Hotspot Research and Development Trend Forecast of Car-Sharing: A Bibliometric Analysis Based on CiteSpace

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Abstract: Car-sharing not only meets the diversified travel needs of people and reduces the number of private cars in urban areas, but also helps alleviate urban traffic congestion and improve the efficiency of urban resource allocation. This paper utilizes CiteSpace bibliometric tools to conduct a systematic visual analysis of English literature in the field of car sharing from 1999 to 2023, revealing the research hotspots and development trends within this domain. Through keyword co-occurrence analysis, key themes such as “car sharing,” “model,” “mobility,” and “systems” emerged, reflecting academic focus on car-sharing models, technological optimization, and integration within transportation systems. Since 2016, as the sharing economy and smart technologies have become more widespread, car-sharing research has significantly increased. This paper summarizes the primary research directions and hotspots in the car-sharing field, providing a theoretical foundation and reference for future research on sustainable shared mobility.

***Keywords*:** car sharing; knowledge graph; research hotspots; development trend

1. Introduction

The concept of car-sharing was introduced in 1987 by Austrian entrepreneur Franz Gertler with the creation of CityCar in Paris, France. It refers to a service where multiple individuals share the use of the same vehicle, with the goal of saving users' time and costs while improving resource utilization. In the 21st century, with the development of the internet and smart technologies, car-sharing services have become more convenient and efficient. In 2007, the U.S. company Zipcar launched a car-sharing service based on a mobile application and membership model. Since then, car-sharing services have gained global popularity and development.

Numerous scholars have analyzed the impact of car-sharing on the reduction of private car ownership[1], as well as explored issues such as the profitability challenges caused by the uneven distribution of car-sharing vehicles from the perspective of the sharing economy[2], and the social attributes and motivational factors of users[3]. Regarding urban transportation, solving the rebalancing issues of shared bicycles[4] and shared cars[5] has attracted widespread academic attention. Furthermore, some scholars have used bibliometric analysis to summarize research related to car-sharing. Hu et al. analyzed the development trends, influencing factors, governance policies, and the impact of ride-hailing, car-sharing, and bike-sharing services in China on low-carbon transformation[6]. Zheng Xiaohong et al. comprehensively summarized the order allocation strategies and corresponding evaluation metrics in the transition from mobile ride-hailing to online taxi services[7]. Ren Xiaohong et al. provided a holistic analysis of the research status, hotspots, and frontiers in the field of shared mobility[8].

However, these studies did not address the overall development of the car-sharing industry. Therefore, it is necessary to conduct a systematic study of the overall development status, trends, and hotspots of the car-sharing industry to provide theoretical guidance for future research and practical development in this field. This paper uses CiteSpace, a visualization software, to conduct bibliometric analysis of the literature related to car-sharing, constructing keyword cluster co-occurrence maps and identifying burst keywords. It analyzes and summarizes the research themes, hot topics, and future development trends in this field, providing valuable insights for researchers seeking to understand this area of study.

2. Research Methods and Data

2.1 Research Methodology

This study selects journal papers from Web of Science databases using the keyword “car sharing.” The retrieved results form the basis for analysis using the CiteSpace visualization tool to generate a knowledge map[9]. The analysis covers

annual publication trends, institutions, keywords, and clusters to reveal the trajectory of research in car sharing.

2.2 Data and Retrieval

The English literature was screened from the Web of Science core database using the following keywords: 'car sharing', 'carsharing', 'carshare', 'cars sharing', 'vehicle* sharing', 'shared autonomous vehicle', 'electric car sharing', 'shared electric vehicle*', 'shared electric car*', 'shared car', 'shared cars', 'car2go', 'shared vehicles', 'shared-use vehicle*', 'shared autonomous taxis', 'shared autonomous electric vehicle* (SAEV)', 'electric vehicles sharing (EVS)', 'electric vehicle carsharing', 'sharing electric vehicle*', 'EV-sharing', 'car sharer*', 'sharing cars', 'time-sharing cars', 'car-share', 'share cars'. After manually screening and removing irrelevant conference papers and newspaper articles, a total of 1,332 relevant papers from 1999 to 2023 were selected. The literature was exported in plain text format, with the time slices set to one year. Co-occurrence maps for institutions, keywords, and burst terms were then created based on the selected English literature.

