

Literature Review of Solar Photovoltaic Adoption Behavior Research: A detailed Scientometric Analysis (1978-2022)

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Abstract: This literature review investigates the Solar Photovoltaic (SPV) adoption behavior in households within the context of achieving Sustainable Development Goals (SDGs) and the global transition to Renewable Energy (RE) systems. From 1978 to 2022, the study addresses gaps in existing research through scientometric analysis, employing bibliometric-R packages and Biblioshiny. Analysis of 276 selected articles reveals an evolving trend in SPV adoption research, with a significant increase in publications from 2010 onwards. The USA leads in publications, followed by China, Germany, Australia, Italy, and India. Social sciences constitute 40.2% of the research, while business management, economics, and decision sciences also contribute substantially. This research results also highlighted the most cited authors and the most relevant journals. Evolutionary trends show an intensifying focus on SPV adoption, with variations in citation patterns over time. The study employs keyword co-occurrence analysis and a topic dendrogram to elucidate research themes, providing valuable insights for academics and practitioners. Despite limitations in database selection and the inductive approach, the research contributes to a significant understanding of SPV adoption behavior and suggests avenues for future exploration and refinement.

1 Introduction

SDGs, SPV, and households

The transition towards Renewable Energy (RE) systems has guided the pursuit of Sustainable Development Goals (SDG). In this pursuit, the Governments are committed to putting substantial efforts into successful

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RE transformation of commercial, transportation, and industrial sectors (Hafezi & Alipour, 2021; Alipour et al., 2019). Solar Photovoltaic (SPV) technology is the single largest potential source and the key player in the RE transition (IEA 2019; Alipour et al., 2019). From 2010 onwards the deployment of SPV as a low-carbon RE solution has witnessed remarkable exponential growth. Specifically, there has been a staggering 2078% increase in the electricity generation segment globally, surging from 32 TWh in 2010 to an impressive 697 TWh by 2019. Furthermore, this trajectory is anticipated to align with SDGs, with a projected 2732 TWh of electricity generation by the year 2030 (IEA, 2019). In the pursuit of sustainable development, households emerge as a pivotal target group, urging governments to recognize their newfound role as a significant market segment (Alipour & Sheykhan, 2017). These households play a crucial role in shaping policy decisions to fulfill SDGs through RE deployment (Agnew & Dargusch, 2015).

1.2 Research Objectives

Researchers have extensively explored various parameters to predict and shed light on household decision-making behavior concerning SPV adoption. For instance, Wolske et al. (2017) dig into the predictors of SPV adoption, considering environmental benefits, consumer goods, and innovative decision perspectives. Recent reviews on SPV adoption-related themes have primarily centered around technical challenges and corresponding measures (Luthander et al., 2015; Haque & Wolfs, 2017). Despite these efforts, the existing literature on SPV adoption behaviors remains largely unsatisfactory (Hafezi & Alipour, 2021). Examining Solar Photovoltaic (SPV) adoption behavior through scientometric tools is an exciting concept to enhance our understanding and track research trends in the SPV adoption and consumer behavior domain. This study addresses a significant research gap by employing scientometric analysis and bibliometric coupling to deepen and enhance the understanding of SPV adoption behavior research. The focus spans five decades (1978–2022), aiming for a comprehensive exploration of the field. The research objectives involve identifying key contributors, including scholars, establishments, and nations involved in SPV adoption behavior research.

It also examines international collaboration patterns through authorship configurations and analyzes global publication and citation trends.

