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ORIGINAL ARTICLE

Mapping the intellectual structure and international collaboration in transportation research: A bibliometric analysis from Scopus top-tier journals

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ABSTRACT

Objective. We analyzed the intellectual structure and collaboration patterns in transportation research based on publications from the top 10% highest-impact journals in Scopus.

Design/Methodology/Approach. We conducted a bibliometric analysis of scientific output in the transportation field. The sample comprised articles published between 2015 and 2024 in the top 10% of journals with the highest impact in Scopus for this area, resulting in a final sample of 39 journals. The data were analyzed using Gephi software, where network maps were created and centrality metrics were computed.

Results/Discussion. The co-word map emphasized the significance of terms related to road safety, infrastructure planning, and sustainability. These clusters demonstrated how current transportation research combines technical viewpoints with interdisciplinary approaches, connecting transportation engineering to public health and risk management. It was observed that the papers with the highest centrality concentrated on methodological studies in transportation modeling, as well as research on system resilience and vulnerability. Regarding international collaboration, the results confirm trends identified by previous studies, with the United States, China, and the United Kingdom playing central roles in the collaborative network.

Conclusions. The results of this study confirm that transportation research is increasingly adopting multidisciplinary approaches, with road safety and sustainability becoming core interconnected issues.

Keywords: bibliometrics; transportation; co-words; co-citation; international scientific collaboration; Scopus.

1. INTRODUCTION

In recent decades, transportation research has not only reflected significant growth in its scientific literature, but the topics addressed also show a trend toward diversity and expansion (Sun & Rahwanb, 2017). Sun & Yin (2017) state that:

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> In terms of transportation research, the problems and challenges encountered have been constantly changing over time, and the scope of transportation research has also become more diverse, with a widening and inter-disciplinary coverage of topics, ranging from those long lasting questions such as traffic congestion and signal control, to emerging technologies such as autonomous vehicles, connected vehicles, big data analytics and artificial intelligence, to societal problems such as sustainability and environmental justice. The field is evolving given the specific questions raised and the advances in solutions/technologies developed. As a result, transportation research has witnessed an explosion of research publications in last decades (p. 49-50).

Various literature review studies have helped deepen the understanding of transportation research from different perspectives; however, bibliometrics can also provide a more direct insight into the issues in this field (Liu *et al.,* 2020). Using bibliometric techniques, aspects related to different types of transport have been explored, such as maritime (Zampeta, V., & Chondrokoukis, 2023), public and urban (Kalaoane *et al.,* 2024; Lawrence *et al.,* 2025; Pambudi & Hwang, 2024), rail (Kadam *et al.,* 2016; Kolesnykova *et al.,* 2019), and air (Karakavuz, 2025); as well as their connection to topics like traffic prediction (Liu *et al.,* 2021), climate change (Peng *et al.,* 2023), carbon emissions (Fan *et al.,* 2023), freight transportation (Vengadesh & Chinna), and the use of artificial intelligence (Karakavuz, 2025).

Studies at the journal level have contributed to the development of this research field. For example, the bibliometric analysis conducted by Modak *et al.* (2019) on the journal Transportation Research, a leading journal established in 1967, revealed six sections: Transportation Research Part A, Part B, Part C, Part D, Part E, and Part F. As a benchmark for research in transportation, the study showed significant growth in these journals, with Transportation Research Part A being the most productive and Part B the most cited. The United States, China, and the United Kingdom were also identified as the most productive countries.

Jiang *et al.* (2020) also performed a journal-level analysis, focusing on Transportation Research Part B during its 40th anniversary. Among the most notable results, the authors found a significant increase in the number of articles published annually since 2010, the dominance of North American and Chinese-European organizations, and a rise in author collaborations within the journal. There is also the case of the study by Hanssen & Jørgensen (2014), who investigated author citations and articles in the transportation field, using a sample of five journals considered to be the most internationally recognized: Transportation (TR), Transportation Research Part A (PA), Transportation Research Part B (PB), Transportation Science (TS), and Journal of Transport Economics and Policy (JT). When analyzing the effect of publication year and the journal in which the articles appeared, the authors found that two factors are positively related to the number of citations: the number of references included and international authorship. Additionally, they observed that articles with shorter titles tend to receive more citations than those with longer titles.

From a citation analysis perspective, Sugishita & Asakuraa (2020) mapped the citation networks of transportation fields and complex networks to clarify their structure. The authors identified three communities: transport vulnerability, metro and shipping, and resilience. Quantitative analysis revealed asymmetric citation patterns between the two fields, indicating that, despite the study of topological properties in transportation networks, a mutual understanding remains lacking.

Using data from 22 journals in the transportation field indexed in the Science Citation Index and Social Sciences Citation Index databases of the Web of Science, Sun & Yin (2017) identified the thematic structure of the field and how it varies. The authors found 50 themes from 1991 to 2015. They also categorized these themes by journals and countries, providing a clearer view of their distribution based on the journals published and research conducted in specific countries. The results showed that topics like sustainable transport, non-motorized mobility, and driving and commuting habits have gained more attention over time, making the field broader and more interdisciplinary overall.

Based on the previous background, this study aims to provide a different perspective that, in some way, enhances the understanding of transportation as a research field. For this reason, we will examine the intellectual structure and patterns of scientific collaboration in transportation based on publications in the top 10% of high-impact journals listed in Scopus. Throughout the study, we will address the following research questions.

1. What co-word patterns represent the conceptual structure of the transportation field in the top-impact journals listed in Scopus?
2. Which papers form the intellectual foundation of transportation research based on co-citation relationships?
3. Which countries are at the forefront of scientific collaboration in transportation, and how are their international cooperation networks organized?

2. METHODOLOGY

We conducted a bibliometric analysis of scientific output in the transportation field. The sample included articles published between 2015 and 2024 in the top 10% of journals with the highest impact in Scopus for this area, resulting in a total of 39 journals. The selected period aimed to capture the most recent developments over the last decade, highlighting the emergence of new research lines and increased international collaboration. Only research articles and reviews were included, as they are the primary means of disseminating scientific knowledge, while other publication types that do not offer comparable academic content were excluded.

