

Carbon Pricing and Green Finance in Road Transport: A Bibliometric Analysis of Low-Carbon Transition Mechanisms.

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Abstract

In the face of the escalating climate crisis, the decarbonization of road transport and the transition towards a low-carbon economy have become strategic priorities for governments, particularly given the transport sector's significant contribution to global greenhouse gas (GHG) emissions. In this context, carbon pricing and green finance have emerged as two complementary policy instruments capable of accelerating the sector's transformation. Carbon taxation seeks to internalize the environmental costs associated with GHG emissions within economic decision-making, while green finance aims to mobilize the financial resources required to support sustainable development, enhance energy efficiency, and promote the adoption of lower-carbon mobility solutions. Despite the growing body of research in both fields, their interplay within the specific context of road transport decarbonization remains relatively fragmented in the scientific literature. This study is based on a systematic review of the scientific literature, primarily using the Scopus database to gather relevant publications on carbon pricing, green finance, and road transport. Bibliometric tools, notably VOSviewer, were employed to analyze and visualize keyword co-occurrence networks, author collaborations, and citation linkages to map the interactions among core concepts. The objective is to identify research trends, major contributions, and scientific gaps concerning the role of carbon pricing and green finance mechanisms in driving the low-carbon transition of the transport sector. The findings highlight a steady rise in academic interest regarding how fiscal instruments and sustainable investments support transportation decarbonization. Additionally, keyword and co-author networks reveal distinct research clusters focused on environmental governance, green economics, and sustainable transport development. These results underscore the critical importance of carbon pricing and green finance as key catalysts for transforming road transport systems.

Keywords: Carbon pricing, carbon tax, green finance, climate finance, road transport, decarbonization, sustainability.

Introduction

Climate change has emerged as one of the most pressing environmental, economic, and social challenges facing the international community today. The recent evolution of key climate indicators provides compelling evidence of the magnitude and persistence of this phenomenon. According to the World Meteorological Organization (WMO), 2025 ranks among the warmest years ever recorded, with the global mean near-surface temperature approximately 1.43°C above the pre-industrial 1850–1900 average. The WMO further confirms that 2015–2025 constitute the eleven warmest years on record, highlighting the persistence and intensification of global warming. At the same time, the global atmospheric concentration of CO₂ reached 423.9 ppm in 2024, corresponding to approximately 152% of the pre-industrial level. Between 2023 and 2024, atmospheric CO₂ concentrations increased by 3.5 ppm, representing the largest annual increase recorded since modern measurements began in 1957 (World Meteorological Organization [WMO], 2025). This deterioration in climatic conditions is also accompanied by significant health-related consequences associated with air pollution. At the global level, combined exposure to outdoor and household air pollution is associated with approximately 7 million premature deaths each year, particularly through increased risks of cardiovascular diseases, stroke, lung cancer, chronic obstructive pulmonary disease, and acute respiratory infections (World Health Organization [WHO], 2020). These environmental and health pressures are driven by the combined effects of several economic sectors, including industry, agriculture, construction, and, most significantly, transport. Indeed, the transport sector represents a major source of greenhouse gas (GHG) emissions. According to the Intergovernmental Panel on Climate Change (IPCC), direct GHG emissions from the transport sector increased from approximately 5.0 gigatonnes of CO₂ equivalent in 1990 to 8.7 gigatonnes in 2019, corresponding to an increase of approximately 74% over the period. In 2019, road vehicles accounted for 70% of direct transport emissions, underscoring the central role of road transport in global decarbonization efforts (Intergovernmental Panel on Climate Change [IPCC], 2022).

The contribution of road transport remains particularly significant at the global level. In 2023, cars and vans generated approximately 3.8 gigatonnes of CO₂, representing more than 60% of road transport emissions. During the same year, global energy-related CO₂ emissions reached a record level of 37.4 gigatonnes, following an increase of approximately 410 million tonnes, or 1.1%, compared with 2022 (International Energy Agency [IEA], 2024). These developments underscore the scale of the challenge facing the transport sector, which remains characterized by a strong dependence on fossil fuels and sustained demand for mobility. Against this backdrop, the decarbonization of the transport sector, and particularly of road transport, has become a central

component of the transition towards a low-carbon economy. Achieving this transition requires public policies capable of progressively reducing emissions while simultaneously supporting the technological, energy, and economic transformations necessary to reshape transport systems.

In this context, climate policies are increasingly placing emphasis on the development of projects and investments aligned with environmental objectives, particularly through the mobilization of green finance. Green finance encompasses the range of financial resources directed towards projects and activities that contribute to environmental protection and the transition towards a more sustainable economy. It can support, in particular, the development of renewable energy, improvements in energy efficiency, the deployment of clean technologies, and the development of lower-emission transport solutions. By directing public and private capital towards investments consistent with climate objectives, green finance mechanisms can contribute to reducing GHG emissions while strengthening economies' capacity to adapt to the impacts of climate change. In this regard, the Organisation for Economic Co-operation and Development (OECD) emphasizes that scaling up climate-aligned finance and investment is essential to accelerating global emissions reductions and keeping the 1.5°C temperature goal within reach (Organisation for Economic Co-operation and Development [OECD], 2024).

The combination of mounting climate pressures, the substantial contribution of road transport to global emissions, and the significant investment requirements associated with its transformation therefore places particular emphasis on the economic and financial instruments supporting the low-carbon transition. Within this perspective, the interaction between carbon-pricing mechanisms and green-finance instruments constitutes a particularly relevant area of inquiry for understanding the economic and financial conditions underpinning the decarbonization of road transport. Their articulation raises important questions regarding the capacity of economic incentives to encourage emission reductions and the role of financial mechanisms in facilitating the investments required to accelerate the transition towards a low-carbon road transport system.

Accordingly, the main objective of this study is to provide a systematic and comprehensive mapping of the scientific literature connecting carbon-pricing mechanisms, green-finance instruments, and the decarbonization of road transport. More specifically, the study seeks to examine the evolution of this research field over time, identify its principal intellectual and thematic structures, assess its geographical and institutional distribution, and highlight the collaboration and citation patterns that shape its development. The analysis is therefore guided by the following overarching research question: **How has the scientific literature evolved at the intersection of carbon pricing, green finance, and road transport decarbonization, and what intellectual, thematic, and geographical gaps remain within this emerging research field?**

To address this overarching question, four subsidiary research questions are considered: How has scientific production evolved over time, across countries, institutions, authors, and publication sources? What are the dominant thematic and conceptual clusters structuring the literature? How are researchers and countries interconnected through co-authorship, citation, and co-citation networks? and to what extent has the literature succeeded in integrating carbon-pricing mechanisms, green-finance instruments, and road transport decarbonization within a coherent analytical framework?