Figure 1 presents the trend of publication volume in English literature related to carsharing research. From 1999 to 2023, the number of English publications in the field of car sharing experienced significant growth, with a particularly rapid increase observed after 2016. In the first decade, the volume of related research remained low, reflecting limited attention to this field, primarily due to the lack of widespread adoption of car sharing. Since 2016, however, the rise of the sharing economy, along with advancements in autonomous driving and the Internet of Things, has garnered increasing academic interest in car sharing. From 2019 to 2022, the number of publications surged, peaking in 2021. By 2023, however, the volume of research began to decline slightly, likely indicating the field's gradual maturation and a shift in research focus toward other areas.

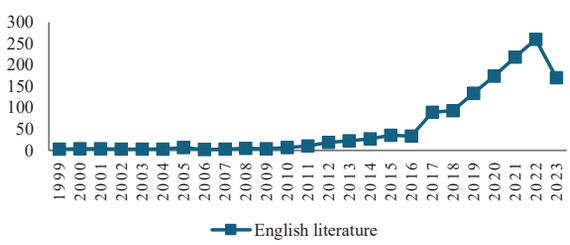

Figure 1. Carsharing-Related Journal Articles in English

3. Keyword Cluster Analysis of Carsharing Research

Figure 2 presents the cluster map of keywords from seven studies related to car-sharing in English literature. The modularity value (Q) of the cluster map for keywords in English literature related to car-sharing research is 0.387, which is greater than the critical value of 0.3. This indicates that the keyword clustering structure is significant, and the clustering effect is favorable. The average silhouette score (S) is 0.6801, which exceeds the critical value of 0.5, indicating that the clustering results are reasonable.

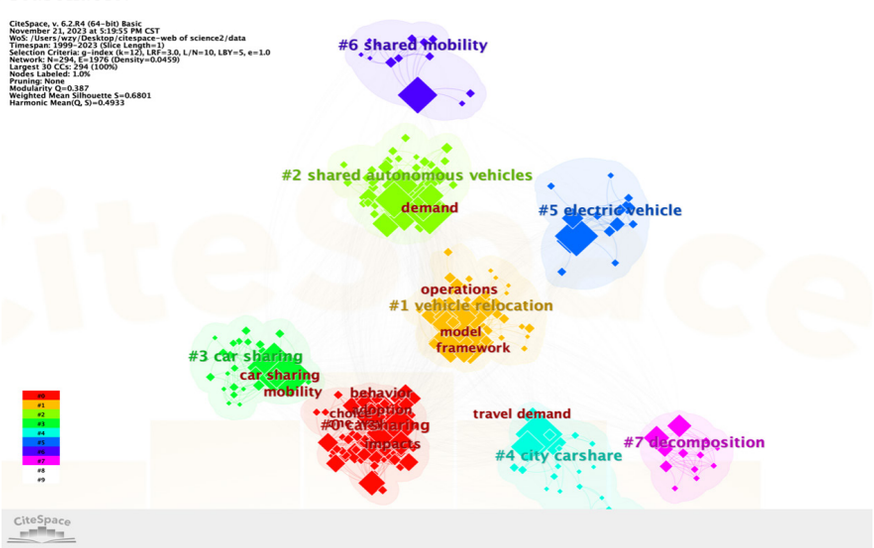

Figure 2. Cluster Network Map of Carsharing Keywords in English Literature

Table 1. Clustering of Carsharing Keywords in English Literature

Cluster number	Cluster size	Proportion of size	Main keywords
#0	71	26.89%	Sharing economy; car ownership; logit model; sustainable consumption; societal status; business model;
#1	53	20.08%	One-way car sharing; integer programming; vehicle relocation optimization; network flow; gradient-based algorithm;
#2	47	17.80%	Shared autonomous vehicles; autonomous driving; travel mode choice; users preference; indirect rebound effects;
#3	30	11.36%	Car sharing; carbon footprint; GHG emissions; spatial capital; urban sustainability;
#4	23	8.71%	City carshare; carlink; growth; new mobility; multicriteria data analysis;
#5	15	5.68%	Electric vehicles; autonomous vehicles; shared vehicles; traffic performance; public transportation;
#6	13	4.92%	Shared mobility; car-sharing services; mobility management; car-sharing systems; smart cities;
#7	12	4.55%	Approximation procedure; decomposition; performance; growth; network model;

Through the analysis of the keyword co-occurrence network cluster in Figure 2 and Table 1, the current research in the field of car-sharing abroad can be roughly categorized into three main areas: research on the industry model of car-sharing services, research on car-sharing system models and functional improvements, and the relationship between car-sharing and sustainable urban transportation.

