Journal of Scientometric Research, 2023; 12(1):114-129.
https://www.jscires.org

Research Article

A Scientometric Review of Solar Energy Research in Business Economics

Mohd Iqbal Mohd Noor[1,4,*], **Naqiah Awang**[2], **Muhammad Fuad Abdullah**[3,4]

[1]Faculty of Business and Management, Universiti Teknologi Mara Pahang, Pahang, MALAYSIA.
[2]Faculty of Accountancy, Universiti Teknologi Mara Pahang, Pahang, MALAYSIA.
[3]Faculty of Business and Management, Universiti Teknologi MARA (UiTM) Puncak Alam Campus, MALAYSIA.
[4]Institute for Biodiversity and Sustainable Development, Universiti Teknologi MARA, Shah Alam, MALAYSIA.

ABSTRACT

There has been a rapid growth for solar energy industry in recent years. The industry has increased its production and power capacity, getting more government subsidies and investment, and achieving lower production cost. The purpose of this study is to synthesize the available research of solar energy in business economics from 2000 to 2019 using scientometric method. This article investigates 968 publications with 26,873 sum of times cited retrieve from Web of Sciences on 17th August 2020. The most prominent contributors are from United States, Germany, United Kingdom and China. The scientometric approach used in the present study has identified research clusters, authors, journals and keyword that had significant impacts on solar energy in business economics research. By adopting visualization and co-citation techniques, this study able to map the frontiers of the specialty, interconnections between publications in the corpus used, and the prominent research trend.

Keywords: Solar Energy, Business Economics, Scientometric Review, Co-citation.

Correspondence:
Mohd Iqbal Mohd Noor
[1]Faculty of Business Management, Universiti Teknologi MARA Pahang, Pahang, MALAYSIA.
[2]Institute for Biodiversity and Sustainable Development, Universiti Teknologi MARA, Shah Alam, MALAYSIA.
Email: mohdiqbalmn@uitm.edu.my
ORCID ID: 0000-0003-2550-614X

Received: 15-06-2022;
Revised: 27-12-2022;
Accepted: 16-02-2023.

INTRODUCTION

Solar energy market is expected to significantly grow over the next decades.[1-3] The industry has increased its production and power capacity, getting more government subsidies and investment, and achieving lower production cost.[4-6] The rise of solar energy market has potential positive direct and indirect impact for our planet and society. With the growth of awareness regarding traditional fossil fuel usage deemed as unsustainable, solar energy has become one of the solutions to help reducing greenhouse gas emissions.[7-9] However, in order to achieve sustainable development of solar technology, research focusing on solar energy economic impact and competitive advantage need to be put in priority.[9-13]

In recent years, there is a surge of interest for solar energy study in business economic areas. Some of these study focusing on the economic feasibilities of solar energy,[10,14,15] communities willingness and ability to adapt on the technology,[10,14,15] firm support and technology competitiveness,[11,12,16] and learning curve impact toward cost reductions.[17,18] Despite the recent growing interest of solar energy in business economics, the current knowledge of study review is scarce.

Although some review studies that have been conducted focused on solar energy in business economics, it has been limited to specific questions. There is a systematic review on factors and barriers of renewable application to social housing.[19] An expert review focusing on the social and political impacts of renewable energy[13,20] and a policy review on the development of solar energy focusing on selected countries.[21,22] While these reviews are valuable in solar energy research, the scope and focus of the study is narrow and none of it include the developments and organizations for the field of business economics.

There is a need for a research in focusing on the dynamics and connectivity between the articles, authors and the journals for studies in the business economics area. By having this information, future research can understand: (i) the intellectual turning points within a specialty, (ii) the links between different specialties, and (iii) the progress of knowledge over time.[23-26] Scientometrics is a study on a class of measurement for scientific performance. It has been widely applied in the areas of research evaluation in various research areas. Aryadoust *et al.*[27] has use scientometric to review the eye tracking technology, Castillo *et al.*[28] is using it to see the landscape of creativity research in the scope of business economics and Wang *et al.*[29] provide research

DOI: 10.5530/jscires.12.1.014

Table 1: Datasets retrieval process.

Date: 17-08-2020	Database: ISI WOS	Search String: Solar energy or Solar Heat or Photovoltaic or Solar Thermal or Solar Photovoltaic
Filter First Stage		Research Areas: Business Economic
Subject areas filter from the WOS Research Areas categories applied		1,266 articles
Filter Second Stage		Document Type: Article
Document filters applied		968 articles

information through atomic power in the advancement on nuclear power.

Scientometric study involves numerous quantitative approaches from descriptive statistics and data visualization to advance econometric methods such as network science, machine-learning algorithms, mathematical analysis and computer simulation.[23-25,30,31] This method has been chosen due to (i) availability of large bibliographic corpora (Web of Science, Scopus, Pubmed),[32, 33] and (ii) availability of visualization and text-mining software packages such as CiteSpace.[23-25,30,34]

Therefore, the purpose of this study is to synthesize the available research of solar energy in business economics from 2000 to 2019 using scientometric method. This study presents a scientometric analysis using CiteSpace as well as an analysis of research time intervals using the Web of Science (WoS) database. The specific objective was to (i) determine the research landscape of solar energy in business economics in terms of the year, journals, co-cited journals, authors, countries, institutions, keywords, and references; (ii) and explore the key topics and developments.

METHODOLOGY

The review study applies a Scientometric method to analyses the journal articles published between 2000 and 2019 in the business economic domain for solar energy research.

Database Searches

Document information was collected from the WoS core collection database by Clarivate Analytics. WoS database has been extensively applied in review articles such as scientometric as it is most reputed and has a very comprehensive database covering most areas of knowledge.[27,35] WoS database rank top countries, journals, scientists, papers, and institutions by field of research. It indexes more than 6,650 major journals across 150 scientific disciplines and includes all cited references captured from indexed articles.[32,33]

This study adapt study by Aryadoust *et al.* and Castillo *et al.*[27,28] in term of determine method for database search. The search in WoS was made using keywords (search code) commonly used to refer to solar energy.[36,37] The Boolean "OR" was used in order to capture at least one of the specified terms used to describe solar energy. A special character "*" was used at the end of some search code to identify variations, thereby broadening the search.[38-40]. WoS searches the title of the manuscript, its abstract, keywords, authors, and Keywords Plus as the search option when the field "TS" is checked.[32,33]

The search code used was *TS= (("solar energy*") OR ("solar heat*") OR ("photovoltaic*") OR ("solar thermal energy*") OR ("solar photovoltaic*")).*

The search code is adapted from Dong *et al.* and Du *et al.*[36,37] in their bibliometric study on solar energy. The search was restricted to articles published between 2000 and 2019 because this study focuses on the solar energy research published in the past two decades. The complete years between year 2000-2019 were targeted. Publication types include only original research articles while reviews, commentaries, short communications of findings, books and book chapters, protocol papers, theory/discussion papers and editorials were excluded. All research designs (quantitative, qualitative, and mixed-methods studies) is included.

The search was conducted on 17th August 2020 and the retrieval process is shown in Table 1. The results of this search yielded a total of 150,894 publications between the year 2000 to 2019, which were filtered by the field "research areas = Business Economic", since this is the area of interest for the analysis, yielding 1,266 documents. The databases was filtered by "articles", obtaining a total of 968 results, which were used to develop the current study. These included 26,873 sums of times cited (articles without self-citations = 25,068).

Data Analysis

Two tools were used in the analysis, Microsoft Excel 2016 is uses for descriptive analysis and CiteSpace for scientometric analysis. Sub-section below explained the used of both tools in more details.

Descriptive Analysis

Descriptive analysis was performed on number papers that were published annually, the names of the journals wherein the papers were published, and the names of the most productive authors, universities/institutes, and countries wherein the authors were residing when the papers were published. To perform the analysis, Microsoft Excel 365 was used to count the annual quantities of publications for solar energy research.

