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Electric Vehicle Research: A Bibliometric Analysis of Research Trends and Knowledge Structure

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Abstract

The transition to electric mobility has led to a significant expansion in scholarly publications on electric vehicles across multiple disciplines. Understanding the growing body of literature helps identify dominant research directions and patterns of growth and development in this field. This study presents a bibliometric analysis of 16,859 publications extracted from the Scopus database between 2016 and 2025. This study uses bibliometric techniques, comparative author impact, conceptual clustering and publication source concentration. The analytical framework integrates four complementary methods: (a) abstract-based keyword thematic classification into eight research domains, (b) title-based VOSviewer clustering to reveal intellectual linkages among research topics, (c) a comparative analysis of full and fractional citation counting to evaluate author-level impact and (d) Herfindahl-Hirschman Index analysis to quantify the concentration of EV publication sources. The results reveal that technological fields dominate Electric vehicle research; a comparative author impact analysis shows notable rank divergence between full and fractional counting methods; the title-based conceptual clustering indicates interconnectedness centred on battery technology, charging infrastructure and AI-based optimisation; and publication source analysis indicates a moderate concentration. Overall, this study offers a structured, multidimensional overview of the intellectual landscape of EV research and a roadmap for guiding future investment in EV scholarship.

Keywords: Bibliometric Analysis, Citation Analysis, Electric Vehicles, Fractional Counting, Full Counting, Thematic Analysis.

Introduction

The global transportation sector is transitioning towards sustainable alternatives to fossil-fuel-based mobility. The transition to Electric Vehicles (EVs) has become a crucial means of reducing greenhouse gas (GHG) emissions, improving energy efficiency and decarbonizing the transport sector (1, 2). Unlike internal combustion engine (ICE)-based vehicles, EVs operate on batteries and have zero tailpipe emissions, thereby presenting an opportunity to develop a sustainable mobility system (3, 4). From a climate and economic perspective, EVs offer a solution for one of the largest-emitting sectors, which contribute 20-25 per cent of global CO2 emissions. Additionally, switching to EVs can provide energy security for major economies by reducing dependence on fossil fuels (5). Consequently, EV development is increasingly oriented towards technological advancement, stimulating new industrial sectors in battery manufacturing, charging infrastructure and clean energy.

EVs have shown rapid adoption worldwide, with more than 17 million vehicles in 2024 and accounting for over 20 per cent of new vehicles sold globally. Sales are expected to reach twenty-five million by 2030, driven by technological innovation, expanding charging infrastructure and continued policy support (6, 7). With the ongoing expansion of the EV industry, scholarly contributions in the EV domain have grown across multiple disciplines, with an average year-on-year growth of 23.3 per cent between 2015 and 2025, as shown in Figure 1. With this exponential growth in research, systematic mapping is necessary to understand where progress has been made in the EV-related research domain.

Figure 1 illustrates the annual publication in EV research-related publications from 2016 to 2025.

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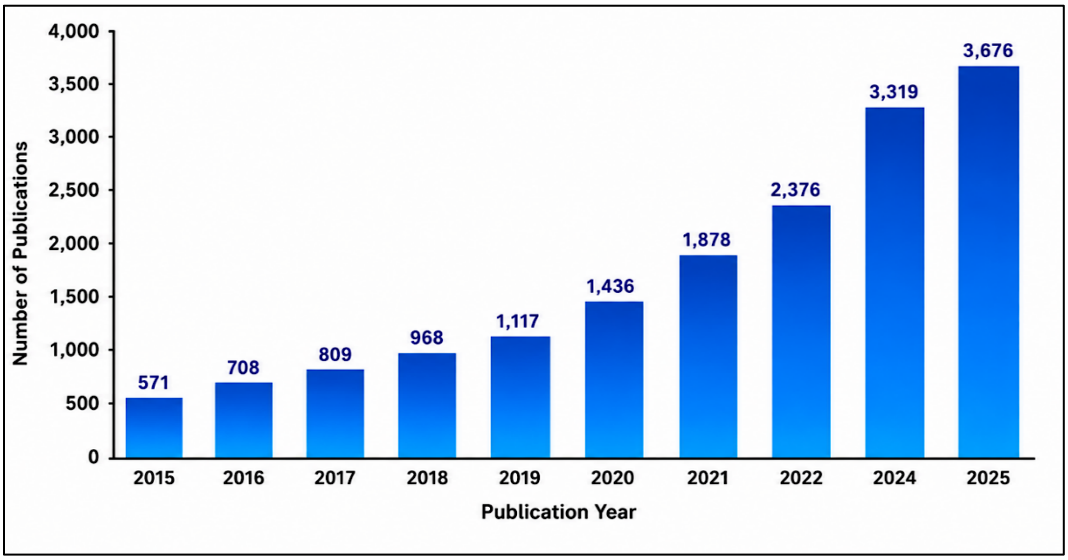

Figure 1: Year-wise Publication of Research from the Period 2016-2025
(Average YoY Growth (2015-2025): 23.3%)

The trend shows a consistent upward trajectory, with sharp growth from post-2020 onwards, reflecting research and industrial investment in the EV sector. India, the world's third-largest automobile market, has seen a rapid surge in EV registrations, driven by the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) and the National Electric Mobility Mission Plan (NEMMP). EV registrations in India crossed 1.5 million units in 2022-23, with two- and three-wheelers accounting for over 90 per cent of the domestic EV fleet (8, 9). Recent production-linked incentives and state-level subsidies in India have set a national target of achieving 30 per cent EV penetration across all vehicle categories by 2030 (10, 11). The representativeness of global EV knowledge mapping allows for a more nuanced understanding of how a major developing economy shapes and contributes to EV research trajectories.

