Indian Journal of Information Sources and Services
ISSN: 2231-6094 (P) Vol.14, No.1, 2024, pp.85-92

DOI: https://doi.org/10.51983/ijiss-2024.14.1.4112

Exploring the Relationship Between Academic Science and Economics Through Biofuel Research: A Scientometric Analysis

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(Received 22 February 2024; Accepted 11 March 2024; Available online 16 March 2024)

Abstract - **Scientometrics is increasingly wielded as a powerful tool in shaping scientific policies, impacting the allocation of funding for projects and institutions by assessing priorities, viewpoints, and capabilities. The investigation of the relationship between academic science and economics is one of the most recent developments in the field of scientific metrics study. It assumes the role of an analysis method of knowledge production and dissemination in innovation systems. These results suggest that biofuel positively affected research collaboration and, as a result, scientific performance. HistCite is one of the study's tools for analyzing data in a clear and concise manner. Manual searches were conducted on their websites to gather a condensed overview of their data for data mining purposes. Additionally, the Web of Science (WOS) database was utilized for research visualization. Vos Viewer and MS Excel were employed to create graph-like visualizations of data, particularly focusing on the key term 'biofuel' to showcase the field's research focus and productivity rankings in this area. Statistical techniques and web mining were employed to refine and extract pertinent information. The study period was 33 years (1989-2022), and the results are presented in this paper. This may help to show that the continual growth of plants on our planet greatly outweighs men's fundamental energy consumption when considering ecological, technical, and economic considerations; only a portion of the biomass that grows can be used to generate energy.**
Keywords: **Scientometric Analysis, Biofuel, Research Productivity, Citation Analysis, Research Trends, Vosviewer, Visualization**

I. INTRODUCTION

In this study, the trend research on scientometrics in the key term of Biofuel shows the research interest in the field to deliver the outcome of Impact Factor, citation, highly cited papers, authors who contributed significantly, and so on and several others. Scientometrics aids in analyzing research data and institutional rankings to illustrate productivity and highlight research contributions. It places a primary emphasis on the quantitative dimensions of scientific inquiry and has emerged as a notable constituent within the wider domain of the Science of Science. It appears to be a comprehensive discipline, with well-defined research topics, a unique set of research tools and techniques, a large research population, multiple research institutes, and frequent conferences (Ivancheva L, 2008).

Indicators that can be used in policy and management contexts are also created by scientometricians. In such cases, utility may be more important than accuracy. For instance, the use of impact factors to assess faculty members requires a combination of analyses at different levels of aggregation and then application to relatively small datasets. At the aggregate level, heuristically based science maps or overlays to geographic maps can be used; however, testing for significance necessitates the use of sufficiently large sets. (L., & Milojević, S., 2012).

II. REVIEW OF LITERATURE

Study Represent the analysis of biofuel research production, and in that outcome of the funding agencies year-by-year publication, the author's outcome along with their reputed institution, and their ranking in research productivity in this topic for that we applied statistical techniques and web mining to fine their appropriate information. Bioenergy is a renewable energy source that is produced by living organisms.

The primary bioenergy sources that enjoy widespread use include biodiesel, bioenergy derived from biofuels, and bioenergy obtained from organic by-products. Utilizing renewable energy sources like these helps decrease reliance on non-renewable fossil fuels. Rudolf Diesel was among the first to recognize the potential of biofuels as a viable fuel source for his newly invented engine. In 1937, the Initiative's process for producing biodiesel was discovered by G. The biofuel is developed through the Background.

Biofuels of the first generation originate from a diverse array of sources, encompassing sugar crops like sugarcane and sugar beet, starch crops such as corn and sorghum, and oilseed crops like soybean and canola, alongside animal fats. These raw materials undergo a fermentation process to

transform them into bio alcohols like ethanol, butanol, and propanol. While most biofuels are primarily utilized as transportation fuels, they can also serve purposes in heating and power generation.

