



AN IN-DEPTH BIBLIOMETRIC ANALYSIS OF PREDICTION IN MICROMOBILITY

Taha DURMAZ*

Yusuf Sait TÜRKAN**

*Doktora Öğrencisi, İstanbul Üniversitesi-Cerrahpaşa, Lisansüstü Eğitim Enstitüsü, Endüstri Mühendisliği Anabilim Dalı, tdurmaz@gmail.com, ORCID: 0009-0000-1327-9301

**Doç. Dr., İstanbul Üniversitesi-Cerrahpaşa, Mühendislik Fakültesi, Endüstri Mühendisliği Bölümü, ysturkan@istanbul.edu.tr, ORCID: 0000-0001-7240-183X

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ABSTRACT

Traffic, personal life requirements, pandemic, sustainability, cost & time efficiency are only a few major reasons of proliferation of micromobility. Especially in urban life, usage of shared & self-owned e-scooters, e-bikes, small cars are increasing day by day. With the growth of the market, more data occurs to work on; usage statistics, vehicle&battery data, legal regularities, injuries and etc. With the help of central management systems of big vehicle fleets, municipalities and big data portals, accessing data gets easier. Because of the high-quality big amount of data, it is critical to analyze the data accurate for business management and public administration by the scientific researchs. In last decade applications of advanced prediction methods on micromobility got high attention from the researchers. This study aims to analyze the existing work in the literature through bibliometric analysis. Existing literature is gained by searching online scientific publications with a systematic keyword search. And the literature data was analyzed and interpreted by different point of views via an academic software application.

Keywords: Micromobility, E-Scooter, Shared Bikes, Prediction, Machine Learning

JEL Clasifications: : C80, D85

MİKROMOBİLİTE'DE TAHMİNLEME ÜZERİNE DERİNLEMESİNE BİR BİBLİYOMETRİK ANALİZ

ÖZET

Trafik, kişisel yaşam gereksinimleri, pandemi, sürdürülebilirlik, maliyet ve zaman verimliliği, mikromobilitenin yaygınlaşmasının önemli nedenlerinden sadece bir kısmıdır. Özellikle kentsel yaşamda, paylaşımlı veya şahsi e-scooterlar, e-bisikletler ve küçük arabaların kullanımı her geçen gün artmaktadır. Pazarın büyümesiyle birlikte, üzerinde çalışılacak daha fazla veri ortaya çıkmaktadır; kullanım istatistikleri, araç ve akü verileri, yasal düzenlemeler, yaralanmalar... gibi. Büyük araç filolarının merkezi yönetim sistemleri, belediyeler ve büyük veri portallarının yardımıyla, veriye erişim daha da kolaylaşmaktadır. Yüksek kalitede büyük miktardaki verinin desteğiyle, bilimsel araştırmalar sonucunda, işletme ve kamu yönetimi için verinin doğru bir şekilde analiz edilmesi büyük önem taşımaktadır. Son on yılda, mikromobilite alanında gelişmiş tahmin yöntemlerinin uygulamaları araştırmacılar tarafından büyük ilgi görmüştür. Bu çalışma, literatürdeki mevcut çalışmalarını bibliyometrik analiz yoluyla irdelemeyi amaçlamaktadır. Mevcut literatür, sistematik bir anahtar kelime aramasıyla çevrimiçi bilimsel yayınlar taranarak elde edilmiştir. Ardından literatür verileri, akademik bir yazılım uygulaması aracılığıyla farklı bakış açılarıyla analiz edilmiş ve yorumlanmıştır.

Anahtar Kelimeler: Mikromobilite, E-Scooter, Paylaşımlı Bisikletler, Tahminleme, Makine Öğrenmesi

JEL Sınıflandırması: C80, D85



1. INTRODUCTION

City centers are getting bigger and more intricate. In 2018, almost 55 per cent of people on the planet reside in cities, compared to 30 per cent in 1950. Additionally, the United Nations Department of Economics and Social Affairs' "World Urbanization Prospects 2018" report projects that it will reach 68 per cent by 2050 (UN, 2019).

The process of decarbonizing urban transportation involves more than just switching from private automobiles to shared and low-carbon forms of transportation. Other logics, such as digitalization and electrification, are at work. The emergence of electric vehicles to replace fossil fuel vehicles is a clear example of the electrification of the hegemonic transportation practices that have dominated urban transport planning legacies. Other forms of electrically powered public transportation, such light trains and subways, are already in place and are still growing both within and between cities, and buses are increasingly following this logic of electrification. Electric micromobility is a rapidly developing market that discursively interpellates energy and transportation policy goals of decarbonization, particularly in urban areas (Sareen et. al, 2021).

The only international organization that addresses all forms of transportation is the International Transport Forum (ITF), which is officially affiliated with the Organization for Economic Co-operation and Development (OECD). Micromobility, according to ITF, is the use of micro-vehicles, which are automobiles with a mass of no more than 350 kg (771 lbs) and a design speed of no more than 45 km/h. According to this definition, the vehicle's kinetic energy is limited to 27 kJ, which is 100 times less than what a tiny automobile can achieve at its maximum speed (OECD, 2020). There are four types of of micro vehicles in two classes according to ITF:

- The primary criterion for classifying micro-vehicles is their top speed. Human-powered vehicles, like bicycles, and vehicles whose power supply cuts out at 25 km/h are examples of Type A and Type B micro-vehicles (Figure 1). This category would include a large number of bicycles, e-bikes, e-scooters, and self-balancing vehicles. In Europe, the primary e-bike classifications are known to be separated by a speed threshold of 25 km/h. E-bikes are often regarded and controlled as bicycles up to 25 km/h.
- A weight barrier of 35 kg can be used to further categorize micro-vehicles, after which authorities may apply further safety regulations. It is proven that braking systems and kinetic energy are impacted by vehicle weight. Another way to think of weight is as a substitute for the ability to carry more individuals as well as cargo.

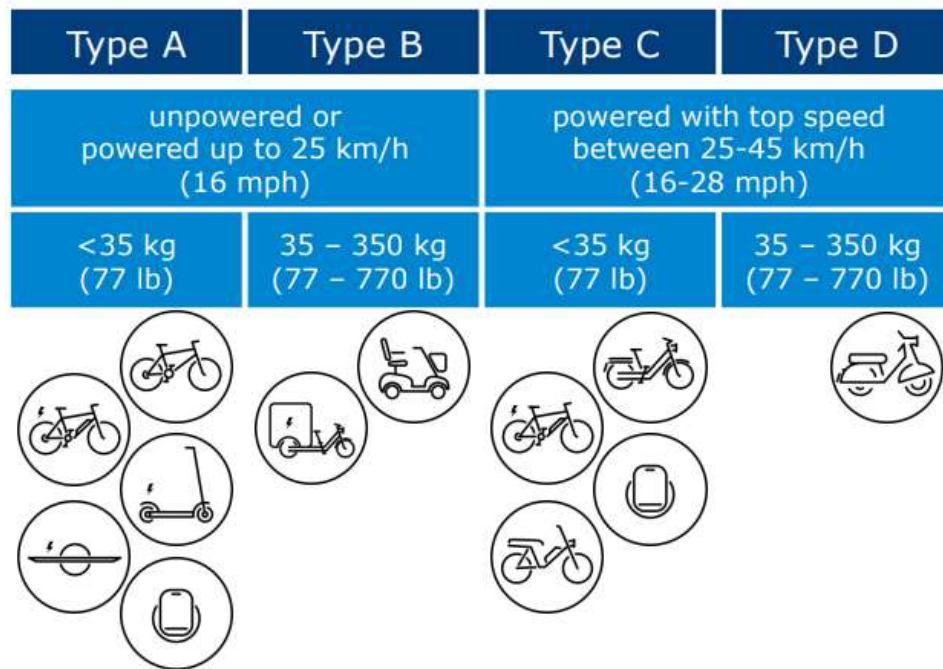


Figure 1. Micromobility definition and classification proposed by ITF-OECD

There are different classification taxonomies for the countries and continents worldwide. The J3194TM Standard, which is issued by SAE International, a U.S.-based professional association and standards-developing organization for engineering professionals across a range of industries, is another significant one. According to this definition, powered micromobility is a group of powered vehicles that are limited into four major properties (SAE, 2019):

- The vehicle can weigh up to 227 kg (500 lb)
- have a maximum width of 1.5 m (5 ft)
- reach a top speed of 48 km/h (30 mph)
- and be powered by either an electric motor or a combustion engine.



	Powered Bicycle	Powered Standing Scooter	Powered Seated Scooter	Powered Self-Balancing Board	Powered Non-Self-Balancing Board	Powered Skates
						
Center column	Y	Y	Y	Possible	N	N
Seat	Y	N	Y	N	N	N
Operable pedals	Y	N	N	N	N	N
Floorboard / foot pegs	Possible	Y	Y	Y	Y	Y
Self-balancing ²	N	N	N	Y	N	Possible

Figure 2. Powered micromobility vehicle types according to SAE

As seen on Figure 3, first applications of micromobility reaches to early 1900's with motor roller skates (Scientific American, 1906) and standing scooters (Gibson, 1915).