EV research covers a wide range of topics. The framework for understanding the diversity and growing volume of research can be systematically analysed using bibliometric methods, offering a structured approach to analysing EV research across domains (12, 13). In this context, this study has three research questions: RQ1: What are the dominant growing themes in EV research domains and how are the research topics in the EV research fields interlinked? RQ2: How do the leading authors' rankings differ when evaluated using the full and fractional citation counting methods? RQ3: How are publications distributed and concentrated across all publication outlets?

Theoretical Background of Bibliometric Analysis

Bibliometric analysis provides a systematic framework for mapping the growth and knowledge of the various research domains within the broader research field (14, 15). Bibliometric analysis includes citation analysis, keyword co-occurrence and clustering of research papers, which reveals the emerging topics, dominant contributors, gaps and future directions for study (16-18). Given the exponential growth of publications in the EV domain, its application to this field can review it without being prone to selective bias.

Thematic and Technological Coverage

The bibliometric analysis of the EV research domain focuses on technological dimensions. Using Scopus and Vosviewer, 15 thematic clusters were identified, including AI-enabled EV infrastructure, logistics and charging infrastructure (19). Trends in new domains such as EV power electronics, charging systems and energy management were analysed using Scopus and Web of Science databases, integrating with policy, which showed it as a key driver alongside lithium batteries, smart charging and V2X. The evolution of EV research was traced into three phases: 2010-14 on battery technology, 2015-19 on consumer adoption and grid connectivity and 2020-24 on AI-based energy management, autonomous EVs and circular battery ecosystems (20, 21).

Adoption, Policy and Sustainability Perspectives

The social and policy domain of EV-based bibliometric research is smaller in volume and depth than the technical domain. Publication growth in EV adoption is highly skewed towards China, the USA and Europe, leaving developing economies underrepresented in this domain (1, 22). The integration of sustainability, clusters related to adoption, the circular economy and supply chain resilience and the rise of environment-related domains post-2017, driven by climate change policy, were analysed using bibliometric methods (2, 23). Infrastructure gaps and upfront costs, which act as both motivators and barriers to EV adoption, were identified through a network-based cluster analysis.

Supply Chain and Cross-disciplinary Studies

The EV supply chain analysis, with a core focus on critical minerals, geographic dependence and recycling inefficiencies, highlights the major risks posed by material shortages in the EV industry (24). The global bibliometric mapping of EV research from 2000 to 2023 identified four dominant research clusters within EV domains: battery technology and materials science; charging infrastructure and smart grids; consumer adoption and policy; and sustainability and life cycle assessment, with strong collaboration networks between European and Chinese universities. Multiple analyses were used within the bibliometric framework, including co-citation, keyword and content analyses. The findings from bibliometric analysis suggest a gradual transition from conceptual adoption studies to technological and infrastructure research (25).

A review of the existing EV-based bibliometric literature reveals three structural gaps. First, existing studies have adopted keyword co-occurrence clustering or content analysis, but not an integrated framework that combines both approaches, thereby limiting the intellectual mapping of studies. Second, the studies used full citation counting as the sole measure for author impact, which can inflate individual influence in highly collaborative studies (14, 26). No prior EV bibliometric studies adopted fractional counting as a comparative method. Third, the publication identified the leading journals, but the distributional concentration of EV research across publication sources has not been quantitatively examined.

Addressing these gaps, this study makes three contributions. Firstly, integrating abstract-based thematic classification with title-based VOSviewer clustering to provide a multidimensional map of research structure. Second, a comparative full and fractional citation counting analysis to reveal the changes in author impact. Third, the application of the Herfindahl-Hirschman Index to quantify the concentration of EV publication sources.

Methodology

Research Design

This study adopts a quantitative research design using bibliometric analysis to systematically examine the intellectual structure, development trajectory, thematic organization and publication patterns of EV research. Bibliometric analysis systematically maps different research domains by evaluating large bodies of literature using statistical and network-based techniques, such as co-authorship networks, keyword co-occurrence and citation analysis, revealing emerging topics and dominant contributors (13).

Data Source

The Scopus database was chosen for the bibliometric analysis because it provides the most comprehensive multidisciplinary coverage among major bibliographic databases, indexing research across science, technology, engineering and social science domains and offering structural metadata for published research, making it a valuable resource for this study. Data were exported using a structured search query designed to capture the literature on EV research domains, including technological, economic, environmental and policy dimensions. Specific keywords were applied in the Scopus search as follows:

"TITLE-ABS-KEY: ("electric vehicle*" OR BEV OR PHEV) AND (ADOPTION OR POLICY OR SUBSID* OR "CHARGING INFRASTRUCTURE" OR "BATTERY TECHNOLOGY" OR SUSTAINABILITY OR "TOTAL COST OF OWNERSHIP" OR EMISSION*)

The initial keyword search yielded 42,361 publications. Furthermore, to capture recent research in the EV domain, the period from 2016 to 2025 was selected, yielding 34,730 documents. The time frame was chosen because it aligns with the major acceleration in global EV research, allowing us to focus on recent expansion trends, thematic shifts and the current state of knowledge development in the field. Next, the top five countries, China, the US, India, the UK and Germany, were selected because of their prominence for the most research publications in this domain. This study provides a focused view of EV research in high-output regions.

