

Research on Electric Vehicles in India and USA: A Scientometric Study

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Abstract - This research paper aims to highlight quantitatively and qualitatively the growth and development of India and United States of America related to Publications and Citations in Electric Vehicles as per Web of Science (WoS) during research study taken for the period from 2011 to 2020. The objective of this study is to perform a Scientometric analysis of research Publications related to all Electric Vehicle in general. The parameters investigated were the growth rate of publications, author collaboration patterns, Co-Authorship Index, and Citation Profile. The Total paper published is 66,758 with 9,21,127 citations globally and India alone constituting 3,131 papers with 21,057 citations, USA authored 12,524 papers with 3,07,781 citations. With India's higher growth rate of (26.93%), USA has only (7.74%) meeting global publications growth rate of (11.47%). The total Citation profile out of 15,655 publication papers were 4,112 (26.27%) which haven't received any citations. India has total of 3,131 publications but 1,328 (42.41%) papers with null citations and United States authoring 12,524 papers published, out of which 2,784 (22.22%) did not receive any citations. The Maximum papers cited were from India and United States with 3,733 (23.85 %) papers in the range of 11-50.

Keywords: Electrical, Electronic, Vehicle, CAGR, Collaboration Co-Efficient, Co-Authorship Index, Citation Profile Scientometric, Web of Science (Wos), India, USA, Global

I. INTRODUCTION

Electric vehicles are fully environment friendly because their motors are powered by electricity. Since it operates on a renewable energy source, it does not release any poisonous emissions or smoke into the air. They are much better than diesel vehicles, because gas-powered hybrids generate emissions that contribute to a safer and green environment. No gas needed, more convenient, no emissions, popularity, safe to drive, cost-effective, low maintenance, and reduced noise pollution are all advantages of electric vehicles. Scientometric research is a quantitative analysis of written correspondence that is critical for successful library management under budget constraints. Quantitative data is used to keep track of the cost of the library collection, as well as the critical books and periodical collections that readers need. In their day-to-day administration, librarians started to use quantitative techniques, especially to assess libraries and their services. In the process of knowledge analysis, scientometric studies are extremely important.

Many reasons are responsible for the development of research in Scientometric and they are discussed here. The major focus of the study is to apply the Scientometric analysis with a view of analyzing the performance of research output on Collaboration in Research on Electric Vehicles comparing India and USA with others Countries. According to <https://www.mycarhelpline.com> the historic price difference between a diesel vehicle and a petrol vehicle has been higher in the past, reaching Rs 24.69 per liter in April 2012 and the Prices of Petrol and Diesel in India (Capital - Delhi) in the Last 18 Years, now in the Negative Zone within eight years, with rising prices from Rs 33.49 per Liter Petrol in April 2003 to Rs 91.17 per Liter in March 2021 observing Diesel Fuel exceeding the price of Petrol in the year June 2020 by Rs. -0.12 as shown in Fig. 1.

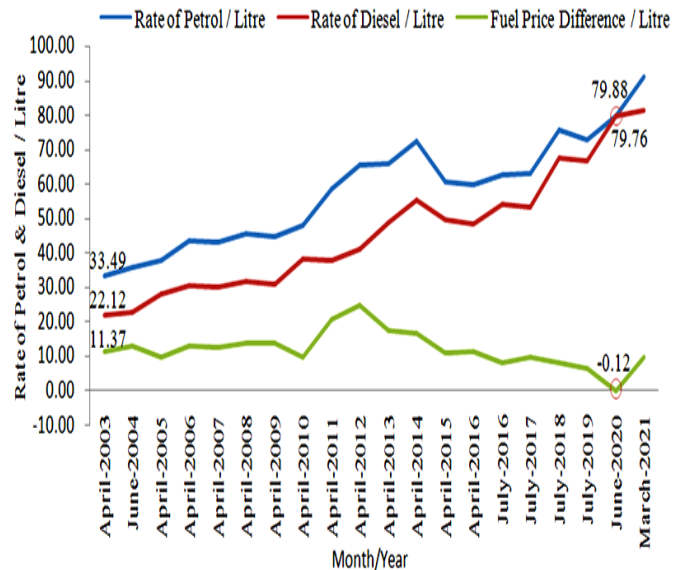


Fig. 1 Historic Fuel Price Difference in India from 2003 to 2021

(Servando, 2020) India, the fourth most powerful nation on the index after Japan, lost economic growth potential in the pandemic and is also ceding strategic ground to Beijing. Lowy projects India will reach 40% of China's economic output by 2030, compared with the 50% estimate last year. "It's certainly delayed India's arrival as the great power in the region," said Lemahieu. "... it also means that India will be quite distracted by the development challenges and by