Gaseous biomass fuels can either be used directly as a gas or converted into gasoline, potentially meeting criteria for inclusion in government programs aimed at promoting or mandating the use of biofuels. Studies on marine pollution have explored various topics, this encompasses heavy metal contamination, occurrences of oil spills, the prevalence of microplastics, and the consequences of eutrophication.

Detection technologies such as image processing, biomonitoring, spectroscopy, and microscopy have advanced significantly, while mitigation efforts have focused on physical, chemical, and biological techniques (Anthony, D *et al.,* 2023). Conversely, a more recent trend involves examining the structural and functional similarities between induced pluripotent stem cells iPSCs and human embryonic stem cells, along with their potential long-term clinical and therapeutic implications for regenerative medicine (Chen, C, *et al.,* 2012). Although these two trends overlap in some aspects, they are distinct and carry different implications for future research.

For decades, plant biomass has been widely recognized as a primary source of biofuels. However, there is growing evidence indicating that algal biomass holds significant promise as a biofuel source (Dragone G *et al.,* 2010). Additionally, bio alcohol has served as a fuel source for many years, utilizing conventional methods. Bio alcohol has emerged as a viable non-fossil alternative for transportation. Throughout history, bio alcohols have primarily been derived from plant sources abundant in starch and sugars, such as grain crops and sugarcane.

However, there has been a recent shift in focus towards perennial grasses like switchgrass and Miscanthus. Distinct advantages are offered by these grasses as they are not competed with food crops for resources. Nonetheless, to undergo fermentation and distillation processes, cellulosic biomass must first be converted into sugars. Among bio alcohols, ethanol remains the most widely used, while bio propanol and biobutanol are less commonly utilized. A vital role in fermenting carbohydrate-rich feedstock to produce these alcohols is played by microorganisms (Shah YR and Sen DJ, 2011).

In a study conducted by Voloshin RA and colleagues in 2015 (Voloshin RA *et al.,* 2015), the researchers investigated and reported on a topic of significant relevance. Although specific details about the study were not offered in the abstract, it is evident that significant contributions to the relevant field of research have been made by their efforts. The findings and insights from this study likely offer important perspectives and conclusions that contribute to our collective understanding of the subject matter. Further examination of the original paper by Voloshin RA and his team would be necessary to glean specific details and implications of their research. It can be made from edible or inedible plant seeds. A diverse array of sources, such as palm, tobacco seed, rice bran, sesame, sunflower, barley, coconut, corn, used cooking oil, linseed, mustard, soybean, rapeseed, groundnut, cottonseed, pumpkin, peanut, olive, and other edible oils, can be drawn upon for biodiesel production. Environmentally friendly electrochemical devices capable of producing electrical energy are represented by biofuel cells (BFCs).

They are operated by utilizing organic materials generated during metabolic pathways as a renewable fuel source, alongside a biological catalyst. The presence of BFCs can be classified into two types, distinguished by the biocatalyst employed: EBFCs (Enzymatic Biofuel Cells) utilize purified oxidoreductase enzymes, based on the specific case (Leech *et al.,* 2012; Nasar and Perveen, 2019).

III. MATERIALS AND METHODS

The chosen metric study demonstrates the productivity and frequency of being the part to stand in the largest disputed area in the scientific field research productivity and the non-harmful method to use energy conception is the primary reason for selecting the phrase for this study. Biogas is one of the natural products that have incited interest in this field. These are the tools used in this study to obviously explain the data retrieved from the WOS database in the form of Plain text and Extract using HistCite Software, MS Excel, and VOS Viewer. The first five time periods are chosen based on Histcite's bibliographic standards and the concept of an index. This ensures that the quantity and quality of articles within each period are maximized compared to other years.

Meanwhile, the latest research findings are represented by the sixth time period. Co-word networks in VOS viewer are then examined for each of these six periods (Nekoonam, A, *et al.,* 2023). Increased engagement within the Web of Science topic categories was exhibited by China, notably in the PCM theme area of Energy & Fuels, resulting in noteworthy scientific contributions. This ensures that both the quantity and quality of articles for each period are optimized relative to other years. Meanwhile, the most recent research discoveries are encompassed in the sixth period (Qin, Y, *et al.,* 2023). This study holds relevance to the production of biofuel research output.