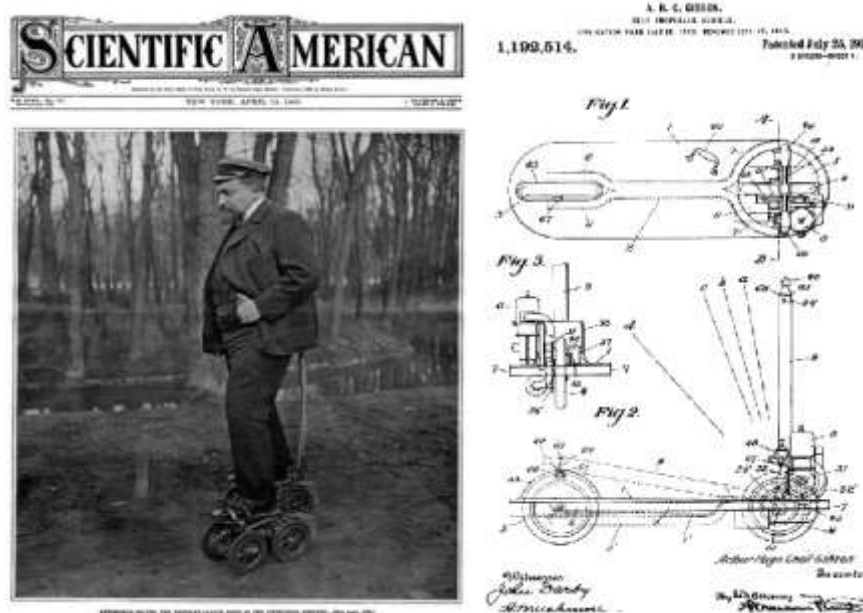


Figure 3. Early micro-mobility applications

First known shared micro-mobility practice is in 2012, Scoot Network San Francisco (Techcrunch, 2012). The growth of popularity increased especially by the shared bikes and scooters. First shared standing scooter practice is in 2016, Neuron Mobility Singapore (Neuron, 2024). A more well-known sample Bird Global is established in USA, 2017 (Jin et. al, 2023). Electric scooter (e-scooter) sharing has experienced an explosive growth all around the world and especially in North America for last decade. For example, by the end of 2023, there were 186 e-scooter and 181 e-bike systems in the North America, and more than one operators in



many cities. Figure 4 explodes the market growth in North America between 2019 and 2023 (NABSA, 2024).

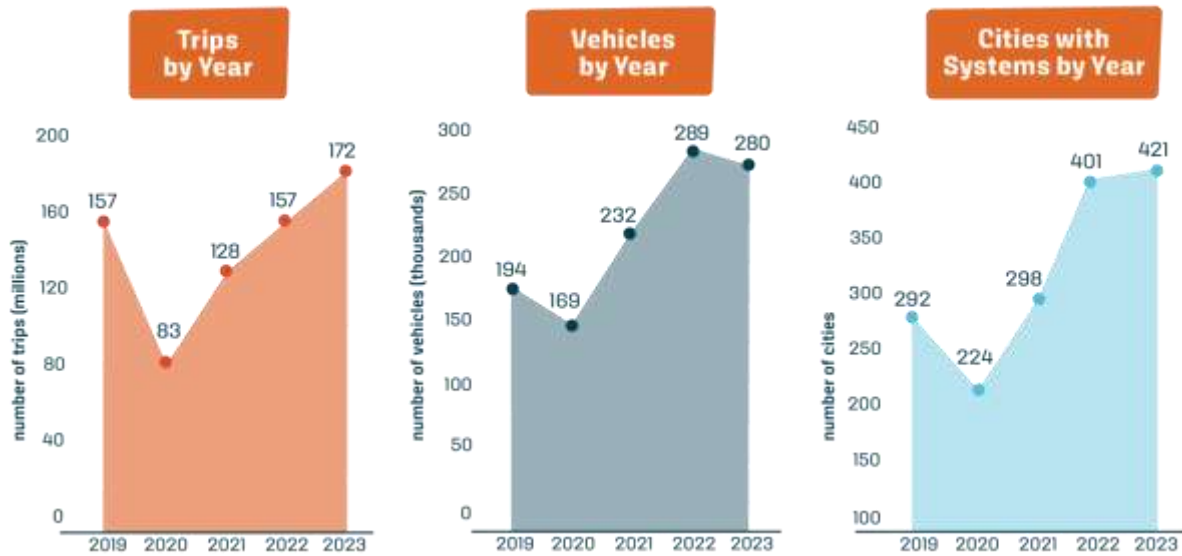


Figure 4. Shared bike&scooters by numbers in North America for last five years

Scooter sharing has two types depend on pick up locations: Docked (with stations) and dockless (free floating). Stations for bikes and scooters can identify the existence of units with their current state, recharge them, and signify when they are prepared for further rental. As with the Mobike approach, another option might be based on free floating sharing, in which more sophisticated units are able to broadcast their position to the central administration servers. The latter model makes managing e-bikes or scooters more difficult because they are left on the road and require staff to put in appropriate effort nearly every day during the recharge phase (Collini et. al, 2021).

Shared micromobility operators need to track and manage their fleets remotely. By the help of the onboard computer and sensors, plenty of features send simultaneously to the central servers via GPRS (General Packet Radio Service) within a small time period. These datasets include a lot of data types about vehicles, environment and users such as vehicle identifier, user information, location coordinates, time, battery information, speed, lock info, engine info, load weight, temperature, remote commands&answers and etc. Because of high privacy content generally a limited feature set is accessible via open data portals. Most recent type of public micromobility data is trip data which can be found on municipality and open data portals (He & Wang, 2024, Yang et. al, 2022, Zhang & Zhao, 2022). Vehicle id, trip start & end location coordinates, start & end times or trip date are main features of this data type.



In this study, micromobility issue underlined by the perspective of prediction. There are plenty of prediction applications in micromobility, if they're grouped under four headings:

- Statistical Distribution (Xue et. al, 2021)
- Stochastic Programming (He & Wang, 2024)
- Machine Learning (Jin et. al, 2023, Zhang & Zhao, 2022)
- Deep Learning (Collini et. al, 2021, Kim et. al, 2022)

The use of shared and private micromobility vehicles is growing daily, particularly in urban areas. As the industry expands, more data becomes available for analysis, including usage patterns, car and battery data, legal regularities, injuries, and more. Accessing data is made simpler by big data portals, municipalities, and central management systems of large micromobility fleets. Due to the large volume of high-quality data, accurate data analysis is essential for public administration and commercial management through scientific research. The aim of this study is to fill the gap in this topic via using bibliometrics to examine the body of current literature.

In the next chapter, bibliometric analysis is explained, methodologies are scrutinized, and a short introduction is provided about some useful software applications. The third chapter explicates the search keywords, exclusions, and methodology. In continuation, the results of the research data are detailed and explained. In the following part, co-citation networks of documents, sources, and keywords are visualized with the thematic map of the research. The paper ends with the conclusion, which includes the brief and suggestions.

2. METHOD

Bibliometrics is defined as a counting-based research field. The term bibliometrics is defined as the statistical and mathematical evaluation of academic knowledge sharing tools such as books, journals, and publications. Bibliometric analysis, on the other hand, is defined as the quantitative examination of the features of the publications such as the number of authors, the published journal, the subject and publication information. Bibliometric research focuses on examining specific features of publications and producing a variety of scholarly communication results (Yılmaz, 2017).

Huge number of papers are publishing in various research fields. By analyzing these studies, new trends, future studies and collaborating researchers can be identified. A collection of techniques known as "bibliometrics" is used to understand, evaluate and analyze scientific studies that have been archived or indexed in massive bibliographic databases. Numerous scientific entities employ bibliometric techniques to investigate the influence of a topic, a group



of scholars, or a specific work. Bibliometrics aids in the advancement of science by enabling us to find information in a variety of ways, including allowing for the evaluation of progress, clarifying the most trustworthy sources of studies, searching the scientific history for the assessment of new improvements, enlightening key authors in the field of science, etc. So that, bibliometrics is a crucial instrument in the majority of scientific fields that are interested in advancement (Gutiérrez-Salcedo et al., 2018).

Bibliometrics is an analysis method performed to evaluate the performance of work-based outputs of scientific studies and has an exclusive place among other statistical analysis. Bibliometric methods were first proposed in the 1950s to calculate the effects of scientific studies. Before the 1950s, few studies about bibliometrics can be found and they are considered to be prehistoric. Bibliometric methods mostly owe their improvement to Price and Garfield. Consequently they are accepted as founders of bibliometrics (Godin, 2006). Performance analysis and scientific mapping analysis are the two key topics in bibliometric analysis, which can be used as a tool for analysis in a particular general research area. These themes are combined to examine at the thematic development of a certain research area. Additionally, conceptual sub-domains are defined and illustrated.

Bibliometric analysis requires a high level of computation. Much software has been developed for bibliometric analysis. And these software packages require bibliometric data sets from different databases such as Scopus, Web of Science and etc. Table 1 lists the prominent software that has been developed so far and their brief information. The basic expectation from these bibliometric analysis tools is that to create interresearch networks from the texts in the literature.

Table 1. Main bibliometric softwares and features

Software	Feature
<i>Bibexcel</i>	It is designed to process bibliometric data and can make a map of relations between publications. Besides no visualization option, it can collaborate with other software (Persson, Danell and Schneider, 2009).
<i>Bibliometrix</i>	It provides a set of tools which are programmed in R, for performing quantitative bibliometric research that are flexible and enable rapid integration and updates (Aria and Cuccurullo, 2017).
<i>Biblioshiny</i>	It is graphical web interface of bibliometrix for no coders (Aria and Cuccurullo, 2017).



<i>CiteSpace</i>	It is java-based software and can group publications by keywords or common reference lists (Chen, 2006).
<i>Gephi</i>	It is a java-based software that can create a network between publications (Bastian, Heymann and Jacomy, 2009).
<i>SciMAT</i>	An open-source software tool designed for science mapping analysis. Unlike others, it contains methods to apply an un-duplication process, data edition, time slicing, and stop words (Cobo <i>et al.</i> , 2012).
<i>Vosviewer</i>	It analyzes the literature and creates visual networks. It is capable of working with different data outputs from various sources (Jan van Eck and Waltman, 2022).

As shown in Figure 5, the evaluation of scientific literature was applied using a bibliometric system via three steps which are search and data collection, performance analysis and the last step is cluster analysis and visualization.

