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Review

Mapping the bike sharing research published from 2010 to 2018: A scientometric review

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A B S T R A C T

An increasing number of studies since 2010 have examined bike sharing from diverse perspectives to provide the best travel practices of "the last mile". However, few studies have attempted to comprehensively review existing literature over the past decade. The present study aims to map bike sharing research published between 2010 and 2018. A total of 208 relevant articles were collected to conduct scientometric analysis. The results revealed that the most significant contributions in bike sharing research primarily originated from the US, China, Canada, England and Australia. Critical institutions, publications and articles were also identified. The knowledge domains of bike sharing research focus mainly on topic categories of factors & barrier, system optimization, behavior & impact, safety & health, and sharing economy. Evolutionary trends in bike sharing research tend to move from the safety and benefits of bike usage to more complex external impacts, system optimization, design and integration with public transit. Furthermore, increasing interests and outputs in the new generation of dockless bike sharing programs were observed from the research community for the past two years. The present study contributes to the existing body of knowledge on bike sharing by presenting a new, integrated and holistic knowledge map. This study offers valuable guidance and in-depth understanding to researchers, operators and policy makers who wish to promote bike sharing sustainability, as well as for follow-up studies, updates and management.

Contents

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1. Introduction

Bike sharing, as a means of sustainable transportation, addresses the travel aspect of “the last mile” and provides benefits for users in terms of finances, health and a low-carbon lifestyle (Shi et al., 2018). Bike sharing has undergone several system updates since the first generation of bike sharing program, namely the “White Bike”, emerged in Amsterdam in 1965. Third-generation programs gained worldwide popularity in the past decade (Shaheen et al., 2010). In 2014, the number of cities that operate bike sharing programs increased to 855, with a total of 946,000 bikes in operation (Fishman, 2016). The new generation of dockless bike sharing programs (e.g., ofo and mobike) emerged in 2016 as the quality and accessibility of information technology develop dramatically. These new bike sharing programs integrate mobile payment and GPS tracking into big data. Venture capitalists provide financial support, whereas bike sharing companies are responsible for the operations and city promotion. As a result, the new generation of bike sharing programs enjoyed an unprecedented scale-up worldwide (Ma et al., 2018; Shen et al., 2018; Shi et al., 2018).

Bike sharing programs were promoted worldwide from 2006 (Fishman et al., 2013). However, relevant research increased significantly only after 2010 (as shown in Fig. 2). Increasing studies investigated the bike sharing phenomenon using various research paradigms and methods from different perspectives and disciplines. A synthetic overview was provided via a critical examination of the growing body of literature on bike sharing to enable scholars and managers to better understand the effectiveness of current programs (Fishman et al., 2013). Several emerging themes of bike sharing from 2013 to 2014 were then summarized by Fishman (2016). Ricci (2015) interpreted and reviewed available evidence on the impact and process of bike sharing program implementation. These reviews evaluate a certain stage or specific theme based on academic and grey literature prior to 2015. In fact, many new-generation programs did not yet emerge before 2015. As more and more cities worldwide operate bike sharing programs, and the fast movement of contemporary information technology, new topics and studies on bike sharing are also emerging. There is a need to look into the current research status, as well as understanding of how this field developed over time, especially in the recent decade.

This study attempted to review the bike sharing research published between 2010 and 2018 to provide researchers with a complete and insightful picture of bike sharing research. A scientometric analysis method based on the knowledge domain visualization is used to construct knowledge maps to assist the author's review analysis. This multiple, time-sharing and dynamic citation analysis visualization technology can display the evolution of a knowledge domain on the network map and can also automatically identify research frontiers by citation node and co-citation