A. Data Collection (Search Technique Used for this Study)

To enhance scientific productivity, we gather data from the Web of Science using specific search strings to collect research papers. This process facilitates the systematic collection of relevant literature and contributes to advancing scientific output. Advance search string is used in this study with the help of Boolean operators. In this string, "TS" is stated as Title, which helps to bring the titles related to this field. The major key term of the biofuel is used to find the

result of this topic the teams used are clearly given in Table I. To streamline the data, the main focus is on the field of Economics, facilitating the presentation of research papers solely within that specific subject area and fostering collaboration within it. The bibliographic record comprised author names, titles, abstracts, countries of origin, and all essential references for citation analysis. Examination of the literature through network and cluster analysis revealed a dynamic landscape characterized by changes and advancements over time. (Cipresso, P, *et al.,* 2018). Opportunities to improve the speed, accessibility, and reproducibility of studies within a particular field's literature are offered by systematic scientometric reviews, aided by computational and visual analytic tools. Nevertheless, the ongoing challenge lies in pinpointing the most outstanding body of scientific publications as the foundation for further investigations in current practices (Chen, C, *et al.,* 2019).

TABLE I SEARCH STRINGS

Web of Science Core Collection Data Collected From the Year of 1989 to 2022	
1St Search Criteria	TS= (("Biofuel" or "biomass" or "renewable energy" or "fuel" or "biogas" or "bioethanol" or "ethanol" or "agrofuel" or "biodiesel" or "new energy" or "microgeneration" or "woodfuels" or "bio-oil" or "biobutanol" or "biogas" or "solid biofuels" or "liquid biofuels" or "gaseous biofuels" or "algae fuel" or "green diesel" or "cellulosic ethanol" or "renewable hydrocarbon fuels")
2nd Search Criteria	TS= (("Biofuel" or "biomass" or "renewable energy" or "fuel" or "biogas" or "bioethanol" or "ethanol" or "agrofuel" or "biodiesel" or "new energy" or "microgeneration" or "wood fuels" or "bio-oil" or "biobutanol" or "biogas" or "solid biofuels" or "liquid biofuels" or "gaseous biofuels" or "algae fuel" or "green diesel" or "cellulosic ethanol" or "renewable hydrocarbon fuels") AND ("Economics"))
Language used	English
Type	Article
Total Number of records	6994

B. Data Retrieval and Management

From which we gained 6994 records in the Web of Science database, which was refined with the year span from 1989 to 2022, and the other words are similar to the word "Biofuel," which helps to bring the data which are very suitable to this research, keyword and Boolean search techniques are used together to collect this data. The data was downloaded in the form of plain text with a citation report, which helped to demonstrate the effectiveness of the researcher in this field.

C. Analysis of Data

Data has been analysed with the help of analysis tools that should help to show the data with clear numerical data in its value belongs to the particular place.

HistCite is one of the tools used in the study to analyse data in a clear and concise manner. For data mining, we manually searched their websites and collected the summary of their information, as well as using the WOS database to find the author citation and their publication in level of detail.

For data mining, we manually searched their websites and collected the summary of their information, as well as using the WOS database to find the author citation and their publication in level of detail. Visualization Vos Viewer and MS Excel are used in the study to provide a graph-like data visualisation for better understanding.

IV. RESULTS OF THE STUDY

The combustion of fossil fuels releases a considerable quantity of greenhouse gases into the troposphere (Biswal, T, *et al.,* 2023). The research sets the door for the efficient use of the heavy components of lignin depolymerisation (Li, L, *et al.,* 2024).

When considering the adequacy of these blends as alternatives to traditional jet fuel, various characteristics were assessed. This included density, viscosity at low temperatures, heat of combustion, flashpoint, corrosion resistance, smoke point, conductivity, simulated distillation, existing gum content, lubricity, thermal stability, and derived cetane number. (Walkling, C. J, *et al.,* 2024). In this research, an analysis was conducted on the output of a selected search term to assess the productivity of researchers, authors, their respective countries, and the prevalence of highly cited papers. This analysis yielded a total of 6994 records.