To answer these questions, the study relies exclusively on scientific records indexed in the Scopus database over the period 2010–2025. The selection process followed a systematic screening procedure based on predefined inclusion and exclusion criteria related to thematic relevance and bibliographic completeness. The initial search, targeting the intersection of carbon-pricing mechanisms, green-finance instruments, and road transport decarbonization, identified 957 records. Following the screening of titles, abstracts, and keywords, and the subsequent assessment of full-text eligibility, a final corpus of 40 scientific documents was retained for bibliometric analysis. VOSviewer was then employed to examine and visualize the structure of the field through publication patterns, author and source productivity, institutional and geographical contributions, co-authorship networks, keyword co-occurrence, citation relationships, and author co-citation structures. The primary objective of this study is to provide a comprehensive bibliometric mapping of the intricate nexus uniting carbon pricing, green finance, and road transport decarbonization. By systematically unveiling the intellectual architecture and collaborative dynamics of this emerging field, the research aims to illuminate critical knowledge gaps and inspire highly integrated policy pathways toward sustainable mobility.

The contribution of this study is threefold. First, it brings together research streams that are frequently examined separately by integrating carbon pricing, green finance, and road transport decarbonization within a single bibliometric framework. Second, it provides a structured representation of the intellectual, thematic, geographical, and collaborative architecture of this emerging interdisciplinary field. Third, it identifies areas of convergence as well as persistent fragmentation within the literature, thereby highlighting opportunities for greater integration between economic instruments, financial mechanisms, technological transformation, and sustainable transport policy.

The remainder of this paper is organized as follows: The first section establishes the methodological framework by detailing the research strategy and the rigorous selection process. The second section provides a descriptive overview of the literature, highlighting publication trends as well as institutional and geographical dynamics. This overview paves the way for the

third section, which offers an in-depth bibliometric analysis of the collaborative networks and thematic structures shaping this field. Finally, the article concludes by synthesizing our main findings and their contribution to advancing the low-carbon transition in the road transport sector.

1-Methodology and Research Results

The objective of this study is to conduct a comprehensive bibliometric analysis of the scientific literature at the intersection of carbon pricing, green finance, and road transport decarbonization. This approach seeks to systematically examine the evolution, intellectual structure, thematic patterns, and emerging research trends within this field by leveraging scientific databases and advanced bibliometric visualization techniques, particularly Scopus and VOSviewer.

1-1 Research Methodology

This article maps the development of scholarly research at the intersection of carbon pricing, green finance, and road transport. It focuses on how the literature connects carbon taxation, emissions trading schemes, fuel taxation, sustainable finance, green investment, fleet renewal, and the decarbonization of road-based mobility. To examine the structure and evolution of this research domain, a bibliometric approach was adopted. This method enables the systematic assessment of publication dynamics, citation patterns, leading authors, influential journals, institutional and national contributions, collaborative networks, and keyword structures. It also helps reveal the dominant conceptual orientations, emerging research themes, and underexplored areas within the field.

The study draws exclusively on records indexed in the Scopus database and covers the period from 2010 to 2025. Following the application of predefined eligibility criteria, including thematic relevance and bibliographic completeness, a final corpus of 40 scientific documents was established. The selected publications address the relationship between carbon-pricing instruments, green finance, and the transition of road transport toward lower-carbon development pathways. This corpus provides the basis for identifying the main intellectual structures, research trends, and knowledge gaps shaping the field (Zupic & Čater, 2015).

The final corpus was established through a systematic screening process based on clearly defined inclusion and exclusion criteria. Figure 1 summarizes the search strategy, filtering parameters, and selection conditions applied to the Scopus records.

Figure 1: Scopus Search Strategy and Bibliometric Parameters



Source: Authors' elaboration based on Scopus data

Tableau 1: Scopus-Based Bibliometric Search Parameters

Type of Analysis	Objective
Analysis of publication trends by year	-Examine the evolution of scientific production over time - Identify periods of growing or declining research interest in carbon pricing, green finance and road transport decarbonization.
Geographical analysis	Identify the most productive and influential countries and regions in research on carbon pricing, green finance and road transport.
Analysis of the most productive authors	Identify the most prolific researchers in the field and highlight their contribution to the development of research on carbon pricing, green finance and transport decarbonization.
Co-occurrence analysis of keywords	- Identify the most frequently occurring keywords. - Examine relationships between key concepts such as carbon pricing, carbon tax, green finance, road transport, decarbonization and low-carbon transition.
Co-citation analysis	Identify the scientific publications, authors or sources that are frequently cited together.

Source: Elaborated by the authors via Scopus

1-2 Research Paradigm and Methodological Approach

The epistemological foundation of this research is firmly rooted in a positivist paradigm, as the study relies upon the systematic exploitation of objective, observable, and measurable bibliographic data retrieved from the Scopus database. Rather than subjectively interpreting the

perceptions or lived experiences of actors within the field, the objective is to deploy robust bibliometric indicators to uncover the principal trends, structural configurations, and underlying dynamics that define the scientific discourse on carbon pricing, green finance, and road transport decarbonization.