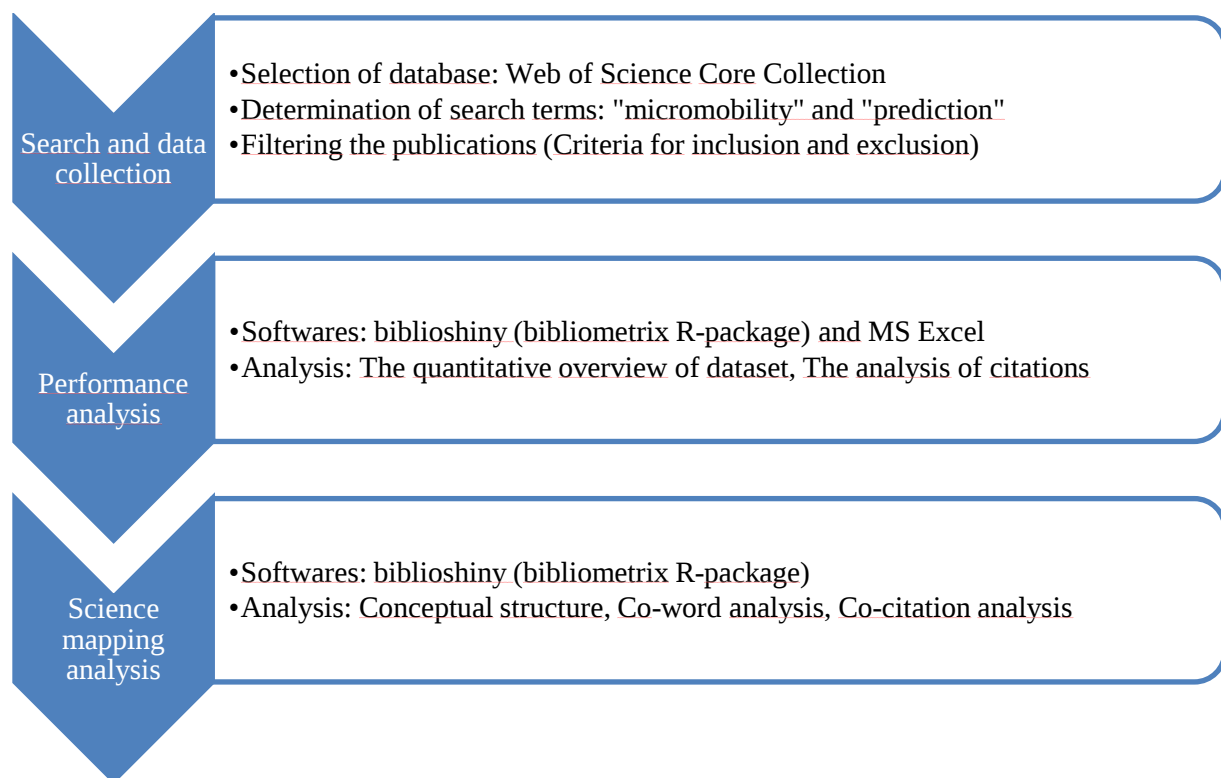


Figure 5. Methodology flow chart of bibliometric analysis

3. SEARCH AND DATA COLLECTION

In order to analyze the data and design associated tables&images, Bibliometrix (v.4.3.0) and MS Excel applications were used. A search from webofscience.com was carried out using a search query in the Topic area which includes title, abstract, keywords plus and



author keywords areas. The query is: ((e-scooter* or "electric scooter*" or "micro-mobility" or "micromobility" or "e-bike" or "electric bike*" or "shared bike*" or "shared scooter*")) and (predict* or forecast* or planning)). Proceeding papers, review articles, editorial materials, data papers, corrections, meeting abstracts and articles before 2005 excluded.

Table 2 shows that of the 545 documents in the dataset, 525 were published articles and 20 early access articles. These studies can be reached from 211 different journals, the average citation count per document is 15,14 and the total reference amount is 21.034 from 545 articles. All the work is the contribution of 1760 different authors.

Table 2. Summary of the data

Definition	Value
MAIN/TOTAL VALUES	
Time range	2006:2025
Publications/Journals	211
Document Count	545
Rate % of Annual Growth	5,95
Average Document Age	2,36
Average citation count per doc	15,14
Reference Count	21034
ABOUT CONTENT	
Keywords Plus (WOS Definition)	972
Keywords	1854
AUTHOR COUNTS	
Total Number of Authors	1760
Authors of one author docs	31
COLLABORATION	
One author documents	39
Co-Author Count per Doc	3,84
International co-authorship	31,56 %
PAPER TYPES	
article	525
article; early access	20



4. RESULTS OF PERFORMANCE ANALYSIS

The performance analysis phase could involve the use of journal impact indicators, citation-based impact indicators, and the quantity of publications (Gutiérrez-Salcedo et al., 2018). Performance metrics in this study included the quantity of publications, the most productive authors, the most referenced articles, the journals and affiliations with the greatest amount of publications, and the most prestigious countries.

4.1. The Quantity of Documents

The annual document quantities between 2006 and 2025 is represented in Figure 6. As of 2018, it is understood that publications started to increase. Accordingly, it is understood that the subject is quite up to date. During the high-yield active period of 2020–2024, publication numbers reached a maximum of 144 in 2024.

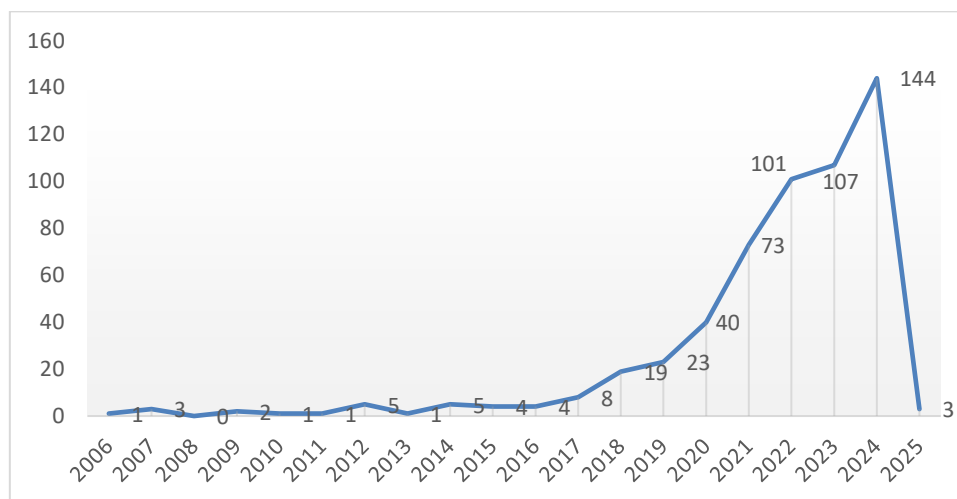


Figure 6. Annual documents published from 2006 to 2025

According to the Figures 4 and 6, it can be stated that micromobility topic and market both has gained an increasing attention over 2020 to 2022 and especially the research topic up to date. It would not be wrong to be said that the 2020 pandemic also had an impact on this.

Figure 7 shows the average citations per articles by each year and the MeanTCperYear value by dividing to citable years (1 citable year for 2024 papers, 19 citable years for 2006 papers). Depend on the figure we can say that the attention on micromobility and prediction has a rising value year by year for last decades but there isn't a big acceleration as the market growth.

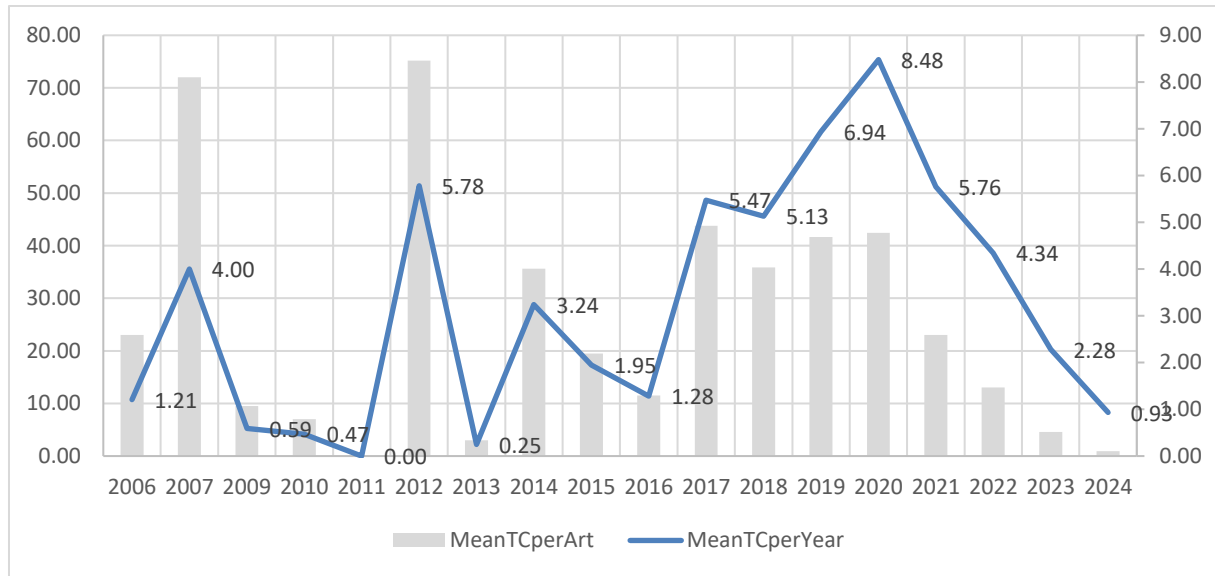


Figure 7. Average citations per articles and means by citable years

4.2. Author Influence

In this study, there are 1760 authors. Table 3 shows the top 30 most influential authors with four or more publications in the dataset.