To retrieve the sample, a query based on the ISSN of the 39 selected journals was used (see Appendix 1) to ensure the search was limited solely to the target publications. A total of 44,068 documents were obtained. After retrieving the records, the variables of interest (countries, keywords, and cited references) were normalized, correcting spelling variations and removing duplicates that could bias the results.

The data were processed using Gephi software, where network maps were built and centrality metrics were computed. Specifically, degree was used to identify the most important nodes in each network, and betweenness highlighted nodes that served as bridges between different communities. The modularity class algorithm was also applied to detect clusters in the co-word and co-citation maps. In the co-word map, only author keywords with at least 20 occurrences were included. In the co-citation map, documents with a minimum of 20 co-citations were considered. In the international collaboration map, countries with two or more publications were analyzed.

Each indicator was directly connected to the research questions. To answer RQ 1, keyword co-occurrence analysis was employed to examine the communities formed by modularity, the centrality of terms, and their relationships within the network. For RQ 2, the document co-citation map was utilized, highlighting the texts with the highest degree and intermediary importance as the discipline's core. Finally, for RQ 3, the international collaboration map based on co-authorship was analyzed, assessing densities, centralities, and regional or intercontinental connections.

It is important to highlight some limitations of the study. First, choosing journals limited to the top 10% with the highest impact in Scopus provided a partial view of the discipline, excluding publications with lower impact factors that might reflect local or specialized approaches. Similarly, using thresholds (≥20 occurrences or co-citations) could exclude emerging concepts or early references with low frequency, but which are relevant in innovative fields. Finally, the metrics used (degree and betweenness) offered strong insights into centrality and connectivity, although they did not cover all the analytical possibilities available in bibliometric networks.

3. RESULTS

3.1. Co-word analysis

After applying the modularity class technique to the co-word network, we generated a map with 4427 nodes (keywords) and 1042135 links (co-occurrences between keywords). The map in Figure 1 shows a thematic structure with five classes, where Class 0 serves as the core of transportation research. Surrounding this core are three main thematic areas: Class 2, which focuses on economic analysis and financial sustainability; Class 5, centered on energy and the environment; and Class 3, which broadens the analysis to logistics and supply chains. More peripheral but equally important, Class 1 introduces technological innovation, while Class 4 incorporates the social dimensions of safety and public health.

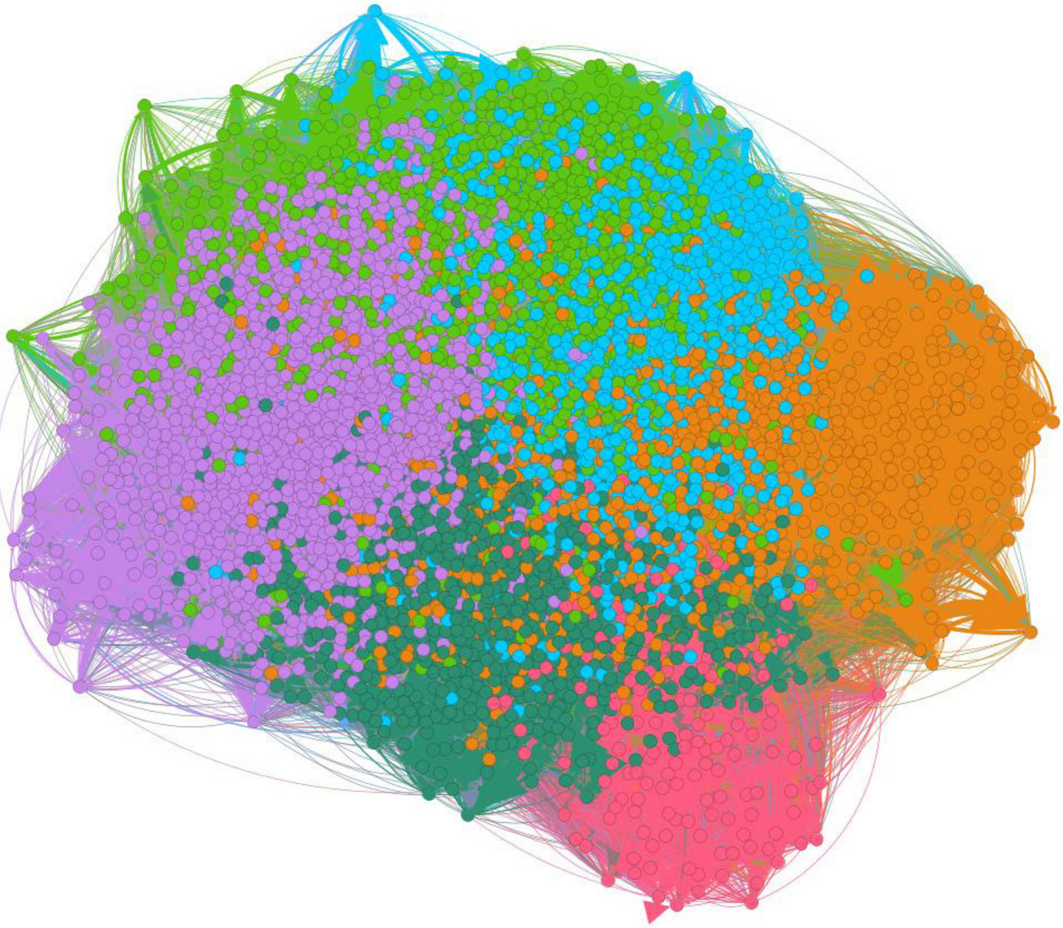

Figure 1. Co-word network of authors' keywords on transportation research.

Centrality metrics show that methodological terms such as *modeling* (betweenness: 123,480), *regression analysis* (betweenness: 85,409), and *public transport* (betweenness: 79,329) serve as bridge nodes connecting different clusters. The map overall reflects a clear thematic system, which we describe below (Table 1).

3.1.1. Class 0: Transport policies, urban mobility and modelin

This cluster constitutes the most robust core of the map and reflects the core of transportation research. Its core terms are *transportation planning* (degree: 3535), *transportation system* (degree: 3481), *urban transport* (degree: 3288), *travel behavior* (degree: 3318) and *public transport* (degree: 3049). These terms are closely connected, reflecting a thematic area that combines territorial planning studies, public mobility policies and empirical analysis of travel patterns. The high intermediation of *public transport* (betweenness: 79329.768515) shows that public transport research functions as a bridge between different thematic areas, from infrastructure studies to behavioral analysis.