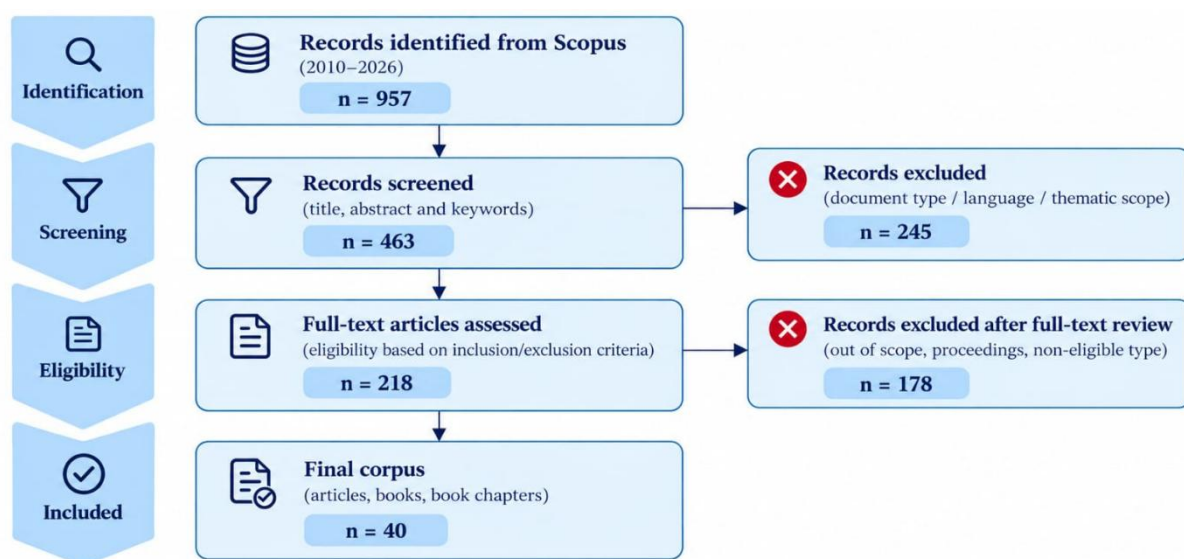
Consequently, the adopted mode of reasoning fundamentally aligns with an exploratory inductive approach. Unlike a hypothetico-deductive framework—which necessitates the formulation of a priori hypotheses for empirical verification—this study does not seek to test pre-established causal relationships. Instead, it is guided by foundational research questions concerning the evolution, structural organization, and primary trajectories of the literature. By

analyzing a meticulously assembled corpus based on predefined search and selection criteria, the bibliometric methodology facilitates the progressive identification of latent regularities, conceptual associations, and thematic clusters within the academic landscape.

1-3 Study selection process

The bibliometric corpus selection process was conducted following the Preferred Reporting Items for bibliometric Reviews and Meta-Analyses (PRISMA) 2010 framework. This framework was used to ensure transparency, traceability, reproducibility, and methodological rigor in the identification, screening, eligibility assessment, and final inclusion of relevant scientific documents. As illustrated in Figure 2, the selection procedure involved four successive stages: identification of records in the Scopus database, screening based on titles, abstracts, and keywords, full-text eligibility assessment, and inclusion of the final bibliometric corpus.

Figure 2: PRISMA flow diagram of the bibliometric corpus selection process



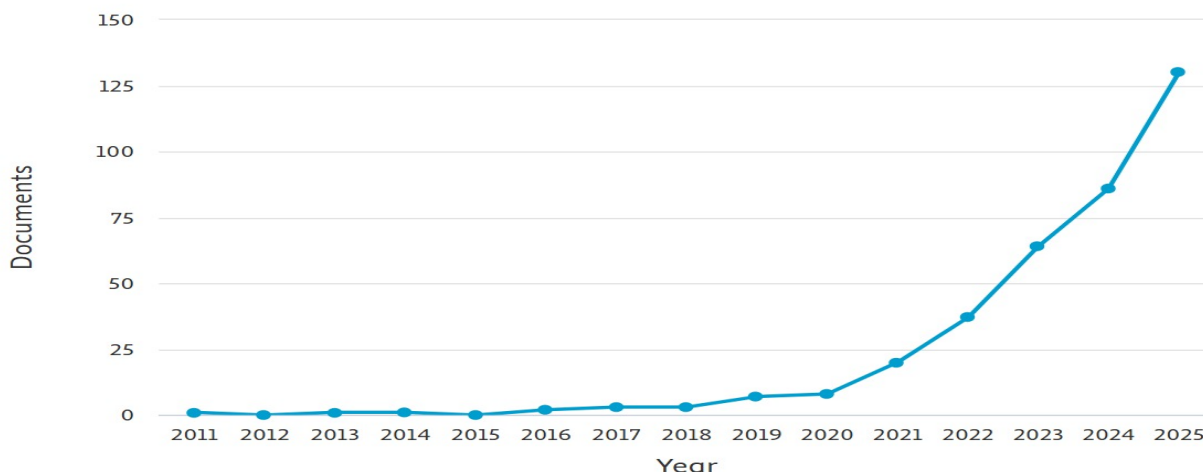
Source: Authors' elaboration based on Scopus data (2010-2025)

Following the PRISMA protocol, the literature review process identified 957 records from Scopus (2010–2025). After screening titles, abstracts, and keywords (excluding 245 records), 218 records were retained. Subsequent full-text assessment of these records led to the exclusion of 178 ineligible items, resulting in a final corpus of 40 selected documents.

2-Results of the Search Conducted on Scopus

Figure3: Annual Scientific Production

Documents by year

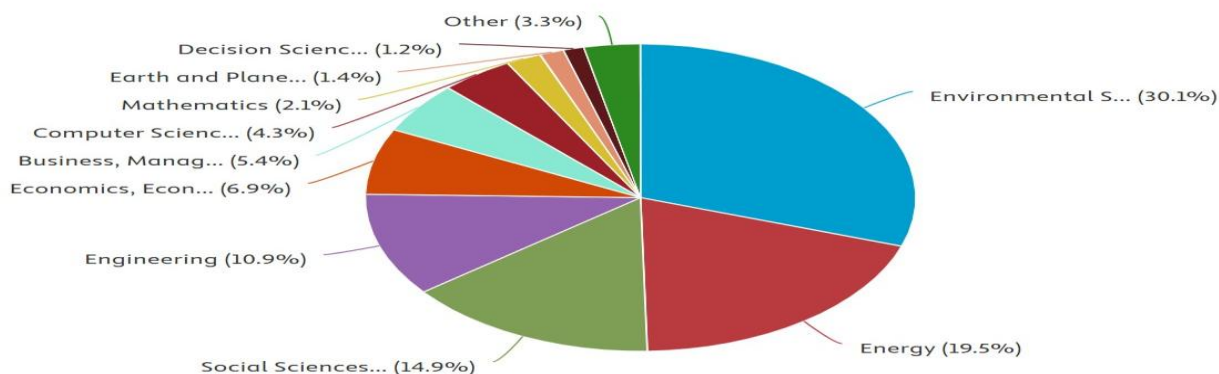


Source: Authors' elaboration based on Scopus data (2010-2025)

Scientific production remained very limited and relatively stable during the initial period from 2011 to 2018, with no more than three publications recorded per year. A first increase became apparent in 2019, when the number of publications reached approximately seven, followed by a further rise to eight documents in 2020. This upward trajectory accelerated markedly from 2021 onwards, with scientific output reaching approximately 20 publications. The growth continued in 2022 and 2023, with around 38 and 64 publications, respectively, before intensifying further in 2024, when the number of publications rose to approximately 87. The highest level of scientific production was recorded in 2025, with nearly 130 publications.