the new poverty rate, with more newly impoverished people in South Asia". The USA is also the world's leading producer of nuclear power and the country accounts for over 30% of the world's demand for nuclear-generated electricity. In 2019, America's reactors generated 809 billion kilowatts of electricity, and another two reactors are in the making. Scientometric Research: Scientometrics, or research, is the analysis of experimental processes using quantitative methods. Understanding the positioning of information statements requires an examination of scholarly publishing and citation practices. (Hansen, Lyytinen, & Markus, 2006). Tier rankings have been developed at the journal level based on two key approaches: perceived journal status is studied through surveys of IS a scholar. (Hardgrave & Walstrom, 1997).

II. REVIEW OF LITERATURE

Kademani, *et al.*, (2006). Gives International Nuclear Information System database, and aims to provide a comprehensive quantitative overview of Indian contributions to Thorium in terms of publications related to production from 1970 to 2004. Indian scientists published a total of 2399 papers in the field of Thorium, compared to just nine papers in 1970. In the year 2000, maximum papers (188) were written. The top two countries that published work on Thorium were the United States with 8049 (28.05 percent) and India with 2399 (8.30 percent), due to the multidisciplinary nature of study involving highly qualified researchers from many disciplines. Alvarez, G *et al.*, (2017).

Examines Scientometric indicators for Brazilian high-energy physics research over a 31-year period, from 1983 to 2013, using data from the Web of Science (WoS). As compared to Brazil's participation in total output indexed in SCI, Brazilian participation in High Energy Physics (HEP) is more representative 1.72%. The United States is the most prosperous nation in HEP (29.78%), followed by Germany 13.60%, Italy 11.77%, the United Kingdom 9.10%, and Russia 9.10%. 8.96%, that the sharp increase in research activity between 2009 and 2013. Mohan, L *et al.*, (2010).

Authors analyzed scientific publications output from Science Citation Index during the year from 1992 to 2008, this research study on Research Trends in field of Nanoscience and Nanotechnology in India, the whole records total 29,6072 on the subject, USA ranked first with total papers publications of 84,561 (28.56%) and followed by China with 43,393 papers and (14.66%) next with Japan 32,431 (10.95%) papers published remaining countries below 5% papers published in the globally.

For a period from 1982 to 2008 a total of 8,326 (2.81%) papers were published from India. More than 95.38 percent of the articles were published in journals with high impact factors, it will be quite interesting if one attempts to carryout citation analysis of these papers which may give interesting insights into the dynamics of this field.

III. OBJECTIVES OF THE STUDY

1. To the analysis of Growth Rate.
2. To study the collaboration pattern of authors.
3. To study the Co-Authorship Index.
4. To the analysis of Citation Profile of Electric Vehicles.

IV. METHODOLOGY AND SOURCE OF DATA

The Web of Knowledge (<http://webofknowledge.com>) of Thomson Reuters (formerly ISI) was chosen because it is one of the most important sources for Scientometrics, citation, and other scholarly impact information of scientific journals. The data study for the period of 2011 to 2020 for a total time span of ten years is considered. Search strategies adopted was as follows: CU= India or USA (TS=electr* vehic* OR TS=electr* Car OR TS=electr* Bike) Time span=2011-2020. The total of records were downloaded in Plain Text and Tab-Delimited formats and exported into "HistCite" software, "Microsoft-Excel" and "VOS" Graphical viewer for analysis of the data.