Scientometric Analysis

CiteSpace software was used to conduct visualization and knowledge graph analysis in this study. CiteSpace, developed by Chen (2004–2006) offers the most comprehensive suite of tools for generating multiple bibliometric networks and conducting multiple methods of analysis. To investigate the inter-domain specialty to specialty trends that link solar research this study used a dual-map overlay.[30] The dual-map overlay categorized the literature into two groups: (i) cited journals and (ii) citing journals (i.e., the latter cited its references from the former). The strength of connections between these groups were visually represented and measured. The map generated in the present study superimposed the eye tracking papers and journal clusters that were often cited in language studies onto a base map derived from the WoS that comprised 10,000 journals.[30]

Different types of bibliometric networks can be constructed in CiteSpace[23,30] and the following analyses were used in this study: (i) Author Co-citation Analysis (ACA) which considers two authors to be co-cited if they are cited together in a paper; (ii) Document Co-citation Analysis (DCA) where a co-citation instance occurs when two sources are cited together in one paper; (iii) Journal Co-citation Analysis (JCA), which is used to identify journals cited together in one paper; and (iv) keyword analysis, where instances of two keywords appearing together are analyzed.[23,30,35] All this analysis was performed to get the cluster co-citing authors, co-citing publications, journals and keywords respectively.

The input data for CiteSpace were retrieved from WoS as discussed above. In order to generate an individual network, threshold settings are required to enable article selection. The two most recommended methods for this are Top N and Top N%. The Top N per slice procedure used in this study, selected the most cited items from each slice to form a network, according to the input value and node type determined by the user. The value of 50 and multiple node types are chosen for this study, so the top 50 most cited items were displayed and ranked accordingly. The Top N% per slice procedure displayed the percentage of most cited items according to a value determined by the user.

A multidimensional clustering method were used for identification of cluster. Log-likelihood ratio (LLR) were used to automatically extract the cluster label. This method was found to provide the best results in terms of uniqueness and coverage. To visualize the shape and form of the network, a timeline and cluster view method are used in the study. Timeline view consisted of a range of vertical lines that represent time zones chronologically, arranged from left to right. The cluster view produced spatial network representations that were color-coded and automatically labeled in a landscape format. CiteSpace V version 5.2.R 2.3.26.2018 for 64-bit windows was used in this study. In the time slicing, the time span was from 2000 to 2019 and the years slice was set as 1. In the text processing, all term source, including title, abstract, author keywords and keywords plus is chosen.

Quality Control and Impact

The qualities and the homogeneity of the analysis and detected clusters were measured using the modularity q-index, the average silhouette metric and betweenness centrality. The modularity q-index ranges between 0 and 1, with larger indices indicating higher reliability. The average silhouette metric ranges between-1 and 1, where values above 0 indicate better homogeneity.[8,24,26,41] Betweenness is a measure of influence that shows the degree to which publications or journals stand between each other. Publications with higher betweenness would have a higher influence on the network, because they connect more publications or journals and, accordingly, more information and paths pass through them.[24-26,41]

In addition, influential publications and journals were determined by computing citation burst ness and sigma. Citation burstness and sigma are temporal metrics. Burst detection is a sudden surge of citations for a specific article and is indicated by a red ring around the node. According to,[8,24,26,41] 'a burst is an abrupt elevation of the frequencies [of citations] over a specific time interval'. Sigma is the combination of betweenness centrality and burstness. It was calculated as $(\text{centrality} + 1)^{burstness}$. This metric (ranged from 0 to 1) was used to identify and measure novel ideas presented in scientific publications, with highest value are associated with high value researches.[8,24,26,41]

RESULTS AND DISCUSSION

The data collected were analyzed based on two types of analysis; descriptive and scientometric. For descriptive analysis, the annual growth, geographical distribution, institutions, publication sources and authorship frequency and percentage are presented. For scientometric analysis, the overlay map of journal publication, author co-citation analysis, document co-citation analysis, journal co-citation analysis and keyword co-citation analysis are presented.

Descriptive Results

Evolution of Published Studies

Overall, solar energy research in business economic has published 968 articles between year 2000–2019. Publication trend by total publications and citations per publication of solar energy research in business economics (Figure 1) and summarized its annual publications and citation structure (Table 2).

Depicts the growth trend of solar energy research in business economics publications, citations per publication and citations per cited articles spread between the year 2000 and 2019 (Figure 1). Although a decline trend in citation per publication is evident in the later year, such drop is not surprising considering the higher number of publications increase over the year. The clear growth in the number of publications might be due to the fallen cost of producing solar energy. The continued rapid cost reductions might put an interest of growth in the industry hence more focus on the R&D.[42] The year 2019 has a highest total publication (131), while 2012 has the highest number of cited publications (2,778) and the most influential year with an *h*-index of 35 (Table 2).

Countries Distribution

The papers featured in the sample come from 77 countries around the world. Lists of top ten countries distribution on the publications shows in Table 3. United States had the most publications (269 articles) and total citations (8,849 citations). Germany had the second highest number of publications (101 articles). Other productive countries include United Kingdom (93 articles), China (79 articles), Australia (64 articles), Brazil (42 articles), France (41 articles), Italy (40 articles), Spain (39 articles) and Netherland (38 articles). In addition, United States holds the highest *h*-index of 52, at least two times greater than other country.

Considering the C/P value, the highest values are in Netherland (38.53) and United States (32.90) as the result of multiple high-qualities articles.[17,43-45] The country with the next highest C/P values is France (31.34), followed by Spain (29.59), Italy (29.15) and Germany (28.91). United States is also the most dominant publishing hub for solar energy in business economy with the highest *h*-index (52).

Influential Institutions

Top affiliated institutions for solar energy between 2000 and 2019 shows in Table 4. United States Department of Energy leads the list, contributing 48 publications, followed by University of California System, with 25 publications. For all the remaining parameters, including total citations (TC), citation per publication (C/P) and the impact presented in the form of *h*-index, United Stated Department of Energy dominates with 2,473, 51.52 and 24 respectively. United States has the research institutions most active in solar energy research between year 2000 and 2019 with 7 institutions.

Productive Journal

A total of 156 journals participated in the publication of solar energy in business economic related articles. The number of citations for paper (TC) are generally considered to reflect the amount of influence a paper has. Journal impact may vary between research fields, so the average number of citations per paper for a journal (C/P) is a relatively good measure of the relative importance of the journal in a specific field. Moreover, the Influential Factor (IF) and *h*-index of these journals can also measure their value according to their role and status in scientific communication.

In terms of number of citations, the top ten most cited journals (Table 5) accounted for 89.9% of the total citations during 2000-2019. Energy policy, energy economics, technological forecasting and social change, and energy journal are the journals that have published more than 20 articles about solar energy in business economic areas. Energy Policy was the most cited (19,247) and published journal (588 articles) with a *h*-index of 69. Energy policy is very much the top choice for publications in this field with 60.8% of the articles. As energy policy is not a mainstream business economics journal, this suggest that the business economics study of solar energy is an area that is somewhat scattered, in terms of the choice of publication.

Ecological Economics had the highest C/P score (63.13), followed by research policy (52.43) and energy economics (42.94) that also have relatively high value of impact factor.

Productive Author

An author's number of publications and citations are an indication of experts in a given field as well as the visibility of their research output. A total of 2,281 authors were recorded. The top ten most productive authors shows in Table 6. According to the data, Ryan Wiser (10 articles) and Joshua M. Pearce (9 articles) dominated the list of publications. Other relevant authors include Galen Barbose, David Faiman and Varun Rai all with 7 articles and Changgui Dong, G. Meron, A.A. Solomon, Chihiro Watanabe and Rolf Wuestenhagen with 6 articles.

Meanwhile, Joshua M. Pearce from Michigan Technological University was the most cited author (408 citations) followed by Ryan Wiser and Galen Barbose who received 327 and 320 citation each. Four of the top 10 authors came from United States, two from Israel, while one from China, Finland, Japan and Switzerland respectively.

Influential Paper

The most cited papers in the field shows in Table 7. The citation statistics were collected from WoS database. The journal is a mixed source from mainstream business economics journals through field journals. The top three articles by[7,17,45] have been very heavily cited, with more than 20 average citation per year.

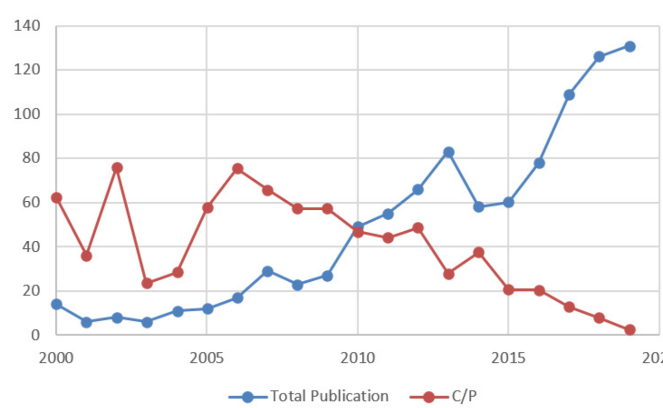


Figure 1: Trend of solar energy research in business economics

Table 2: Publication and citation trend in solar energy research between 2000 and 2019.