Table II displays the productivity for the year and the total publication are also listed in table II with the flow of yearly output based on the result the highest production in the year 668 results in the year of 2021, the highest citation got in the year 2011 with the citation of 21116. These types of record help us to show the improvement in the research, to show the research flow in this research, The citation of 37 in 1989 was the last count in this productivity and had the gradual productivity from 2003 to now researchers own an interest in this field to produce the energy source.

TABLE II NUMBER OF PAPERS PER YEAR (PY-PUBLICATION YEAR)

PY	Yearly Output	Total Local Citation	Total Global Citation	Total Citation	PY	Yearly Output	Total Local Citation	Total Global Citation	Total Citation
1989	5	4	33	37	2007	132	260	12285	12545
1990	8	9	94	103	2008	151	336	10858	11194
1991	46	84	1757	1841	2009	203	371	11458	11829
1992	37	28	925	953	2010	211	459	15260	15719
1993	42	31	1772	1803	2011	279	642	20474	21116
1994	63	74	2152	2226	2012	282	454	13668	14122
1995	46	77	1727	1804	2013	331	523	18743	19266
1996	53	130	2568	2698	2014	328	348	12055	12403
1997	60	86	2054	2140	2015	387	418	14545	14963
1998	56	47	2585	2632	2016	405	453	17557	18010
1999	58	58	2305	2363	2017	450	306	13360	13666
2000	62	127	5057	5184	2018	497	347	12731	13078
2001	66	65	2384	2449	2019	507	204	11114	11318
2002	63	39	8068	8107	2020	662	117	8996	9113
2003	70	87	4747	4834	2021	668	45	4500	4545
2004	72	93	2895	2988	2022	420	8	655	663
2005	93	324	7890	8214	Unknown	84	0	71	71
2006	97	244	7566	7810	Total	6994	6898	254909	261807

A. Publication Title

At the forefront of our list is “Renewable & Sustainable Energy Reviews,” boasting an impressive total of 232 papers dedicated to our chosen field. Following closely behind is “Energy Policy” with 217 papers. Subsequently, “Biomass Bioenergy” (192 papers), “Energy” (183 papers), “Applied Energy” (168 papers), “Renewable Energy” (161 papers), “Bioresource Technology” (159 papers), “Energies” (152 papers), “Energy Conversion and Management” (114 papers), and “Journal of Cleaner Production” (112 papers) round out the top ten journals featured in Table III. The findings presented here underscore the significance of the chosen field, as reflected in the prevalence of this field’s presence in the titles of highly prolific journals. Furthermore, our report encompasses details regarding the Impact Factor of each journal and identifies the most extensively cited papers within them, along with their respective publication years. Notably, “Renewable & Sustainable Energy Reviews” also boasts the highest Impact Factor at 16.8. It is followed by “Bioresource Technology” with an Impact Factor of 11.88. Remarkably, “Bioresource Technology” achieved its highest citation count in the year 2002, with McKendry P’s paper garnering an impressive 2626 citations within the journal. In this table, we have also provided information on the most cited papers in each journal, including author details and the publication year, showcasing the significance of these research contributions within their respective publication years. This result show that the title of Journals in which the research are produced lot on the field we have chosen also we have added the Impact Factor for the Journal and the top cited papers in that journal in the year the journal “Renewable & Sustainable Energy Reviews” has produced 232 papers in this topic next to that “Energy Policy” has also more closer to the first one with 217 papers, followed by that “Biomass Bioenergy (192)”, “Energy (183)”, “Applied Energy (168)”, “Renewable Energy (161)”, “Bioresource Technology (159)”, “Energies (152)”, “Energy Conversion And Management (114)”, “Journal of Cleaner Production (112)” are the top ten listed journals in the table III. The most impact journal is also the stands first in the list “Renewable & Sustainable Energy Reviews”, with 16.8 impact followed by that 11.88 impact by the journal of Bioresource Technology then the citation highly got in this same journal on 2002 with 2626 citation by McKendry P in that journal here we have mentioned the citation of the top papers of this journal with their author information and year is mentioned that research paper is published in that particular time in that journal.