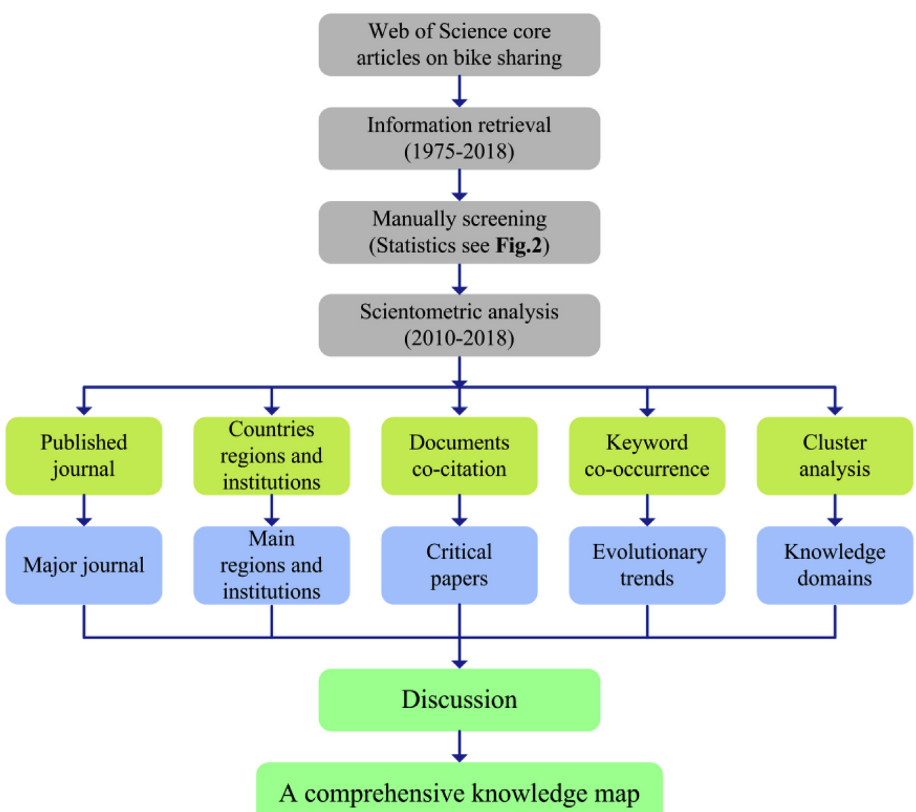

Fig. 1. Research framework.

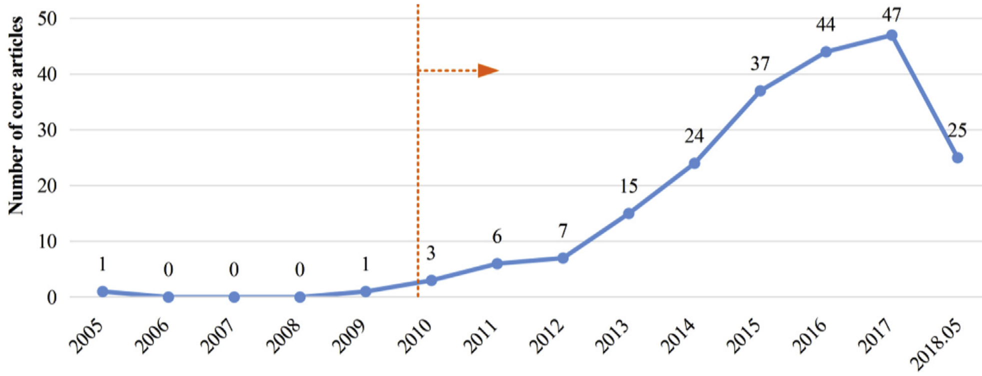

Fig. 2. Core literature statistics of bike sharing.

clustering on the map as the basis of knowledge (Chen, 2015; Chen et al., 2009). Therefore, the main objectives of this study are: (1) to summarize the bike sharing research published during 2010–2018; (2) to understand the overall research status for bike sharing from the perspective of country, institution, document co-citation and keyword co-occurrence, as well as to identify divisions in research topic; (3) to present a new, integrated and holistic knowledge map of the bike sharing field, including the knowledge domains, evolutionary trends, and future directions.

The remainder of this study is organized as follows: In Section 2, we elaborate the research methodology, data collection and processing. Then, we present the research results in Section 3, which includes an analysis of published journals, network of countries and institutions, network of document co-citation, network of keyword co-occurrence and a cluster analysis. A comprehensive knowledge map and corresponding discussion based on scientometric analysis are presented in Section 4. The final section concludes this study and proposes some future directions.