Likewise, *modeling* (degree: 3203) and *regression analysis* (degree: 2985) appear with great weight, reflecting the relevance of statistical and simulation methods in the structuring of the research. These methodological terms

Class	Term	Degree	Betweenness
0	transportation planning	3535	33881.19324
0	transportation system	3481	34992.29101
0	united states	3399	32919.098847
0	travel behavior	3318	28295.188784
0	urban transport	3288	19020.005271
0	modeling	3203	123480.563833
0	transportation	3145	31745.015649
0	transportation development	3126	24865.617176
0	urban transportation	3065	17899.061865
0	public transport	3049	79329.768515
1	china	3634	66761.940781
1	sustainable development	3207	62823.369244
1	sustainability	3104	59397.103244
1	economic and social effects	2917	57572.662967
1	economics	2822	50506.738413
1	urban area	2748	21413.995388
1	energy utilization	2664	51880.593913
1	energy efficiency	2526	46271.946048
1	urban planning	2433	12142.627099
1	climate change	2386	20151.619027
2	electric vehicle	3023	72750.736837
2	electric vehicles	2666	53255.769571
2	efficiency	2554	50187.034574
2	emission control	2475	37779.012659
2	carbon emission	2453	16395.618454
2	environmental impact	2345	36641.814678
2	greenhouse gases	2241	36947.966821
2	carbon dioxide	2225	13876.686382
2	charging (batteries)	2094	13164.989022
2	traffic emission	2020	14227.387296
3	numerical model	3772	184951.090357
3	decision making	3708	101421.858868
3	optimization	3453	141356.448043
3	algorithm	3079	12925.196087
3	costs	3039	50132.169218
3	sensitivity analysis	2616	57795.646631
3	uncertainty analysis	2520	17923.108287
3	commerce	2495	23647.103687
3	stochastic systems	2494	32492.260799
3	investments	2452	58864.387972
4	performance assessment	2755	76489.456503
4	experimental study	2031	38163.784767
4	railway	978	7302.479906
4	pavements	877	4705.680556
4	pavement	847	5278.089324
4	aggregates	817	532.541478
4	three-dimensional modeling	690	3098.51809
4	recycling	661	2939.977563
4	loading	646	3932.605644
4	bridge	644	1034.030483
5	vehicles	3111	20691.737468
5	traffic congestion	3041	36606.685048
5	roads and streets	2990	73360.823938
5	computer simulation	2902	40403.659488
5	traffic management	2800	27483.01753
5	motor transportation	2709	70790.93702
5	machine learning	2669	75834.818674
5	forecasting	2587	60490.243155
5	behavioral research	2545	14987.526586
5	risk assessment	2529	50665.388096

Table 1. Centrality measure of top keywords per cluster.

are not only recurrent but also act as nodes of connection between research on urban mobility and those related to sustainability or economics. The close relationship between *travel demand* (degree: 2733) and *transportation policy* (degree: 2996) confirms that much of the field revolves around how travel patterns condition policy formulation.

3.1.2. Class 1: Technological innovation and digitization applied to transport

This group brings together terms linked to emerging technologies, particularly in simulation and advanced manufacturing. *3D modeling* (degree: 273) and *3D printing* (degree: 96) stand out, whose presence evidences the interest in applying digital design and additive manufacturing tools to mobility and logistics problems. The co-occurrence between these terms shows a clear convergence towards the development of prototypes, simulation scenarios and digital solutions to optimize transportation infrastructures and processes. Although the centrality values are lower than in class 0, this cluster plays a cross-cutting role, since it connects with infrastructure studies in class 0 and with technical sustainability in class 5. This may reflect the contribution of novel methodologies that enrich applied research in some way.

3.1.3. Class 2: Transportation economics, sustainability and mitigation costs

This cluster focuses on topics related to economic studies and sustainable management. Terms like abatement costs (degree: 349), closely linked to environmental externalities, and academic research (degree: 341), which involves methodological reflections on economic evaluation, stand out. The terms in this group are strongly connected to concepts such as efficiency, transportation costs, and impact analysis. This indicates a significant interest in measuring economic benefits against environmental mitigation costs.

The connection between Class 2 and Class 0 can be seen, for example, in the link between *transportation policy* and *cost analysis;* this clearly demonstrates that mobility policies are evaluated based on economic viability. This grouping of keywords provides a practical approach to decision-making by emphasizing the thematic link between financial and environmental sustainability, influenced by the potential impact of regulatory measures.

3.1.4. Class 3: Logistics, supply chains, and freight transport

The fourth thematic group centers on terms related to logistics and global value chains. Key terms include *supply chain management, distribution,* and *freight transport,* which are closely connected within the cluster. These terms highlight studies on operational efficiency, managing the flow of goods, and integrating transportation with production processes. The internal relationships show how *freight transport* links to *distribution* and *supply chains,* emphasizing logistics optimization. The fact that this cluster connects with Classes 0 and 2 indicates that logistics research is linked with mobility policies and economic assessment. This reflects a broadening of the transport field toward a highly relevant productive and commercial perspective.

3.1.5. Class 4: Road safety, risk, and public health

Although this is the smallest cluster in terms of number, it has a well-defined specialization. Key terms include *road safety, injury prevention,* and *risk assessment,* which are strongly linked to other terms related to accident prevention and risk reduction in transportation. This grouping of terms reflects a thematic area that involves social and health aspects of transportation research.

We observe that the relationship between *road safety* and *infrastructure design* connects this class with Class 0 planning studies. This confirms that safety is seen as an interdisciplinary aspect of mobility policies. Moreover, the links with terms related to public health emphasize its multidisciplinary nature (e.g., accident prevention, transportation safety, highway accidents, accidents, risk assessment), building a bridge between transportation, preventive medicine, and risk management.