V. RESULTS AND DISCUSSION

A. Year-Wise Growth Rate India and USA

"Growth Rate is being measured with Compound Annual Growth Rate (CAGR). The mathematical formula of CAGR (Ajiferuke, Burrel, & Tague, 1988) is given below".

$$CAGR = \left(\frac{\text{Ending Value}}{\text{Beginning Value}} \right)^{\frac{1}{n-1}} - 1$$

Total paper published were 66,758 with 9,21,127 citations globally and India has 3,131 papers with 21,057 citations with globally ranking 4th (4.7%), the USA 12,524 papers with 3,07,781 citations and ranked 2nd (18.9%), China ranking first place on research in Electric Vehicles publications constituting 17,958 papers published(26.9%). The research output of Indian Electric Vehicles and USA during the period from 2011 to 2020 growth of publications in planned with the above method and presented in the Table I.

TABLE I YEAR WISE OUTPUT AND GROWTH RATE

Year	India	USA	World
2011	60	758	3116
2012	105	966	4190
2013	149	1020	4664
2014	223	1177	6216
2015	263	1162	6254
2016	373	1360	7314
2017	452	1444	8161
2018	519	1584	8952
2019	474	1570	9612
2020	513	1483	8279
Total	3131	12524	66758
Growth in %	26.93	7.74	11.47

Out of total publications, USA 12,524 (80%) papers, followed by India 3,131 (20%). India accounts for 519 papers in the year 2018, USA in the year 2018 with highest papers published 1,584 and highest in the year 2019 globally was wise 9612 publications.

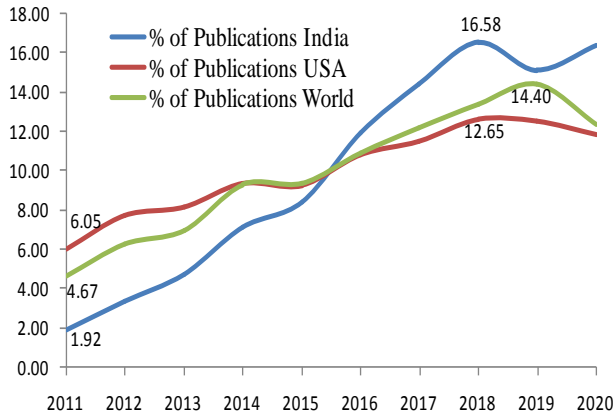


Fig. 2 Year Wise Output and Growth Rate

It can be noticed that in the year 2018 after paper publication decreased up to 2020 showing Fig. 2.

Among the India and USA countries, India recorded the higher growth rate of 26.93%, USA 7.74% and global growth rate of 11.47%.

B. Collaboration Rate

“Collaboration Co-efficient suggested by (Ajiferuke, Burrel, & Tague, 1988), has been used to assess the strength of collaboration and the mathematical formula is given below.

$$CC = 1 - \frac{\sum_{j=1}^{j=k} \left(\frac{1}{j}\right) F_j}{N}$$

Where, F_j = the number of j authored research publications, N = total number of research publications and k = the greatest number of authors per publication. Collaboration Coefficient is a number between 0 and 1. The more it is bigger than 0.5 the better is the collaboration rate among authors. When it is near 0, it means that authors have a weak collaboration”.

TABLE II COLLABORATION RATE INDIA AND USA

Year/Authors	India						USA					
	1	2	3	>3	Total	CC	1	2	3	>3	Total	CC
2011	4	20	16	20	60	0.61	52	165	162	379	758	0.66
2012	3	35	30	37	105	0.64	78	193	218	477	966	0.65
2013	5	48	36	60	149	0.65	64	214	244	498	1020	0.66
2014	10	82	62	69	223	0.61	59	248	266	604	1177	0.67
2015	12	82	72	97	263	0.64	47	220	248	647	1162	0.69
2016	14	109	102	148	373	0.64	37	245	283	795	1360	0.70
2017	16	137	137	162	452	0.64	57	234	287	866	1444	0.70
2018	15	167	145	192	519	0.64	48	221	318	997	1584	0.72
2019	6	136	139	193	474	0.66	57	196	304	1013	1570	0.72
2020	15	146	126	226	513	0.66	55	196	243	989	1483	0.72
Total	100	962	865	1204	3131	6.39	554	2132	2573	7265	12524	0.68
%	3	30	27	38		11	4	17	20	58		10