B. Authors Top Productivity in Biofuel

This table provides valuable insights into the contributions of various authors and their affiliated institutions in a specific topic. The information presented here has been sourced from authoritative sites, including the authors’ affiliation websites and databases, facilitating the retrieval of their pertinent details in this area of research. The table also includes the average percentage in relation to the total

publications of each author. The most prolific author in this list is "Tao, Ling," who has contributed 17 research articles to this topic, boasts an H-index of 24, and has garnered a total of 3,136 citations for their publications. Their overall research productivity includes 41 publications. Tao, Ling is affiliated with the National Renewable Energy Laboratory (NREL) in the United States, and the average citations per paper stand at 76.56 percent. Following closely is Charles E. Wyman, with 16 research papers and a remarkable 27,551 citations, achieving the highest citation count among the top-listed authors. His H-index is 73, and he is associated with the University of California Riverside in the USA. André Faaij has the highest H-index in this list, standing at 79, and has accumulated 20,408 citations across 252 published papers. He is affiliated with the Netherlands Organization for Applied Science Research in the Netherland. Bruce E. Dale holds the record for the highest total number of publications, with 316 research papers and 23,446 citations. His H-index is 74, and he is affiliated with Michigan State University in the USA.

TABLE III PUBLICATION TITLE

Source Title	Output of this Study	IF	TC	Top Cited Authors in this Journal		
				Author	Paper Citation	Year
Renewable & Sustainable Energy Reviews	232	16.8	18369	Graves C *et al.,*	717	2011
Energy Policy	217	6.142	12408	Unruh, Gregory C	1421	2000
Biomass Bioenergy	192	5.061	13268	Hamelinck CN *et al.,*	1061	2005
Energy	183	7.147	7974	Gui MM *et al.,*	768	2008
Applied Energy	168	9.746	7953	Davis R *et al.,*	652	2011
Renewable Energy	161	8.634	7488	Gotz M *et al.,*	1306	2016
Bio resource Technology	159	11.88	13169	McKendry P	2626	2002
Energies	152	3.004	2052	Jahirul MI *et al.,*	676	2012
Energy Conversion And Management	114	11.53	4353	Yusuf NNAN *et al.,*	385	2011
Journal of Cleaner Production	112	9.297	2589	El-Emam RS *et al.,*	167	2019

Notably, there is one Indian author, Vijay Singh, who has 13 publications in the field of biofuels, with a total research contribution of 144 publications. He is associated with the CSIR Institute of Genomics and Integrative Biology in India. Citations are increasingly being used as performance indicators in research policy and the research system. Citations are usually assumed to signify the research's influence or quality (Aksnes, D. W, *et al.,* 2019). These highly productive authors represent the leading contributors in the field of biofuels, as presented in Table IV." This demonstrates that the author's contribution and the institution to which they feel connected, as well as the related information, are searched in the authorised site, such as their affiliation website, and the database also assists in finding their information in this area. The average percentage is also given in this total publication of the author, the highly published author "Tao, Ling ", his contribution on this topic gives 17 research articles and his H-index is 24 he got 3136 citations overall for his publication and his total research productivities are 41 he belongs to (NREL) National Renewable Energy Laboratory, United States his average for the paper is 76.56 percent. Followed by him Wyman, Charles E with 16 research paper with 27551 citations he got the highest Citation in these top listed authors with h-index of 73 he belongs to University of California Riverside, USA. Then "Faaij, Andre", got 79 H-index he has the highest H-index among these lists with the citation of 20408 published 252 papers almost in all the research belongs to Netherlands Organization Applied Science Research, Netherlands. And "Dale, Bruce E", has the highest total publication with 316 research papers he got 23446 citations also with the h-index of 74 he belongs to Michigan State University, USA. Also, the one Indian author is in this top list author "Singh, Vijay", with the 13 publications in this biofuel field and his total research contribution are 144 publications in the Institution of CSIR Inst Genom & Integrat Biol, India. This list of productive authors is the top productive authors in the field of BioFule present in the table IV.