The bibliographic record was exported to CSV and RIS formats and processed in R using the bibliometric package. The pre-processing steps included removing duplicate records via title-author string matching in Zotero and those with missing rows and data using Excel—the final cleaned dataset comprised 16,859 documents, which formed the basis for all subsequent analyses. The processed bibliographic dataset used in this study is publicly available on Mendeley Data.

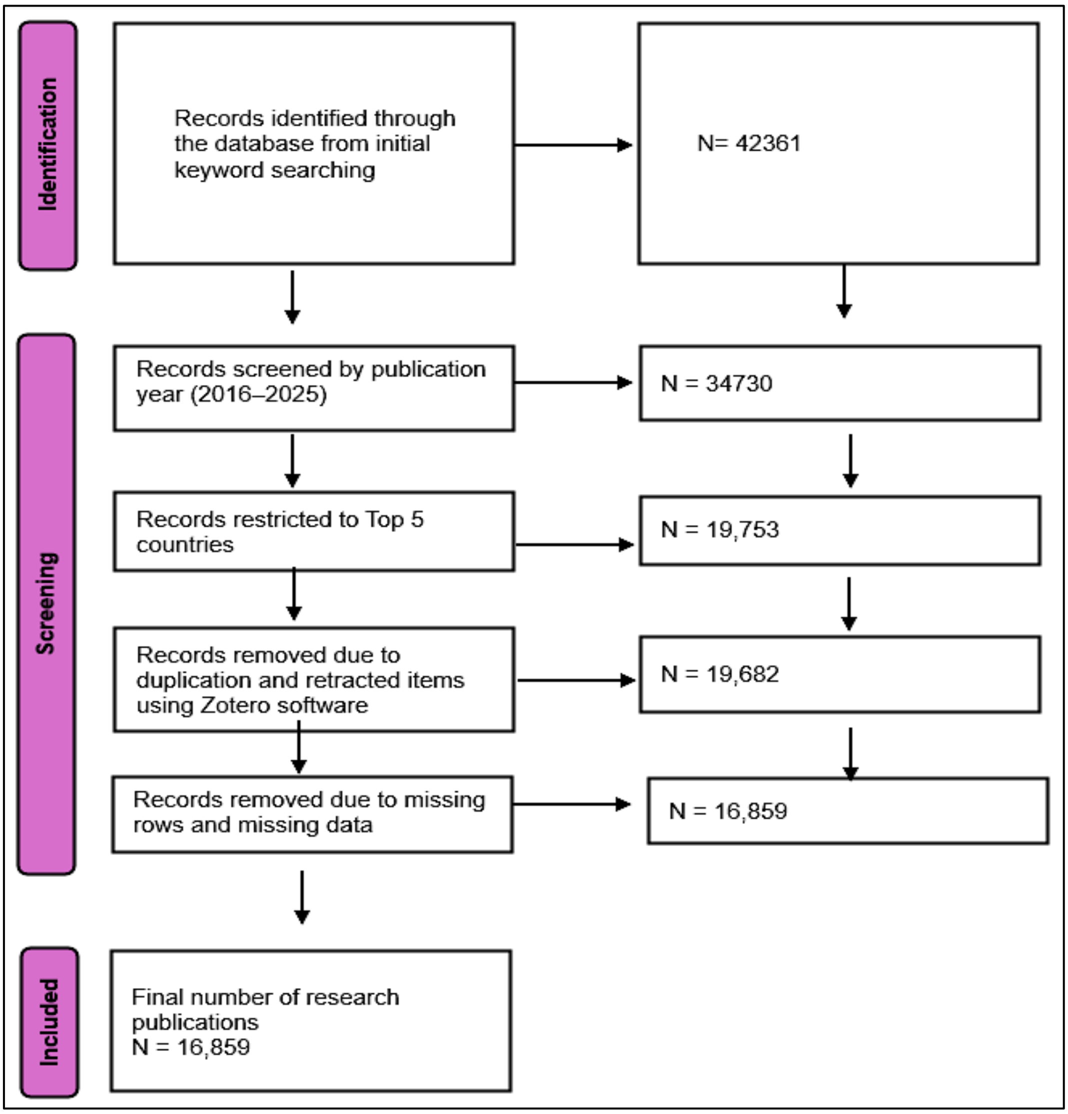

Figure 2: Prisma Flow Diagram of Publication Selection

Figure 2 presents the PRISMA flow diagram detailing the systematic selection of publications used in the study. From an initial set of 42,361 records, 16,859 publications were screened and included in the bibliometric analysis.

Analytical Procedures

Identification of influential contributors

Influential contributors to research publications were identified using citation-based indicators and publication counts. Authors were ranked by total citation impact and number of publications to identify the leading contributors in the dataset. EV research is highly collaborative, involving large interdisciplinary teams (19, 21, 25). The study adopts the two counting methods, full and fractional counting, to evaluate how authors' ranks under the two methods translate into changes in contributors' influence, which is not considered in prior EV bibliometric studies.

In the Full counting method, each co-author of a publication receives full credit for the publication's citation count. Therefore, this method reflects the collaborative nature of research and can overestimate authors' influence in highly collaborative fields (14, 27). In contrast, in Fractional Counting, citation credit is divided equally among all authors and co-authors, calculated by dividing the total citations of the publication by the number of co-authors. Therefore, fractional citation counting ensures that each author's contribution to a publication is divided equally among all co-authors, so that the sum of the credit assigned to all authors equals the total citation for each publication, rather than being counted multiple times, as in the full-counting approach (28). Using both methods enable the identification of influential authors, providing a more balanced comparison by allowing the study to evaluate how author rankings change when collaborative effects are taken into account (29).