3.1.6. Class 5: Energy, emissions, and environmental sustainability

The last cluster examines the relationship between transportation and the environment. Key words such as *'acceleration'* (degree: 718), related to the physical dynamics of transport, are connected to terms involving *fuel consumption, greenhouse gases,* and *emissions reduction.* These links highlight an approach focused on analyzing energy performance and assessing environmental impacts from transportation. The internal links within this cluster show how studies of emissions and energy use are integrated with technical transportation models, emphasizing engineering and environmental sustainability as core themes. The cluster also directly connects with transportation economics (Class 2), concerning environmental costs, and with the urban mobility core (Class 0), where policies aimed at reducing impacts are discussed. Therefore, it serves as a thematic bridge that unites technical, environmental, and economic aspects within the research field.

3.2. Document co-citation analysis

Through document co-citation analysis we identified six main thematic clusters, which are shown in Figure 2 and Table 2. The results show that the co-citation network is organized around a central core composed of behavioral foundations and discrete choice models (Class 2), strongly linked to technological innovation and smart mobility (Class 1). Around it are the clusters of social perceptions (Class 5) and statistical methods (Class 3), which operate as cross-cutting support axes. Further on the periphery are clusters of documents linked to pandemic and resilience (Class 6), as well as normative classics (Class 4). In the following, we will describe each of the identified clusters; but from their order of importance within the map.

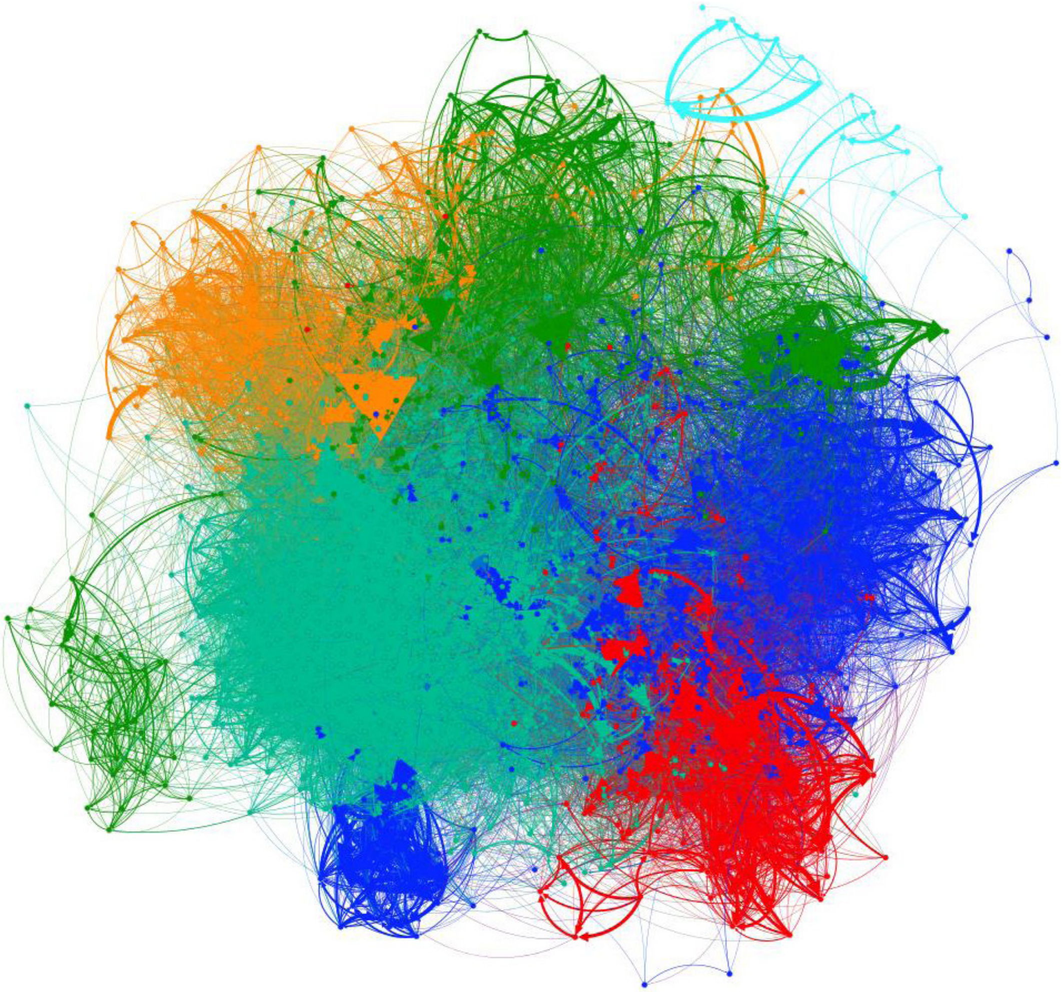

Figure 2. Document co-citation map of transportation research.

3.2.1. Class 2: Behavioral fundamentals, choice models, and sustainability

We begin by describing Class 2 as it is the largest and most central in the network. It is composed of 598 documents and concentrates the foundational references on transportation behavior, discrete choice theory and sustainable mobility. At the core of the cluster are texts such as *Discrete Choice Analysis: Theory and Application* (degree: 564; betweenness: 51,882), considered the methodological basis of the discipline, and *Ajzen, The Theory of Planned Behavior* (degree: 464; betweenness: 27,837), which provides the psychological framework for understanding attitudes and decisions in mobility. Also noteworthy are works on urban planning and transportation such as *Cervero, Travel demand and the 3Ds* (degree: 279; betweenness: 19,769) and *Banister, The Sustainable Mobility Paradigm* (degree: 247; betweenness: 21,079), which link sustainability, territorial planning and travel patterns. The presence of reference compilations such as the *Handbook of Transportation Science* (degree: 226) evidences the consolidation of a corpus that articulates behavioral theory and mobility policies.