2. Research methodology

2.1. Method and framework

Scientometric analysis is a technology that demonstrates the scientific development process and structure relationship based on the knowledge domain (Chen et al., 2009). Scientometric analysis provides a quantitative analysis for a specific field through the application of mathematical and statistical methods. In addition to statistics and clustering of the same or similar topics, scientometric analysis can discover their potential relationships through co-occurrence network presenting quantitative results (Borner et al., 2003). Scientometric analysis is both a visual knowledge figure and a serialized knowledge pedigree that focuses on displaying scholarly communities, discovering knowledge domains, identifying trends in research fields, and discovering relationships among authors and organizations (Chen et al., 2010). Many software have been developed to conduct a scientometric analysis, such as BibExcel, Ucinet, SCIMAT, VOSviewer and CiteSpace. Some software focus on co-occurrence analysis (e.g., BibExcel and Ucinet) and evolutionary trend detection (e.g., SCIMAT), while others specialize in visualization (e.g., VOSviewer). CiteSpace integrates co-occurrence analysis, evolutionary trend detection and visualization functions to provide one-stop approach for scientometric analysis (Chen, 2015). It should be noted that scientometric analysis can help reveal the unbiased and quantitative links between various studies, but it cannot replace a manual review (Li et al., 2017; Lowry et al., 2004). Some important topics may be lost, especially in cluster analysis, because they are not highly co-referenced. Thus, the knowledge domains must be manually supplemented.

Previous studies with scientometric analysis using CiteSpace normally followed a research order. In this study, we construct an integrated analysis framework to visualize the bike sharing research published from 2010 to 2018. The study encompasses six scientometric techniques: (1) published journal analysis (i.e., understanding the major journals that published bike sharing research); (2) network analysis of country and institution (i.e., presenting the co-occurrences of countries and institutions in the indexed corpus of journal articles); (3) network analysis of document co-citation (i.e., presenting the co-cited authors and co-cited articles); (4) network analysis and timezone view of keyword co-occurrence (i.e., visualizing the top keywords occurring frequently and analyzing the evolutionary trends); (5) cluster analysis (i.e., classifying the journal articles into several knowledge domains). A discussion will be conducted to create a comprehensive knowledge map in the end. Details of the framework are shown in Fig. 1.

2.2. Information retrieval

To achieve the goal of this study, the core collection database of the *Web of Science* (WoS) was used to obtain research data for the field of bike sharing. Compared with other scientific databases, WoS covers more than 12,000 highly influential journals and is considered the most comprehensive global document database (He et al., 2017). The core collection database of WoS also contains the most high-quality journals worldwide (de Castro e Silva Neto et al., 2016), articles published in these journals have passed strict peer reviews. In view of these two reasons, previous scientometric studies (e.g., Li et al., 2017; Olawumi et al., 2017; Olawumi and Chan, 2018; Zhao, 2017) adopted the core collection of WoS for data acquisition.

Through the advanced search function of WoS, a theme of retrieval was conducted in the core database, in the form of a string. Given that scholars have used different terms for different generations of bikes, the content of the string search was set to "TS=("bike sharing" OR "bicycle sharing" OR "bike share" OR "shared bicycle*" OR "bikesharing" OR "shared bike*" OR "public bicycle*" OR "public bike*")". The symbol * denotes other forms of a word, such as "bike" and "bikes". The time range of literature retrieval was set from 1975 to 2018 (as of May 16). Literature type was limited to journal articles written in English.

A total of 345 articles were presented by WoS on the basis of above retrieval criteria. Inevitably, some articles were obviously not relevant to the topic of bike sharing, such as Scarinci et al. (2017), which was published in the *Journal of Transportation Research Part*

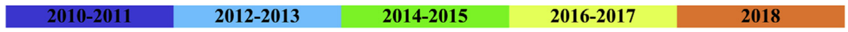

Fig. 3. Colour interpretation. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

C. Although bike sharing was mentioned in an abstract manner, the theme of the author's study was the network design of a traffic system. Similarly, van der Veen et al. (2017) used bike sharing, car sharing and family water-saving systems as the three main cases, to test the constructed model. However, this paper is not a study that focuses on the topic of bike sharing. To address this problem, these unrelated articles were removed through a manual screening process. As a result, the representative papers were identified and displayed in Fig. 2 according to the publication year. An increasing number of scholars have started to pay close attention to the field of bike sharing since 2010. The number of studies has increased rapidly in recent years. Based on the consideration of research focus and continuity, 208 articles from 2010 to 2018 were ultimately selected for further scientometric analysis. This number was considered adequate to represent the research work of bike sharing in the most recent nine years.