For fractional counting, the following procedure was performed in R:

(a) Author names were standardized by removing formatting inconsistencies. (b) Citation counts were extracted from the dataset's metadata. (c) Multi-author strings were separated to generate individual author entries. (d) For each publication, the citation count was divided by the number of authors. (e) The fractional citations were then aggregated across all publications associated with each author.

Thematic Extraction from Abstract

Ensure reproducibility in the thematic categorisation of EV research over time, a keyword-based classification procedure is applied to the abstracts of all publications. In which predefined themes were first generated through an inductive review of the dataset's abstracts and keywords. Then, these themes were used to classify large datasets of publications into research themes based on domain-specific terms in the abstracts (12, 16, 30). The procedure involved categorization of the literature into eight themes. For each theme, a set of representative keywords was constructed, as shown in Table 1. Steps involved in this procedure:

Step 1: Tokenization and stop word removal yielded the main terms such as "battery," "adoption," "electric vehicle deployment," "urban charging infrastructure," "city power demands," "sustainable growth," "findings" and others given in Table 1.

Step 2: Calculating term frequencies; high-occurrence concepts such as "charging station," "grid," "Lithium," "algorithm," and "load" were noted.

Step 3: The terms were then mapped to predefined conceptual themes, applying semantic representation methods for keyword analysis in bibliometric research (31). The extraction translated the unstructured text into meaningful themes, as shown in the table.

Assess the classification: a random sample of 100 classified abstracts was manually reviewed to confirm theme consistency.

Table 1: Showing Themes Generated by Using an Abstract

Theme	Extracted Keywords from Abstract	Description
Battery and Energy Storage	"battery", "lithium", "cathode", "anode", "storage"	Research on battery chemistry, materials and storage technologies.
Charging & Infrastructure	"charge"," charging station"," charging infrastructure."	Development of charging systems and infrastructure planning.
Consumer Adoption	"Adoption," "acceptance," "intention," "attitude," "user"	Behavioural and psychological factors influencing EV uptake.
Grid Integration	"grid"," V2G"," Demand management", "Distribution", "Load"	Integration of EVs with power systems and load management.
Environmental Impact	"Emission," "carbon"," environmental," " sustainable," renewable"	Environmental and sustainability implications of EVs.
Policy and regulation	"Policy," "subsidy," "incentive", "regulation," "Strategy"	Government interventions, incentives and regulatory frameworks.
Economics and Market	"Cost," "market," "price," "economic," "industry"	Economic feasibility, pricing and market dynamics.

AI, Modelling and Optimisation	"Algorithm," "optimisation," "model," "simulation," "AI"	Computational models, optimisation and AI applications.

Table 1 presents eight abstract-based thematic domains identified through keyword extraction. 'Extracted Keywords from Abstract' lists the high-frequency terms identified after tokenisation and stop word removal that were assigned to each theme. 'Description' provides a brief characterisation of the research focus represented by each domain.

Conceptual Structure Analysis Using Tittle Clustering

Examine intellectual linkages among research topics. A clustering analysis was conducted using publication titles as a complementary analytical layer to abstract-based thematic classification, which contains highly conceptual information, to reveal relationships among documents and identify research fields within a domain (32). Clustering of scientific publications groups documents by similarity or citation relationships, enabling the identification of emerging research areas. Using titles rather than abstracts for clustering to reduce frequently used repetitive methodological terms used in publications and to further distinguish one research area from another. VOS viewer software was used to construct bibliometric networks and visualize clusters. VOS viewer is specifically designed to create and analyse bibliometric maps, enabling exploration of relationships between publications and themes (28). The minimum term-occurrence threshold was set to five. Further, the composition of clusters emerging from the title-based analysis was then compared with the eight themes identified through abstract classification, complementing each other in the thematic analysis of the EV research domain.

Publication Output Source Analysis

The distribution of knowledge across publication channels was evaluated using publisher-level output. The number of publications attributed to each publisher, the number of publications per publisher and the distribution concentration within the field were assessed.

The Herfindahl-Hirschman Index (HHI) was used to quantify concentration. The HHI is used in bibliometric research to evaluate concentration patterns, including author contributions, journal distributions and publication outputs, by measuring the number of entities and the inequality in their output shares, as given in Equation [1] (33). where si represents the proportional publication share of publisher i and the index ranges from 0 to 1, with lower values indicating a more dispersed distribution and higher values indicating a greater concentration.

$$HHI = \sum_{i=1}^{n} s_i^2 \quad [1]$$

Table 2: Table Showing the Herfindahl-Hirschman Index concentration range

HHI Range	Interpretation
0.00–0.10	Low concentration
0.10–0.18	Moderate concentration
>0.18	High concentration

Table 2 shows that the Herfindahl-Hirschman Index (HHI) ranges from 0 to 1. A value of 0.00–0.10 indicates low concentration, meaning EV publications are broadly dispersed across many sources. A value of 0.10–0.18 indicates moderate concentration. A value above 0.18 indicates high concentration, reflecting significant dominance by a small number of outlets.

This procedure extends from descriptive analysis to quantification of whether EV knowledge is centralised in a limited set of journals or dispersed across a broad range of journals.

Software and Visualisation tools

The two analytical software programs used were R statistical software and VOSviewer. R software was used for data preprocessing, trend analysis, ranking and thematic analysis. The VOS viewer was used to visualize the bibliometric network and clusters.