Year	TP	Percentage (%)	NCP	TC	C/P	*h*
2000	14	1.446	807	872	62.29	11
2001	6	0.62	217	217	36.17	5
2002	8	0.826	553	607	75.88	8
2003	6	0.62	140	141	23.50	4
2004	11	1.136	306	311	28.27	9
2005	12	1.24	676	693	57.75	11
2006	17	1.756	1144	1281	75.35	15
2007	29	2.996	1775	1910	65.86	22
2008	23	2.376	1269	1318	57.30	19
2009	27	2.789	1469	1549	57.37	23
2010	49	5.062	2093	2300	46.94	29
2011	55	5.682	2228	2421	44.02	30
2012	66	6.818	2778	3202	48.52	35
2013	83	8.574	2086	2312	27.86	24
2014	58	5.992	1938	2177	37.53	28
2015	60	6.198	1124	1244	20.73	21
2016	78	8.058	1467	1590	20.38	24
2017	109	11.26	1188	1389	12.74	20
2018	126	13.017	884	1000	7.94	16
2019	131	13.533	288	339	2.59	8
Total	968	100.00				

Notes: TP=total number of publications; NCP=number of cited publications; TC=total citations; C/P=average citations per publication; C/CP=average citations per cited publication and h=*h*-index.

Table 3: Top ten countries distribution of publications.

Country	TP	NCP	TC	C/P	*h*
United States	269	6811	8849	32.90	52
Germany	101	2565	2920	28.91	29
United Kingdom	93	2246	2490	26.77	28
China	79	1514	1766	22.35	25
Australia	64	1523	1713	26.77	23
Brazil	42	660	770	18.33	15
France	41	1204	1285	31.34	16
Italy	40	1067	1166	29.15	21
Spain	39	1081	1154	29.59	18
Netherland	38	1407	1464	38.53	18

Article citation is an indicator that shows the impact of a study in its research field. Based on previous study, the direction of one research field is associated with its frequently cited articles.[25,32] Gerbens *et al.*[45] research focus not just on solar but also wind energy. This is not a fully business economics research but more focusing on energy storage. A high citation of this paper might be due to the fact that this paper suggests that with a flexible system of renewable energy, it supply might meet the electricity demand. Gregory F. Nemet[17] study the importance of learning experience in determine the cost of photovoltaic. However, he found that the ability to raise capital and large risk of investment in manufacturing play bigger roles than learning experiences in enabling cost reduction. Tsoutsos, *et al.*[7] analyze the socio-economic impacts of solar energy technologies based on

Table 4: Top ten influential institutions.

Affiliation	Country	TP	NCP	TC	C/P	*h*
United States Department of Energy	United States	48	2,175	2,473	51.52	24
University of California System	United States	25	1,046	1,158	46.32	16
University of California Berkeley	United States	21	950	1,047	49.86	15
National Renewable Energy Laboratory USA	United States	20	901	956	47.80	11
Lawrence Berkeley National Laboratory	United States	17	479	588	34.59	14
Eth Zurich	Switzerland	13	502	584	44.92	8
Massachusetts Institute of Technology MIT	United States	13	303	312	24.00	9
University of Texas System	United States	13	187	212	16.31	7
Australian National University	Australia	12	198	213	17.75	7
University of Cambridge	United Kingdom	12	192	193	16.08	6

Table 5: Top ten productive journal.

Source Title	TP	NCP	TC	C/P	*h*	Publisher	IF (2019)
Energy Policy	588	12895	19247	32.73	69	Elsevier	5.042
Energy Economics	47	1834	2018	42.94	20	Elsevier	5.203
Technological Forecasting and Social Change	33	767	833	25.24	17	Elsevier	5.846
Energy Journal	22	298	324	14.73	22	The International Association for Energy Economics	2.394
International Journal of Energy Sector Management	19	61	65	3.42	4	Emerald Group Publishing	0.9
Research Policy	14	625	734	52.43	11	Elsevier	5.351
Ecological Economics	8	505	505	63.13	7	Elsevier	4.482
Futures	7	276	276	39.43	6	Elsevier	2.769
Technology Analysis Strategic Management	7	41	41	5.86	4	Taylor and Francis	1.867
Economics of Energy Environmental Policy	6	106	110	18.33	3	The International Association for Energy Economics	3.217

environmental impact assessment method. The study finds that most of the potential impact is associated with loss of amenity and can be minimized by proper project design by the investors, developers and permitting authorities.

Scientometric Results

Overlay Map

In order to determine the link of solar energy research in business economics had with other research fields, a dual-map overlay was generated. The current view represents the z-score function and the significance of the connections is illustrated by the thickness of the connecting lines. The thicker the line, the more significant the connection citing journal and cited journal are. The citing journals are on the left, the cited journals are on the right, and the citation links show which journal the citing journal cited from. The trajectory of the citation links provides an understanding of multi-disciplinary relationships. A shift in trajectory from one trajectory to another indicate that a paper under one discipline was influence by other articles from another discipline.

Even though, the focus of this paper is business economics and the citing and cited journal are dominated by economic discipline, it's evident that the cited articles were also from other type of discipline. Based on the result, the circle of study is focusing on Economics, Political Psychology, Education and Health (Figure 2). While the cited articles are dominated by psychology, education, social, economic and political. This results is in line with previous study focusing on economics research.[46,47] From the results, to further develop business economics study in solar energy, additional contribution on multi-disciplinary and cross ideas research need to be made in the future.

Table 6: Top ten most productive author.

Author's Name	Affiliation	Country	TP	NCP	TC	C/P	*h*
Ryan Wiser	Lawrence Berkeley National Laboratory	United States	10	284	327	32.70	8
Joshua M. Pearce	Michigan Technological University	United States	9	305	408	45.33	8
Galen Barbose	Lawrence Berkeley National Laboratory	United States	7	253	320	45.71	7
David Faiman	Ben Gurion University	Israel	7	76	150	21.43	7
Varun Rai	University of Texas Austin	United States	7	147	152	21.71	5
Changgui Dong	Renmin University of China	China	6	51	69	11.50	5
G. Meron	Israel Electric	Israel	6	69	141	23.50	6
A.A. Solomon	Lappeenrant University of Technology69	Finland	6	69	141	23.50	6
Chihiro Watanabe	Tokyo Institute of Technology	Japan	6	248	278	46.33	6
Rolf Wuestenhagen	University of St Gallen	Switzerland	6	196	204	34.00	5