Figure 4: Analysis of Publications by Scopus Subject Area

Documents by subject area



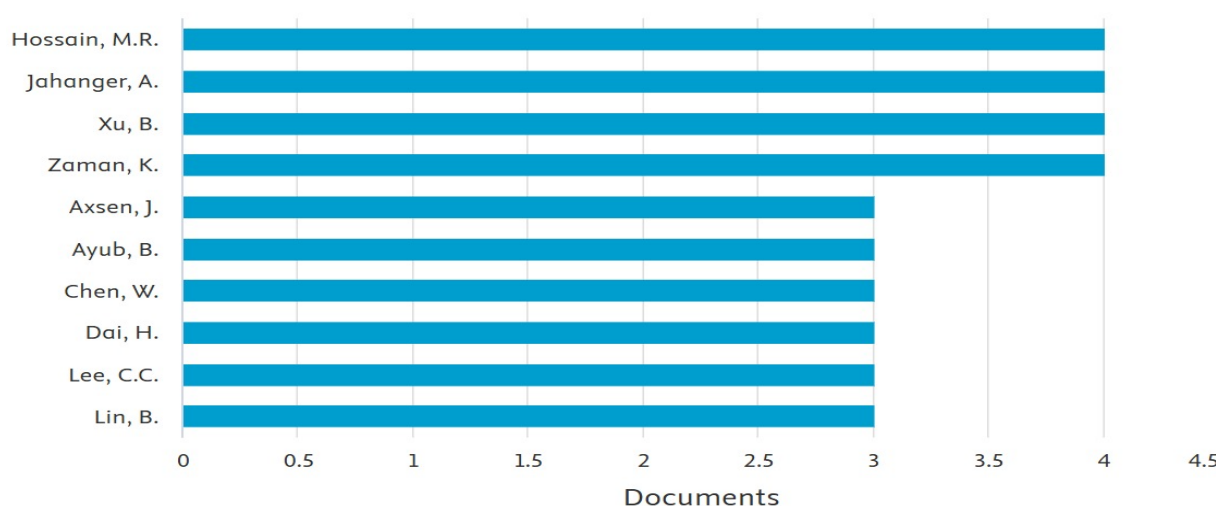
Source: Authors' elaboration based on Scopus data (2010-2025)

The figure illustrates the distribution of the scientific output within the corpus across the main disciplinary areas indexed in Scopus. *Environmental Sciences* emerges as the most represented field, accounting for 30.1% of the publications, followed by *Energy*, which represents 19.5% of the corpus. *Social Sciences* ranks third, with 14.9%, while *Engineering* accounts for 10.9% of the documents. The fields of *Economics, Econometrics and Finance* and *Business, Management and Accounting* represent 6.9% and 5.4% of the publications, respectively. Other disciplines are represented to a lesser extent, including *Computer Science* (4.3%), *Mathematics* (2.1%), *Earth and Planetary Sciences* (1.4%), and *Decision Sciences* (1.2%). The remaining subject areas collectively account for 3.3% of the corpus.

Figure 5: Number of Documents Published by Author

Documents by author

Compare the document counts for up to 15 authors.



Source: Authors' elaboration based on Scopus data (2010-2025)

The chart illustrates the distribution of scientific publications among the leading authors identified in the dataset. It highlights two distinct levels of contribution: Hossain, M.R., Jahanger, A., Xu, B., and Zaman, K. occupy the leading position, with four documents each. They are followed by Axsen, J., Ayub, B., Chen, W., Dai, H., Lee, C.C., and Lin, B., who have each contributed three documents. Overall, the distribution indicates a relatively concentrated publication output among a limited group of authors, although the difference between the two groups remains modest, amounting to only one document.

Figure 6: Annual Distribution of Publications across the Leading Sources

Documents per year by source

Compare the document counts for up to 10 sources.

[Compare sources and view CiteScore, SJR, and SNIP data](#)



Source: Authors' elaboration based on Scopus data (2010-2025)

The figure illustrates the annual distribution of publications across the five leading sources contributing to the scientific literature under investigation over the period 2018–2025. *Sustainability Switzerland* records the earliest and most sustained presence, with two publications in both 2018 and 2020, followed by a marked increase to four publications in 2022 and a peak of ten publications in 2023. *Environmental Science and Pollution Research* displays a more recent but particularly pronounced growth, rising from one publication in 2019 to thirteen in 2023, before declining to nine in 2024 and three in 2025. *Journal of Cleaner Production* also shows substantial growth, reaching eleven publications in 2024 after a temporary decline to one publication in 2023, and subsequently recording five publications in 2025. *Journal of Environmental Management* follows a relatively steady upward trajectory, increasing from one publication in 2019 to eight in 2024, before declining slightly to five publications in 2025. Finally, *Energy* maintains a comparatively moderate publication output throughout the period, with three publications in 2023, two in 2024, and an increase to eight publications in 2025.

Figure 7: Scientific Output by Institutional Affiliation

Documents by affiliation

Compare the document counts for up to 15 affiliations.



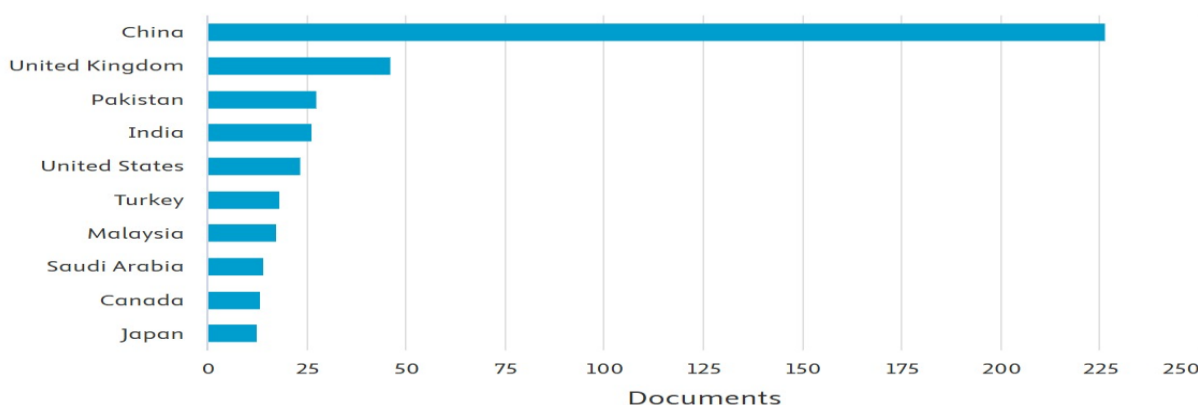
Source: Authors' elaboration based on Scopus data (2010-2025)