Table II represents collaboration indices for 10 years (2011-2020) for publications by Electric Vehicles the India and USA country. The table also shows that the publication pattern of single and multi authorship pattern. India during the year 2011 has CC range of 0.61 and it and increases to 0.66 in the year 2020 and constituting total average of 6.39, whereas USA in the year 2012 came with CC range of 0.65 increasing to 0.77 in 2020 with total average of 0.68. According to (Vellaichamy & E, 2016) “... Collaborative

coefficient indicates the differences between the levels of authorship pattern. In 2001 the CC range is 0.07 and increases to 0.59 in the year 2014. Collaborative coefficient indicates that the differences between the levels of authorship pattern. In 2001 the CC range is 0.07 and increases in the year 2014 to 0.59” (cited from p.13). In India the CC value is 0.61 for the year 2011 which has increased in the year 2012, 2013 and again decreased in the year 2014 and in the year 2015 to 2018 stable the range of CC 0.64. USA in the year 2011 has CC range of 0.66 and

again decreased to 0.65 in the year 2012 and in the year 2018 to 2020 stable the range of CC is 0.72. Further, the value collaborative coefficient is greater than 0.5 for all the years 2011 to 2020 from the Fig. 3.

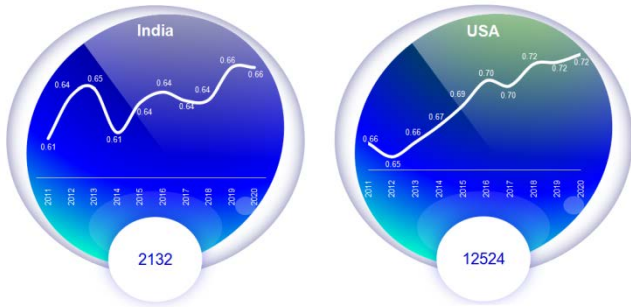


Fig. 3 Collaboration rate India and USA

C. Co-Authorship Index

The Co-Authorship Index is calculated by dividing the number of single-authored, two-authored, and multi-authored papers proportionately.

TABLE III CO-AUTHORSHIP INDEX INDIA AND USA

Country	Single Author	CAI	Two Authors	CAI	Three Authors	CAI	>3 Authors	CAI	No. of Records
India	100	76	962	155	865	126	1204	71	3131
USA	554	106	2132	86	2573	94	7265	76	12524
	654		3094		3438		8469		15655

Presented in Table III, It is found that the India country Co-authorship Index for two and three authored articles is increased during the period of 2011 to 2020, It indicates that the Electric Vehicles research is moving towards a pattern of collaborative research with a research team composed of only two and three authors and one and more than three authors decreased articles. USA with Co-authorship Index for only single-author articles is increased during the period of 2011 to 2020 and two and more than authors lower than average, which means that country indicates the researcher prefers to work as a split sowing Fig. 4.

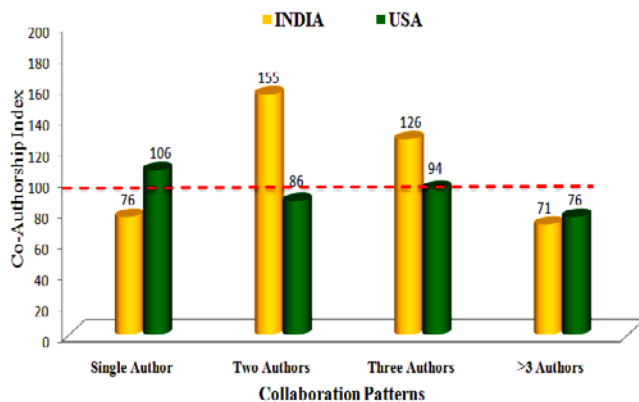


Fig. 4 Co-Authorship Index India and USA

The formula for Co-Authorship Index suggested by is as follows: (Garg & Padhi, 2001) and (Guan & Ma, 2007) has been put to use.

$$CAI = \left(\frac{N_{ij}}{N_{oj}} \right) \div \left(\frac{N_{io}}{N_{oo}} \right) \times 100$$

N_{ij} = Number papers having j authors in block i;

N_{io} = Total output of block i;

N_{oj} = Number of papers having j authors for all blocks;

N_{oo} = Total number of papers for all authors and all blocks; $j = 1, 2, 3, \geq 3$.