Table 3. Most productive authors

Author	Articles	Author	Articles
JI YJ	8	HUANG FH	4
LIU Y	8	JIAO JF	4
ZHANG F	7	KIM S	4
LI ZB	6	KUBIK A	4
LI H	5	LIN CH	4
SUN HJ	5	LIU YG	4
WANG H	5	LV HT	4
WU JJ	5	WANG B	4
ZHANG Y	5	WANG D	4
CAMPISI T	4	WU Y	4
CHANG XM	4	XU CC	4
COMI A	4	YANG Y	4
DOZZA M	4	ZHANG YJ	4
FYHRI A	4	ZHAO XL	4
GUO YY	4	ALAI H	3



List is ordered by number of articles and Author surnames alphabetically. Except one, four authors standing out are from the same organization; Southeast University, China: Yanjie Ji with eight articles, Yu Liu (from China Automotive Engineering Research Institute) with eight articles, Fan Zhang with seven articles and Zhibin Li with six articles. Following authors are five authors publishing five articles, 20 authors publishing four articles, 40 authors with three articles, 150 authors with two articles and 1541 authors with one article. Sixteen articles from top two researchers are listed in Table 4.

Table 4. Publications of top 2 relevant authors (TCpY: Total Citations per Year)

Author	Year	Title	Journal	TC / TCpY
Yanjie Ji	2024	Deployment of battery-swapping stations: Integrating travel chain simulation and multi-objective optimization for delivery electric micromobility vehicles	Energy	3 / 3
Yanjie Ji	2024	Activity-Based travel chain simulation for Battery-Swapping demand of electric micromobility vehicles	Transportation Research Part D: Transport and Environment	4 / 4
Yanjie Ji	2024	Insights into User Acceptance of Battery Swapping Services for Sustainable Micromobility Using the Unified Theory of Acceptance and Use of Technology 2 Model	Transportation Research Record	0 / 0
Yanjie Ji	2023	Understanding the illegal charging intention of electric micro-mobility vehicle users by extending the theory of planned behavior	Journal of Cleaner Production	6 / 3
Yanjie Ji	2023	Battery swapping demand simulation for electric micromobility vehicles considering multi-source information interaction and behavior decision	Journal of Cleaner Production	8 / 4
Yanjie Ji	2022	Self-reported anger among ordinary and delivery electric bike riders in China: A comparison based on the cycling anger scale	Transportation Research Part F: Traffic Psychology and Behaviour	11 / 3,67
Yanjie Ji	2021	Incentive measures to avoid the illegal parking of dockless shared bikes: the relationships among incentive forms, intensity and policy compliance	Transportation	25 / 6,25
Yanjie Ji	2021	Optimization Model for the Supply Volume of Bike-Sharing: Case Study in Nanjing, China	Information	2 / 0,5



Yu Liu	2024	Evaluating the bikeability of urban streets using dockless shared bike trajectory data	Sustainable Cities and Society	5 / 5
Yu Liu	2024	Voltage fault diagnosis and prognostic of lithium-ion batteries in electric scooters based on hybrid neural network and multiple thresholds	Journal of Power Sources	0 / 0
Yu Liu	2024	Optimizing vehicle Front-End structure for e-bike rider Safety: An advanced Multi-Objective approach using injury prediction models	Accident Analysis & Prevention	0 / 0
Yu Liu	2023	Unraveling the mode substitution of dockless bike-sharing systems and its determinants: A trip level data-driven interpretation	Sustainable Cities and Society	14 / 7
Yu Liu	2023	Understanding the illegal charging intention of electric micro-mobility vehicle users by extending the theory of planned behavior	Journal of Cleaner Production	6 / 3
Yu Liu	2022	Online Resource Provisioning for Wireless Data Collection	ACM Transactions on Sensor Networks	6 / 2
Yu Liu	2022	A novel approach to investigate effects of front-end structures on injury response of e-bike riders: Combining Monte Carlo sampling, automatic operation, and data mining	Accident Analysis & Prevention	9 / 3
Yu Liu	2020	A study on cyclist head injuries based on an electric-bicycle to car accident reconstruction	Traffic Injury Prevention	12 / 2,4

4.3. Influential Sources

In this study, an analysis is applied on the published article numbers in selected academic journals.

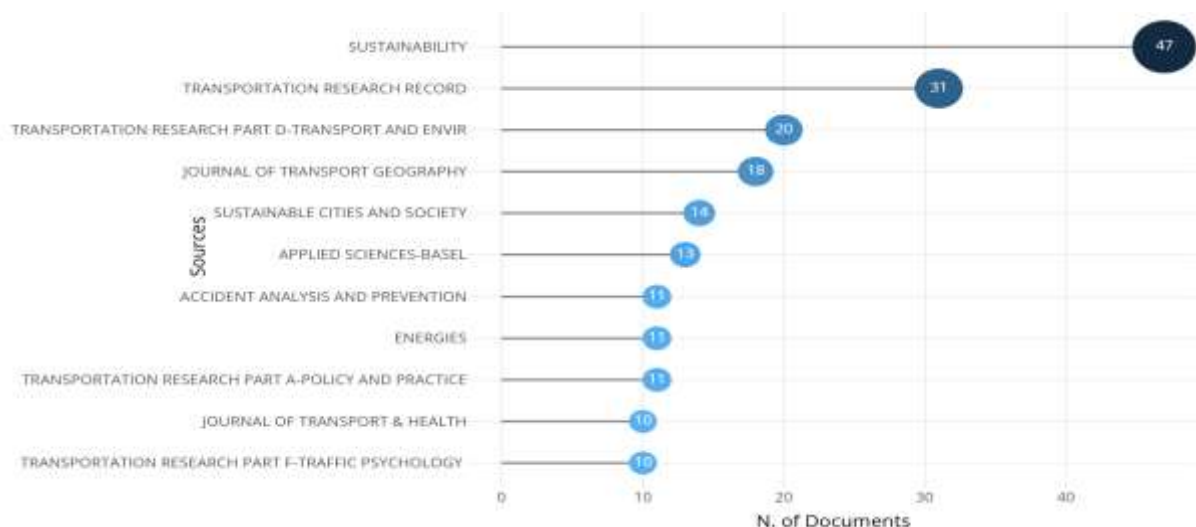


Figure 8. Most relevant sources



Figure 8 presents the journals with the greatest impact within the research topics and the quantity of articles published in each. The journals with the highest number of articles include Sustainability (47 articles), Transportation Research Record (31 articles), Transportation Research Part D: Transport and Environment (20 articles), Journal of Transport Geography (18 articles), Sustainable Cities and Society (14 articles) and Applied Sciences-Basel (13 articles). These journals cover interdisciplinary topics, appealing to a broad academic audience with a focus on sustainability, transportation and prediction. Additionally, journals such as Accident Analysis and Prevention, Energies, Transportation Research Part A: Policy and Practice, Journal of Transport & Health and Transportation Research Part F: Traffic Psychology each feature 11 and 10 articles respectively. These journals exert a significant influence, particularly in fields such as sustainability, transportation, policies, health issues and all-around prediction applications. This analysis highlights the journals most frequently preferred by academic communities and indicates where specific topics are more extensively covered, thereby guiding researchers in source selection. The figure includes a total of 11 journals, each with at least ten publications. Within the dataset, consisting of 211 sources, eighteen sources have article quantity ranges between nine and four. Next eighteen sources have three articles, 22 sources have two articles and one publication in 142 journals.

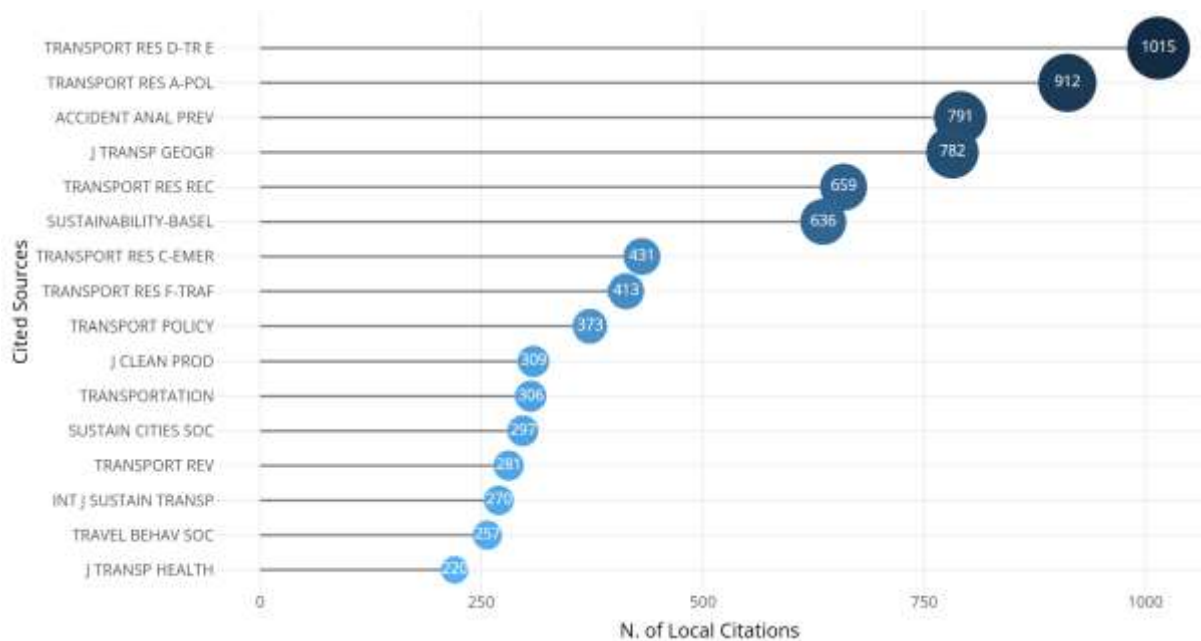


Figure 9. Most local cited sources

Scientific journals' citation counts, which indicate their importance and influence within their respective domains, are frequently used to gauge their impact in the context of



academic research. The sources with the most local citations are identified in this bibliometric analysis. Figure 9 displays sixteen sources with a total of 200 or more local citations. Transportation Research Part D: Transport and Environment leads the list with 1015 local citations. It is followed by Transportation Research Part A: Policy and Practice with 912 local citations, Accident Analysis and Prevention with 791 and Journal of Transport Geography with 782 local citations. Transportation Research Record has 659, Sustainability-Basel has 636 local citations, and all these journals reflect the growing interest in prediction practices in micro-mobility.