Results

Growth and Thematic Transformation of EV Research

Assess the scale of EV research output and the EV domain over time. This study integrates annual publications with trends from abstract-based classification. The annual number of publications provides foundational insights into the magnitude and publications from 2016-2025 were analysed using the final 16,859 published documents.

The thematic categorization of abstracts into dominant research domains shows that the annual publication volume of EV research is concentrated across different EV domains. Categorization was conducted into eight major themes: Charging and Infrastructure, Battery and Energy Storage, Environmental Impact, AI-Modelling and Optimization, Grid Integration, Economics and Market, Policy and Regulation and Consumer Adoption.

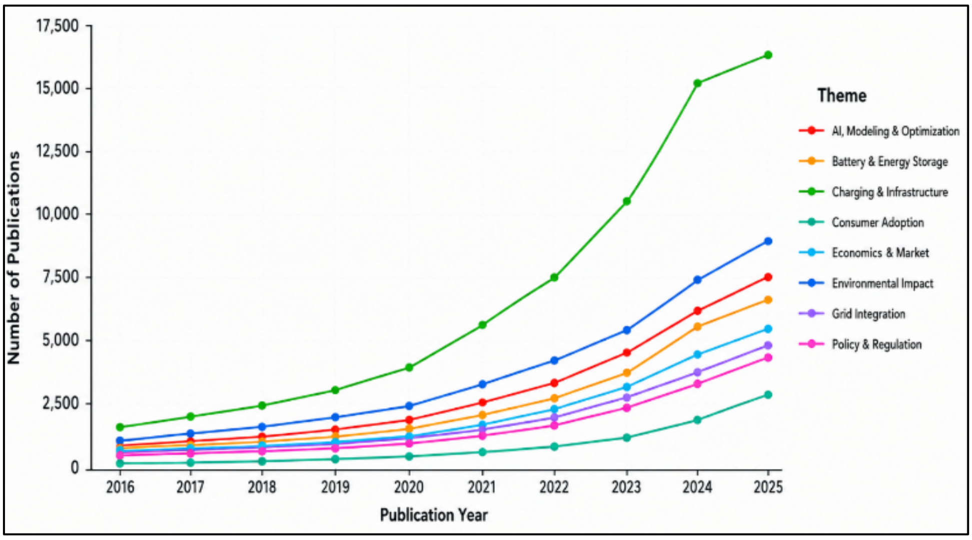

Figure 3: Rising Trajectory of EVs Research Domain

Figure 3 shows the growth of eight EV research themes from 2016 to 2025. Charging and Infrastructure, Battery Storage, AI-Modelling and Grid Integration are expanding steadily, whereas Policy, Regulation and Consumer Adoption are showcasing slow growth.

The Figure shows that all major themes, in which charging and infrastructure exhibit the most dramatic growth, particularly after 2021, suggesting that infrastructure scalability has become a central concern within the EV research ecosystem. Environmental impact displayed a strong upward trend from 2021, indicating increasing attention to sustainability assessment.

Battery and energy storage, AI modelling and optimization and grid integration have continued to expand in the EV research domain since 2020. This domain has experienced accelerated growth since 2022, as evidenced by the increasing number of research efforts on system-level integration of technological systems in the EV domain.

Economic and market indicators showed lower but consistent growth in the EV research domain, indicating that affordability remains a key variable and a major concern. In contrast, policy, regulation and consumer adoption demonstrated a comparatively slower expansion in the number of publications in this domain. This indicates that technological challenges continue to dominate research priorities, with behavioural and policy-oriented research publications lagging.

Structure of Scholarly Influence and Comparative Author Impact

Moving beyond publication growth, we examined scholarly contributions to the EV research domain. This study evaluates author-level impact using both cumulative citation counts (full counting) and fractional counting approaches.

Table 3: Top 20 Authors Based on the Full-counting Approach

Rank	Authors	Total citations	Number of Papers
1	Sovacool, Benjamin K.	5741	40
2	Lu, Jun	5419	4
3	Chen, Zhongwei	4509	7
4	Heidrich, Oliver	3818	6
5	Gaines, Linda L.	3629	3
6	Cano, Zachary P.	3518	2
7	Wang, Zhenpo	3356	19
8	Kendrick, Emma	3208	3
9	Abbott Andrew P.	3131	2
10	Slater, Peter R.	3124	2
11	Lambert, Simon M.	3076	2
12	Anderson, Paul A.	3047	1
13	Christensen, Paul Andrew	3047	1
14	Driscoll, L. L.	3047	1
15	Harper, Gavin D.J.	3047	1
16	Ryder, Karl S.	3047	1
17	Sommerville, R.	3047	1
18	Stolkin, Rustam	3047	1
19	Walton, Allan	3047	1
20	Hu, Xiaosong	3011	17

Table 3 shows 'Total Citations' based on cumulative citation counts under the full counting method, in which each co-author receives full credit for all citations accrued by shared publication. 'Number of Papers' denotes the total publications attributed to each author within the dataset. Authors are ranked in descending order of total citations.

As shown in Table 3, the full counting results indicate that many authors with only a single publication appear among the top-ranked contributors because of exceedingly high citation counts for that publication. This occurs when multiple authors contribute to a single highly cited paper, in which collaborative functions overestimate the influence of individual contributors. Analysis shows that the distribution of citations is highly uneven, with a small proportion of authors accounting for a large share of total citations.