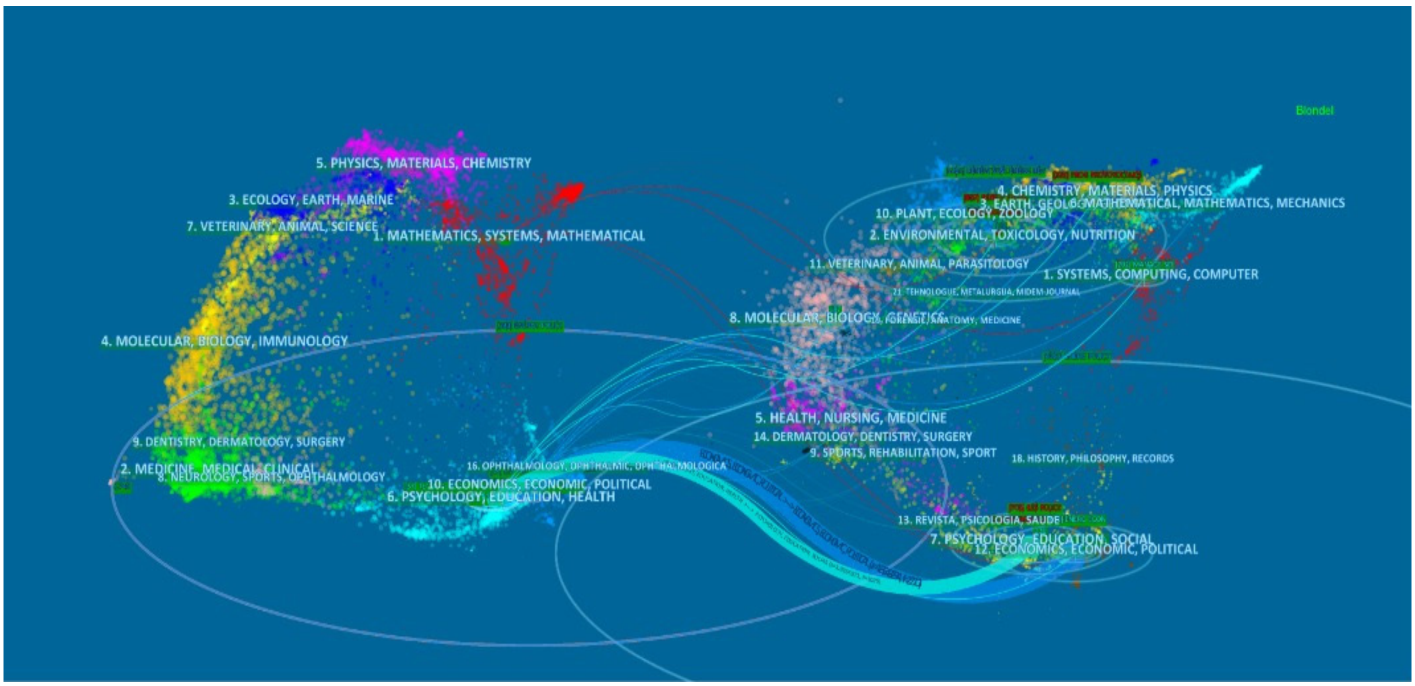


Figure 2: Overlay map.

Author Co-citation Analysis (ACA)

The modularity Q score of the ACA network was 0.3767. This score suggested that the networks and clusters had a low degree of connectedness. This shows that the boundaries separated cluster were not definitive. However, with a mean silhouette score of 0.8024, suggested that the cluster has high heterogeneity. The top 10 of author burst computed with ACA shows in Table 8. The author with the highest burst strength was Paul Denholm (8.6298), whose burstiness started in 2010 until 2013, followed by Varun Rai (strength = 7.1527, 2017-2019) and Alan McDonald (strength = 6.8643, 2006-2010). The strength of the burstiness reflect the growing importance of the authors papers and ideas.[27,35]

Document Co-citation Analysis (DCA)

The modularity q-index and mean silhouette metric for DCA network were 0.622 and 0.5602, respectively. It is an evidence that the network is at acceptable level of reliability and homogeneity. A total of 24 cluster emerged from the analysis. Figure 3 shows the top 11 largest clusters. Cluster #0 on "government support", was the largest cluster and showed activity from 1980 until present. The size of the cluster was 136 and this accounted for 16.59% of all clusters. Cluster #1 is labeled as "energy supplier" was the second

Table 7: Top Ten cited paper.

Title	Authors	Source Title	Publication Year	Total Citations	Average per Year
Grid flexibility and storage required to achieve very high penetration of variable renewable electricity.	Paul Denholm; Maureen Hand	Energy Policy	2011	388	38.8
Beyond the learning curve: factors influencing cost reductions in photovoltaics.	Gregory F. Nemet	Energy Policy	2006	349	23.27
Environmental impacts from the solar energy technologies.	T. Tsoutsos; N. Frantzeskaki;V. Gekas	Energy Policy	2005	306	19.13
The market value of variable renewables The effect of solar wind power variability on their relative price.	Lion Hirth	Energy Economics	2013	297	37.13
A methodology or optimal sizing of autonomous hybrid PV/wind system.	S. Diaf; D. Diaf; M. Belhamel;M. Haddadi;A. Louche	Energy Policy	2007	280	20
Peer Effects in the Diffusion of Solar Photovoltaic Panels.	Bryan Bollinger;Kenneth Gillingham	Marketing Science	2012	246	27.33
Willingness-to-pay for renewable energy: Primary and discretionary choice of British households' for micro-generation technologies.	Riccardo Scarpa;Ken Willis	Energy Economics	2010	242	22
The water footprint of energy from biomass: A quantitative assessment and consequences of an increasing share of bio-energy in energy supply.	P.W. Gerbens-Leenes; A.Y. Hoekstra;Th. van der Meer	Ecological Economics	2009	234	19.5
Technology and the diffusion of renewable energy.	David Popp;Ivan Hascic;Neelakshi Medhi	Energy Economics	2011	189	18.9
The technical, geographical, and economic feasibility for solar energy to supply the energy needs of the US.	Vasilis Fthenakis;James E. Mason;Ken Zweibel	Energy Policy	2009	177	14.75

largest cluster with a size of 130 (15.85%), followed by cluster #2 (solar photovoltaic industry) with a size of 118 (14.39%) and cluster #3 (energy technology) with a size of 95(11.59%). The cluster view of the DCA network is presented in Figure 4. The cluster labels were off for clarity and only the author's name of some influential publications was displayed.

Cluster #0 is the largest cluster with 136 articles and a silhouette value of 0.703. It is labeled as "*energy supplier*" by the Log-Likelihood Ratio (LLR) test method. The high silhouette value indicate that these clusters had clear differences in the network. This cluster focus more toward government as its population. In this cluster,[45,48-51] were identified as the most influential publications. This cluster focuses on the economic feasibility of solar photovoltaics and the needs of government support in term of policy issues.

The research shown that it is clearly feasible to focus on developing solar energy industries.[50, 51] However, it requires a radical transformation of current energy systems and political intervention in term of incentives to advance the technologies and achieve cost competitiveness. Most of the articles in this cluster find evidence that the current solar energy development is

Table 8: Top ten author burst computed via author co-citation analysis (ACA).

Author	Strength	Begin	End	Span
Paul Denholm	8.6298	2010	2013	3
Varun Rai	7.1527	2017	2019	2
Alan McDonald	6.8643	2006	2010	4
Vasilis Fthenakis	6.7555	2010	2014	4
Philippe Menanteau	6.6209	2011	2014	3
Joern Hoppmann	6.4308	2017	2019	2
Thilo Grau	6.1176	2015	2016	1
Lena Neij	5.6002	2006	2013	7

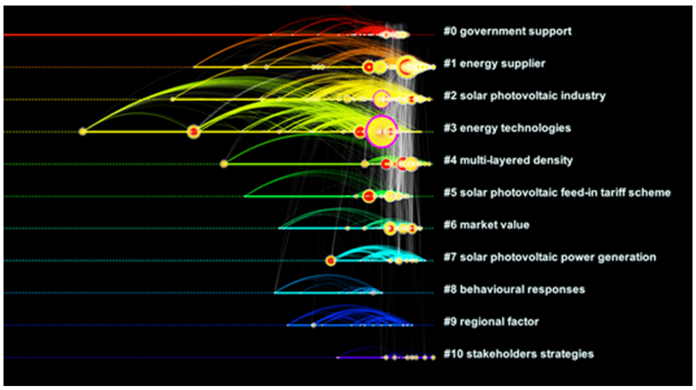


Figure 3: The top 11 largest clusters (refer appendix 2).

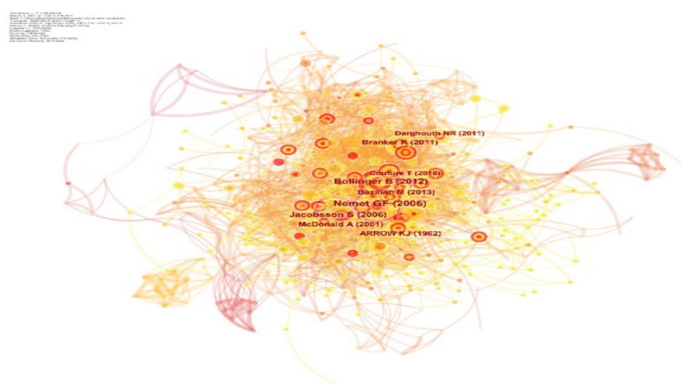


Figure 4: Cluster view of the DCA network (Refer appendix 3).

not constraint by the raw materials issues but more on its storage and system flexibilities.

Cluster #1 is the second largest cluster with 130 articles and silhouette value of 0.658. It is labeled as *"spatial econometric approach"* and[10,14,15,52,53] were identified as the most influential publications. This cluster focus on communities/ resident as its population. This cluster mostly discuss the socio-economic impacts of solar energy on residential customers. It analyzes the effectiveness and cost of intervention program that promote solar energy adaption such as solar subsidies and net-metering.