Class	Document	Degree	Intermediation
1	Agatz, N., Erera, A., Savelsbergh, M., & Wang, X. (2012). Optimization for dynamic ride-sharing: A review. *European Journal of Operational Research,* 223(2), 295-303.	213	3893.324885
1	Alonso-Mora, J., Samaranayake, S., Wallar, A., Frazzoli, E., & Rus, D. (2017). On-demand high-capacity ride-sharing via dynamic trip-vehicle assignment. *Proceedings of the National Academy of Sciences, 114*(3), 462-467.	209	9446.379351
1	Bansal, P., Kockelman, K. M., & Singh, A. (2016). Assessing public opinions of and interest in new vehicle technologies: An Austin perspective. *Transportation Research Part C: Emerging Technologies, 67,* 1-14.	202	12376.475298
1	Ahujia, R. K., Magnanti, T. L., & Orlin, J. B. (1993). Network flows: Theory, algorithms and applications. *New Jersey: Rentice-Hall, 3.*	147	2084.738743
1	Bansal, P., & Kockelman, K. M. (2017). Forecasting Americans' long-term adoption of connected and autonomous vehicle technologies. *Transportation Research Part A: Policy and Practice, 95,* 49-63.	143	8725.438208
1	Bektaş, T., & Laporte, G. (2011). The pollution-routing problem. *Transportation Research Part B: Methodological, 45*(8), 1232-1250.	117	8546.134881
1	Bösch, P. M., Becker, F., Becker, H., & Axhausen, K. W. (2018). Cost-based analysis of autonomous mobility services. *Transport Policy, 64,* 76-91.	115	6025.827474
1	Agatz, N., Erera, A. L., Savelsbergh, M. W., & Wang, X. (2011). Dynamic ride-sharing: A simulation study in metro Atlanta. *Procedia-Social and Behavioral Sciences, 17,* 532-550.	108	257.002058
1	Bertsimas, D., & Sim, M. (2004). The price of robustness. *Operations Research, 52*(1), 35-53.	107	8306.518556
2	Ben-Akiva, M. E., & Lerman, S. R. (1985). *Discrete choice analysis: theory and application to travel demand* (Vol. 9). MIT press.	564	51882.026244
2	Ajzen, I. (1991). The theory of planned behavior. *Organizational behavior and human decision processes, 50*(2), 179-211.	464	27837.48319
2	Cervero, R., & Kockelman, K. (1997). Travel demand and the 3Ds: Density, diversity, and design. *Transportation Research part D: Transport and Environment, 2*(3), 199-219.	279	19769.724874
2	Banister, D. (2008). The sustainable mobility paradigm. *Transport Policy, 15*(2), 73-80.	247	21079.721313
2	Anable, J. (2005). 'Complacent car addicts' or 'aspiring environmentalists'? Identifying travel behaviour segments using attitude theory. *Transport Policy, 12*(1), 65-78.	239	1152.329985
2	Anable, J. (2005). 'Complacent car addicts' or 'aspiring environmentalists'? Identifying travel behaviour segments using attitude theory. *Transport Policy, 12*(1), 65-78.	237	10022.061228
2	Breiman, L. (2001). Random forests. *Machine Learning, 45*(1), 5-32.	227	32003.02631
2	Ben-Akiva, M., Bierlaire, M., & Hall, R. (1999). *Handbook of transportation science.*	226	5752.700896
2	Beirão, G., & Cabral, J. S. (2007). Understanding attitudes towards public transport and private car: A qualitative study. *Transport Policy, 14*(6), 478-489.	225	17834.05948
2	Alonso, W. (1964). *Location and land use: Toward a general theory of land rent.* Harvard University Press.	205	4626.467778
3	Anderson, J. C., & Gerbing, D. W. (1988). Structural equation modeling in practice: A review and recommended two-step approach. *Psychological Bulletin, 103*(3), 411.	203	17175.212348
3	Baron, R. M., & Kenny, D. A. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology, 51*(6), 1173.	167	18879.284738
3	Bagozzi, R. P., & Yi, Y. (1988). On the evaluation of structural equation models. *Journal of the Academy of Marketing Science, 16*(1), 74-94.	161	12888.418184
3	Armstrong, J. S., & Overton, T. S. (1977). Estimating nonresponse bias in mail surveys. *Journal of Marketing Research, 14*(3), 396-402.	102	3133.658935
3	Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management, 17*(1), 99-120.	82	11691.677802
3	Aiken, L. S., West, S. G., & Reno, R. R. (1991). *Multiple regression: Testing and interpreting interactions.* Sage.	80	1741.03382
3	Bentler, P. M., & Bonett, D. G. (1980). Significance tests and goodness of fit in the analysis of covariance structures. *Psychological Bulletin, 88*(3), 588.	73	2530.496592
3	Cohen, J. (1988). *Statistical power analysis for the behavioral sciences.* Routledge.	72	101.341681
3	Baker, D. A., & Crompton, J. L. (2000). Quality, satisfaction and behavioral intentions. *Annals of Tourism Research, 27*(3), 785-804.	71	977.817453