1.3 Research Significance

This research holds significant implications for advancing understanding and guiding action in the realm of Solar Photovoltaic (SPV) adoption behavior. By systematically analyzing five decades of literature (1978-2022) through scientometric tools, the study not only fills existing gaps in SPV adoption research but also provides a comprehensive resource for scholars, policymakers, and practitioners. The identification of key contributors, including authors and countries, facilitates collaboration and knowledge exchange. The evolution of research trends over time, coupled with insights into publication patterns and highly cited works, offers a valuable historical context for developing SPV adoption behavior research. The focus on household behavior as a pivotal element in achieving Sustainable Development Goals aligns with the global imperative for sustainable energy solutions. Moreover, the detailed subject area analysis, ranging from social sciences to business management and decision sciences, highlights the interdisciplinary nature of SPV adoption research. The implications extend to guiding future research endeavors, refining methodologies, and addressing the limitations identified in the study. Ultimately, this research serves as a foundational contribution to the understanding of SPV adoption behavior, supporting informed decision-making in the pursuit of renewable energy and sustainable development objectives.

2 Research Methodology

The study conducts scientometric analysis by utilizing the Bibliometric-R package and Biblioshiny for a thorough analysis, incorporating visualizations such as word growth dynamics and topic dendrogram to elucidate the knowledge domain landscape. Scientometric analysis statistically, graphically, and quantitatively depicts the landscape of

various academic fields (Majeed & Ainin, 2020; Dominko & Verbič, 2019). Particularly, researchers in the areas of knowledge management, strategy, leadership, entrepreneurship, socioeconomic research, psychology, HRM, and organizational behavior have utilized a scientometric approach for knowledge synthesis (Zupic & Čater, 2015). Co-citation and co-occurrence analysis are the key techniques employed in scientometric analysis (Boyack & Klavans, 2010). Furthermore, bibliometric analysis facilitates scientific researchers to explore, organize, and approach large amounts of research data and makes it possible to approach, understand, and analyze past research and apprehend future research and developments (Albort-Morant & Ribeiro-Soriano, 2016). Bibliometric analysis approach is meticulous and it has been widely studied in disciplines of management (Podsakof et al., 2008), social entrepreneurship (Rey-Martí et al., 2016), education (Diem & Wolter, 2013), innovation (Chatterjee & Sahasranamam, 2018), and knowledge management (Gaviria-Marin et al., 2019), leadership (Batistič et al., 2017), and medicine (Franks et al., 2006). A scientometric analysis is driven by a quality dataset that is extracted from world-renowned databases. Databases such as Scopus, Web of Science, ScieLO, and Google Scholar compile large statistical databases for bibliometric data analysis (Archambault et al., 2009). Current research uses the Scopus database which possesses a huge range of scientific research work in the fields of business, management sciences, and economics as its main strength (Mongeon & Paul-Hus, 2016).

2.1 Selection Criteria

At the first stage, the initial search produced 1892 articles. Research regarding “SPV Adoption Behavior” from 1978 to December 2021 is analyzed in this article. In the second stage further search, limited to subject areas: social sciences, business management and accounting, economics, econometrics and finance, and decision sciences, reduced the research results to 386. Furthermore, applying the filter of only published research articles produced 276 pieces of research. The keyword search scope was within the title, abstract, and keywords to be used in the

bibliometric technique (Batistič et al., 2017). The selection criteria are shown in Table 1.

Table 1 Selection criteria for sample articles

Serial	Search Steps	Records
1	Keywords: “solar” AND “photovoltaic” OR “purchase” AND “decision” OR “adoption” AND “behavior” OR “residential” OR “renewable”	1892
2	Year limit: 1978-2022, Search Scope: Title, Abstract, Keywords,	1892
3	Subject Area: Social Sciences, Business Management and Accounting, Economics Econometrics and Finance, Decision Sciences	392
4	Language limit: English	386
5	Document Type: All published articles	276

2.2 Research Design

To fulfill the objectives of this research project, a scientometric analysis of research work evolved during the period of more than four decades 1978-1990, 1991-2000, 2001-2010, and 2011-2021 is performed. The research themes with designated keywords, using keywords “solar”, “photovoltaic”, “purchase”, “decision”, “adoption”, “behavior”, “residential”, and “renewable” were extracted to know the major trends in the field of SPV behavior among households. Scientometric analysis was performed using R-Studio software with the Biblioshiny package. To conduct bibliometric analysis a full counting method is used which has been explained in the following schema.