3. Scientometric analysis

In this section, a scientometric analysis is conducted to visualize the review of the bike sharing knowledge area. In the following network (Figs. 4–6), blue denotes the links that occurred in 2010–2011, whereas orange represents the links that occurred in 2018. The transition from cool tones to warm tones represents the time span from past to present (Chen, 2006). Detailed colour expression is shown in Fig. 3.

3.1. Published journals

The 208 articles selected in this study were published in 83 different journals. Table 1 displays the top 20 most productive journals that have published at least three articles of bike sharing from 2010 to 2018. The top 20 journals accounted for approximately 65% of the 208 publications. *Transportation Research Record* and *Journal of Transport Geography* published 19 articles on bike sharing and were tied for first place, followed by *Transportation Research Part A: Policy and Practice* (17 articles), *International Journal of Sustainable Transportation* (12 articles) and *Journal of Cleaner Production* (9 articles). These top five journals accounted for 37% of the total articles, which might indicate that they were the most influential publications in the field of bike sharing for the past eight years. As can be seen from the journal list, the study of bike sharing involves multiple disciplines. Although transportation science and technology are the dominant disciplines, other disciplines are also closely related to bike sharing, such as sustainable development, human health, operations and management science. The six journals of *Transportation Research* series (i.e., Parts A to F), which have different aims and scopes, are all in the top 20. This finding also confirms that the bike sharing research have covered a relatively wide knowledge range.

3.2. Countries/regions and institutions

Fig. 4 shows the contribution network of countries/regions and institutions to the body of knowledge in the bike sharing field, which includes 70 nodes and 163 links. The size of the node represents the research contribution or number of publications. The US (64 articles, 30.77%), China (47 articles, 22.60%), Canada (24 articles, 11.54%), England (23 articles, 11.06%), Australia (18 articles, 8.65%) and France (11 articles, 5.29%) all made major contributions to the research on bike sharing from 2010 to 2018. It is noteworthy that although the US is a relative latecomer to bike sharing (Fishman, 2016), 74 US cities were operating bike sharing programs by 2015, and 80 additional cities plan to introduce bike sharing (Godavarthy and Rahim Taleqani, 2017). China has simultaneously operated the largest number of traditional public bikes and new generation of dockless bike sharing in the world (Du and Cheng, 2018; Fishman, 2016). Other countries all have their own famous bike sharing programs, such as Bixi in Canada, Boris bike in

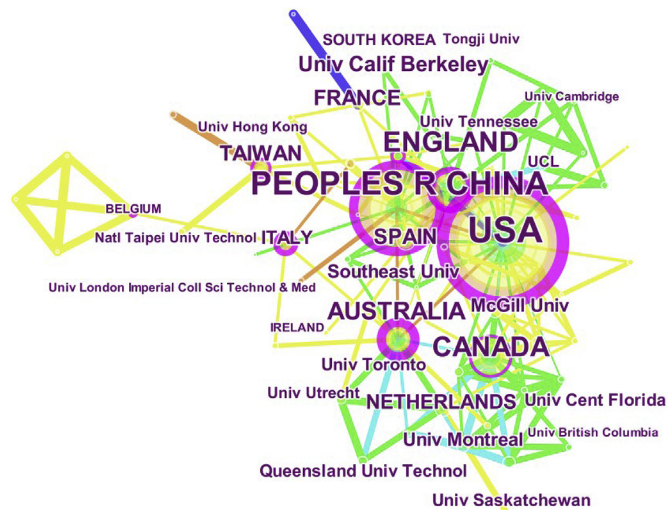

Fig. 4. Network of countries/regions and institutions: 2010–2018.