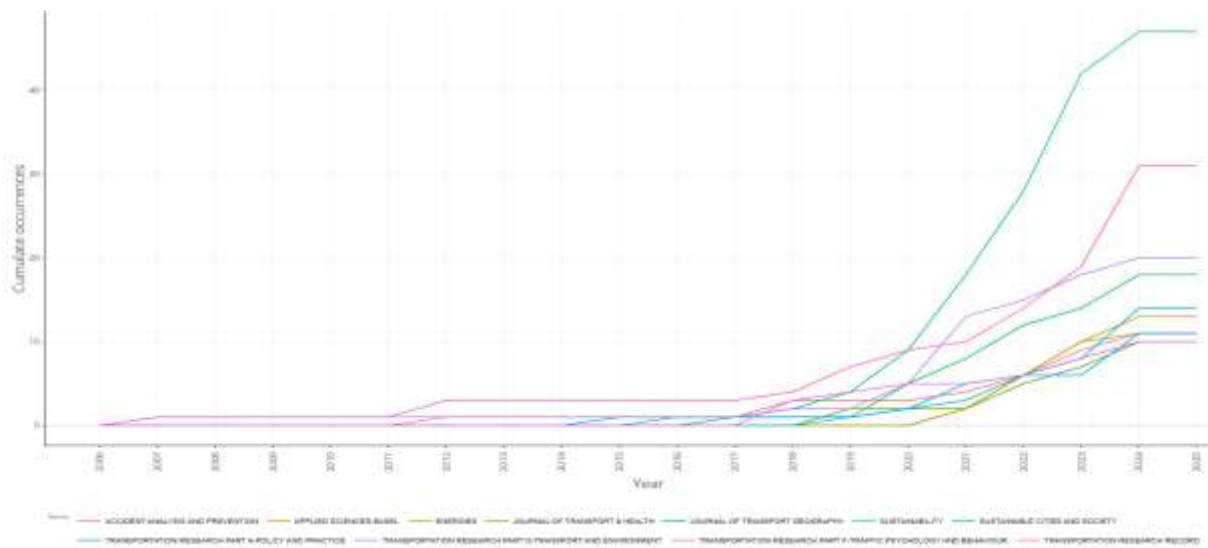


Figure 10. Temporal Distribution of Sources with the Highest Number of Publications

Figure 10 illustrates the yearly distribution of articles published in the various interdisciplinary sources listed in Figure 8, highlighting an upward trend in academic interest. The sources examined in this study include Sustainability, Transportation Research Record, Transportation Research Part D: Transport and Environment, Journal of Transport Geography, Sustainable Cities and Society, Applied Sciences-Basel, Accident Analysis and Prevention, Energies, Transportation Research Part A: Policy and Practice, Journal of Transport & Health and Transportation Research Part F: Traffic Psychology. A marked increase of publication volume in 2021 appears directly linked to the acceleration of micro-mobility market growth (Figure 4). This trend reflects a growing interest in micro-mobility and its prediction applications, as well as a heightened focus on these subjects by researchers. Additionally, the impact of the COVID-19 pandemic likely contributed to the increased number of publications starting in 2020.

**Table 5.** Sources' Local Impact by h index

Source	H Index	G Index	M Index	TC	NP	PY Start
Transportation Research Part D: Transport and Environment	15	20	0,833	926	20	2007
Sustainability	14	27	1,556	781	47	2016
Journal of Transport Geography	11	18	1,375	405	18	2017
Accident Analysis and Prevention	8	11	0,615	507	11	2012
Sustainable Cities and Society	8	14	1,333	289	14	2019
Transportation Research Record	8	21	0,444	458	31	2007
Transportation Research Part F: Traffic Psychology and Behaviour	7	10	1	273	10	2018
Case Studies on Transport Policy	6	8	1,2	108	8	2020
Computers Environment and Urban Systems	6	7	1	332	7	2019
Transportation Research Part A: Policy and Practice	6	11	0,6	201	11	2015
Energies	5	7	1,25	63	11	2021
IEEE Transactions on Intelligent Transportation Systems	5	9	0,714	134	9	2018
Journal of Cleaner Production	5	7	1,25	55	7	2021
Journal of Transport & Health	5	10	0,833	147	10	2019
Transport Policy	5	7	1,25	87	7	2021
Travel Behaviour and Society	5	9	1,25	101	9	2021

Table 5 presents an analysis of the impact values and local influence of academic sources based on metrics such as the h-index. According to the data, the journal Transportation Research Part D: Transport and Environment stands out with the highest impact value, possessing an h-index of 15 and accumulating a total of 926 citations since 2007. Sustainability has the highest g-index (27) and m-index (1,556) scores. And second h-index of 14, reflecting a notable impact in environmental and sustainability issues, with nine of its publications receiving 781 citations since 2016. The Journal of Transport Geography maintains high g and m index values: 18 and 1,375. And h-index of 11, with 405 citations since 2017.

Journals such as Accident Analysis and Prevention, Sustainable Cities and Society, Transportation Research Record, Transportation Research Part F: Traffic Psychology and Behaviour and Computers Environment and Urban Systems have also generated substantial impact through recent publications, accruing 507, 289, 458, 273 and 332 citations from articles published in 2023, respectively.

Overall, this analysis demonstrates the significant impact of these journals within specific fields and their enduring influence in academic literature. Through metrics such as the



h-index and other bibliometric indicators, understanding the local and global impacts of these sources holds substantial importance for guiding academic work and accumulating knowledge.

4.4. Influential Affiliations

The study analyzed the most impactful affiliation, focusing on the academic publication performance of universities with ten or more publications, as presented in Table 6. According to the data, the Southeast University (China) ranks the highest with 44 publications. This is followed by the Beijing Jiaotong University (China) with 25 articles, University of California System (USA) with 22 articles, Tongji University (China) with 21 articles. Chinese Academy of Sciences (China) has 18, Zhejiang University (China) has 15, State University System of Florida (USA) has 14 and Chang'an University (China) has 12 publications. Next four organizations; Helmholtz Association (Germany), Seoul National University (South Korea), Shanghai Jiao Tong University (China) and Swiss Federal Institutes of Technology Domain (Switzerland) have 11 publications each one. Last three organizations in the list; Eth Zurich (Switzerland), Purdue University (USA) and Purdue University System (USA) have 10 publications each. There are 604 different organizations listed in the contained publications researchers' affiliations. In the remaining affiliations, there are seven organizations with nine publications, four organizations with eight publications, eleven organizations with seven publications, eighteen organizations with six publications and fifteen organizations with five publications. Respectively four, three, two and one publications from 28, 64, 123 and 319 organizations.

Table 6. Most relevant affiliations

Affiliation	Articles
Southeast University, China	44
Beijing Jiaotong University, China	25
University of California System, USA	22
Tongji University, China	21
Chinese Academy of Sciences, China	18
Zhejiang University, China	15
State University System of Florida, USA	14
Chang'an University, China	12
Helmholtz Association, Germany	11
Seoul National University, South Korea	11



Shanghai Jiao Tong University, China	11
Swiss Federal Institutes of Technology Domain, Switzerland	11
Eth Zurich, Switzerland	10
Purdue University, USA	10
Purdue University System, USA	10