The figure presents the distribution of scientific publications across the leading institutional affiliations represented in the corpus. *Hainan University* ranks first, with 11 publications, followed by *Xiamen University* and the *Chinese Academy of Sciences*, with 9 publications each. *Beijing Institute of Technology*, *University College London*, and *Tsinghua University* each account for 8 publications. The *Ministry of Education of the People's Republic of China*, *Zhengzhou University*, *Beijing University of Technology*, and the *University of Cambridge* contribute 7 publications each. Overall, the distribution reveals a relatively concentrated institutional structure, with the leading affiliations contributing between seven and eleven publications to the corpus.

Figure 8: Distribution of Scientific Documents by Country or Territory

Documents by country or territory

Compare the document counts for up to 15 countries/territories.

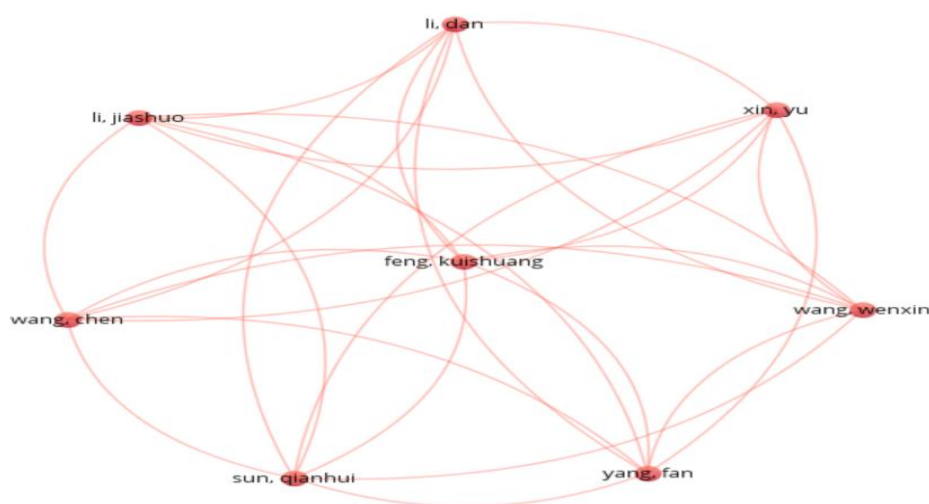


Source: Authors' elaboration based on Scopus data (2010-2025)

The graph illustrates the distribution of scientific documents according to the countries or territories represented. China ranks first by a considerable margin, with approximately 226 documents, clearly exceeding all the other countries shown. The United Kingdom occupies second

place, with nearly 46 documents, followed by Pakistan with around 27 documents and India with approximately 26 documents. The United States accounts for about 24 documents, while Turkey and Malaysia record approximately 18 and 17 documents, respectively. Saudi Arabia, Canada, and Japan occupy the final positions, with estimated totals of 14, 13, and 12 documents.

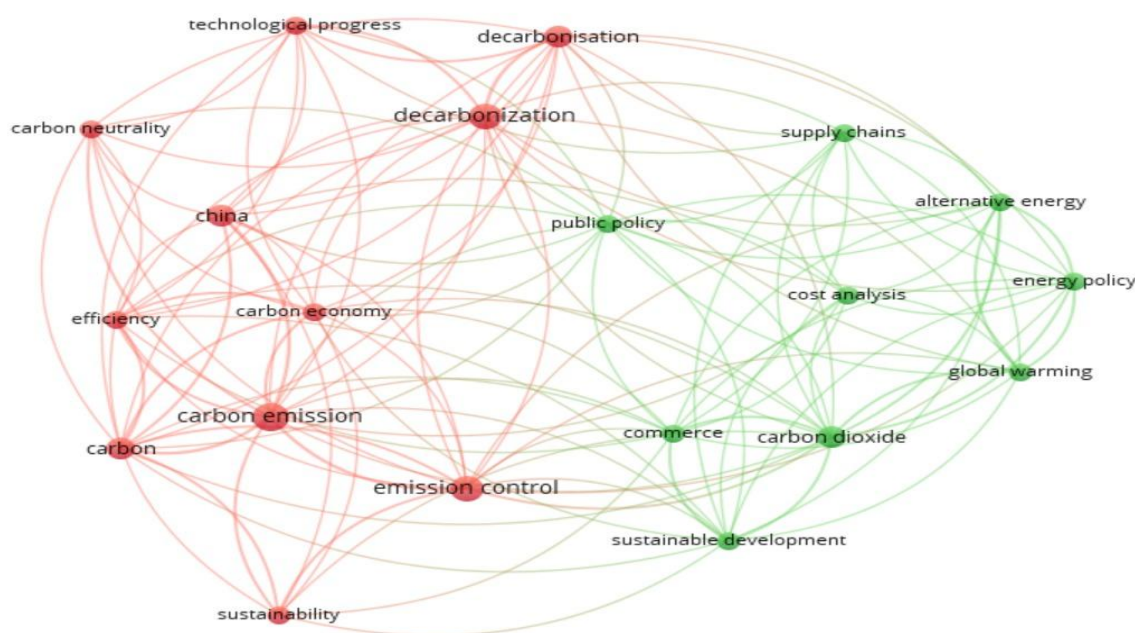
Figure 9: Co-Authorship and Researcher Collaboration Network Map



Source: Authors' elaboration based on Scopus data (2010-2025)

The visual inspection of this network map reveals a highly integrated scientific community structured around eight principal academic contributors: *li, dan*, *xin, yu*, *wang, wenxin*, *yang, fan*, *sun, qianhui*, *wang, chen*, *li, jiashuo*, and *feng, kuishuang*. The nodes, arranged in a circular topology, are interconnected by multiple arcs whose density and frequency illustrate the intensity of collaborative ties and scholarly exchanges. A pronounced centrality is observed among researchers such as *feng, kuishuang* and *xin, yu*, who occupy pivotal positions at the core of the network, maintaining robust and direct connections across virtually all participating entities. This cohesive circular arrangement demonstrates a unified research cluster where academic contributions intersect fluidly, with no noticeable fragmentation or isolated sub-groups.