To better understand the author's influence, fractional citation counting is applied, allocating citations proportionately across co-authors. Specifically, authors who collaborate with multiple authors tend to show reduced citation impact. Under fractional counting, authors with more independent-authored or small-team publications demonstrate a more stable ranking.

Table 4: Top Twenty-ranked Authors Based on the Fractional Counting Method

Rank	Authors	Total fractional citations	Number of papers
1	Manthiram, Arumugam	1814	5
2	Sovacool, Benjamin K.	1453	40
3	Muratori, Matteo	958	19
4	Hardman, Scott J.	717	16
5	Chen, Zhongwei	712	7
6	Noel, Lance	673	22
7	He, Hongwen	612	26
8	Cui, Yi	588	7
9	Hu, Xiaosong	587	17
10	Lin, Boqiang	583	16
11	Wang, Shanyong	575	13
12	Kockelman, Kara Maria	567	9
13	Tal, Gil	541	20
14	Wang, Zhenpo	538	19
15	Plötz, Patrick	514	23
16	Kester, Johannes	511	17
17	Kumar, Rajeev Ranjan	511	6
18	Alam, Mohammad Saad	502	11
19	Zhou, Yuekuan	501	7
20	Hao, Han	491	27

Table 4 shows that 'Total fractional citations' reflects citation counts allocated proportionately among co-authors. For example, a paper with 4 co-authors attracting 100 citations contributes 25 fractional citations to each author. 'Number of papers' denotes the total publications attributed to each author. Authors are ranked in descending order of total fractional citations.

The findings in the table reveal a divergence in citation metrics calculated using the fractional method, leading to a shift in author rankings. For instance, several who appear in the top ranks in the full-counting method do not maintain the same position, indicating that full counting is attributable to a collaborative network effect rather than to purely individual contributions. Thus, fractional counting adjustment provides a more nuanced understanding, indicating that influence is driven not only by productivity volume but also by how they collaborate with others. Authors such as Armugam Manthiram rank higher under fractional counting because their publications receive more citations while involving fewer authors, resulting in higher fractional citation shares per author.

The changes in ranking divergence between the two methods demonstrate that the choice of counting approach alters the ranking of scholarly influence in EV research.

Network Structure and Connectivity of EV Research

Title-based clustering analysis was conducted to reveal structural relationships among research topics. The resulting network maps reveal interconnected cluster domains within the EV ecosystem. The clustering algorithm identifies seven distinct clusters, as shown in the figure, representing domains within EV research.

Figure 4 presents the VOSviewer-generated conceptual cluster map of EV research topics derived from title-based keyword co-occurrence analysis. Seven distinct thematic clusters are visible, each represented by a different colour.

The clustering algorithm identified seven major thematic clusters, each of which was characterised by a high frequency of key title keywords and showed strong links between keywords and clusters, as shown in Figure 4: The cluster's major keywords are centred on technologically oriented terms such as “lithium-ion battery,” “material,” “fuel cell,” “advancement,” “challenge,” “life cycle analysis,” and “recycling.” Showing the technological core of EV research. Cluster two represents the infrastructure-related keywords covering charging-station deployment, system integration and power management strategies. It shows strong linkages with cluster one. Clusters 3 and 7 capture the computational dimension of EV research, showing integration of AI, deep learning, cloud, blockchain and V2G. Clusters 3 and 7 function as bridges between battery technology clusters 1 and 2, which cover infrastructure-related studies and represent emerging innovation themes in EV research.

The remaining three clusters relate to the market domain of EV research, while Cluster 4 pertains to the psychological and economic domains. The major keywords cover consumer behaviour, barriers, regulatory incentives and diffusion. Whereas cluster five prominently features regional and empirical case-study-based research, keywords such as “China,” “city,” “pattern,” “transport sector,” and “Shanghai” highlight the importance of national and regional studies. At last, cluster six reflects the transition of conventional internal combustion engines towards full battery electrification. Keywords such as “hybrid vehicle,” “engine, “combustion,” and “electric mobility” dominate this cluster. The analysis of all seven clusters shows that EV research has evolved into a multi-dimensional domain. Core research focuses on technological, infrastructural and battery innovation. Further extending into the electrification of the transport sector, behavioural adoption studies and regional policy contexts.

Distribution and Source Concentration

The sources of EV research publications reveal how scholarly output is distributed across the publication outlets. Identifying leading publishers and examining the concentration of research allows evaluation of whether publications are centralised or dispersed across various publication channels.