Class	Document	Degree	Intermediation
3	Baloglu, S., & McCleary, K. W. (1999). A model of destination image formation. *Annals of Tourism Research, 26*(4), 868-897.	71	1236.891143
4	Bilgin, B., Magne, P., Malysz, P., Yang, Y., Pantelic, V., Preindl, M., ... & Emadi, A. (2015). Making the case for electrified transportation. *IEEE Transactions on Transportation electrification, 1*(1), 4-17.	16	5394.604347
4	Ahmad, A., Alam, M. S., & Chabaan, R. (2017). A comprehensive review of wireless charging technologies for electric vehicles. *IEEE Transactions on Transportation Electrification, 4*(1), 38-63.	11	0.0
4	Sarlioglu, B., & Morris, C. T. (2015). More electric aircraft: Review, challenges, and opportunities for commercial transport aircraft. *IEEE Transactions on Transportation Electrification, 1*(1), 54-64.	10	3952.856174
4	Yang, Z., Shang, F., Brown, I. P., & Krishnamurthy, M. (2015). Comparative study of interior permanent magnet, induction, and switched reluctance motor drives for EV and HEV applications. *IEEE Transactions on Transportation Electrification, 1*(3), 245-254.	9	1163.708744
4	Cao, W., Mecrow, B. C., Atkinson, G. J., Bennett, J. W., & Atkinson, D. J. (2011). Overview of electric motor technologies used for more electric aircraft (MEA). *IEEE Transactions on Industrial Electronics, 59*(9), 3523-3531.	7	5.0
4	Madonna, V., Giangrande, P., & Galea, M. (2018). Electrical power generation in aircraft: Review, challenges, and opportunities. *IEEE Transactions on Transportation Electrification, 4*(3), 646-659.	7	657.118947
4	Ronanki, D., Singh, S. A., & Williamson, S. S. (2017). Comprehensive topological overview of rolling stock architectures and recent trends in electric railway traction systems. *IEEE Transactions on Transportation Electrification, 3*(3), 724-738.	6	1191.274181
4	Sayed, E., Abdalmagid, M., Pietrini, G., Sa'adeh, N. M., Callegaro, A. D., Goldstein, C., & Emadi, A. (2021). Review of electric machines in more-/hybrid-/turbo-electric aircraft. *IEEE Transactions on Transportation Electrification, 7*(4), 2976-3005.	6	2.166667
4	Bostanci, E., Moallem, M., Parsapour, A., & Fahimi, B. (2017). Opportunities and challenges of switched reluctance motor drives for electric propulsion: A comparative study. *IEEE Transactions on Transportation Electrification, 3*(1), 58-75.	5	601.0
4	Wheeler, P., & Bozhko, S. (2014). The more electric aircraft: Technology and challenges. *IEEE Electrification Magazine, 2*(4), 6-12.	5	0.0
5	Angrist, J. D., & Pischke, J. S. (2009). *Mostly harmless econometrics: An empiricist's companion*. Princeton university press.	110	8368.947562
5	Baltagi, B. H., & Baltagi, B. H. (2008). *Econometric analysis of panel data* (Vol. 4, pp. 135-145). Chichester: John Wiley & Sons.	96	2226.814321
5	Albalate, D., Bel, G., & Fageda, X. (2015). Competition and cooperation between high-speed rail and air transportation services in Europe. *Journal of Transport Geography, 42,* 166-174.	86	2918.80477
5	Banister, D., & Berechman, Y. (2001). Transport investment and the promotion of economic growth. *Journal of Transport Geography, 9*(3), 209-218.	84	3266.936763
5	Bertazzi, L., & Speranza, M. G. (2012). Inventory routing problems: an introduction. *EURO Journal on Transportation and Logistics, 1*(4), 307-326.	83	2811.358572
5	Blondel, V. D., Guillaume, J. L., Lambiotte, R., & Lefebvre, E. (2008). Fast unfolding of communities in large networks. *Journal of Statistical Mechanics: Theory and Experiment, 2008*(10), P10008.	82	7472.247827
5	Barabási, A. L., & Albert, R. (1999). Emergence of scaling in random networks. *Science, 286*(5439), 509-512.	78	5480.073779
5	Banker, R. D., Charnes, A., & Cooper, W. W. (1984). Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Management Science, 30*(9), 1078-1092.	76	8390.745211
5	Behrens, C., & Pels, E. (2012). Intermodal competition in the London-Paris passenger market: High-Speed Rail and air transport. *Journal of Urban Economics, 71*(3), 278-288.	76	5672.099591
5	Agarwal, R., & Ergun, Ö. (2008). Ship scheduling and network design for cargo routing in liner shipping. *Transportation Science, 42*(2), 175-196.	73	667.858143
6	Beckmann, M., McGuire, C. B., & Winsten, C. B. (1956). *Studies in the Economics of Transportation* (No. 226 pp.).	158	834.741303

Class	Document	Degree	Intermediation
6	Arnott, R., De Palma, A., & Lindsey, R. (1990). Economics of a bottleneck. *Journal of Urban Economics, 27*(1), 111-130.)	153	7653.877846
6	Rabin, M. (1993). Incorporating fairness into game theory and economics. *The American Economic Review,* 1281-1302.	139	2161.541616
6	Daganzo, C. F. (1994). The cell transmission model: A dynamic representation of highway traffic consistent with the hydrodynamic theory. *Transportation Research Part B: Methodological, 28*(4), 269-287.	102	2659.263787
6	Aboudolas, K., & Geroliminis, N. (2013). Perimeter and boundary flow control in multi-reservoir heterogeneous networks. *Transportation Research Part B: Methodological, 55,* 265-281.	100	2294.157912
6	Bazaraa, M. S., Sherali, H. D., & Shetty, C. M. (2006). *Nonlinear programming: theory and algorithms.* John Wiley & Sons.	97	5751.297386
6	Daganzo, C. F. (2007). Urban gridlock: Macroscopic modeling and mitigation approaches. *Transportation Research Part B: Methodological, 41*(1), 49-62.	88	2349.174946
6	Arnott, R. (2013). A bathtub model of downtown traffic congestion. *Journal of Urban Economics, 76,* 110-121.	85	2463.19935
6	Daganzo, C. F. (1995). The cell transmission model, part II: network traffic. *Transportation Research Part B: Methodological, 29*(2), 79-93.	85	1490.973369
6	Arnott, R., De Palma, A., & Lindsey, R. (1994). The welfare effects of congestion tolls with heterogeneous commuters. *Journal of Transport Economics and Policy,* 139-161.	85	1171.276164

Table 2. Centrality measures of top co-cited documents per cluster.

3.2.2. Class 1: Technological innovation and intelligent transportation

The second cluster, with 351 papers, groups together the literature on technological innovation in mobility, particularly linked to intelligent transportation systems and new models of shared mobility. Papers such as *Agatz, Optimization for Dynamic Ride-Sharing* (degree: 213; betweenness: 3,893) and *Alonso-Mora, On-Demand High-Capacity Ride-Pooling* (degree: 209; betweenness: 9,446) are central in establishing the foundations of research in on-demand mobility services. This group also incorporates empirical assessments of the social acceptance of these innovations, such as *Bansal, Assessing Public Opinions of Connected Vehicles* (degree: 202; betweenness: 12,376), as well as recent theoretical developments on e-hailing *(Ban, General Equilibrium Model for E-Hailing Services).* This Class 1 presents strong connections with class 2, since new transportation models need to be grounded in the discrete choice and sustainability frameworks. In addition, there are links with the literature on big data and machine learning, through co-citation with methodological contributions such as *Breiman, Random Forests* (degree: 227; betweenness: 32,003).

3.2.3. Class 5: Social psychology, consumer behavior and perceptions

A third thematic area, including 254 papers, focuses on the psychological and social aspects of mobility. Key works include *Anable, Complacent Car Addicts* (degree 237; betweenness 10,022), which looks at car dependence, and *Beirão, Understanding Attitudes Toward Public Transport* (degree 225; betweenness 17,834), which studies perceptions and motivations related to public transportation. This group also includes research from marketing and consumer studies, showing an interdisciplinary approach that links transportation with environmental perception and technological acceptance. Its connection to Class 2 is explained through the theory of planned behavior, highlighting that sustainable mobility depends on shifting social attitudes and beliefs.