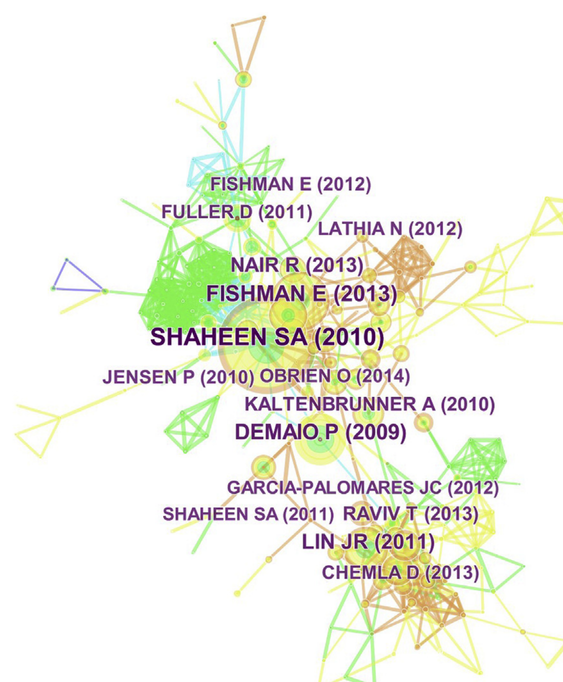

Fig. 5. Network of documents co-citation: 2010–2018.

Fig. 6. Top keyword occurring more than ten times: 2010–2018.

Table 1
Major journals that published bike sharing research from 2010 to 2018.

No.	Journal Name	No. of Articles	%
1	Transportation Research Record	19	9.13%
2	Journal of Transport Geography	19	9.13%
3	Transportation Research Part A: Policy and Practice	17	8.17%
4	International Journal of Sustainable Transportation	12	5.76%
5	Journal of Cleaner Production	9	4.33%
6	Sustainability	7	3.37%
7	Transportation Research Part B: Methodological	5	2.40%
8	Transportation Research Part D: Transport and Environment	5	2.40%
9	Transportation Research Part C: Emerging Technologies	5	2.40%
10	Transport policy	4	1.92%
11	Plos One	4	1.92%
12	Transportation Research Part E: Logistics and Transportation Review	4	1.92%
13	Journal of Transport & Health	4	1.92%
14	ITE Journal-Institute of Transportation Engineers	3	1.44%
15	European Journal of Operational Research	3	1.44%
16	OMEGA-International Journal of Management Science	3	1.44%
17	Mathematical Problems in Engineering	3	1.44%
18	Journal of Urban Planning and Development	3	1.44%
19	Transportation Research Part F: Traffic Psychology and Behavior	3	1.44%
20	Transportation	3	1.44%

England, CityCycle and MBS in Australia, and Velib in France.

Research institutions that conduct bike sharing research have been very prolific in producing a number of studies, such as the University of California, Berkeley, US (10 articles), McGill University, Canada (eight articles), University of Montreal, Canada (seven articles), Southeast University, China (seven articles), University of

Central Florida, US (six articles), University of Queensland, Australia (six articles), University of Toronto, Canada (six articles) and University of Saskatchewan, Canada (six articles). These institutions are the most productive institutions in the field of bike sharing research in recent decade. The statistical methods of the number of countries and institutions are full counting, that is, information for all authors in each document is counted. Four significant collaborative groups exist in bike sharing research institutions (cooperation more than twice). The first group consists of six institutions in Canada (i.e., University of Montreal, University of Toronto, University of Central Florida, University of Saskatchewan, McGill University and University of British Columbia). The second group consists of three institutions in England (i.e., University College London, London School of Hygiene & Tropical Medicine and University of Cambridge). The third group consists of two institutions in the US (i.e., University of California, Berkeley and University of Tennessee). The fourth group consists of two institutions in Australia and the Netherlands (i.e., Queensland University of Technology and Utrecht University). This result shows that cross-institutional cooperation often occurs in a certain country, yet cross-country institutional cooperation is lacking.

3.3. Document co-citation

Fig. 5 presents a co-citation network consisting of 430 nodes and 1221 links, which includes the documents cited by the 208 articles selected in this study. Each node represents one document, and the link connecting nodes represent co-citation relationships, whereas different colour express corresponding time slices (each time slice represents two years). For instance, a large area of yellow and orange links occupies the network, which indicates that the document co-citation was cited mostly between 2016 and 2018. Furthermore, the larger nodes suggest that these articles have been cited by numerous scholars, which indicates that they can be considered significant in the field of bike sharing knowledge. According to the document co-citation network shown in Fig. 5, the top 10 cited articles are listed in Table 2. All of the articles contributed to the bike sharing research.