(1) Research on the Industry Model of Car-Sharing Services.

Co-occurrence keywords: business model; users' preferences; growth; travel demand; travel surveys; stated preferences; demand side management, etc.

As a development model of the sharing economy, car-sharing has attracted considerable attention. However, a successful operational model and management mechanism for the car-sharing industry have not yet emerged. Scholars have studied car-sharing services by linking the business models, business development, and operational patterns of car-sharing companies to explore industry models that suit their growth. Guido Perboli et al. studied the business models of car-sharing services and found that most car-sharing manufacturers are developing towards a "Mobility as a Service" paradigm, suggesting that a key element in defining car-sharing services is the development of customized pricing plans[10]. Since driving performance comes at the cost of fuel efficiency, Ioannis Bellos et al. examined the role of business model selection and product line design, finding that carpooling can enhance the fuel efficiency of Original Equipment Manufacturers' (OEM) vehicles[11]. The continuous improvement of car-sharing platforms is crucial to gaining customer loyalty, which is key to their success. Fei Ma et al., using theories of perceived value, trust, and transaction costs, explained customer loyalty and found that the relationship between continuous improvement and customer loyalty is mediated by perceived value, trust, and transaction costs[12]. At present, more development models for car-sharing companies remain to be explored, and the choice of operational models will significantly affect their economic performance. Only by adopting the optimal business model can the development of the car-sharing market be effectively promoted.

(2) Research on Car-Sharing System Models and Functional Improvements.

Co-occurrence keywords: adoption; vehicle relocation; optimization; one-way carsharing; shared autonomous vehicle; life cycle assessment; electric vehicle; vehicular ad; risk analysis, etc.

Currently, the car-sharing market includes shared fuel-powered cars, shared electric vehicles, and shared autonomous vehicles. However, the performance of these vehicles has not yet been adequately improved or structurally optimized, which can reduce travel efficiency to some extent. Therefore, in recent years, scholars have extensively researched the improvement of car-sharing system models. Claudio Gambella et al. proposed a mathematical model for managing the daily operation of electric vehicle-sharing systems and a model for overnight vehicle relocation, optimizing car-sharing management systems[13]. Mehdi Nourinejad et al. introduced a dynamic optimization policy model that helps establish a robust one-way car-sharing system, enhancing customer satisfaction[14]. Mor Kaspi et al. proposed a parking reservation strategy that reduces uncertainty in car-sharing systems[15]. Based on extensive research, car-sharing urgently needs large-scale transformation and upgrades. Further feasibility testing of these studies is needed, along with their practical application, to advance the development of the car-sharing market.

(3) Car-Sharing and Sustainable Urban Transportation.

Co-occurrence keywords: car ownership; sustainable consumption; carbon footprint; GHG emissions; spatial capital; urban sustainability; solar panels, etc.

Car-sharing is one of the pillars of intelligent transportation infrastructure, helping to alleviate urban traffic congestion, parking difficulties, and environmental pollution. To promote sustainable urban development, many scholars have investigated sustainable transportation. Chiara Boldrini et al. studied the relationship between car-sharing demand, social demographics, and urban factors. They found that car-sharing demand is positively correlated with higher education levels and nightlife activities, and negatively correlated with the proportion of commuters living outside the city[16], offering valuable insights into determining the number of car-sharing vehicles and operational areas in cities. Ana María Arbeláez Vélez et al. explored the impact of car-sharing on individual and urban transportation greenhouse gas emissions and found that B2C and P2P car-sharing models can have a positive effect on traffic emissions[17]. Donald A et al. employed experimental methods to examine the impact of car-sharing on urban car usage, concluding that car-sharing is a key factor in reducing urban car usage[18]. Car-sharing will be an important component of future urban transportation, but for car-sharing to truly reduce urban traffic issues and promote sustainable urban transportation, a combination of government policies, changes in individual perspectives, and other conditions are necessary. Achieving widespread urban car-sharing remains a challenging and long-term task."

Figure 3 presents the top 25 burst keywords with the highest burst strength in English carsharing-related literature. Based on the emergence timeline of burst terms, the research on car-sharing abroad can be divided into three time periods: 2009-2013, 2013-2018, and 2018-2023. Using CiteSpace, co-occurrence maps for keywords in these three time periods are generated, resulting in Figures 5, 6, and 7. By analyzing the breakpoints and literature trends, this study explores the frontier areas and development trends in the research on car-sharing abroad.