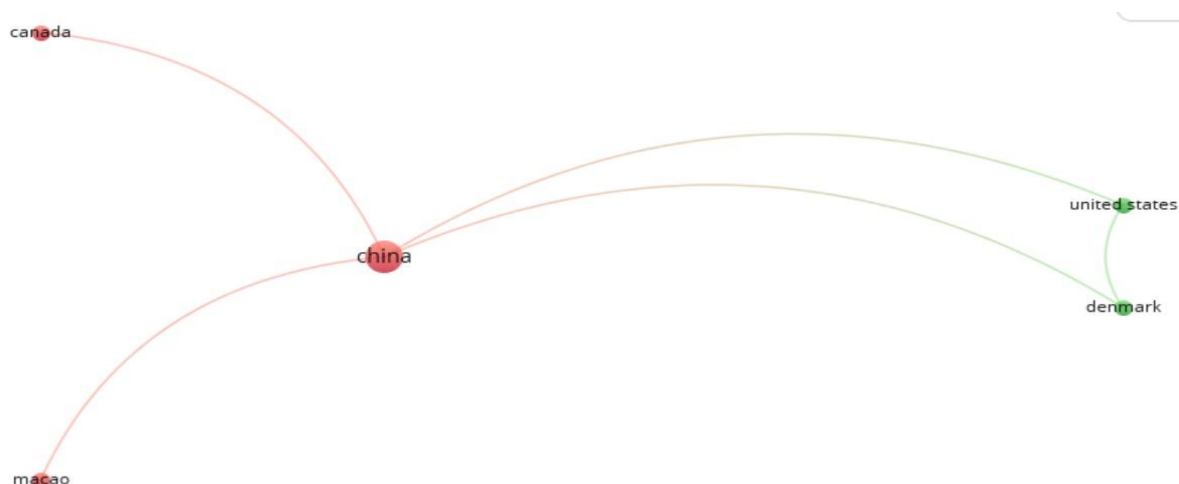
Figure 10: Co-occurrence of All Keywords: Mapping the Dynamics of Decarbonization and Sustainable Policy



Source: Authors' elaboration based on Scopus data (2010-2025)

A detailed observation of this co-occurrence graph reveals a bipartite structure, harmoniously articulated around two major semantic clusters distinguished by their color coding. The highly dense red cluster is organized around anchor nodes such as "carbon emission," "decarbonization," and "emission control," while integrating components related to innovation ("technological progress") and geopolitics ("china"). Conversely, the green cluster aggregates a macro-environmental and politico-economic lexicon, dominated by cardinal terms like "carbon dioxide," "sustainable development," "public policy," and "energy policy". The network of arcs connecting these entities demonstrates a pronounced capillarity, not only within each respective pole but also through multiple intersections that directly link the two hemispheres of the graph.

Figure 11: Country Co-authorship Network in Research on Decarbonization and Sustainable Policies



Source: Authors' elaboration based on Scopus data (2010-2025)

The figure illustrates the international co-authorship network across countries represented in the scientific corpus. The network comprises five visible countries: China, Canada, Macao, the United States, and Denmark, connected through a series of collaborative links. China occupies a central position within the network and is connected to Canada and Macao, as well as to the United States and Denmark through broader international collaboration links. The network is structured around two main groups: a cluster centred on China, Canada, and Macao, and another involving the United States and Denmark, with China serving as the principal connecting node between these groups.

Figure 12: Citation Network of the Most Influential Authors

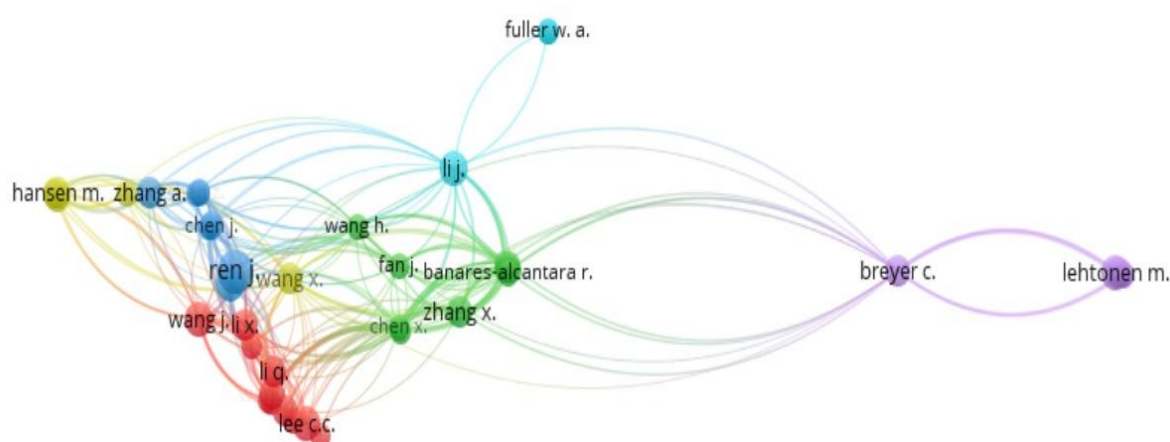


Source: Authors' elaboration based on Scopus data (2010-2025)

The figure presents the citation network of the authors represented in the scientific corpus. The visualization includes a diverse set of researchers from different academic and geographical

backgrounds, including *Lee Chien-Chiang*, *Zhou Fengxiu*, *Zhang Bingqian*, *Lehtonen Matti*, *Garcia Pablo Venegas*, *Jokinen Ilkka*, *Chen Ming*, *Wang Wentao*, *Koskinen Risto*, *Hirvonen Janne*, *Hamidoglu Ali*, and *Sysoeva Liubov*, among others. The authors are represented by individual nodes, with different colors indicating distinct groups or clusters identified by the bibliometric analysis. The relatively dispersed configuration of the nodes, together with the limited number of visible connections, reflects the distribution of citation relationships across the authors included in the corpus.