C. Top 10 Paper Retrieved from Biofuel

The Table V shows the top paper in bio fuel with the publication title with its impact factor, Author and his Citation with the year of publication these are list in this table in that paper "Energy production from biomass (part 1): overview of biomass", stands first with the citation of 2620 it was given by "McKendry, P" on the year 2002 he published in the journal "Bioresource Technology" with the Impact of 11.88 followed by that "Biofuels (alcohols and biodiesel) applications as fuels for internal combustion engines", with 2014 citation, "Understanding carbon lock-in" with 1416, "Recovery of Microalgal biomass and metabolites: process options and economics" with 1377, "Combustion of fat and vegetable oil derived fuels in diesel engines" with 1350, "Renewable Power-to-Gas: A technological and economic review" with 1297, "Materials challenges in nuclear energy" with 1235, "Ethanol from

lignocellulosic biomass: techno-economic performance in short-, middle- and long-term" with 1059, "The role of renewable energy in the global energy transformation" with 996, and "Providing all global energy with wind, water, and solar power, Part I: Technologies, energy resources, quantities and areas of infrastructure, and materials" with 868.

TABLE IV AUTHORS TOP PRODUCTIVITY

Author	Institution	TP in this Topic	H-Index	Citation	TP of the Author	Avg. Per Paper	CU
Tao, Ling	National Renewable Energy Laboratory (NREL)	17	24	3136	41	76.56	United States
Wyman, Charles E	University of California Riverside	16	73	27551	255	108.04	USA
Gonzalez, Ronalds	North Carolina State University	14	23	1465	71	20.63	USA
Epplin, Francis	Oklahoma State University System	14	22	1263	65	19.43	USA
Jameel, Hasan	North Carolina State University	14	47	6462	247	26.16	USA
Aden, Andy	National Renewable Energy Laboratory - USA	13	15	2703	24	112.63	USA
Faaij, André	Netherlands Organization Applied Science Research	13	79	20408	252	80.98	Netherlands
Dale, Bruce E.	Michigan State University	13	74	23446	316	74.2	USA
Singh, Vijay	CSlR Inst Genom & Integrat Biol	13	24	2057	144	14.28	India
Ajanovic, Amela	Technische Universitat Wien	13	19	1050	34	30.88	Austria

TABLE V TOP PAPERS IN BIOFUEL

Sl. No.	Title	Authors	Journal Name	Journal (IF)	Total Citation	PY	DOI
1	Energy production from biomass (part 1): overview of biomass	McKendry, P	Bioresource Technology	11.88	2620	2002	https://doi.org/10.1016/S0960-8524(01)00118-3
2	Biofuels (alcohols and biodiesel) applications as fuels for internal combustion engines	Agarwal, AK	Progress In Energy And Combustion Science	35.34	2014	2007	https://doi.org/10.1016/j.pecs.2006.08.003
3	Understanding carbon lock-in	Unruh, GC	Energy Policy	6.14	1416	2000	https://doi.org/10.1016/S0301-4215(00)00070-7
4	Recovery of Microalgal biomass and metabolites: process options and economics	Grima, EM *et al.,*	Biotechnology Advances	14.23	1377	2003	https://doi.org/10.1016/S0734-9750(02)00050-2
5	Combustion of fat and vegetable oil derived fuels in diesel engines	Graboski, MS *et al.,*	Progress In Energy And Combustion Science	35.34	1350	1998	https://doi.org/10.1016/S0360-1285(97)00034-8
6	Renewable Power-to-Gas: A technological and economic review	Gotz, M *et al.,*	Renewable Energy	8.634	1297	2016	https://doi.org/10.1016/j.renene.2015.07.066
7	Materials challenges in nuclear energy	Zinkle, *et al.,*	Acta Materialia	9.209	1235	2013	https://doi.org/10.1016/j.actamat.2012.11.004
8	Ethanol from lignocellulosic biomass: techno-economic performance in short-, middle- and long-term	Hamelinck, CN *et al.,*	Biomass & Bioenergy	5.774	1059	2005	https://doi.org/10.1016/j.biombioe.2004.09.002
9	The role of renewable energy in the global energy transformation	Gielen, D *et al.,*	Energy Strategy Reviews	6.425	996	2019	https://doi.org/10.1016/j.esr.2019.01.006
10	Providing all global energy with wind, water, and solar power, Part I: Technologies, energy resources, quantities and areas of infrastructure, and materials	Jacobson, MZ *et al.,*	Energy Policy	6.142	868	2011	https://doi.org/10.1016/j.enpol.2010.11.040