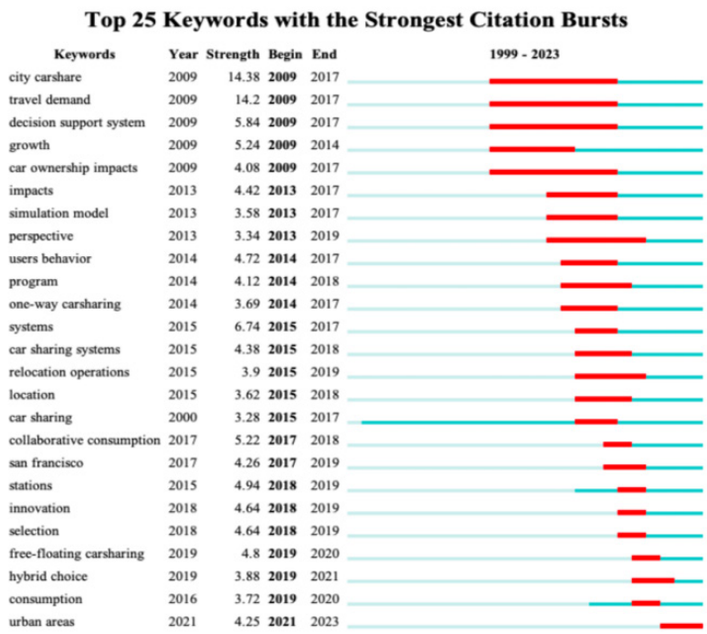

Figure 3. Burst Detection Map of Keywords in the Carsharing Field in English Literature

(1) 2009-2013 Time Period.

Figure 4 illustrates the key research topics in the field of car-sharing during the 2009-2013 period. The number of nodes is 104, the number of connections is 241, and the density is 0.045. Car-sharing began relatively early abroad, and as shown in Figure 1, this period marks the developmental stage of car-sharing in foreign countries, with scholars focusing on research and exploration in specific areas. From Figure 4, it is evident that terms such as 'city car share', 'travel demand', 'decision support system', 'growth', and 'car ownership impacts' show strong bursts of activity, indicating that during this time, car-sharing was widely applied in urban transportation, and scholars paid significant attention to analyzing consumer behavior in car-sharing services.

(2) 2013-2018 Time Period.

Figure 5 illustrates the key research topics in the field of car-sharing during the 2013-2018 period. With 240 nodes and 1,043 connections, and a density of 0.0364, the high number of nodes and connections indicates that research on car-sharing abroad significantly increased, with strong interrelationships between keywords. According to Figure 1, this period marks the prosperous development phase of the car-sharing industry abroad, with scholars delving deeper into the subject. From Figure 4, terms such as 'impacts', 'simulation model', 'perspective', 'user behavior', 'program', 'one-way carsharing', 'system',

Figure 4. Keyword Co-occurrence Map of Foreign Literature (2009-2013)

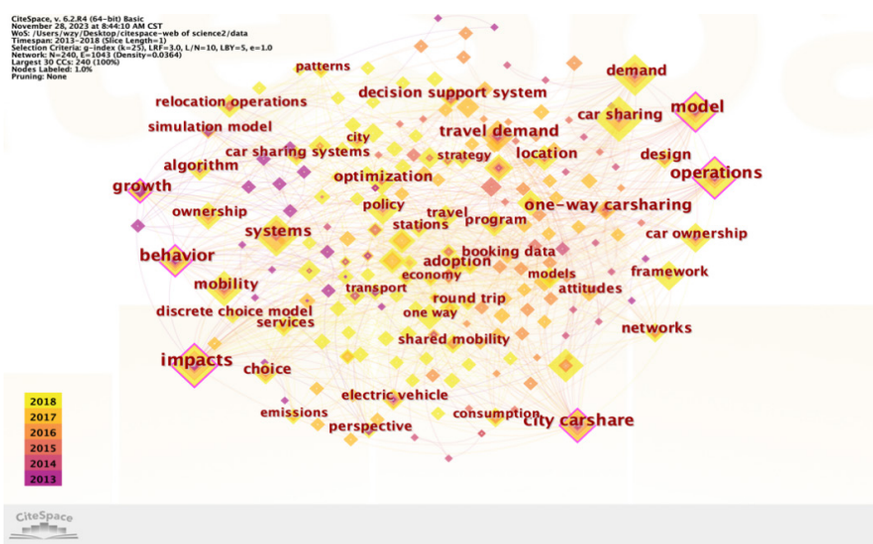

Figure 5. Keyword Co-occurrence Map of Foreign Literature (2013-2018)