Incentive such as rebate and subsidies for solar energy usage has large effect for community's adoption.[14,15] Incentive need to be plan strategically and systematic as some of the studies show that peer effects play a major role in diffusion of this technology.[10,52,53]

The third largest cluster (#2) has 118 members and a silhouette value of 0.671. It is labeled by log-likelihood (LLR) test method as *"techno-economic assessment"*. Articles in this cluster focus on population in the industry. The articles published by[11,12,16,54,55] were the most influential in this cluster. Studies in this cluster discuss solar energy innovation and firm investment. Most of the articles agree that the solar energy is still in its infancy, and investment might has double edge sword impact due to global spillover impact.[11,12]

Firms knows that there is a cost for early investment, but it come with high opportunities in the global market. However, in order to for the market to growth, further innovation in a large scale is needed.[16,54,55] Study show that, in order to improve competitive advantage, countries and firm need to foster innovation and push for technology policies that well suited the demand. The innovation spillover will be lower and investor interest will flourish.[10,16,54]

The 4th largest cluster (#3) has 95 articles and a silhouette value of 0.812. It is labeled as *"residential consumption"*. The main topic covered in this cluster were learning curve impact on solar photovoltaic cost. Articles published by Alan McDonald[56] and Tsoutsos, *et al.*,[17] examining the association between learning curve and cost reduction in photo curve and cost reductions in photovoltaics. Both studies find that the association only weakly explain change in factors such as plant size, module efficiency and the cost of silicon.

However, study by Lena Neij,[18] find that learning rate have improved the efficiency and the operating and maintenance costs of solar photovoltaics. Frank W Geels[57] suggested that the "variation and selection" might be good in understanding the impact of learning curve while evolution as "unfolding" may trigger further changes if changes at the landscape level create pressure and new opportunities. Taken together, these studies reveal the varied ways, learning curve can be manipulated to achieve lower cost of solar energy production.

Table 9: Top ten document burst computed via document co-citation analysis (DCA).

Author	Year	Title	Journal	Burst Strength	Begin	End	Span
Bryan Bollinger	2012	Peer Effects in the Diffusion of Solar Photovoltaic Panels.	Marketing Science	9.32	2017	2019	2
Naim R. Darghouth	2011	The impact of rate design and net metering on the bill savings from distributed PV for residential customers in California.	Energy Policy	6.53	2017	2019	2
Alan McDonald	2001	Learning rates for energy technologies.	Energy Policy	6.01	2006	2011	5
Paul Denholm	2007	Evaluating the limits of solar Photovoltaics (PV) in electric power systems utilizing energy storage and other enabling technologies.	Energy Policy	5.98	2008	2012	4
Gregory F. Nemet	2006	Beyond the learning curve: Factors influencing cost reductions in photovoltaics.	Energy Policy	5.77	2008	2009	1
Paul Denholm	2007	Evaluating the limits of solar Photovoltaics (PV) in traditional electric power systems.	Energy Policy	5.15	2010	2012	2
Jonathan E. Hughes	2015	Getting Green with Solar Subsidies: Evidence from the California Solar Initiative.	Journal of the Association of Environmental and Resource Economists	5.06	2017	2019	2
Cherrelle Eid	2014	The economic effect of electricity net-metering with solar PV: Consequences for network cost recovery, cross subsidies and policy objectives.	Energy Policy	5.06	2017	2019	2
Philippe Menanteau	2003	Prices versus quantities: choosing policies for promoting the development of renewable energy.	Energy Policy	5.03	2011	2014	3
Calvin Lee Kwan	2012	Influence of local environmental, social, economic and political variables on the spatial distribution of residential solar PV arrays across the United States.	Energy Policy	4.84	2017	2019	2

Document burst

A burst detection analysis was performed to identify the most influential or landmark publication in the field that had drawn researcher's attention. The top 10 major bursts in citations, with the duration shows in Table 9. The top 3 articles with the highest burst are (McDonald and Schrattenholzer, 2001; Darghouth, Barbose and Wiser, 2011; Bollinger and Gillingham, 2012). Bollinger and Gillingham (2012), study the association between social interaction (peer) effect and diffusion of solar photovoltaic panel. The study finds a strong correlation between causal peer effect and increase in adoption rate of solar PV panel.

Darghouth *et al.*[14] analyze the financial impact of net metering (a compensation mechanism to promote photovoltaics adoption) in term of bill saving. The study suggests that the mechanism work

Table 10: Articles with high centrality and high sigma.

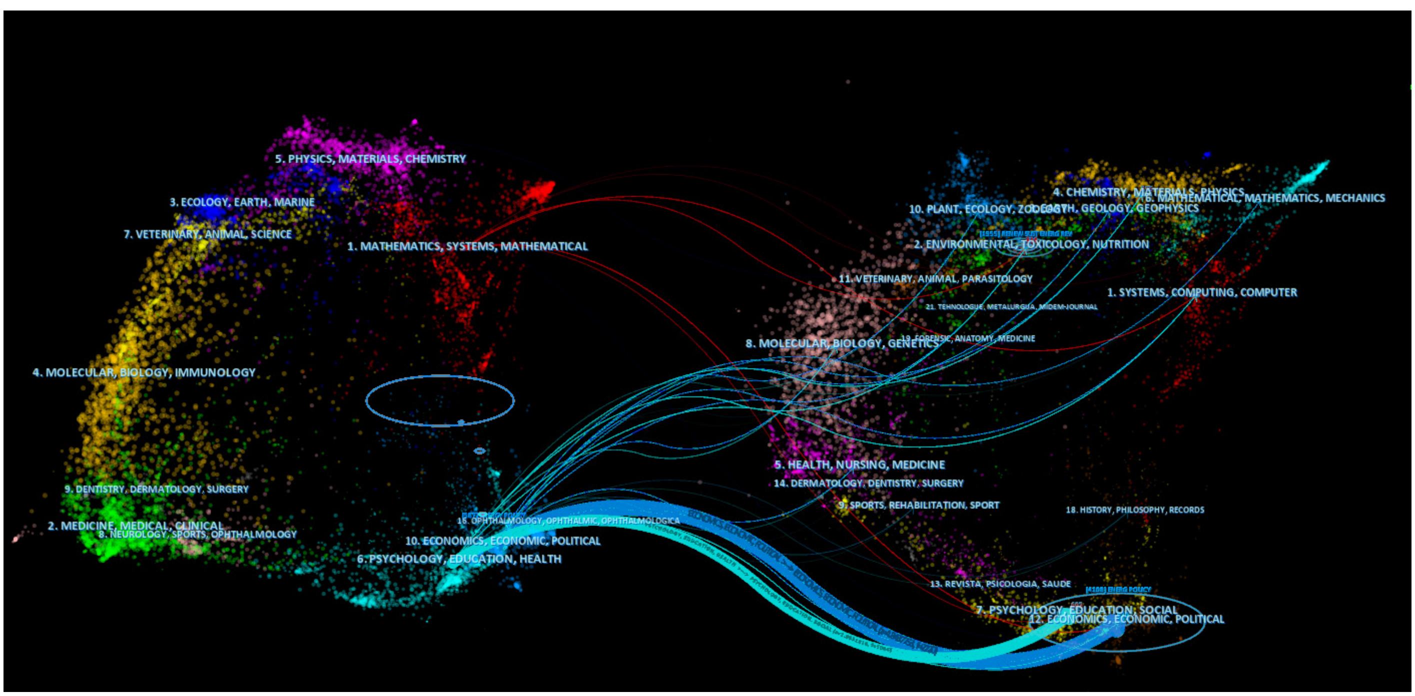
Centrality	Author	Year	Title	Source	Cluster ID
0.3	Gregory F. Nemet	2006	Beyond the learning curve: factors influencing cost reductions in photovoltaics.	Energy Policy	3
0.17	Staffan Jacobsson	2006	The politics and policy of energy system transformation-explaining the German diffusion of renewable energy technology.	Energy Policy	2
0.09	Vasilis Fthenakis	2009	The technical, geographical, and economic feasibility for solar energy to supply the energy needs of the US.	Energy Policy	0
0.09	Jasper Rigter	2010	Cost and optimal feed-in tariff for small scale photovoltaic systems in China.	Energy Policy	7
0.08	Joshua M. Pearce	2002	Photovoltaics-a path to sustainable futures.	Futures	4
0.08	C.K. Prahalad	1990	The Core Competence of the Corporation.	Harvard Business Review	9
0.07	Bryan Bollinger	2012	Peer Effects in the Diffusion of Solar Photovoltaic Panels.	Marketing Science	1
0.07	Morgan Bazilian	2013	Re-considering the economics of photovoltaic power.	Renewable Energy	4
0.06	Adam B. Jaffe	2005	A tale of two market failures: Technology and environmental policy.	Ecological Economics	2
0.05	Paul Denholm	2007	Evaluating the limits of solar Photovoltaics (PV) in traditional electric power systems.	Energy Policy	0
4.62	Gregory F. Nemet	2006	Beyond the learning curve: factors influencing cost reductions in photovoltaics.	Energy Policy	3
1.96	Bryan Bollinger	2012	Peer Effects in the Diffusion of Solar Photovoltaic Panels.	Marketing Science	1
1.47	Vasilis Fthenakis	2009	The technical, geographical, and economic feasibility for solar energy to supply the energy needs of the US.	Energy Policy	0
1.34	Morgan Bazilian	2013	Re-considering the economics of photovoltaic power.	Renewable Energy	4
1.29	Paul Denholm	2007	Evaluating the limits of solar Photovoltaics (PV) in traditional electric power systems.	Energy Policy	0
1.22	Alan McDonald	2001	Learning rates for energy technologies.	Energy Policy	3
1.21	Philippe Menanteau	2003	Prices versus quantities: choosing policies for promoting the development of renewable energy.	Energy Policy	5
1.21	Naim R. Darghouth	2011	The impact of rate design and net metering on the bill savings from distributed PV for residential customers in California.	Energy Policy	1
1.2	Thilo Grau	2012	Survey of photovoltaic industry and policy in Germany and China.	Energy Policy	2