Co-citation analysis assessed the references cited in the 208 articles. Shaheen et al. (2010) obtained the highest citations frequency (102), which integrated the past, present and future of bike sharing development in Europe, the Americas, and Asia. This study not only focuses on the first three generations of bike sharing, but also holistically proposes the concept and features of the fourth generation program, including GPS tracking and flexible docking stations. This may be the main reason why this article has received the most attention and recognition in the past nine years. The second largest body of articles Fishman et al. (2013) provided a review, via a critical examination of the growing body of literature on bike sharing programs to enable scholars and managers to better understand the effectiveness of current programs. DeMaio (2009) reviewed the history of the first three-generations of bike sharing and discussed the fourth generation of the program for the first time. Unlike Shaheen et al. (2010), DeMaio emphasized provision models and the costs of a bike sharing program. These three articles were usually cited by other works to introduce the history and research progress of bike sharing. The other seven articles are mostly system-oriented and focus on the design of large-scale systems, demand prediction, and rebalancing problems. These seven articles were generally cited by other works in the literature review, algorithm introduction and discussion of optimization research on bike sharing systems. Regardless of the specific area of research, summarizing all 10 critical papers consider a bike sharing program to be an effective sustainable transportation alternative that can bring about various environmental and social benefits.

An explanation should be given as to why only one of the 10 articles in Table 2 was written by co-authors from China despite the fact that China has a larger number of bike sharing programs. This is because the traditional Chinese public bicycle programs did not attract sufficient research attention, Fishman (2016) also found this apparent imbalance between practice and research. In addition, the cited frequency of the articles produced by CiteSpace is inconsistent with other scientific databases. For example, Lin and Yang Ta-Hui (2011) was cited 301 times on Google Scholar. However, the cited frequency produced by CiteSpace is only 49 times. The reason for this finding is that CiteSpace only considered the circumstance of 208 journal articles and their references. As discussed earlier, publications (such as books, reports or journal articles) that are unrelated to bike sharing were excluded in the screening process.

3.4. Keyword co-occurrence

Keywordsare the descriptive words that present the core content of the article. An analysis of keyword co-occurrence is helpful in identifying the primary topics in the research area of bike sharing. The network of keyword co-occurrence includes 112 nodes and 433 links, and is shown in Fig. 6. This network highlights the keywords that occur more than 10 times in the 208 articles selected in this study. The size of keyword is proportional to the frequency of occurrence. The keyword “impact” has the highest frequency (36 times), which refers to the related impacts of bike sharing use. The term of “impact” covers the impact of the external environment on bike sharing. For example, Faghih-Imani et al. (2014) examined the impact of urban spatial form and land-use type on bike sharing usage, and proposed some solutions on station size and location decision-making. Mateo-Babiano et al. (2016) surveyed Australia's largest bicycle sharing program and investigated the role of natural and architectural environmental characteristics on bike sharing

Table 2
The top 10 critical papers in the bike sharing discipline.

Author & year	Title	Cited frequency	Google scholar
Shaheen et al. (2010)	Bikesharing in Europe, the Americas, and Asia: past, present, and future	102	574
Fishman et al. (2013)	Bike share: a synthesis of the literature	61	242
DeMaio (2009)	Bike-sharing: History, Impacts, Models of Provision, and Future	55	583
Lin and Yang Ta-Hui (2011)	Strategic design of public bicycle sharing systems with service level constraints	49	301
Nair et al. (2012)	Large-scale vehicle sharing systems: analysis of Vélib'	40	171
Kaltenbrunner et al. (2010)	Urban cycles and mobility patterns: Exploring and predicting trends in a bicycle-based public transport system	34	256
Raviv et al. (2013)	Static repositioning in a bike-sharing system: models and solution approaches	34	253
Chemla et al. (2013)	Bike sharing systems: solving the static rebalancing problem	32	217
Lathia et al. (2012)	Measuring the impact of opening the London shared bicycle scheme to casual users	29	147
O'Brien et al. (2014)	Mining bicycle sharing data for generating insights into sustainable transport systems	29	169

usage. "Impact" also includes the impact of bike sharing use on the external environment. For instance, Bullock et al. (2017) explored the impact of bike sharing on the sustainable development and effective operation of cities, and found that bike sharing brought extensive urban economic benefits by saving travel time and improving spatial connectivity. Finally, "impact" includes the impact of bike sharing on the user's health. Fuller et al. (2013a) and Woodcock et al. (2014) studied the impact of bike sharing on users and found that the bike sharing system generally had a positive impact on users' health, but not for all user groups. Keywords related to these three aspects include "physical activity" (17 times), "walking" (16 times), "health" (14 times), "benefit" (11 times), "weather" (10 times) and "built environment" (10 times).