$CAI < 100$ indicates that the number of papers is lower than the average.

$CAI = 100$ indicates that the number of papers corresponds to the average within a co-authorship pattern.

$CAI > 100$ indicates that the number of papers is higher than the average.

D. Citation Profile of India and USA

The Citation profile of the India and USA countries is tabulated in the following Table IV.

TABLE IV CITATION PROFILE OF INDIA AND USA

Citations Range	India	USA	Total	%
0	1328	2784	4112	26.27
1	449	1166	1615	10.32
2	202	793	995	6.36
3	162	679	841	5.37
4	106	550	656	4.19
5	94	448	542	3.46
6-10	275	1514	1789	11.43
11-50	439	3294	3733	23.85
51-100	56	728	784	5.01
101-500	20	525	545	3.48
>500	0	43	43	0.27
Total	3131	12524	15655	
Total Citations	21057	307781	328838	
Average Citation	6.73	24.58	21.01	
H-Index	59	207	208	

Out of 15,655 publication papers, 4,112 (26.27%) publications did not receive any citations, and remaining 11,543 (73.73%) publications received citations during the period of study from 2011 to 2020. India out of 3,131 papers published and 1,328 (42.41%) papers did not receive any citations (Zero Citation) and USA 12,524 papers published and 2,784 (22.22%) not receive any citations.

The Figure-5 shows that during the period 2011 to 2020 a maximum of 3,733 (23.85 %) papers cited from the range of 11-50 citations followed by 1,789 (11.43%) papers having citations within the range from 6 – 10. The average citation per paper for India and USA countries is (21.01%). USA received citations more than the average citation rate (24.58%), Indian average citation is 6.73% research conducted during 2011 to 2020 and USA has h-index 207 followed by India having 59 h-index.

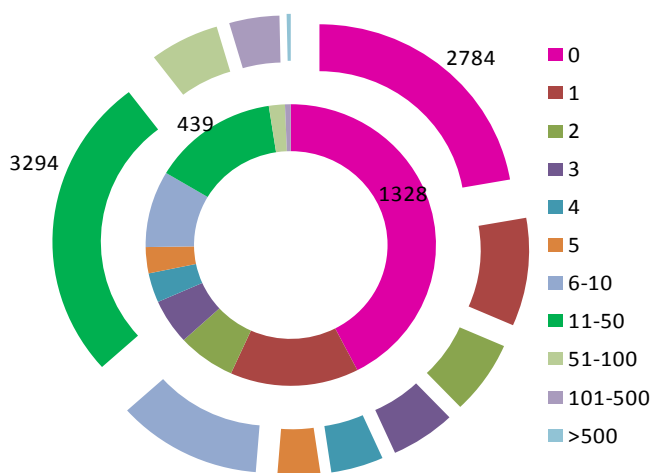


Fig. 5 Citation Profile of India and USA

VI. CONCLUSION

The study and analysis of research publications and details in the field of Electric Vehicles reveals that the total paper published is 66,758 with 9,21,127 citations globally and India with 3,131 papers published with 21,057 citations. USA has 12,524 papers published with 3,07,781 citations for the period considered during the year 2011 to 2020. India's higher growth rate of 26.93%, USA only 7.74% and therefore global growth rate is 11.47%. Collaboration Coefficient the Indian in the year 2011 the CC range is 0.61 and it comes in 2020 CC is 0.66 and total average of 6.39 and USA country in the year 2012 the CC range is 0.65 and it comes in 2020 CC is 0.77 and total average of 0.68. Both the countries have the value collaborative coefficient greater than 0.5 for all the years. Indian Co-authorship Index for two and three authored articles is increased, research team composed of only two authors, and USA Co-authorship Index for only single-author articles is increased, and two and more than authors lower than average that indicates researcher prefers to work as a split. Citation profile out of

15,655 publication papers, 4,112 (26.27%) publications did not receive any citations, India total 3,131 papers published but 1,328 (42.41%) papers did not receive any citations and USA 12,524 papers published and 2,784 (22.22%) not receive any citations, India and USA country maximum of 3,733 (23.85 %) papers cited from the range of 11-50 citations. It's showing that compare to the USA. The above details conveys that research papers published from India has very less citations and therefore we conclude that it is very much essential that lot of quality work has to come out in future years.

