per year. It also reflects the mean doubling time required for every seven years. The data expressed that in 2000 the doubling time was found 1.051, and in 2020 the doubling time for the publication is 0.239. It means that the ASME journals have increased productivity, so the required time for making the publication double is decreasing. It is also found that the

mean doubling time required during 2000-2006 is 0.490. Moreover, from 2007 to 2014, it was found to be 0.312. In the same way, the mean doubling time for 2015 to 2020 is found to be 0.260. It shows that the relative growth rate increased by more than double, so doubling time also reduced by half in amount.

According to the data presented in table No.10, the relative growth rate in terms of citations received by the ASME journals in 2001 is 0.64, and it leads towards 6.33 in 2020 within 21 years. It is found that the average citations relative growth in receiving citations during the study years is 2.64. The relative growth rate in citations is consistently increasing. It is found that the mean relative growth in citations is 1.19 from 2000 to 2006, 2.64 from 2007 to 2013 and 4.08 from 2014-2020.

It is found that in the year 2000, the rate of doubling time for receiving the citations is 1.074, which is very high. As the citations increase chronologically, the rate of doubling time decreases and in 2020, it remains at 0.109. On average, the mean doubling time during the study year remains 0.312. The data reflects those citations received from 2000 to 2006 are 303764, which required the mean doubling time of 0.49 to increase in double. During the years 2007 to 2013 mean doubling time required was 0.27, and during the year 2014-2020, it is found 0.18. It shows the inverse correlation relationship between relative growth rate and doubling time. As the citations are increasing chronologically, the doubling time required for getting the citations double in amount is chronologically decreasing. The relative growth rate for receiving citations was found similar to the linear growth rate.

5.6 County-wise distribution of Domestic and International Collaboration:

Authors generally collaborate his/her research efforts with others at three levels: local, domestic, and international collaboration. Local collaboration happens when both the authors belong to the same institute, whereas Domestic collaboration means the collaboration authors belong from the same country. Moreover, if the collaborated authors belong from different countries are called international collaboration. Table No. 6 enumerates the country-wise Domestic and International collaboration status found in ASME journals publications. Two indicators are used to analyse the domestic and international collaboration rate: The domestic collaborative index (DCI) and the International collaborative index (ICI).

The table represents that Taiwan is the highest country in collaboration with its research efforts at the domestic level. Its domestic collaboration rate is 125.29 DCI. The second higher domestic collaboration was found in the USA with a 115.77 DCI value. The third highest domestic collaboration efforts are found in India, with a 114.73 DCI value. The fourth and fifth-ranked countries in domestic collaboration are Japan and Iran, with 107.85 and 106.36 DCI values. It is found that only six countries have a domestic collaborative index value of more than 100, which means that only these six countries have domestic collaboration efforts, which is higher than the world average. Those countries that have higher domestic collaboration rates means they have lower international collaboration efforts.

Table No. 6County wise distribution of Domestic and International Collaboration

Sr. No	Country	Records	Papers in DC	DCI	Papers in IC	ICI
1	USA	19486	15418	115.77	4068	65.95
2	Peoples R China	5474	3590	95.96	1,884	108.73
3	Canada	2537	1712	98.74	825	102.73
4	England	2356	1279	79.43	1,077	144.41
5	Japan	1917	1413	107.85	504	83.06
6	Germany	1829	1047	83.76	782	135.07
7	India	1802	1413	114.73	389	68.20
8	Italy	1489	983	96.59	506	107.35
9	France	1446	854	86.41	592	129.33
10	South Korea	1117	639	83.70	478	135.19
11	Taiwan	842	721	**125.29**	121	45.40
12	Iran	769	559	106.36	210	86.27