Figure 13: Co-citation of Authors: Mapping Intellectual Foundations and Academic Influence



Source: Authors' elaboration based on Scopus data (2010-2025)

A visual exploration of this author co-citation network reveals an asymmetrical topology, remarkably structured around a dense core that extends toward a peripheral branch. The heart of the graph, situated on its left hemisphere, concentrates a multitude of intensely interconnected nodes, segmented into several chromatic clusters (red, yellow, blue, and green). Within this epicenter, prominent figures such as *ren j.* and, to a lesser extent, *li j.*, stand out due to the substantial size of their nodes, reflecting a particularly high frequency of joint citations. Conversely, the right extremity of the map breaks away from this density to form a highly distended purple pole, where the researcher *breyer c.* acts as an exclusive bridge connecting the central core to the author *lehtonen m.*, illustrating an isolated bilateral connection distinct from the main cluster's activity.

3- Bibliometric Analysis

3-1 Annual Evolution of Publications

Beyond the mere quantitative increase, the observed evolution reflects a remarkable rise in scientific interest in the intersection of carbon pricing, green finance, and road transport decarbonization. The relatively limited volume of research during the first decade suggests that

the integration of these dimensions initially constituted an emerging and relatively fragmented field of inquiry. By contrast, the acceleration observed from 2021 onwards marks a genuine turning point in the publication dynamics. The particularly pronounced increase between 2022 and 2025 indicates a broadening of academic attention towards the economic, financial, and regulatory mechanisms capable of supporting the transition towards a low-carbon transport sector. This evolution may be interpreted as evidence of a gradual convergence between several research agendas that had previously been examined more independently, namely carbon pricing, sustainable finance, the energy transition, and transport decarbonization.

3-2 Analysis of Publications by Subject Area

The disciplinary structure of the corpus highlights the inherently interdisciplinary nature of the research field, situated at the intersection of environmental, energy, economic, financial, and technological concerns. The predominance of *Environmental Sciences* (30.1%) underscores the centrality of issues related to emissions reduction, the transition towards a low-carbon economy, and environmental policy. The strong representation of *Energy* (19.5%) further emphasizes the pivotal role of energy-related considerations in the decarbonization of road transport, particularly in terms of energy efficiency, the substitution of fossil fuels, and electrification. At the same time, the substantial contribution of *Social Sciences* (14.9%), *Engineering* (10.9%), and, to a lesser extent, *Economics, Econometrics and Finance* (6.9%) reflects the growing integration of economic, financial, regulatory, and technological perspectives within the field. This disciplinary diversity suggests that the transition towards low-carbon road transport cannot be adequately understood through a single scientific perspective; rather, it requires an integrated approach that brings together climate policy instruments, financing mechanisms, technological innovation, and transformations in energy and transport systems.

3-3 Analysis of Publication Volume by Author

The analysis of individual productivity highlights a remarkably homogeneous and tightly clustered distribution at the apex of this corpus's academic hierarchy. The graph reveals the absence of a monopolistic leading figure in favor of a bimodal structure composed of two distinct strata of contribution. On one hand, a leading cohort of four prolific researchers (Hossain, M.R., Jahanger, A., Xu, B., and Zaman, K.) stands out with an identical output of four documents each. On the other hand, this vanguard is closely followed by a highly compact second group (including Aksen, J., Ayub, B., Chen, W., Dai, H., Lee, C.C., and Lin, B.), whose contributions uniformly stand at three publications per author. This strongly egalitarian configuration suggests the existence of highly structured and collaborative research networks, where knowledge production

is not driven by the isolated figure of a "star researcher," but rather by steady research teams or consortia that co-author their studies at similar, consistent rates.

3-4 Annual Distribution of Publications across the Leading Sources

The evolution of publication output across the leading sources reveals a dynamic and increasingly diversified scientific landscape surrounding the research topic. *Sustainability Switzerland* and *Environmental Science and Pollution Research* appear to have played a particularly important role during the period of accelerated scientific production, while *Journal of Cleaner Production* and *Journal of Environmental Management* demonstrate a notable strengthening of their contribution in the most recent years. The pronounced fluctuations observed across several sources suggest that research activity has not developed uniformly across journals, but rather through successive waves of scientific attention. The strong expansion recorded by several leading outlets from 2022 onwards may reflect the growing convergence of research on environmental policy, energy transition, sustainable finance, and transport decarbonization. Overall, the distribution indicates that the field has progressively attracted a broader range of established journals, reflecting both the increasing maturity of the research agenda and its inherently interdisciplinary character, situated at the intersection of environmental sciences, energy studies, sustainability, transport, and economic policy.

3-5 Institutional Affiliation and Research Productivity

The institutional distribution highlights the prominent role of major research and higher-education institutions in shaping the scientific development of the field. The strong representation of Chinese institutions is particularly noteworthy, with several universities and the *Chinese Academy of Sciences* occupying the leading positions. This concentration suggests a substantial contribution from China to research at the intersection of carbon pricing, green finance, energy transition, and road transport decarbonization. At the same time, the presence of prestigious international institutions such as *University College London* and the *University of Cambridge* indicates that the research agenda extends beyond a single national context and involves broader international academic participation. Taken together, the institutional profile points to a research landscape characterized by strong contributions from established academic centres, while the coexistence of Chinese and international affiliations reflects the increasingly global and interdisciplinary nature of research on low-carbon transport transitions.

3-6 Distribution of Scientific Documents by Country or Territory

The distribution highlights a strong concentration of scientific production in China, whose number of documents is substantially higher than that of all the other countries represented. This predominance may reflect a particularly strong academic interest in the subject, as well as the

significant involvement of Chinese universities and research institutions. The presence of the United Kingdom, Pakistan, India, and the United States also confirms the international dimension of the research field, although the differences between countries remain considerable. Moreover, the representation of several Asian and Middle Eastern countries suggests the growing involvement of emerging economies in this area of research. Nevertheless, these findings should be interpreted with caution, since the number of publications alone does not necessarily reflect the quality, scientific impact, or influence of the research produced.

3-7 Co-Authorship and Researcher Collaboration Network Map

This network configuration highlights a deeply collaborative and synergistic research dynamic characteristic of fast-evolving scientific domains. The exceptional density of inter-nodal ties points to strong thematic convergence and shared intellectual frameworks, ensuring seamless multidirectional knowledge transfer. Furthermore, the abundance of multi-layered connections signifies frequent co-authorship patterns and collective problem-solving, validating the structural integrity of this research corpus. Ultimately, the visualization underscores not merely individual academic productivity, but the resilience and efficacy of a tightly knit, collaborative scholarly ecosystem.