Table 11: Top ten journals burst computed via journal co-citation analysis (JCA).

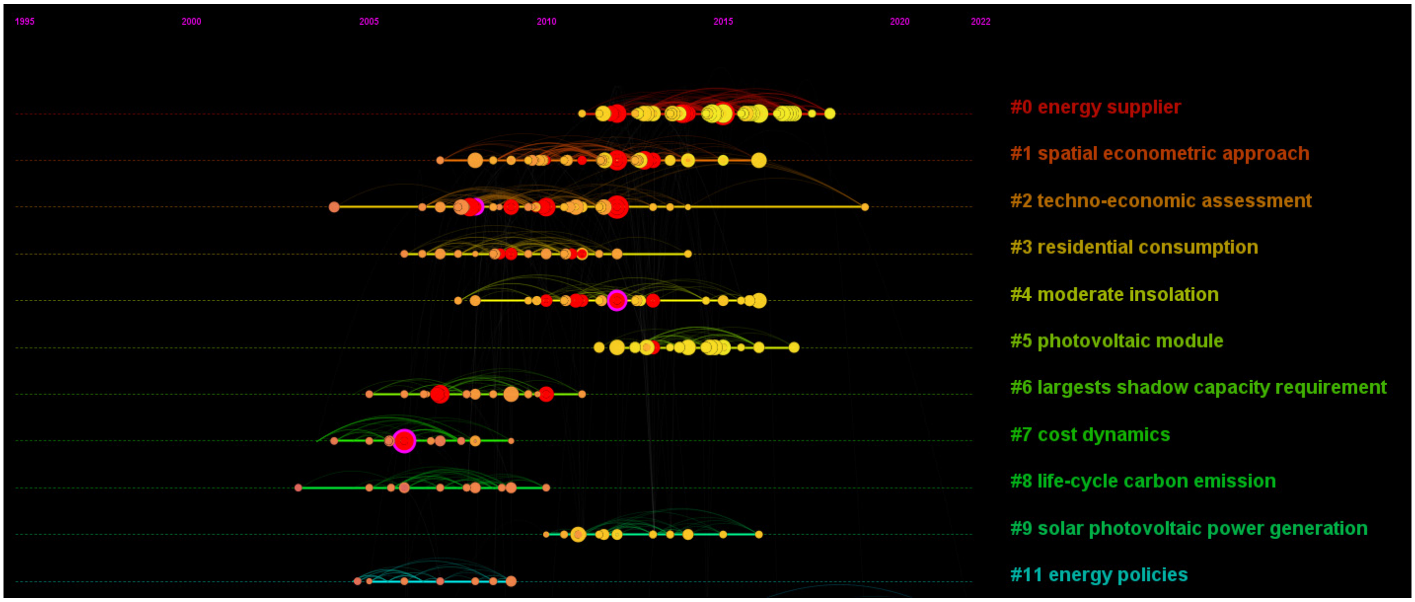
Entity	Strength	Begin	End	Span
Solar Energy	12.3949	2006	2010	4
Energy Research and Social Science	11.4767	2017	2019	2
Annual Review of Environment and Resources	8.4106	2000	2011	11
Progress in Photovoltaics: Research and Applications	7.8076	2004	2010	6
Solar Energy Materials and Solar Cells	6.1258	2006	2012	6
Communication	5.706	2001	2015	14
Energy Conversion and Management	5.3173	2006	2013	7
Annual Review of Resource Economics	5.3064	2015	2017	2
International Journal of Energy Research	5.0781	2006	2014	8
Journal of Economic Literature	4.9305	2009	2013	4

Table 12: Top ten keyword bursts computed via keyword analysis.

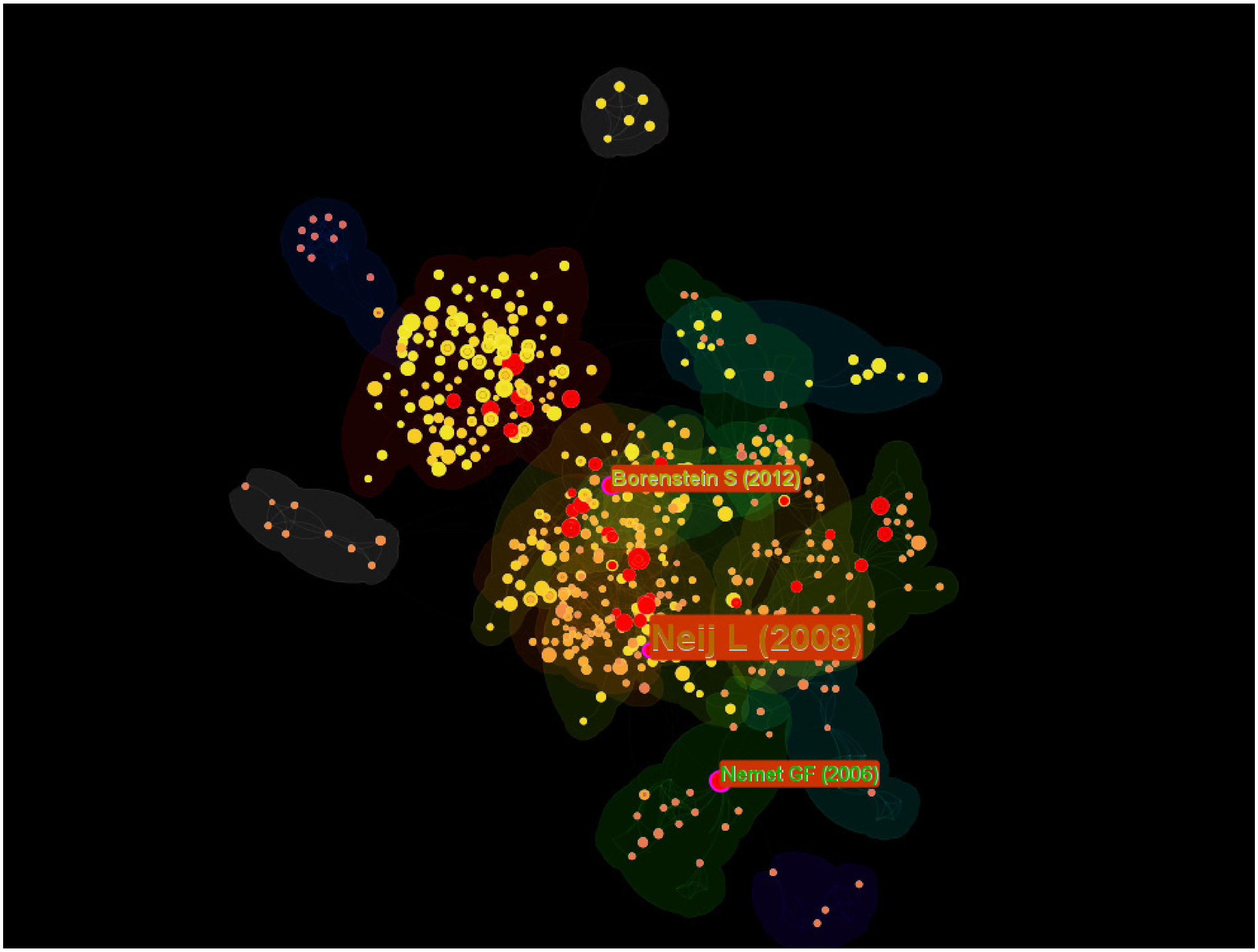
Sl. No.	Entity	Strength	Begin	End	Span
1	Photovoltaics	10.0321	2005	2012	7
2	Feed-in tariff	5.6631	2013	2014	1
3	Solar photovoltaic	4.5022	2011	2014	3
4	Distributed generation	4.3476	2015	2017	2
5	Experience curve	4.2044	2004	2012	8
6	Energy	4.0195	2000	2010	10
7	Electricity market	3.8484	2011	2013	2
8	Model	3.8083	2008	2011	3
9	Power	3.501	2012	2013	1
10	Bioma	3.3883	2007	2014	7



Appendix 1.