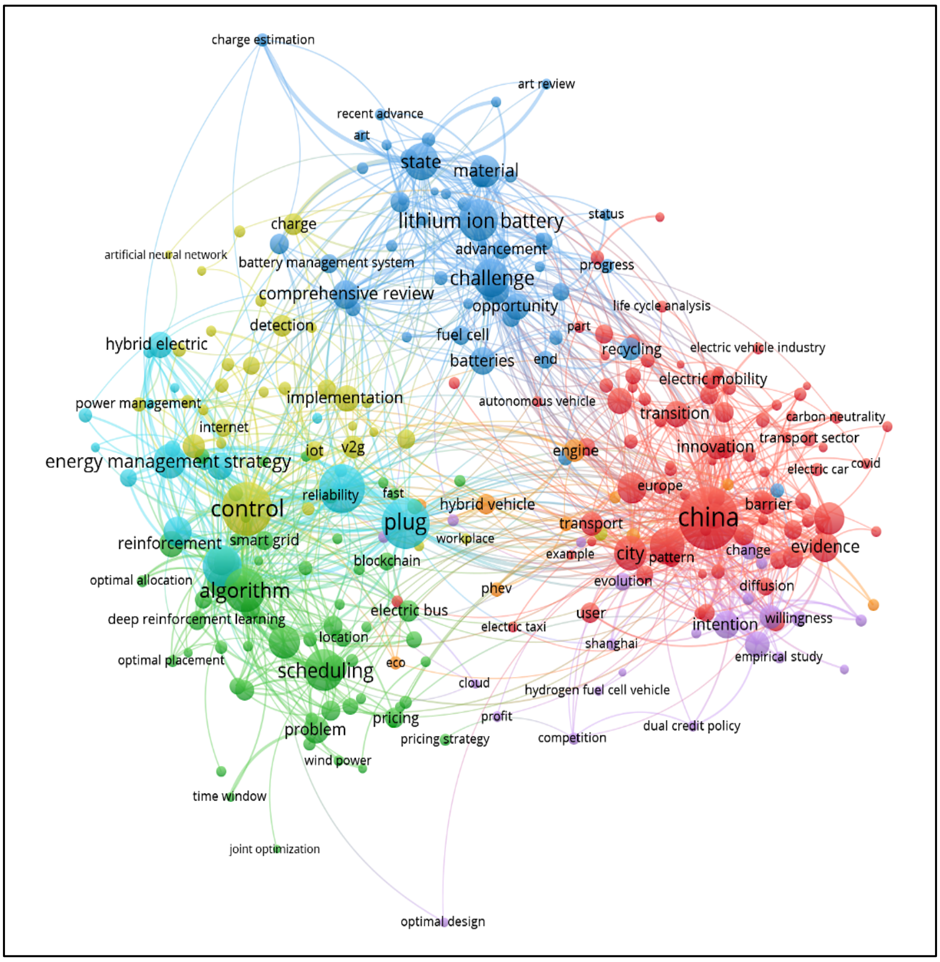

Figure 4: Conceptual Structure Created Using the Vos Viewer Software

. **Table 5:** Top Ten Publishers with the Highest Number of Publications

Publisher	Number of Papers
Institute of Electrical and Electronics Engineers Inc.	4747
Elsevier Ltd	3882
Elsevier B.V.	757
Multidisciplinary Digital Publishing Institute (MDPI)	671
Springer Science and Business Media Deutschland GmbH	616
SAE International	469
MDPI	434
John Wiley and Sons Inc	291
Taylor and Francis Ltd.	206
IEEE Computer Society	20

Table 5 shows that the 'Number of Papers' refers to the total EV-related publications indexed in Scopus (2016–2025) and the top five research-producing countries attributed to each publisher.

The analysis is based on a 16,859 dataset of publications, from which publisher shares were calculated. The table shows the top ten publication outlets, revealing an uneven distribution of EV research, with IEEE accounting for 28.15 per cent of the total dataset, followed by Elsevier with 3,882 publications. The calculated HHI for EV publication sources is 0.1403106, which falls within the moderate concentration range. The presence of other multidimensional journals among the top ten publication outlets indicates a diverse set of platforms across fields such as environmental economics, consumer and market and public policy.

The moderate level of concentration reflects the program's interdisciplinary nature, spanning engineering, environmental science and multidisciplinary studies. This implies that knowledge is distributed across various channels, enhancing accessibility and visibility.

Discussion

The study's findings indicate that a technology-based research field dominates research on electric vehicles (EVs). The observed growth pattern in the results highlights the predominance of technological domains, including AI, Modelling and Optimisation, Energy storage and battery technology and Charging Infrastructure, suggesting that EV research remains supply-side oriented. This finding is consistent with previous research, which has characterised the 2020–2024 period as one of AI-based energy management and autonomous EV systems (19, 22). While on the demand side, themes related to the socio-economics field, such as consumer adoption, policy, economics and markets, grow at slower rates despite being important determinants of whether technical advances translate into real-world scenarios, highlighting structural imbalances like the geographic and thematic skew in adoption research and literature on EV research showed insufficiently integration into the policy framework, indicating that adoption, sustain-ability and policy are underexplored domains(34, 35).

The study applied the full and fractional methods to the same dataset to assess author rankings. The divergence in author ranking shows a measure-ment problem in how scholarly contributions are evaluated. Results reveal that authors of a single highly cited multi-author paper maintain a high ranking under full counting, attributable to collaborative network effects rather than purely individual contributions (26, 27, 29), where large interdisciplinary teams and collaborative authorship structures are prevalent. Whereas the disappearance of several single-publication authors under the fractional counting method shows that authors who ranked highly under full counting are solely due to a single highly cited research paper, demonstrating the bias of full counting, which disproportionately benefits authors embedded in large collaborative networks rather than those with sustained independent contributions (14). Fractional counting corrects for this distortion by proportionally allocating citation credit, producing rankings that better reflect patterns of sustained, productive research engagement. Although fractional counting measures contribution rather than connectivity, its adoption as a standard evaluation practice in collaborative engineering is long overdue (26, 27). In contrast, the public source analysis, with an HHI of 0.1403, which falls within the moderate level, reveals an interdisciplinary nature, with EV research appearing across engineering, environ-mental science and economics (25, 33, 35). However, the concentration of 28.15% of all output within IEEE signals indicates that engineering framing continues to dominate EV research, as shown in the thematic analysis. As with many EV publications, which are channelled through engineering-based publication houses, the structural underrepresentation of social science and policy-based perspectives identified in the thematic analysis will persist. Although the growing body of EV research in social science and policy journals can serve as a prerequisite for translating technical advances into real-world adoption (22, 36, 37). Notably, the inclusion of India's publication record in the five-country dataset reveals an emerging research economy in which policy-driven market transformation, including the FAME scheme and the National Electric Mobility Mission Plan, is producing substantive scientific output.