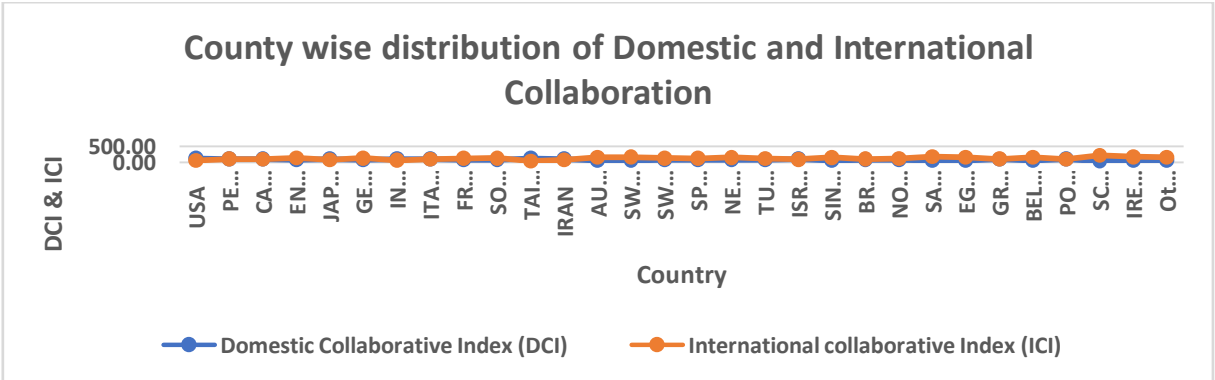
13	Australia	659	310	68.83	349	167.30
14	Switzerland	618	285	67.48	333	170.22
15	Sweden	529	299	82.70	230	137.35
16	Spain	518	304	85.87	214	130.51
17	Netherlands	458	236	75.39	222	153.13
18	Turkey	452	272	88.05	180	125.80
19	Israel	416	290	102.00	126	95.68
20	Singapore	384	192	73.16	192	157.95
21	Brazil	378	243	94.06	135	112.82
22	Norway	361	215	87.14	146	127.76
23	Saudi Arabia	342	144	61.61	198	182.89
24	Egypt	267	133	72.88	134	158.55
25	Greece	254	165	95.05	89	110.69
26	Belgium	248	118	69.62	130	165.60
27	Poland	210	143	99.63	67	100.79
28	Scotland	199	60	44.12	139	**220.66**
29	Ireland	190	86	66.23	104	172.92
30	Other	3030	1444	69.73	1586	165.36
Total		**50577**	**34567**	**NIL**	**16010**	**NIL**

DC=Domestic Collaboration, **DCI**= Domestic Collaborative Index, **IC**=International Collaboration, **ICI**= International Collaborative Index

The lowest Domestic collaboration rate was found in Scotland country with a 44.12 DCI value. The same country is the highest international collaboration rate with a 220.66 ICI value. It means Scotland published 199 documents in ASME journals, and out of those documents, 139 research articles have international collaboration, and only 60 research articles have domestic collaboration. The second rank in international collaboration reserved by Saudi Arabia 182.89 ICI value. Ireland is the third highest country in international collaboration with a 172.92 ICI value.

The countries that have ICI value more than 100 means these countries collaborative effects in international collaboration are higher than the world's average. It is found that countries like Switzerland (170.22), Australia (167.30), Belgium (165.60), Egypt (158.55), Singapore (157.95), Netherlands (153.13), England (144.41), Sweden (137.35), South Korea (135.19), Germany (135.07), Spain (130.51), France (129.33), Norway (127.70), Turkey (125.80), Brazil (122.82), Italy (107.35), Canada (102.73), and Poland (100.79) are having collaboration efforts higher than the world average in the publications of ASME journals. The value discussion regarding Domestic and International collaborative efforts clears that the authors of many countries have international collaboration trends. It means the ASME journals publications followed international collaboration trends. The information of table No. 6 is shown in graph No.1

Graph No. 1 Country wise Domestic and International Collaboration found in ASME Journals