Appendix 2.



Appendix 3.

well in early stages of market development but in the long run, the difference in compensation is problematic. The third articles with high burstiness is Alan McDonald,[56] the study focus on how technological learning can improve cost reductions in energy productions. From the study, there is a significant variable found in performance, experiences and economic of scales.

The articles with high centrality and high sigma shows in Table 10. An article with high centrality scores were highly influential and articles with high sigma score indicate scientific novelty. In the field of solar energy in business economics, articles by Gregory F. Nemet[17] was both highly influential and contained potentially scientific novel results. As articles with high centrality are likely connected two or more clusters, it is evident that the top articles form a bridge of different ideas into a new one.

The top authors with the highest bursts included Paul Denholm, Varun Rai, Alan McDonald, Vasilis Fthenakis, Philippe Menanteau, Joern Hoppmann, Thilo Grau and Lena Neij. Unlike the Dual Map Overlay results, majority of the authors with high burst are expertise on multidisciplinary research's (Paul Denholm, Varun Rau, Vasilis Fthenakis, Joern Hoppman and Lena Neij). This is in line with other scientometric research results for ACA,[46,47,58] as author with multidisciplinary idea is growing better with time due to the wide range of research it research topic can cover.

Journal Co-citation Analysis

The top ten journals burst computed via Journal Co-citation Analysis (JCA) shows in Table 11. The modularity q-index and mean silhouette metric for JCA network were 0.213 and 0.6995, respectively. The modularity q-index score suggested that the network was partly structured and the boundaries that delineated the clusters were not clear. However, the high mean silhouette score suggested that the network has high heterogeneity. Impactful journals in-term of burstiness strength include Solar Energy, Energy and Social Science and Annual Review of Environment and Resources. It is interesting to note that the top burst journal is not include in the top output sources. This suggest that the paper cited in the context of business economics is at an intersection with other disciplinary. Journal with largest burstiness was solar energy (strength = 12.3949, 2006-2010). Energy research and social science (strength = 11.4767, 2017-2019) had the second largest burst and the burstiness was still growing. Communication had the longest burst span of 14 years from 2001 to 2015.

Keyword Co-citation Analysis

The top ten keyword bursts computed via keyword analysis Shows in Table 12. The Modularity Q score is 0.248 and the mean silhouette is 0.4333. This score suggested that network boundaries is not clear, but the heterogeneity is respectable. Keyword with largest magnitude is "photovoltaics" (strength = 10.0321), with a burst span of 7 years. Next keyword is "feed-in tariff" (strength = 5.6631, 2013–2014) and followed by "solar photovoltaic" (strength = 4.5022, 2011–2014). The longest burst span of 10 years was "energy" (strength = 4.0195, 2000–2010) and "experience curve" (strength = 4.2044, 2004–2012).

This finding is logical because photovoltaic and solar photovoltaic is used to explain the research. "fee-in tariff" suggest that research has mostly centered on the cost need to be burden by the industry and community to adopt the solar energy. The theme of market demand and cost is most prominent in this network ("feed in tariff", "distributed generation", experience curve" and electricity market"), showing its relative importance in the field of business economic for solar energy. This finding also suggests that other types of business economic factors have received less attention from researchers.

Limitations

This study assesses the dynamics and connectivity of the articles, authors and the journals for studies of solar energy in business economics. The trends and status of selected areas were comprehensively analysed by using the scientific method of scientometric analysis. However, this study is not without its limitation. First, this study only uses WoS, other databases such as Scopus, PubMed and Embase were not included. Such decision may lead to omission of some important studies from the dataset. However, WoS is deemed better for investigating solar energy givens its wider databases and scope compared with other available datasets.[32,33] WoS also is the most used database in scientometric analysis.[26,30,41] Future research could compare other set of databases with WOS for investigating solar energy in business economics or other research topics and decide on database to use.

Secondly, all datasets were identified using CiteSpace and WoS, rather than being collected manually. The dataset might be subject to bias due to the chance of including irrelevant subjects. The decision to balance between stringent criteria and over-excluding certain studies is a challenge. Future research who aim for high precision can consider using more stringent keyword searches to reduce the likelihood of irrelevant studies. Lastly, only the names of the principal (first) authors were used in the co-citation analyses performed in this study. Databases of cited publications downloaded from WoS did not include the names of other contributing authors even though citing publications did not possess such restriction. If additional author names were made available by these databases, the co-citation analysis may yield different results.

CONCLUSION

In summary, the scientometric approach used in the present study has identified research clusters, authors, journals and keyword that had significant impacts on solar energy in business economics research. By adopting visualization and co-citation techniques, this study able to map the frontiers of the specialty, interconnections between publications in the corpus used, and the prominent research trends. An interesting research agenda for the future would be to investigate the evolution of solar energy across all relevant specialties. This would constitute a large-scale study that would shed light on the progress and decline of impactful research trends across specialties.

AUTHORS' CONTRIBUTION

Mohd Iqbal Mohd Noor: Conceptualization, data analysis, writing, review and editing. Muhammad Fuad Abdullah and Naqiah Awang: Conceptualization, literature search, data collection, organization and analysis.

ACKNOWLEDGEMENT

This work was supported by the grant Young Talent Research PY/2022/01000 of the Universiti Teknologi MARA (UiTM).