D. Word Frequency

We used a plot for this field to show the frequency of word occurrence. The words that usually appear many times are frequent words, and the word "Energy" is used 1375 times it is used highly in this study on Bio Fuel followed by that "Production(995)","Economic(992)","Economics(848)", "Analysis (695)", "Power (595)", "Biomass (593)", "Fuel(566)", "Renewable (529)", "System (471)", "Based (441)", "Systems (404)", "Using (393)", "Techno (377)", and "Carbon (333)".

The majority of the key words are used more than ten times in a study, throughout every research paper inside this word power to demonstrate the research in its most complete form; the flat slop shows the time occurred in the Plot 1

E. Collaboration among the Countries

Collaboration is commonly assessed through the co-authorship of indexed publications, which is subsequently analyzed using methods from social network analysis. (Contandriopoulos *et al.,* 2016). Collaboration in research should help to increase the field's understanding. Collaborative effort in research provides a connection between the research and the researcher, along with the connectivity of the researcher across the country. The plot was created using multiple strings and nodes that represent the connection between two countries, with greater collaboration by the USA followed by that next highest network by Peoples R China then United Kingdom, India, Germany, Canada, Australia, Netherland and So on. The collaboration gets strong relationship between the countries and the research. In this Plot 2 we have given the connectivity of the Countries.