3.2.4. Class 3: Advanced statistical methods and modeling

The fourth group (132 papers) gathers the methodological literature that supports much of the applied research in the field. Here, *Anderson, Structural Equation Modeling* (degree: 203; betweenness: 17,175), a work widely co-cited as a reference for modeling latent relationships in mobility studies, stands out. This cluster directly connects to the literature on machine learning and data mining, especially through *Breiman's Random Forests,* which, although more centrally located in another cluster, shows strong links with the methodological texts.

3.2.5. Class 6: Pandemics, resilience, and disruptions in transportation

Class 6, with 151 papers, focuses on a new research area related to how the COVID-19 pandemic has affected mobility and transportation. A good example is *Aaditya, Psychological Impacts of COVID-19* (degree: 52), which shows how travel patterns have been influenced by psychological and social factors. This group is tied to social perceptions (Class 5) and shared mobility patterns (Class 1), indicating that the pandemic not only changed transportation demand but also led to shifts in system acceptance and resilience. Although it is a smaller and emerging group, it is gaining importance.

3.2.6. Class 4: Classical studies and normative manuals

Finally, a smaller group of 17 documents gathers historical and normative works that have established the foundation for urban and transportation planning. *Location and Land Use (1964)* (degree: 205; betweenness: 4,626), a classic in transportation geography, stands out, along with normative manuals such as the *Policy on Geometric Design of Highways and Streets.* Although small, this cluster lends historical and regulatory legitimacy to the field, serving as a background for the conceptual development of the other groups.

3.3. Country collaboration analysis

After generating the country collaboration map (Figure 3), we observe that the most prominent node is the United States (degree: 108). This indicates that it collaborates with more than a hundred countries and holds the most strategic position on the map. It is followed by the United Kingdom (degree: 105), China (degree: 93), and Spain (degree: 85). These four countries form the core of the network, with significantly higher degrees of collaboration than the others.

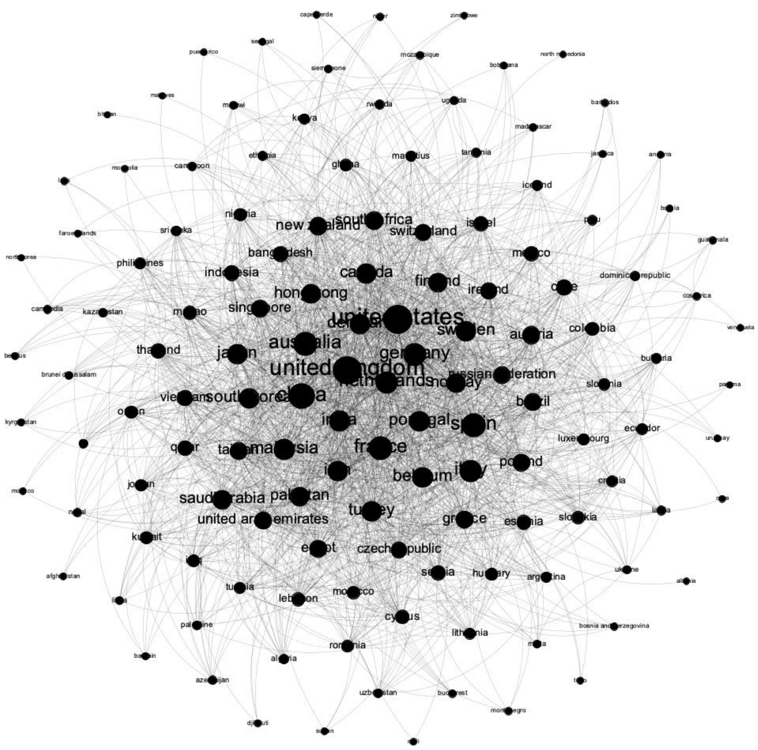

Figure 3. Country collaboration map of transportation research.

While the number of collaborations (degree) indicates the size of a country's network, the betweenness centrality reveals which countries act as links between different scientific communities (see Table 3). In this regard, China ranks first (452.4), serving as a true bridge between Asia and the West. It is followed by Italy (376.6), France (374.6), Spain (329.7), and the Netherlands (325.4), demonstrating the connecting role of Southern and Western Europe in the global system. Malaysia (241.8) and New Zealand (159.2) also stand out as regions that are not the most prolific in volume but are key regional connectors.

At the other extreme, there are countries with very low connection density. Countries like Albania, Bhutan, or North Macedonia have little collaboration (degree 1). Others such as Zimbabwe, Venezuela, Panama, Mali, or Maldives have minimal degrees (2), indicating a marginal presence in the global network. These peripheral positions suggest a low level of internationalization in scientific production, relying on occasional collaborations with more established centers.

Country	Degree centrality	Betweenness centrlity
United States	108	91.347396
United Kingdom	105	21.65196
China	93	452.379042
Spain	85	329.766723
Australia	84	43.209298
France	83	374.609396
Italy	77	376.599831
Germany	76	209.289671
Netherlands	76	325.406174
Malaysia	72	241.80754
India	69	119.138701
Portugal	68	110.343597
Turkey	68	3.703909
Sweden	68	93.347295
Belgium	68	101.044378
Denmark	67	106.102191
Canada	66	80.983788
South Korea	66	82.405897
Japan	66	215.836066
Iran	66	92.63225

Table 3. Centrality measures of top countries in the collaboration map.

In regional terms, Western Europe is the most dense and cohesive region, with multiple connections among its main powers (United Kingdom, Germany, France, Italy, Netherlands, Spain). This area acts as a connecting core along with the United States and China, forming a "triad" that drives global scientific collaboration. In Latin America, the network is more fragmented. For example, Brazil and Mexico are more interconnected, while Argentina and Chile have a notable presence but with less intermediary activity. In contrast, Central America and the Caribbean show low density, with countries like Panama and Cuba positioned on the periphery.