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

REFERENCES

1. Dobrotkova Z, Surana K, Audinet P. The price of solar energy: Comparing competitive auctions for utility-scale solar PV in developing countries. Energy Policy. 2018;118:133-48.
2. Talavera D, Muñoz-Cerón E, Ferrer-Rodríguez J, Pérez-Higueras PJ. Assessment of cost-competitiveness and profitability of fixed and tracking photovoltaic systems: The case of five specific sites. Renewable Energy. 2019;134:902-13.
3. Rosa CB, Wendt JFM, Chaves DM, Thomasi V, Michels L, Siluk JCM. Mathematical modeling for the measurement of the competitiveness index of Brazil south urban sectors for installation of photovoltaic systems. Energy Policy. 2020;136:111048.
4. Liu Y, Zhang R-Q, Ma X-R, Wu G-L. Combined ecological and economic benefits of the solar photovoltaic industry in arid sandy ecosystems. Journal of Cleaner Production. 2020;262:121376.
5. Mahmoudi S, Huda N, Behnia M. Environmental impacts and economic feasibility of end of life photovoltaic panels in Australia: a comprehensive assessment. Journal of Cleaner Production. 2020;260:120996.
6. Rad MAV, Toopshekan A, Rahdan P, Kasaeian A, Mahian O. A comprehensive study of techno-economic and environmental features of different solar tracking systems for residential photovoltaic installations. Renewable and Sustainable Energy Reviews. 2020;129:109923.
7. Tsoutsos T, Frantzeskaki N, Gekas V. Environmental impacts from the solar energy technologies. Energy Policy. 2005;33(3):289-96.
8. Centi G, Perathoner S. Opportunities and prospects in the chemical recycling of carbon dioxide to fuels. Catalysis Today. 2009;148(3-4):191-205.
9. Jean J, Brown PR, Jaffe RL, Buonassisi T, Bulović V. Pathways for solar photovoltaics. Energy and Environmental Science. 2015;8(4):1200-19.
10. Bollinger B, Gillingham K. Peer effects in the diffusion of solar photovoltaic panels. Marketing Science. 2012;31(6):900-12.
11. Peters M, Schneider M, Griesshaber T, Hoffmann VH. The impact of technology-push and demand-pull policies on technical change–Does the locus of policies matter? Research Policy. 2012;41(8):1296-308.
12. Hoppmann J, Peters M, Schneider M, Hoffmann VH. The two faces of market support—How deployment policies affect technological exploration and exploitation in the solar photovoltaic industry. Research Policy. 2013;42(4):989-1003.
13. Sheikh NJ, Kocaoglu DF, Lutzenhiser L. Social and political impacts of renewable energy: Literature review. Technological Forecasting and Social Change. 2016;108:102-10.
14. Darghouth NR, Barbose G, Wiser R. The impact of rate design and net metering on the bill savings from distributed PV for residential customers in California. Energy Policy. 2011;39(9):5243-53.
15. Eid C, Guillén JR, Marín PF, Hakvoort R. The economic effect of electricity net-metering with solar PV: Consequences for network cost recovery, cross subsidies and policy objectives. Energy Policy. 2014;75:244-54.
16. Grau T, Huo M, Neuhoff K. Survey of photovoltaic industry and policy in Germany and China. Energy Policy. 2012;51:20-37.
17. Nemet GF. Beyond the learning curve: Factors influencing cost reductions in photovoltaics. Energy Policy. 2006;34(17):3218-32.
18. Neij L. Cost development of future technologies for power generation—A study based on experience curves and complementary bottom-up assessments. Energy Policy. 2008;36(6):2200-11.
19. McCabe A, Pojani D, van Groenou AB. The application of renewable energy to social housing: A systematic review. Energy Policy. 2018;114:549-57.
20. Passey R, Spooner T, MacGill I, Watt M, Syngellakis K. The potential impacts of grid-connected distributed generation and how to address them: A review of technical and non-technical factors. Energy Policy. 2011;39(10):6280-90.
21. Alemán-Nava GS, Casiano-Flores VH, Cárdenas-Chávez DL, Díaz-Chavez R, Scarlat N, Mahlknecht J, *et al*. Renewable energy research progress in Mexico: A review. Renewable and Sustainable Energy Reviews. 2014;32:140-53.
22. Quitzow R. Assessing policy strategies for the promotion of environmental technologies: A review of India's National Solar Mission. Research Policy. 2015;44(1):233-43.
23. Chen C. Searching for intellectual turning points: Progressive knowledge domain visualization. Proceedings of the National Academy of Sciences. 2004;101(S1):5303-10.
24. Chen C. CiteSpace: a practical guide for mapping scientific literature: Nova Science Publishers Hauppauge, NY; 2016.
25. Chen C, Chen Y, Horowitz M, Hou H, Liu Z, Pellegrino D. Towards an explanatory and computational theory of scientific discovery. Journal of Informetrics. 2009;3(3):191-209.
26. Chen C. Mapping Scientific Frontiers The Quest for Knowledge Visualization. 2 ed. London: Springer; 2014.
27. Aryadoust V, Tan HAH, Ng LY. A Scientometric review of rasch measurement: the rise and progress of a specialty. Frontiers in Psychology. 2019;10:2197.
28. Castillo-Vergara M, Alvarez-Marin A, Placencio-Hidalgo D. A bibliometric analysis of creativity in the field of business economics. Journal of Business Research. 2018;85:1-9.
29. Wang Q, Li R, He G. Research status of nuclear power: A review. Renewable and Sustainable Energy Reviews. 2018;90:90-6.
30. Chen C, Leydesdorff L. Patterns of connections and movements in dual-map overlays: A new method of publication portfolio analysis. Journal of the Association for Information Science and Technology. 2014;65(2):334-51.
31. Ciriminna R, Simakova IL, Pagliaro M, Murzin DY. A Scientometric Analysis of Catalysis Research. Journal of Scientometric Research. 2020;9(3):335-43.
32. Bar-Ilan J. Which *h*-index?-A comparison of WoS, Scopus and Google Scholar. Scientometrics. 2008;74(2):257-71.
33. Adriaanse LS, Rensleigh C. Web of Science, Scopus and Google Scholar: A content comprehensiveness comparison. The Electronic Library. 2013.
34. Mondal D. Scientometric Assessment of Indian Scientists' Contribution to Selected Physical Review Journals during 2004-2018. Journal of Scientometric Research. 2020;9(2):146-53.
35. Aryadoust V, Ang BH. Exploring the frontiers of eye tracking research in language studies: a novel co-citation scientometric review. Computer Assisted Language Learning. 2019:1-36.
36. Dong B, Xu G, Luo X, Cai Y, Gao W. A bibliometric analysis of solar power research from 1991 to 2010. Scientometrics. 2012;93(3):1101-17.
37. Du H, Li N, Brown MA, Peng Y, Shuai Y. A bibliographic analysis of recent solar energy literatures: The expansion and evolution of a research field. Renewable Energy. 2014;66:696-706.
38. Kitchenham B. Procedures for performing systematic reviews. Keele, UK, Keele University. 2004;33(2004):1-26.
39. Denyer D, Tranfield D. Producing a systematic review. 2009.
40. O'Connor A, Sargeant J, Wood H. Systematic reviews in Veterinary Epidemiology. 4 ed: John Wiley and Sons Ltd., 2017.
41. Chen C, Ibekwe-SanJuan F, Hou J. The structure and dynamics of cocitation clusters: A multiple-perspective cocitation analysis. Journal of the American Society for information Science and Technology. 2010;61(7):1386-409.
42. Sangster AJ. Solar photovoltaics. Electromagnetic Foundations of Solar Radiation Collection: Springer; 2014. p. 145-72.
43. Jager W. Stimulating the diffusion of photovoltaic systems: A behavioural perspective. Energy Policy. 2006;34(14):1935-43.
44. Gerbens-Leenes P, Hoekstra AY, Van der Meer T. The water footprint of energy from biomass: A quantitative assessment and consequences of an increasing share of bio-energy in energy supply. Ecological economics. 2009;68(4):1052-60.
45. Denholm P, Hand M. Grid flexibility and storage required to achieve very high penetration of variable renewable electricity. Energy Policy. 2011;39(3):1817-30.
46. Zhang N, Wan S, Wang P, Zhang P, Wu Q. A bibliometric analysis of highly cited papers in the field of Economics and Business based on the Essential Science Indicators database. Scientometrics. 2018;116(2):1039-53.
47. Corbet S, Dowling M, Gao X, Huang S, Lucey B, Vigne SA. An analysis of the intellectual structure of research on the financial economics of precious metals. Resources Policy. 2019;63:101416.

48. Denholm P, Margolis RM. Evaluating the limits of solar photovoltaics (PV) in traditional electric power systems. Energy Policy. 2007;35(5):2852-61.
49. Denholm P, Margolis RM. Evaluating the limits of solar photovoltaics (PV) in electric power systems utilizing energy storage and other enabling technologies. Energy Policy. 2007;35(9):4424-33.
50. Fthenakis V, Mason JE, Zweibel K. The technical, geographical, and economic feasibility for solar energy to supply the energy needs of the US. Energy Policy. 2009;37(2):387-99.
51. Jacobson MZ, Delucchi MA. Providing all global energy with wind, water, and solar power, Part I: Technologies, energy resources, quantities and areas of infrastructure, and materials. Energy Policy. 2011;39(3):1154-69.
52. Kwan CL. Influence of local environmental, social, economic and political variables on the spatial distribution of residential solar PV arrays across the United States. Energy Policy. 2012;47:332-44.
53. Hughes JE, Podolefsky M. Getting green with solar subsidies: evidence from the California solar initiative. Journal of the Association of Environmental and Resource Economists. 2015;2(2):235-75.
54. Jaffe AB, Newell RG, Stavins RN. A tale of two market failures: Technology and environmental policy. Ecological Economics. 2005;54(2-3):164-74.
55. Jacobsson S, Lauber V. The politics and policy of energy system transformation—explaining the German diffusion of renewable energy technology. Energy Policy. 2006;34(3):256-76.
56. McDonald A, Schrattenholzer L. Learning rates for energy technologies. Energy policy. 2001;29(4):255-61.
57. Geels FW. Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. Research Policy. 2002;31(8-9):1257-74.
58. Chen L, Wei Q, Li J, Liao D, Feng D. A scientometric visualization analysis for global toxicology and pharmacology research of natural products from 1962 to 2018. Phytomedicine. 2020;68:153190.

Cite this article: Noor MIM, Abdullah MF, Awang N. A Scientometric Review of Solar Energy Research in Business Economics. J Scientometric Res. 2023;12(1):114-29.