Stage 1: Historical evolution of themes about “Photovoltaic Adoption Behavior” among households embedded in the publications (title, abstract, keywords) in the field of business. social science. and economics.

Stage 2: Co-citation analysis, giving a brief profile of leading references which are co-cited

Stage 3: Co-authorship analysis, to provide analysis of networks formed through co-authorship from different geographical regions.

Stage 4: Intellectual knowledge and conceptual structures of the major contributors in the field

Stage 5: Keyword Analysis

3 Data analysis and key results

3.1 Most contributing authors

Table 2 specifies the information about the top 30 leading authors (score based on most publications). Authors Wolske KS, Higgins A, Pearce JM, Sigrin B have written 3 articles each whereas Palm A, Wüstenhagen R, Palm J, Kang H-Y, Simpson G, Ahmad S, Zhang Y, Ma C, Best R, Sun L, Muñoz-Cerón E, JR, Foliente G, Guo Q, Hong T, and Yang D, have published 2 articles each.

Table 2 Authors with most number of publications

Authors	Articles
Wolske KS, Higgins A, Pearce JM, Sigrin B	3
Palm A, Wüstenhagen R, Palm J, Kang H-Y, Simpson G, Ahmad S, Zhang Y, Ma C, Best R, Sun L, Muñoz-Cerón E, Jr, Foliente G, Guo Q, Hong T, Yang D, Bruckner T, Li X, Scheller F, Schulte E, Leibowicz BD, Schelly C, Bertsch V, Zhou L, Xu X, Siluk JCM	2

Table 3 specifies the information about the most cited authors. The authors who are among the highly cited are Scarpa R and Willis K with 317 citations, Amer M and Daim TU with 242 citations, Gillingham K and Graziano M with 224 citations, Girod B, Hoppmann J, and Huenteler J with 189 citations. Furthermore, the authors who have contributed to the relevant literature are Choi J-K, Fthenakis V, Heath GA, Hsu DD, Kim HC, O'donoughue P, Sawyer P, and Turney DE with 184 citations, Palm A with 183 citations, Wolske KS with 182 citations, Dietz T, and Stern PC with 140 citations.

3.2 Evolution of publication and citations trend by year

The data analysis for year-wise annual production reveals the publication trend regarding the research on solar-based photovoltaic adoption behavior. The research slowly started in 1981 with just 1 published article and 1 article in 1982. No research was published during the years 1983 to 1992. In 1993 only 1 article was published. The publication trend began to rise during the 1990s slowly and 2000s. In the year 2010 onwards till 2021 there was a continuous rise in the number of publications. The number of publications rose to 57 in the year 2021. The evolution of publication and citation trends is shown in Table 4. The trend analysis is divided into three equal periods. Articles published from 1981-1994 show the lowest number of citations (17), citations/year (1.21), and average citations (5.7). The period of 1995-2008 shows a huge rise in the citations trend with citations rising to 229, citations/year 16.36 and an average citations score of 32.7 was also good. The citation trend rose high from 2009 to 2021 as a total of 622 citations were recorded with 44.43 citations per year but the average citation trend was reduced to 2.3 only.

Table 3 Authors Impact with most cited authors.

Authors	Citations	Articles	Citations/article
Scarpa R	317	1	317

Willis K	317	1	317
Amer M	242	1	242
Daim TU	242	1	242
Gillingham K	224	1	224
Graziano M	224	1	224
Girod B	189	1	189
Hoppmann J	189	1	189
Huenteler J	189	1	189
Choi JK	184	1	184
Fthenakis V	184	1	184
Heath GA	184	1	184
Hsu DD	184	1	184
Kim HC	184	1	184
O'donoghue P	184	1	184
Sawyer P	184	1	184
Turney DE	184	1	184
Palm A	183	2	91.5
Wolske KS	182	3	60.7
Dietz T	140	1	140
Stern PC	140	1	140

Table 4 Evolution of articles, citations trend, and citations/year

Period	1981-1994	1995-2008	2009-2022
Results-Articles	3	7	266
Total Citations	17	229	622
Results/year	0.21	0.50	19.00
Citations/year	1.21	16.36	44.43
Average Citations	5.7	32.7	2.3

3.3 Analysis by country

Table 5 shows that the USA has produced the most number of publications preceded by China, Germany, Australia, Italy, and India.