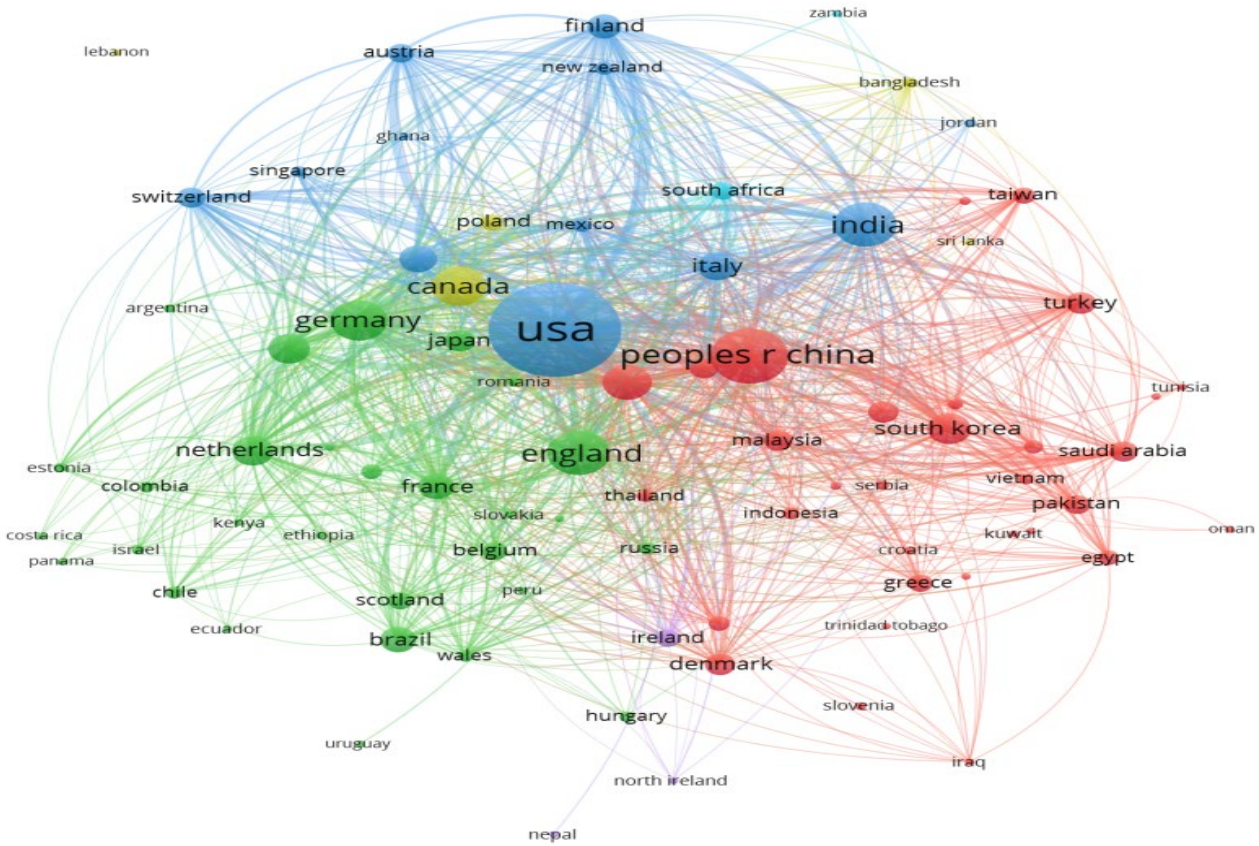

Fig. 1 Plot 2 Research Collaboration among the Countries

V. DISCUSSION

In this study, our research investigations in the field of biofuels, coupled with a comprehensive scientometric analysis, have unveiled crucial insights into the current state and trajectory of biofuel research. Our findings indicate a steady increase in research activity in recent years, reflecting a growing global interest in sustainable energy sources. (Vinayak Hakkarak 2023) Scientometrics has become more popular in research, and most researchers choose scientometrics as a tool for their research to find trends and the best contribution for the research. Furthermore, the research shows the most productive journal, author in that related field. This study and the tools aid in demonstrating the productivity in the research area.

Scientometric investigations have been greatly facilitated by the recent advancement in information and communication technology, enabling unprecedented access, exchange, and processing of scientific information. Integrating

scientometric data into comprehensive expert information systems, such as Web of Knowledge, to offer policymakers and decision-makers strategic insights is now feasible. Another notable progress is the expansion of the scope of scientometric analysis, which now includes new sources like corporate information, websites, discussions, and curriculum vitae (Dietz *et al.,* 2000). Science managers and policymakers are increasingly requesting bibliometric studies to support research assessment decisions. At this analytical level, numerous indicators are often devised, typically considering both scientists' output and the impact of their publications. These indicators may include metrics such as the total number of citations, citations per document, or the presence of highly cited papers. It is commonly advised to utilize a combination of multiple indicators to gain insights into various facets of scientific output (Costas R & Bordons M 2007). The advancement of information and communication technologies has greatly aided scientometric studies by providing unanticipated options for access, exchange, and processing of scientific knowledge.

VI. CONCLUSION

The findings of this study suggest that collaboration positively influences productivity and quality in biofuel research, enhancing both the quantity and caliber of research output. Methodological tools offered by social network analysis quantify collaboration, while metrics provided by scientometrics evaluate scientific performance. This study underscores the theoretical relationship between biofuel research and scientometrics. Although not conclusive, it implies the potential for further investigation to strengthen the connection between these disciplines. This type of research can help to identify trends in a study, as well as the productivity of authors, institutions, and collaborations. This method is used to measure scientific trends; such studies aid in demonstrating the growth of research from one period to the next. These findings demonstrate a case in which biofuel increased research collaboration and, as a result, scientific performance. The research focuses on biofuel and is supported by network analysis and scientometric approaches. Because no single model fits all scenarios, the results can be helpful in understanding knowledge management in context.

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