6. Result discussion and Conclusion

ASME organization published the articles in 17 journals. Total 42596 articles were published from 2000 to 2020. These articles received 618187 citations with 14.51 ACPI and 14.51 ACPY, which shows that ASME is one of the leading publications in Mechanical Engineering and has much visibility by the researcher. In these published documents, the highest publication was found in article form, which means the authors from Mechanical Engineering prefer to publish their research in articles. However, it is observed that review articles have been increasing in recent years. The year-wise publication indicates that consistency grew in publication with the fluctuations in 2015, 2016 and 2019. The highest published documents are recorded in 2019, with 2722 records which have 6.39 % contribution to the total with 6088 citations. The lowest publications were found in 2000 with 1477 records, with 3.47% contribution to the total and 38898 citations. The study reveals that the average number of citations per citable year decreases, so the citations increase continuously with a slight fluctuation in 2016, 2018, 2019 2020. It means that as the citable years' increase, the average citation count decreases. In other words, the utilization of older documents is increasing slowly. It is the absolute value of the documents published each year.

Within the 17 ASME journals, 'The Journal of Heat Transfer' published the highest number of articles, that is 4320, with 10.14 % publications. This journal is from the core field of Mechanical Engineering. The lowest productivity was found by the Journal of Offshore Mechanics and Arctic Engineering with 1207 contributions which are 2.83 % of the total. It is found that the journals devoted to the core subject have high productivity while the journals which deal with the interdisciplinary obtain a significantly smaller number of published articles. The Journal of Heat and Transfer received 77848 citations for 4320 published articles with the rank first.

On the contrary, the Journal of Solar Energy Engineering, which deals with solar power generation Technology, has only 1685 research articles but received 26678. It means that solar power generation is an emerging field in Mechanical Engineering and significantly impacts research scholars. The Journal of Offshore Mechanics and Arctic Engineering is 9007 with 1.46 % citations to the total, which is a very specialized field of Mechanical Engineering.

The highest prestigious ASME journal is the Journal of Manufacturing Science and Engineering which obtained a 1.36 SJR score. It means that this journal received a higher number of citations and citations from higher prestigious SJR valued journals. The Journal of Mechanical Design received the highest impact factor with 2.79 in 2020 and 3.16 impact factor within the last five years. It means that this journal consistently received the high citation. In other words, this journal is the most utilized journal among the researchers from Mechanical Engineering.

The relative growth rate for the year 2000 was 0.659, and it continuously moved on and reached 2.897 in 2020. It is found that the relative growth rate of ASME journals increased continuously through the study years. On the contrary, in 2000, the doubling time was found to be 1.051, and in 2020 the doubling time for the publication is 0.239. The ASME journals have increased productivity, so the required time for making the publication double is decreasing. It is found that the mean relative growth in citations is 1.19 from 2000 to 2006, 2.64 from 2007 to 2013 and 4.08 from 2014-2020, which is found consistent growth in citations.

The highest immediacy index was found in 2019, with a 0.59 immediacy index score. The Immediacy index score continuously increased from 2000 to 2020, except the decline is found in 2008(0.7), 2009 (0.10) and 2013 (0.18). During the years 2014 to 2020, the Immediacy index continuously increases significantly. From 2000 to 2010, the value of RCI indicators is more than 1, indicating that during these years, the year-wise articles have received the higher citation rate of the publications of the total journal and onwards it was found decreasing trends.

Taiwan is the highest country in domestic collaboration 125.29 DCI. Scotland has found the highest international collaboration rate with a 220.66 ICI value. Out of 30 countries total, 18 countries have an international collaborative

index higher than100. It shows that major publication from ASME has higher international collaboration.

In conclusion, the American Society of Mechanical Engineers is the prominent organization that greatly impacts the researcher from Mechanical Engineering. It has some of the leading journals that have got world recognition. The USA is the most dominating country in this field and published a more considerable research contribution to this organization.

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