Conclusion

This study provides a structural and conceptual organisation of the research field through a comprehensive bibliometric-based assessment of 16,859 EV-related publications from the Scopus database, spanning 2016 to 2025. By integrating abstract-based thematic classification, title-based VOSviewer clustering, comparative full- and fractional-citation counting and HHI-based analysis of publication-source concentration, the study provides a multidimensional map of the EV research domain. Firstly, the research integrates abstract-based thematic classification and title-based clustering to provide themes of EV research domains, revealing that technological aspects dominate the research. Second, while showcasing the shift in author rankings when the fractional method is applied, prior EV bibliometric studies lack methodological refinement. Showing how full citation counting can inflate author rankings in collaborative research environments, with fractional counting providing a more equitable and defensible measure of individual scholarly influence. Third, applying HHI to quantify the concentration of publication sources in EV research indicates a moderate level, reflecting the field's interdisciplinary nature. However, the dominance of engineering-oriented outlets indicates that broader disciplinary representation remains an important goal.

Limitations

The study has limitations that should be acknowledged. Firstly, the dataset is restricted to five leading research-producing countries, such as China, the USA, India, the UK and Germany and excludes emerging EV markets in Southeast Asia, Latin America and Africa. This leads to an underrepresentation of research themes, author rankings and concentration patterns for global EV research.

The abstract-based thematic classification relies on predefined keywords, which can systematically exclude relevant publications that use different terminology for the same concept. The assigned keyword groups each publication into specific research themes, which may underrepresent the multidisciplinary nature of publications spanning multiple domains. The fractional citation counting method, though, measures individual contribution but does not distinguish between first authorship and other contributory roles.

The study also draws exclusively from the Scopus database and triangulation with the Web of Science database may yield complementary insights. Also, the period from 2016 to 2025 reflects a short-term evaluation of a rapidly evolving field.

Practical Implications

The findings of this study show an under-representation of consumer adoption, policy and socio-economic themes relative to the technological domains of EV research. Future research and funding in this domain can be actively incentivised to support interdisciplinary studies that connect engineering to behavioural adoption research. Encouraging the submission and indexing of policy and socio-economic EV research in multidisciplinary journals would increase publication numbers across non-engineering dimensions of the EV domain. The full and fractional citation counts show changes in authors' rankings; the journal's editor could consider assessing both metrics at the author level. The integrated framework, combining abstract-based keyword thematic classification, VOSviewer network clustering, comparative full- and fractional-citation counting and Herfindahl-Hirschman Index analysis of source concentration, fully captures the intellectual structure of a rapidly evolving, interdisciplinary research domain. Together, these three interventions would address the thematic, evaluative and dissemination imbalances identified by this study, thereby defining the structural constraints of the current EV research domain.

Future Research

The findings from the thematic classification collectively identify five domains in which targeted future research is needed. Research in the technology and battery systems domain produced more publications, with a cluster focused on lithium-ion batteries, solid-state batteries, fuel cells and recycling. However, these battery sub-domains are advancing independently with limited integration. Future research should link battery chemistry to life-cycle assessment and recycling.

Infrastructure, grid integration, optimisation and digital systems showed strong growth post-2021. Clusters showed fragmented yet emerging linkages among physical infrastructure, digital systems and blockchain. Future studies should examine real-time grid-EV interaction across geographic and economic settings between high-income and emerging economies.

Finally, the adoption, economics, environmental, regional and policy-related themes, with their clusters, show weak connections to the technological clusters. Confirming that demand-side research is developing independently, while the comparative lifecycle analysis of hybrid electric and battery electric vehicles in emerging markets remains limited. Future studies should connect market economics to technical performance by extending comparative life-cycle studies in emerging EV markets to support evidence-based adoption policy, thereby producing a globally representative study.

Abbreviations

AI: Artificial Intelligence, BEV: Battery Electric Vehicle, ICE: Internal Combustion Engine, V2G: Vehicle-to-Grid, VOSviewer: Visualization of Similarities Viewer.

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Author Contributions

Pradumnya Sachan: Conceptualization, Methodology, Data Collection, Data Curation, Formal Analysis, Visualization, Writing Original Draft and Editing, Sharad Dixit: Supervision, Conceptualization, Validation, Mohammad Nazim Malik: Data Curation, Investigation, Writing Review and Editing, Alok Prajapati: Formal Analysis, Software, Writing, Review, Editing, Sachi Pal: Review and Editing, Ritu Makhija: Investigation, Editing, Sagar Kumar: Software usage and editing. All authors have read and agreed to the definitive version of the manuscript.

Conflict of Interest

The authors declare no conflict of interest.

Data Availability

The data are available from the corresponding author upon a reasonable request.

Declaration of Artificial Intelligence (AI) Assistance

Artificial Intelligence tools were used during the preparation of this manuscript to assist with language refinement and structural editing. All scientific content, data analysis, interpretation of results and conclusions are solely the work of the authors. The authors take full responsibility for the integrity and accuracy of this publication.

Ethics Approval

This study is based entirely on secondary bibliometric data extracted from the publicly available Scopus database. It did not involve human participants, animal subjects, clinical trials, or any collection of personal data. Ethical approval was therefore not required for this study.

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