3-8 Keyword Co-occurrence: Mapping the Research Landscape of Decarbonization and Sustainable Policies

Analytically, this topology sharply illustrates the conceptual duality characterizing contemporary research on the ecological transition. On one hand, the red sphere reflects a resolutely operational and systemic approach, focusing on the tangible mechanisms of climate mitigation, carbon management, and industrial efficiency. On the other hand, the green sphere embeds these technical imperatives within a broader institutional and socio-economic framework, encompassing financial viability ("cost analysis," "commerce") and climate governance. The strong intertwining of these two domains evidences the emergence of a holistic academic paradigm: the scientific literature establishes that achieving carbon neutrality is no longer merely a technological challenge, but rather requires an inextricable synergy with the structuring of public policies and the economics of sustainable development.

3-9 Country Co-authorship Network in Research on Decarbonization and Sustainable Policies

The co-authorship structure highlights the international and interconnected nature of scientific collaboration within the research field. The central position of China suggests that it plays an important role in linking different national research communities, particularly between the Asian and Western scientific spheres. The connections involving Canada and Macao indicate a relatively

concentrated regional dimension, while the links with the United States and Denmark demonstrate the extension of collaborative relationships beyond geographical boundaries. Overall, the network reflects a pattern of international scientific cooperation in which a central research community acts as a bridge between geographically distinct clusters, illustrating the increasingly global character of research on decarbonization and sustainable policies.

3-9 Citation Network of the Most Influential Authors

The citation structure reveals a relatively fragmented intellectual landscape, characterized by the presence of several author groups rather than a single dominant citation network. The coexistence of researchers from different scientific and geographical backgrounds suggests that the literature draws upon a broad range of academic contributions and perspectives. The dispersion of authors across distinct clusters may also indicate that research on carbon pricing, green finance, and road transport decarbonization has developed through partially differentiated research streams, encompassing environmental policy, energy transition, transport studies, sustainability, and economic analysis. This configuration highlights the multidisciplinary character of the field while also suggesting opportunities for greater intellectual convergence and cross-disciplinary integration among the different research communities.

3-10 Co-citation of Authors: Mapping Intellectual Foundations and Academic Influence

Analytically, this spatial architecture reflects the coexistence of a fundamental theoretical bedrock and a specialized disciplinary niche. The density and entanglement of the central mass (red, blue, and green clusters) indicate a strong intellectual consensus: the works of these authors constitute the essential reference corpus, regularly mobilized in concert by the scientific community to ground its research. Pivotal authors like *ren j.* act as true conceptual crossroads, seamlessly unifying various schools of thought. On the other hand, the elongation of the purple cluster toward the right suggests the existence of highly specific applied literature or a distinct academic perspective. Although connected to the overarching matrix, these peripheral researchers likely provide unique methodological expertise or a specialized thematic focus, enriching the field of study without entirely dissolving into its central orthodoxy. Ultimately, this visualization elegantly illustrates the vitality of a research domain anchored in robust, shared foundations while actively expanding toward new exploratory frontiers.

Conclusion

This study examined how the scientific literature has connected carbon pricing, green finance, and road transport decarbonization within the broader transition towards low-carbon transport systems. Using a bibliometric analysis of scientific publications indexed in Scopus over the period 2010–2025, the research sought to determine whether these three domains are increasingly converging around a common understanding of the economic, financial, technological, and policy mechanisms required to decarbonize road transport. The findings show that the field is expanding rapidly and becoming increasingly interdisciplinary, although its intellectual, geographical, and collaborative structures remain only partially integrated.

The temporal analysis reveals that scientific production remained relatively limited during the first years of the period under review, before accelerating markedly from 2021 onward. This expansion became particularly pronounced between 2022 and 2025, reflecting the growing academic interest in climate policy instruments, sustainable finance, energy transition, and transport decarbonization. The increase in publication output suggests that carbon pricing and green finance are no longer treated as isolated policy areas, but are progressively being examined as complementary components of a broader low-carbon transition framework. Nevertheless, the rapid growth of the literature has not yet produced a fully unified research field, as several thematic and intellectual strands continue to evolve in parallel.

The thematic analysis provides the main response to the study's research problem. Keyword co-occurrence reveals two broad and closely connected research orientations. The first is structured around carbon emissions, decarbonization, emission control, and technological progress, reflecting an operational and mitigation-oriented perspective. The second is organized around carbon dioxide, sustainable development, public policy, and energy policy, emphasizing the institutional and socio-economic dimensions of the transition. The strong interaction between these two thematic spheres indicates that the literature increasingly recognizes road transport decarbonization as a multidimensional process requiring the combined mobilization of technological, regulatory, economic, and financial instruments. At the same time, the persistence of distinct thematic clusters suggests that carbon pricing, green finance, and transport decarbonization are still not always analyzed within a fully integrated conceptual framework.

This finding represents the principal theoretical contribution of the study. By mapping the relationships among these research streams, the analysis highlights the need for a more integrated perspective in which carbon pricing is considered not only as a mechanism for internalizing the environmental cost of emissions, and green finance not only as a source of investment capital, but both as mutually reinforcing instruments of transport transformation. Such a perspective places

greater emphasis on the conditions under which carbon-pricing mechanisms can alter relative costs and investment incentives, while green-finance instruments can facilitate the financing of cleaner fleets, energy-efficient technologies, low-emission infrastructure, and broader mobility transitions. The study also makes an important methodological contribution. Bibliometric analysis provides a systematic means of examining a multidisciplinary and rapidly evolving field whose intellectual boundaries remain relatively fluid. The combined use of publication trends, subject-area analysis, author productivity, source distribution, institutional affiliations, country-level scientific production, co-authorship networks, keyword co-occurrence, citation analysis, and co-citation mapping makes it possible to identify both established knowledge structures and areas of fragmentation. This approach complements conventional literature reviews by providing a quantitative and visual representation of the scientific architecture of the field.

The significance of this review therefore lies in identifying this fragmentation and clarifying the conceptual space in which future empirical and theoretical research can develop. Future studies should pay greater attention to the interaction between carbon-pricing mechanisms and green-finance instruments, particularly in emerging and developing economies where investment constraints, fleet structure, technological capacity, and institutional conditions may substantially shape the effectiveness of low-carbon policies. In this respect, road transport decarbonization should be understood not merely as a technical shift towards cleaner vehicles, but as a broader economic and financial transformation in which carbon pricing, green finance, technological change, and public policy jointly determine the pace and effectiveness of the transition towards sustainable mobility.

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