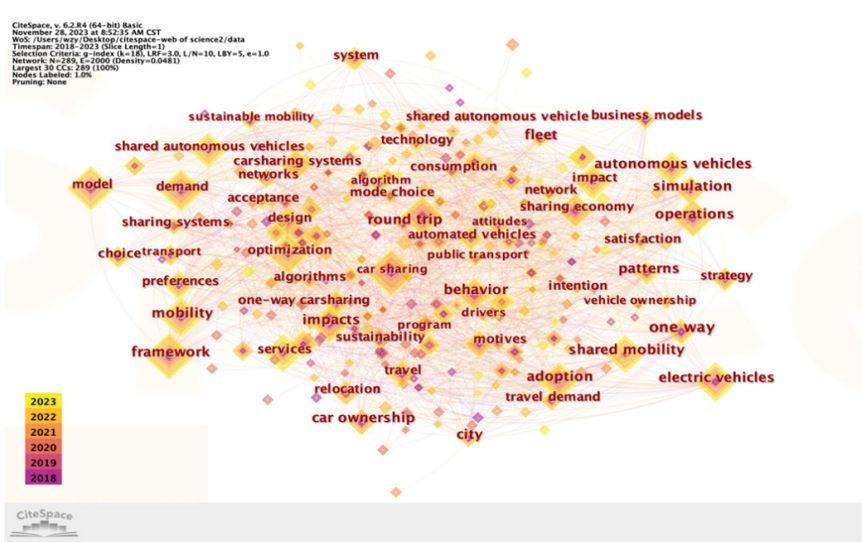

Figure 6. Keyword Co-occurrence Map of Foreign Literature (2018-2023)

'carsharing systems', 'relocation operations', 'location', 'car sharing', 'collaborative consumption', and 'San Francisco' exhibit strong bursts, with numerous emerging terms spanning multiple areas, including the impacts of car-sharing, technological applications, and consumer behavior. This suggests that during this period, scholars elevated their research on car-sharing to economic and technological dimensions, conducting feasibility studies and analyses for future development.

(3) 2018-2023 Time Period.

Figure 6 illustrates the key research topics in the field of car-sharing during the 2018-2023 period. With 289 nodes, 2,000 connections, and a density of 0.0481, the relationships between keywords have become more tightly integrated, and scholars' research on car-sharing has become more comprehensive. According to Figure 1, this period marks a decline in car-sharing research abroad, influenced by technological limitations and the challenges associated with car-sharing. Scholars' research has entered a bottleneck phase. As shown in Figure 4, terms such as 'stations', 'innovation', 'selection', 'free-floating carsharing', 'hybrid choice', 'consumption', and 'urban areas' exhibit strong bursts of activity, indicating that during this period, scholars have focused on in-depth studies of car-sharing model innovations. From Figure 7, it is evident that the node colors are predominantly darker, suggesting that research has slowed in recent years. Car-sharing requires technological breakthroughs to achieve sustainable development.

4. Conclusion

The analysis reveals that the major research hotspots in car sharing include keywords such as "car sharing," "model," "mobility," "systems," "electric vehicles," "sustainable consumption," "carbon emissions," and "optimization," indicating a focus on car-sharing model optimization, sustainable transportation, user behavior, and technological innovation.

Future trends in car-sharing research may focus on several key areas: firstly, intelligent and technological innovation will continue to drive car sharing, particularly through the application of artificial intelligence and the Internet of Things in vehicle management and trip optimization. Keywords such as "electric vehicles," "autonomous driving," and "smart dispatch" are likely to expand, promoting efficient scheduling and resource optimization. Secondly, sustainable urban transportation and environmental impacts will remain prominent research areas. Keywords like "carbon emissions," "urban areas," and "transportation systems" suggest that future studies will further explore the long-term effects of car sharing on traffic congestion and carbon footprint, providing support for policy-making. Lastly, user behavior and demand analysis will become increasingly important; with keywords like "user preference," "sharing economy," and "service experience" suggesting a future emphasis on user behavior modeling and demand forecasting to enhance service personalization and customer satisfaction. These trends are expected to strengthen the role of car sharing in smart cities and green transportation, contributing to the establishment and improvement of sustainable mobility systems.

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