REFERENCES

- [1] Ajiferuke, I., Burrell, Q., & Tague, J. (1988). Collaborative coefficient: A single measure of the degree of collaboration in research. *Scientometrics*(14), 421-433.
- [2] Alvarez, G., Vanz, S. A., & Barbosa, M. C. (2017). Scientometric indicators for Brazilian research on High Energy Physics, 1983-2013. *Annals of the Brazilian Academy of Sciences*, 89 (3), 2525-2543.
- [3] Biradar, N., & Tadasad, P. G. (2015). Authorship Patterns and Collaborative Research in Economics. *Journal of Indian Library Association*, 51 (4), 21-29.
- [4] Devasena, T. (2018). Collaboration Pattern In Cryptography Research output (1976 – 2015) A Scientometric Study. *Rao, Nageswara P*, 7 (2), 18-29.
- [5] Elango, B., Rajendran, P., & Manickraj, J. (2013). Tribology Research Output in BRIC Countries : A Scientometric Dimension. *Library Philosophy and Practice (e-journal)*, 935.
- [6] Garg, K. C., & Padhi, P. (2001). A study of collaboration in science and technology. *Scientometrics*, 51(2), 415-427.
- [7] Guan, J., & Ma, N. (2007). A Bibliometric study of China's semiconductor literature compared with other major asian countries. *Scientometrics*, 70 (1), 107-124.
- [8] Gupta, B. M., Dhawan, M. S., Gupta, R., & Jalana, M. (2015). Facebook Research: A Scientometric Assessment of Global Publications, 2005-14. *Library Philosophy and Practice (e-journal)*, 1-17.
- [9] Hansen, S., Lyytinen, K., & Markus, M. L. (2006). The Legacy Of 'Power and Politics' in Disciplinary Discourse: A Citation Analysis. *the 27th International Conference on Information Systems*, 24-29. USA: Milwaukee,.
- [10] Hardgrave, B. C., & Walstrom, K. A. (1997). Forums for MIS Scholars. *Communications of the ACM*, 119-124.
- [11] Kademani, B. S., Kumar, V., Sagar, A., Kumar, A. M., & Sutwase, G. (2006). Scientometric Dimensions of Thorium Research in India. *DESIDOC Bulletin of Information Technology*, 23(3), 9-25.
- [12] Mohan, L., Prakasan, E. R., Kademani, B. S., Surwase, G., Kumar, A., & Kumar, V. (2010). Research Trends in Nanoscience and Nanotechnology in India. *DESIDOC Journal of Library & Information Technology*, 30(2), 40-58.
- [13] Mulimani, R. S., & Hadagali, G. S. (2018). Pharmacy and Pharmacology Research in the BRICS Countries: A Scientometric Analysis. *Webology*, 15(1), 77-87.
- [14] Ramish, S. K. (2016). Publication Trends in Global Output of Spintronics: A Scientometric Profile. *Library Philosophy and Practice (e-journal)*, 1480.
- [15] Servando, K. (2020, 18th October). Who wields most power in Asia? US tops Lowy index but China is catching up, India ranks 4th. Retrieved from <https://theprint.in: https://theprint.in/world/who-wields-most-power-in-asia-us-tops-lowy-index-but-china-is-catching-up-india-ranks-4th/526428/>
- [16] Vellaichamy, A., & E, A. (2016). Scientometric portrait of Mike Thelwall. *Library Philosophy and Practice (e-journal)*, 1487.
- [17] Retrieved from https://www.mycarhelpline.com/index.php?Option=com_easyblog&view=entry&id=808&Itemid=91