In Asia, however, a duality exists. On one side, major scientific powers such as China, Japan, India, and South Korea are highly integrated into the network; on the other, some countries with less academic development barely establish collaborations. Malaysia and Hong Kong are noteworthy because of their roles as bridging partners between East and West. Regarding Africa, the network density is low; however, South Africa (57; betweenness 151.3) stands out on the continent, acting as a link between core countries and other African nations. Finally, in Oceania, Australia (84 collaborations) is a key node, while New Zealand (56; betweenness 159.2) functions as a regional bridge, connecting the region to the global scientific community.

In summary, the map in Figure 3 displays a clearly hierarchical structure. At the top are the United States, the United Kingdom, China, and the Western European bloc, which collectively have the highest density and centrality in the network. These powers not only generate the largest volume of collaborations but also act as intermediaries, facilitating the flow of knowledge between regions. Secondary levels include countries such as Spain, Italy, France, Germany, and the Netherlands, known for their high degree and role in connecting research. The third level consists of emerging countries with strong regional intermediation, like India, Malaysia, South Africa, and New Zealand. Lastly, countries with low representation, many from Africa, Central America, or Central Asia, are on the periphery, with minimal integration into the network.

4. DISCUSSION AND CONCLUDING REMARKS

This study's results provide a comprehensive view of transportation research based on the top 10% of journals indexed in Scopus. It highlights both the conceptual structure seen in co-word analysis and the intellectual foundation shown through co-citation of documents. Overall, the findings help us identify overlaps, complementarities, and conflicts with earlier research in the field.

First, the co-word map highlighted the importance of terms related to road safety, infrastructure planning, and sustainability. These clusters demonstrate how current transportation research blends technical perspectives with interdisciplinary approaches, connecting transportation engineering with public health and risk management. This aligns somewhat with the findings of Sun and Yin (2017), who noted that topics like sustainable transportation and non-motorized mobility have gained increasing significance over time, forming a broader, interdisciplinary field. However, while Sun and Yin mapped 50 themes over a longer period, the results here focus more on recent strategic areas centered on safety and sustainability, indicating an evolution toward priority and globally shared directions.

The analysis of co-citation among documents enhances this perspective by highlighting the most influential texts that form the intellectual foundation of the discipline. It was observed that the papers with the highest centrality related to methodological studies in transportation modeling, as well as research on system resilience and vulnerability. This pattern aligns with the study of Sugishita and Asakura (2020), who identified citation communities connected to transportation vulnerability, subway and marine transportation systems, and resilience. However, unlike their results, which emphasized links to complex network analysis, the present study reveals a stronger focus on applied approaches to road safety and sustainability, which could indicate a shift in intellectual interest toward practical global challenges.

The comparison between co-words and co-citation helps us identify both similarities and differences in themes. For example, terms like road safety or infrastructure design appear in both analyses, confirming that road safety is a key focus and a central reference point. However, some differences are also noticeable: while the co-word network shows emerging trends around sustainable mobility, the co-citation analysis still emphasizes classic papers focused on optimizing quantitative models and methods. This gap indicates that the academic community continues to rely on traditional theoretical frameworks when researching current issues.

Regarding international collaboration among countries, the results support trends observed by earlier studies. The dominance of the United States, China, and the United Kingdom in the collaborative network aligns with findings by Modak *et al.* (2019) and Jiang *et al.* (2020) at the journal level. Likewise, the strong presence of European countries like Germany and the Netherlands emphasizes a research landscape centered around established scientific hubs. Nevertheless, the limited bilateral links for peripheral countries highlight an uneven distribution of scientific output and visibility, which aligns with Fan *et al.* (2023), indicating that research on carbon emissions in transport is controlled by a small core of nations.

Overall, the findings show that transportation research is currently focused on themes, with safety and sustainability shaping both ideas and teamwork. At the same time, well-established methodological traditions remain important, providing continuity in key references, though they also present the challenge of quickly incorporating new ideas around digitalization, smart systems, and urban resilience.

In summary, the results of this study confirm that transportation research is moving toward greater integration of multidisciplinary approaches, where road safety and sustainability are emphasized as cross-cutting issues, while the co-citation of papers indicates the continued influence of classical methodological frameworks that still guide the field's development. The central role of a small group of countries in the collaborative network highlights a scientific dynamic that remains concentrated, although there are signs of expanding to new regions. This evidence suggests that the future of the field will depend both on renewing its intellectual foundations and on expanding international cooperation, so that progress addresses global transportation challenges with increased equity and scope.

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Conflict of interest

The authors declare that they have no conflicts of interest.

Contribution statement

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Statement of data consent

The data generated during the development of this study have been included in the manuscript.

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APPENDIX

Appendix 1. List of 10% transportation journals with the highest impact in Scopus

Journal	Number of documents
Sustainable Cities and Society	5601
Transportation Research Part C Emerging Technologies	3107
Transportation Research Part D Transport and Environment	2954
Transportation Research Part A Policy and Practice	2603
IEEE Transactions on Transportation Electrification	2340
Transportation Research Part E Logistics and Transportation Review	2209
Transport Policy	1952
Journal of Transport Geography	1938
Tourism Management	1801
Transportation Research Part B Methodological	1642
Iet Intelligent Transport Systems	1350
Transportation Geotechnics	1349
Journal of Air Transport Management	1217
Transportation Research Interdisciplinary Perspectives	1173
Utilities Policy	993
Journal of Travel Research	937
Transportation	932
Travel Behaviour and Society	802
Research in Transportation Business and Management	798
Transportation Science	785
International Journal of Tourism Research	779
Research in Transportation Economics	749
International Journal of Sustainable Transportation	723
Maritime Policy and Management	641
International Journal of Logistics Management	562
Journal of Traffic and Transportation Engineering English Edition	547
European Transport Research Review	502
International Journal of Physical Distribution and Logistics Management	433
Iatss Research	384
Transport Reviews	379

Journal	Number of documents
Journal of Tourism and Cultural Change	335
Energy and Built Environment	306
Etransportation	298
Maritime Economics and Logistics	283
Analytic Methods in Accident Research	234
Railway Engineering Science	140
Journal of Intelligent and Connected Vehicles	105
Communications in Transportation Research	95
Multimodal Transportation	90