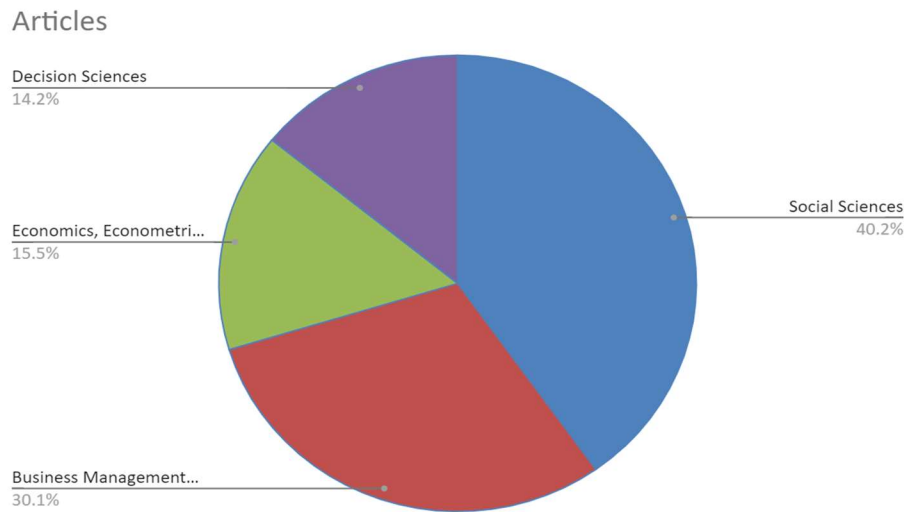
Table 5 Country-wise spread of publications

Country	Articles
USA	181
China	88
Germany	47
Australia	44
Italy	43
India	38
Spain	37
Brazil	33
Iran	28
South Korea	24
UK	20

3.4 Analysis by Subject Area

Figure 1 shows the common research areas in the field of photovoltaic adoption behavior. The social sciences area is at the top with 40.2% of the total research work, business management contributes 30.1%, economics and econometrics contributes 15.5% and the decision sciences area contributes 14.2%.

Figure 1 Key domains -subject areas



3.5 Analysis by source (Journals)

Table 6 shows the most productive journals. The most productive journals are the Journal of Cleaner Production with 39 articles, Sustainability with 34 articles, Energy Research and Social Science with 16 articles, and Energy Economics with 15 articles. Other journals in the list have published 10 or less than 10 articles.

3.6 Mapping Analysis

Keyword co-occurrence analysis as shown in Figure 2 (Treemap) is used to classify the succeeding themes in photovoltaic adoption behavior research. Figure 2 shows the larger occurrence for the keywords with higher frequency and vice versa. The presentation of keyword frequency in the form of a tree map helps the researchers to identify key research areas and the subsequent gaps for further research debates. The hierarchy of data sets is based on color combinations, size, and dimensions of the cubes in the tree map. The treemap highlights the combination of keywords signifying the research in the relevant field.