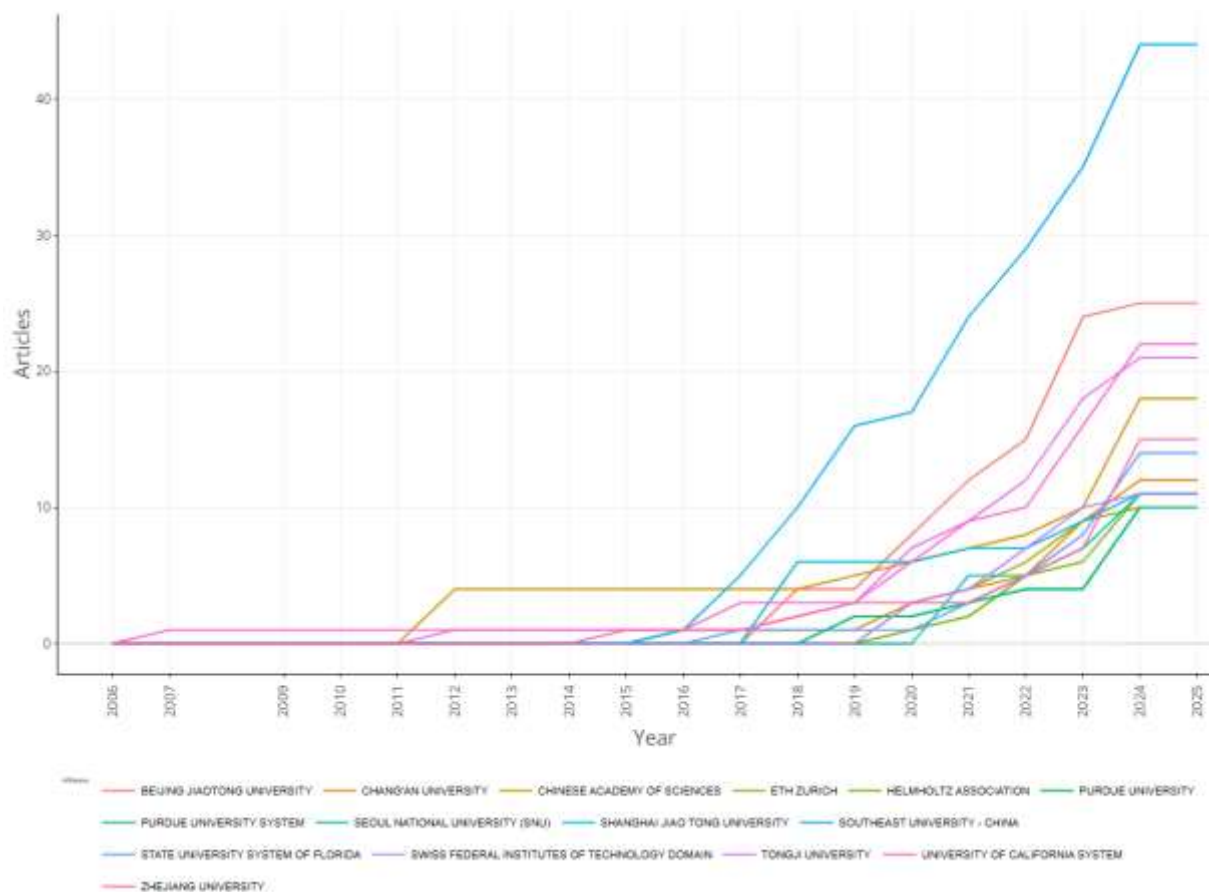


Figure 11. Temporal cumulative distribution of affiliations with the Highest Number of Publications

Figure 11 provides a detailed examination of changes over time in the academic publication output of the 15 universities with the highest publication counts. The data reveal that while certain affiliations have recorded significant increases in publication productivity, others have shown relatively stable or declining trends.

According to the analysis, since 2016, the Southeast University (China) has emerged as one of the affiliations with the most substantial growth, marking a stable and continuous improvement in publications during 2017-2024. This suggests that investments in research activities and strategies aimed at enhancing international visibility have been successful for this



Chinese university. A similar trend is observed for another Chinese organization Beijing Jiaotong University, which has maintained a consistent rise in publication output since 2018.

The differences in publication performance among affiliations may be linked to factors such as research funding, international collaborations, and academic strategies. In this context, bibliometric analyses provide valuable insights into the publication strategies and research presence of academic affiliations.

4.5. Influential Countries

Within the scope of the study, the productivity of the countries was discussed from different perspectives.

Table 7. Most relevant countries

Country	Freq	Country	Freq	Country	Freq
China	189	Canada	8	Japan	5
USA	84	Portugal	8	Singapore	5
Italy	27	Switzerland	8	Belgium	4
Germany	25	Poland	7	Denmark	4
Korea	18	Sweden	7	France	4
United Kingdom	17	Greece	6	Iran	4
Australia	14	Netherlands	6	Mexico	4
Spain	14	Hungary	5	New Zealand	4
Norway	11	India	5	Türkiye	4

Table 7 examines the ranking and academic productivity of the countries with the highest number of publications. According to the data, China leads by a wide margin with 189 publications, reflecting its substantial investments in scientific research and its influence on the international academic stage. The USA ranked second with 84 publications. These two countries have significant global impact, aided by their national research capacities and extensive academic collaboration networks. The first two countries in the table account for about half of the total productivity of countries with 50.1%. Italy and Germany ranked third and fourth with 27 and 25 publications respectively, and Korea ranked fifth with 18 publications. Other countries, such as United Kingdom, Australia, Spain and Norway, also stand out with eleven or more publications.

Countries such as Canada, Portugal, Switzerland, Poland and Sweden have also good positions, each with eight and seven publications, showcasing their national academic



capacities at the international level. They are followed by Greece, Netherlands, Hungary, India, Japan and Singapore, each with between six and five publications. Belgium, Denmark, France, Iran, Mexico, New Zealand and Türkiye have four publication each, complete the top 27 countries list which have four or more publications. Outside of these top 27, the remaining 28 countries each contributed between one and three publications, maintaining a more limited scope of global academic contributions.

This analysis highlights the contribution levels of specific countries to the international scientific literature. Leading countries like China and the USA play a decisive role in academic productivity, while other countries make significant regional and global contributions to knowledge production.

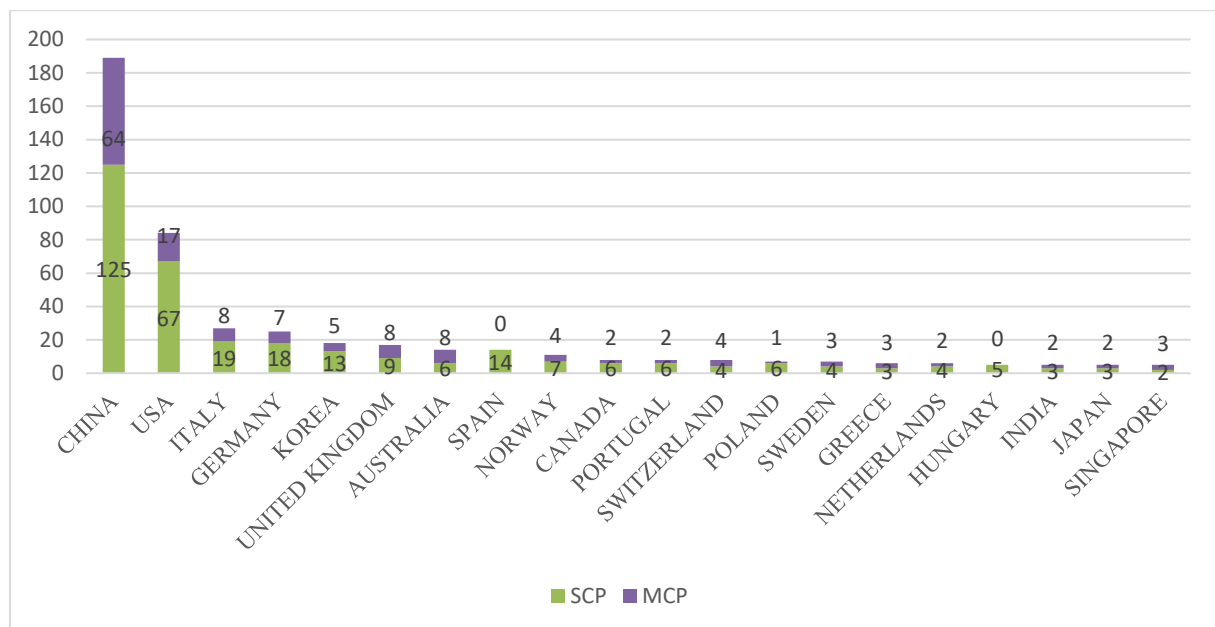


Figure 12. Corresponding author's countries

The 20 most productive countries by corresponding authors are displayed in Figure 12. SCP (single country paper) shows the quantity of papers produced by authors from that country only, while MCP (multiple country paper) shows the number of publications that include co-authors from other countries as well as the relevant country.

This differentiation allows for an evaluation of both local academic productivity and the extent of international research collaboration. China stands out as the leading country, with a total of 189 publications. Of these, 125 are SCPs, highlighting a high level of independent local research output. However, the presence of 64 MCPs indicates that China engages in international collaborations to a limited extent. And more conservative local literatures who



hasn't got any MCPs like Spain with fourteen publications and Hungary with five publications. On the other hand, two countries in this top 20 publisher countries list, have higher MCP value than SCP value. Australia has eight MCPs, six SCPs and Singapore has three MCPs, two SCPs. This bibliometric analysis reveals geographical differences in research collaboration patterns. These findings provide a foundation for deeper exploration into the factors promoting international collaborations and the influence of local research policies on publication trends.

Table 8. Most cited countries

Country	Average Article		Country	Average Article	
	TC	Citations		TC	Citations
China	3071	16,2	Canada	250	31,2
USA	1656	19,7	United Kingdom	239	14,1
Norway	469	42,6	Greece	217	36,2
Italy	387	14,3	Germany	192	7,7
Netherlands	253	42,2	Switzerland	172	21,5

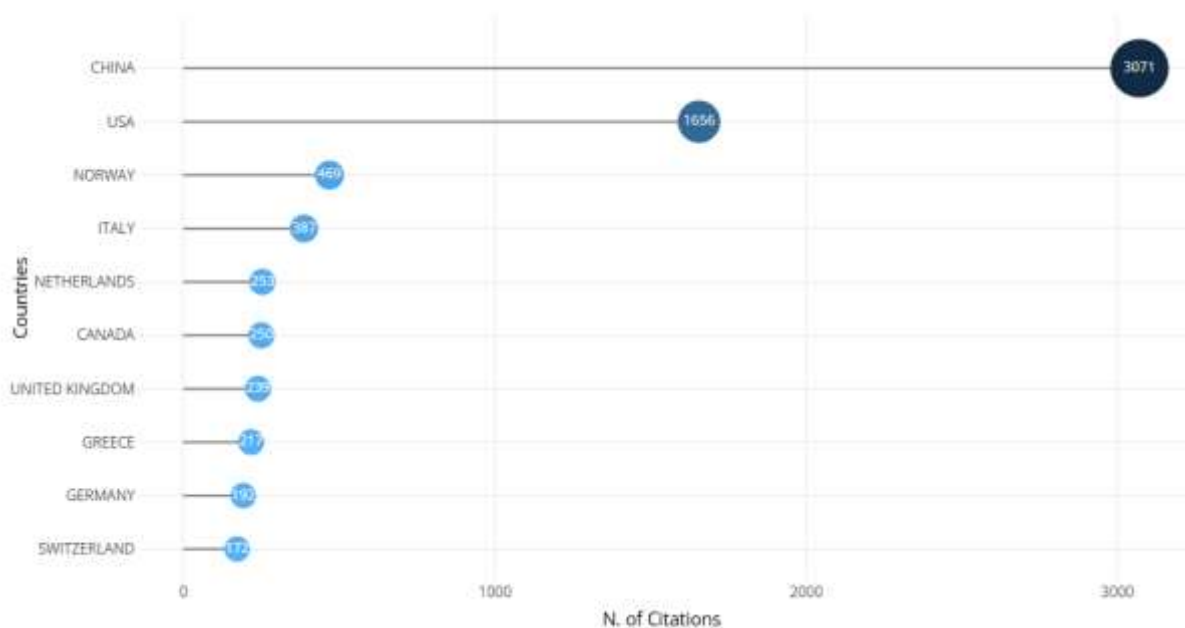


Figure 13. Most cited countries

Table 8 and Figure 13 illustrate countries with a total citation count exceeding 160, along with their respective average citation counts. As indicated by the chart, China stands out with 3071 citations, significantly surpassing other countries and holding the highest citation count in this domain. This reflects China's influence in the research field and underscores the