Table 6 List sources-journals with the most number of articles

Sources	Articles
Journal of cleaner production	39
Sustainability (Switzerland)	34
Energy research and social science	16
Energy economics	15
Energy for sustainable development	10
Technological forecasting and social change	10
Sustainable cities and society	8
International journal of energy sector management	5
Ecological economics	4
International journal of energy economics and policy	4

3.7 Topic Dendrogram

Another cluster analysis is performed to reveal the similarities and dissimilarities between the classified objects. A complete dendrogram presents such classification through a dendrogram. A dendrogram facilitates the researcher to evaluate the estimated number of clusters but it restricts to discovery of the perfect association among these clusters (Andrews, 2003). The horizontal axis represents the dissimilarity among the clusters and the vertical lines represent the pooled topics. The dendrogram is divided into two strands with maximum developments and divisions. Each block clusters different areas of interest.

Figure 2 Tree maps of themes



4 Conclusion and recommendations

4.1 Conclusion and discussion

Research on photovoltaic adoption behavior continues to nurture several study and research disciplines and countries with solid roots in business management academic research. The current study covers the largest sample (1978-2022) of published research on SPV adoption behaviors of households as suggested a huge gap by (Alipour et al., 2020) through scientometric analysis to statistically and quantitatively show the landscapes of different research fields in academics just like the studies performed by (Majeed & Ainin, 2020; Dominko & Verbič, 2019). Previously, the seminal works of (Alipour et al., 2020) and (Alipour et al., 2021) have not only synthesized the collection and combinations of various predictors but also developed a taxonomy of these predictors to affect SPV adoption behaviors. The review work done by (Wolske et al., 2017) has also synthesized the SPV adoption literature within the context of behavioral theories. Previously, a diversity of quantitative and qualitative techniques, methodologies, and methods edified a huge pile of literature that raises adequate space for stocktaking for future research. Modern tendencies in research on SPV adoption behaviors have urged to establishment of a methodological and succinct review. Currently, synthesizing the research on SPV adoption behavior has given valuable insights to academics, and practitioners. This research article has quantitatively presented the research leads, sources, collaborations, and origins that have been adored by the research community while doing the SPV adoption behavior research. Current research is an effort to trace this progression through the historical context (1978-2022) by distinguishing the most influential authors, journals, organizations, and countries. This methodology can be replicated, to sum up the advanced knowledge and research in various business research fields and is particularly relevant for the researchers dedicated to the field of SPV adoption behaviors.

4.2 Limitations

Although this research covers a comprehensive datasets with an ample span of years, still it engulfs some perceptible limitations. The selection criteria for subject area and document type raise the principal constraint in

the research design. Nevertheless, this limitation in the meanwhile offers room for future research endeavors by setting an enlarged selection criterion to extract the sample articles from Scopus or any other database. Furthermore, we conducted this research with an inductive approach accompanying an objective stance to have rich findings through raw data. This research is limited to finding its primary objective of exploring the evolution and development of photovoltaic adoption behavior research. In this pursuit, the inquiry about macro contextual factors in this domain with a multidisciplinary approach is still unheard of and can be rediscovered with the same sample size. In co-authorship instances, the deep insight into the social ties among the authors is not included in the scope of this research. This limitation can be worked on in the future for further understanding of intellectual advancement and social linkage of authors and shared working experiences among authors. The evolution progress of SPV adoption behaviors is demonstrated against the criterion of specific time zones. This limitation can be further addressed in the future through a fine-grained criterion of sub-themes, and keywords.

4.3 Implications and future research directions

From an academic point of view this study can guide the researchers well to witness the dynamic changes in the mentioned domain through distinguished representations and models. Bibliometric with science mapping has helped the researcher to distinguish leading authors, most productive journals, and most researched themes in the research domain of solar-based renewable energy adoption decisions. The bibliometric analysis has also figured out the most cited authors, journals, databases, and the evolution of research themes within the timeline of 1978-2022. Database limitation affects the basics of bibliometric analyses i.e. bibliometric coupling, science mappings, co-citation analysis, etc. By delimiting the database selection choice the basic results of bibliometric analysis can give altogether a different picture of revolution progress in the relevant field. Finally, future research can focus on a practitioner-focused approach which will be a nice move towards practitioner achievement from the academic dialogues.

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