magnitude of its contributions to academic literature. However, when examining average citation counts, China has an average of 16.2, which is lower than that of some other countries. This suggests that while China has a large volume of publications, the average impact per publication is comparatively lower. Like publication counts, USA ranks second with a total citation count of 1656 and an average citation count of 19,7; positioning it above China in terms of citation impact. This indicates that, although USA produces fewer publications, its research outputs tend to receive more citations, thus reflecting a higher impact. In summary, the relationship between total citation counts and average citation values for each country reveals distinct differences between academic productivity and the impact of these publications. These data illuminate how scientific output and influence vary by country, with some countries generating a larger quantity of studies, while others produce relatively fewer but more impactful works.

4.6. Influential Documents

Papers with a global citation count of 100 or more are presented in the Table 9. This table shows valuable insights into the international academic impact of specific studies. For each article, both the total citation count and the annual average citation rate are provided. At the top of the table is an article by Gössling (2020); “Integrating e-scooters in urban transportation: Problems, policies, and the prospect of system change” published in Transportation Research Part D: Transport and Environment, which stands as the most cited article. Paper received 217 global citations and an impressive annual average of 43.4 citations. This high citation count indicates that Gössling’s work has drawn an important attention in the field of micromobility and especially in e-scooters, suggesting a substantial international impact.

Table 9. Most Global Cited Documents

Paper	DOI	Total Citations	TC per Year
GÖSSLING S, 2020	10.1016/j.trd.2020.102230	217	43,40
SI HY, 2020	10.1016/j.resconrec.2019.104513	197	39,40
WU CX, 2012	10.1016/j.aap.2011.06.001	184	14,15
CHEN ZY, 2020	10.1080/01441647.2019.1710306	150	30,00
CAMPISI T, 2020	10.3390/su12218829	146	29,20
XU Y, 2019	10.1016/j.compenvurbsys.2019.02.002	135	22,50
MCKENZIE G, 2020	10.1016/j.compenvurbsys.2019.101418	130	26,00
ECCARIUS T, 2020	10.1016/j.trd.2020.102327	126	25,20

MATHEW JK, 2019	10.1109/ITSC.2019.8917121	125	20,83
GUO YY, 2018, -a	10.1016/j.aap.2018.03.006	122	17,43
GUO YY, 2017	10.1371/journal.pone.0185100	113	14,13
YAO L, 2012	10.3141/2314-07	101	7,77

The high citation counts not only advance knowledge within these areas but also shape academic discourse within these disciplines. In conclusion, bibliometric analyses such as this are invaluable for identifying the studies that receive the most attention within academic communities and understanding the topics that hold greater importance on a global scale.

5. RESULTS OF SCIENCE MAPPING

5.1. Co-citation Analysis

Co-citation analysis is a method used to better understand the evolution of important topics in a particular field of study. It entails assessing the references mentioned by the scientific publications that are part of the chosen dataset and examining the connections between the cited publications. As seen in Table 1, a total of 21.034 references were used in the documents included in the dataset. In this study, papers and sources were analyzed for co-citation analysis.

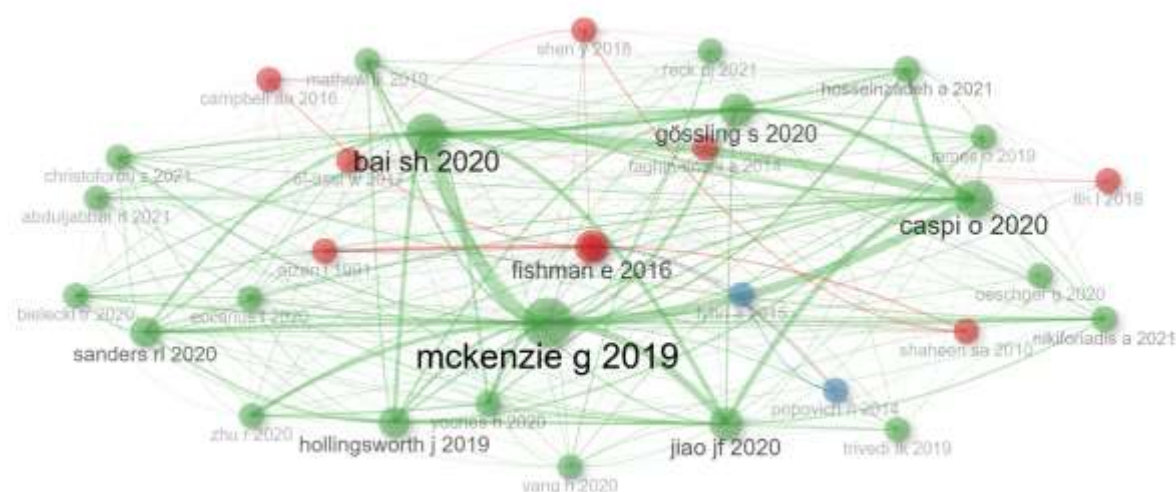


Figure 14. The co-citation network of cited articles

As seen in Figure 14, the most cited papers are Mckenzie (2019) and Fishman (2016) are in the green and the red clusters. Each cluster represents the attention to the research, referred to as the theme of the study (Rao and Shukla, 2023). 33 nodes were included in the analysis, and it is seen that the green cluster has an higher density among the three clusters obtained.

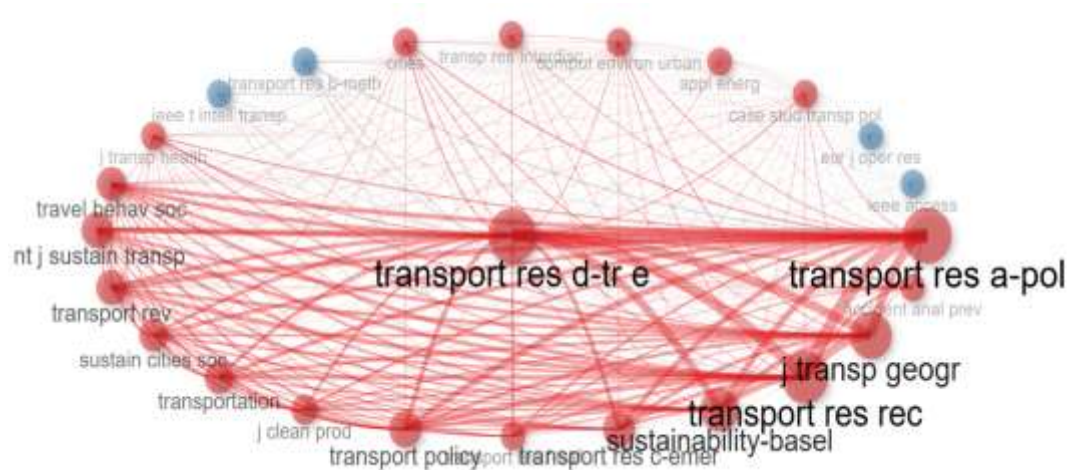


Figure 15. The co-citation network of sources

When the co-citation analysis is performed for the sources in the dataset, two different clusters are obtained for multi-nodes as shown in Figure 15. The blue cluster consists of four journals, all of which have high betweenness ratings. The red cluster includes 21 journals with four trending: Transportation Research Part C: Emerging Technologies, Transportation Research Part A: Policy and Practice, Transportation Research Part D: Transport and Environment, and Transportation Research Record.

5.2. Co-word Analysis

Discovering the frequency distributions of keywords may reveal interesting directions for further study. (Kevork and Vrechopoulos 2009, from Khaldi and Prado-Gascó, 2021).

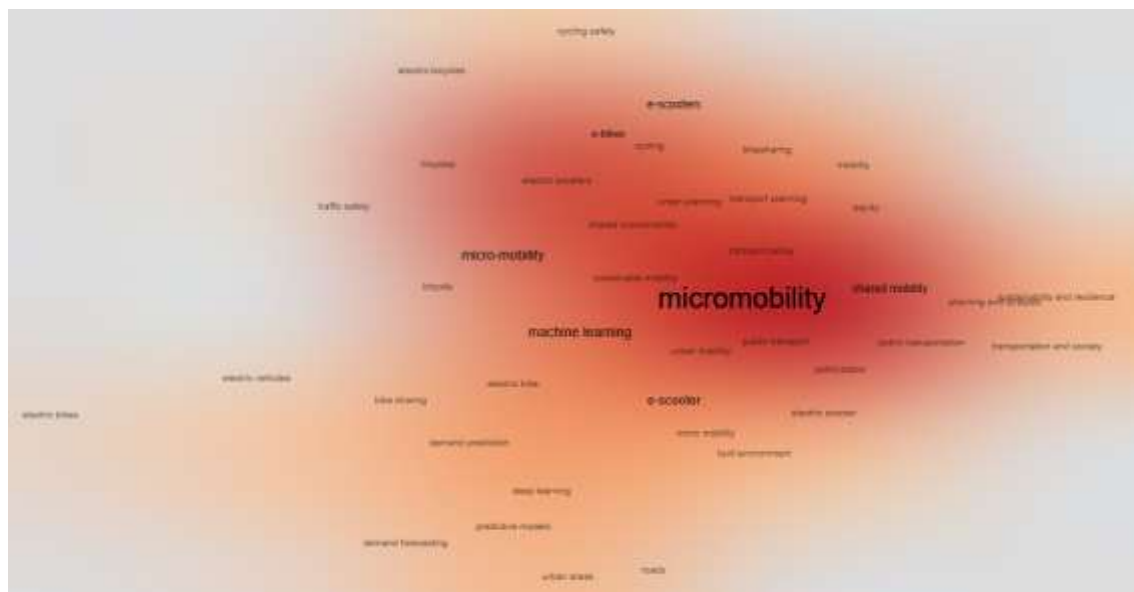


Figure 16. The co-occurrence of author's keywords density diagram

**Table 10.** The co-occurrence of author's keywords

Author's Keywords	Frequency	Author's Keywords	Frequency
micromobility	739	e-scooters	58
machine learning	268	demand prediction	44
e-scooter	212	electric bicycles	44
shared mobility	200	public transportation	44
micro-mobility	128	electric vehicles	44
cycling	94	planning and analysis	43
e-bike	94	bike-sharing	40
e-bikes	88	covid-19	29
sustainable models	73	sustainability and resilience	19
predictive models	70	transportation and society	19
deep learning	61	transport policy	15

It is clear that based on Table 10, quantities of the keywords indicate a marked research interest in the intersection of “micromobility” (739 occurrences) and “machine learning” (268 occurrences), underlining the growing relevance of ML applications in micromobility. In particular, terms such as “e-scooter” (212 occurrences), “shared mobility” (200 occurrences), “e-bike” and “e-bikes” (94 and 88 occurrences) reveal an emphasis on the attention on AI based prediction technologies, into micromobility areas. “machine learning”, “sustainable models”, “predictive models”, “deep learning”, “demand prediction” and “planning and analysis” are most relevant methods and applications.

Out of a total of 1854 author's keywords, the two most frequently occurring keywords were micromobility and machine learning. The “mobility” author's keyword has a total of 8 occurrences different types as shown at Table 11.

Table 11. Forms where “mobility” appears as author's keyword

Author's Keywords	Frequency	Author's Keywords	Frequency
micromobility	739	urban mobility	1
shared mobility	200	micro mobility	1
micro-mobility	128	mobility	1
sustainable mobility	73	shared micromobility	1



Out of a total of 972 keyword plus, the five most frequently occurring keywords were behaviour (124 occurrences), planned-behaviour (56 occurrences), impact (55 occurrences), model (53 occurrences), bicycle (50 occurrences).

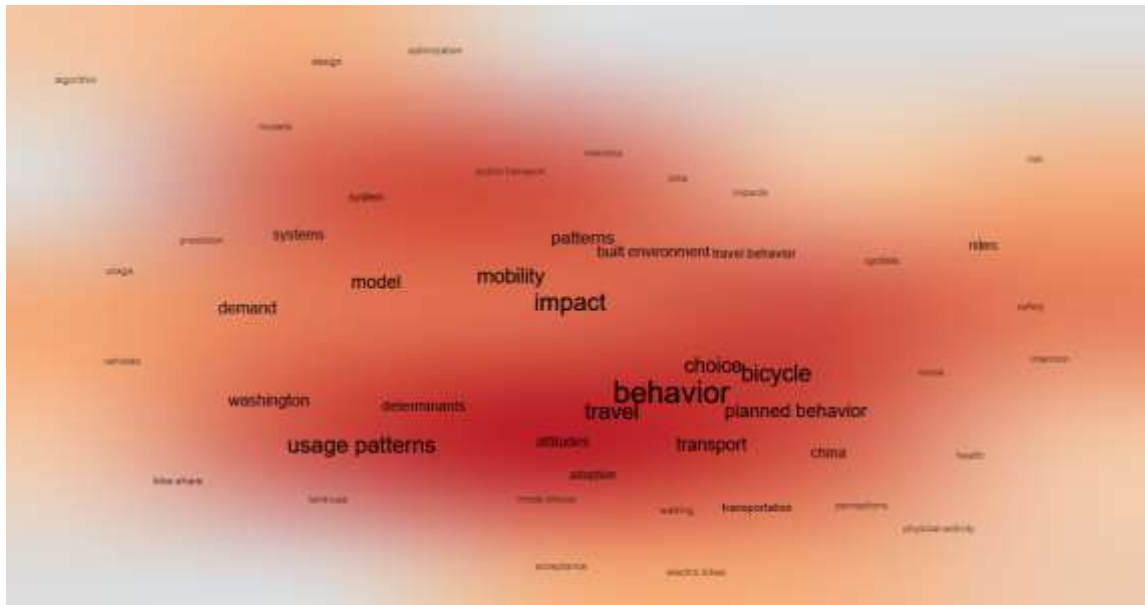


Figure 17. The co-occurrence of keyword plus density diagram

5.3. Thematic Map

The thematic map diagram presents an analysis of themes across two dimensions: centrality and density. The horizontal axis indicates the centrality degree, and the vertical axis represents the degree of development density.

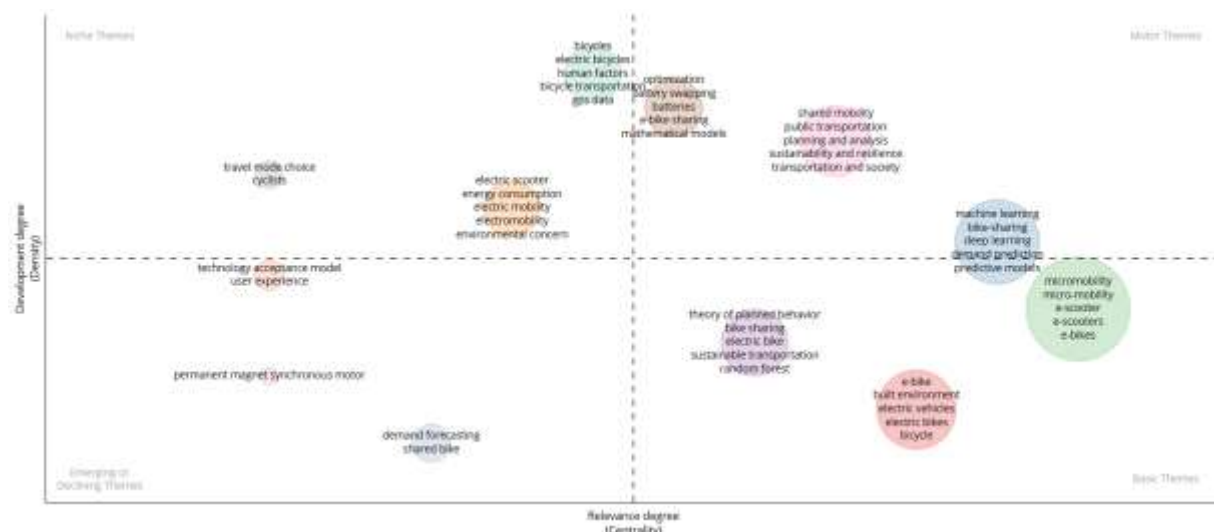


Figure 18. Thematic Map



The thematic map diagram is divided into four main quadrants:

Niche Themes: Located in the left upper quadrant, these themes indicate low centrality but high density, representing specific areas of expertise. Examples include "travel mode choice" and "bicycles & human factors".

Motor Themes: Positioned in the upper right quadrant, these themes show both high density and high centrality, indicating critical and well-developed topics within the field. "Machine learning", "shared mobility" and "optimization & battery swapping" are examples of such themes.

Emerging or Declining Themes: Found in the left lower quadrant, these themes display both low centrality and low density, suggesting the items are either emerging or diminishing in importance. "permanent magnet synchronous motor" and "demand forecasting" fall into this category.

Basic Themes: Found in the right lower quadrant. These themes are identified by low density but high centrality, indicating fundamental yet underdeveloped topics within the field. Examples include "e-bike & built environment" and "micromobility & e-scooters".

6. CONCLUSION

This study examined the influence of prediction in micromobility through bibliometric analysis. The fact that the number of publications in this discipline has increased recently indicates that the field is contemporary. The impact of the COVID-19 epidemic and the significance of necessities of life on micromobility may also be to blame for the large volume of publications during the past five years. An essential tool for identifying trends in a certain field of study is bibliometric analysis. Bibliometric analysis can measure the reach of specific research topics or journals, identify research trends, and evaluate the academic influence of individual studies (Gutiérrez-Salcedo et al., 2018).

According to the findings of this study, the most productive four authors are Yanjie Ji and Yu Liu with eight articles each, Fan Zhang with seven articles and Zhibin Li with six articles. From the most cited documents point of view in Table 9, none of these four authors are in the top 12 most cited documents. Top two documents (Gössling S, 2020, Si HY, 2020) have almost 200 total citations and 40 citations per year.

According to the other segments of biometric analysis, the most productive journal is Sustainability magazine, the most productive institution is Southeast University, China and the most productive country is China. China shows a clear superiority in the field of study. Nine of ten most productive authors and four of five most productive affiliations are from China.



Featured categories from the application perspective on reviewed micromobility studies are “machine learning”, “sustainable models”, “predictive models”, “deep learning”, and “demand prediction”. Also, legal policies and regulations, sustainability and resilience, and health and injuries are important research topics of the last decade.

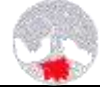
This paper offers a systematic review of micromobility prediction research from 2006 to 2024. In last division, a thematic map was created for use in subsequent studies. Research studies on autonomous vehicles and deep learning on micromobility are recommended for application studies.

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