The keyword "system" (32 times) and "design" (31 times) rank second and third in frequency, respectively, both of which indicated the optimization of bike sharing system. The objectives of the optimization include station location (e.g., Lin and Yang Ta-Hui, 2011; Park and Young Sohn, 2017), station capacity (e.g., Cruz et al., 2017; Wang and Szeto, 2018), vehicle routing (e.g., Alvarez-Valdes et al., 2016; Ghosh et al., 2017), inventory rebalancing and redistribution (e.g., Chemla et al., 2013; Fricker and Gast, 2012; Haider et al., 2018; Pal and Zhang, 2017). Keywords related to "system" and "design" include "algorithm" (15 times), "model" (14 times), "station" (14 times), "location" (14 times), "optimization" (12 times),"demand" (10 times) and "traveling salesman problem" (8 times).

The keyword group of "bicycle", "bicycle sharing system", "bike share", and "bike sharing" are all treated as stop-words. These conceptual keywords have the same meaning and do not add substantial value to the current analysis (Chen et al., 2018). In the context of bike sharing as a means of urban sustainable transportation, the keyword "city" (23 times) and "transportation" (20 times) also have a high frequency of occurrence. This series of studies mainly include the interaction between public transportation and bike sharing, and case studies on the theme of a particular city. For instance, Saberi et al. (2018) used the subway strike in London as a case to explore the impact of public transportation disruption on bike-haring usage; Zhao and Li (2017) used Beijing as a case to investigate how to promote bicycle-metro integration in a growing city.

Keyword co-occurrence network is a static expression of a particular area that does not take into account changes over time in the manner that the terms are used (Chen and Chen, 2005). Fig. 7 shows a timezone view of keywords that occur more than twice from 2010 to 2018. Each term is arranged in chronological order to present the trend and interaction of keywords. As shown in Fig. 7, the font size of the keywords that occurred from 2010 to 2014 is larger than other keywords. The finding indicates that these keywords appeared more frequently in the past nine years. The frequency of keywords occurring in the past four years is low, but the numbers and types of these keywords are increasing, especially since 2014. This finding illustrates that growing concerns about bike sharing have attracted an extensive range of disciplines that are now participating in research.

As shown in Fig. 7, no keywords appeared in 2010 because two of the three articles in 2010 did not have keywords (i.e., Krykewycz et al., 2010; Shaheen et al., 2010). The keywords in another article occurring no more than twice (Jensen et al., 2010). Topics that emerged from 2011 to 2013 are "safety", "policy", "city" and "benefit". New topics appeared in 2014 and 2015, which mainly include "impact", "system", "optimization", "design", "barrier", "infrastructure" and "built environment". With the rapid development of information technology, research on bike sharing in the past three years tended to examine system "redistribution", "rebalancing", and integration with "public transit or transport". In addition, research on service condition ("usage"), behavioral factors ("attitude and choice") and barriers ("determinant and weather") were afforded sufficient attention given that the new-generation of dockless bike sharing came out in 2016 and has achieved rapid development worldwide. Fig. 7 shows the overall research evolution of bike sharing from 2010 to 2018.

3.5. Cluster analysis

The co-occurrence network, timezone and outbreaks of keywords have been conducted to analyze the main research contents and trends of the past nine years. However, the potential structure and subject division in the bike sharing knowledge domain remain indistinct. Cluster analysis is an exploratory data mining technique used to analyze and identify significant topics, content and interrelationships (Wilks, 2011). Examining a literature cluster can help classify a large number of studies into manageable units and then objectively infer information about each group or cluster. CiteSpace provides this auto-tagging function and allows the extraction of noun phrases from titles, keywords or abstracts of publications and using them as tags for different groups. Considering that the keywords (or terms) of each group must be related to one another and are different from other groups, the Log Likelihood Ratio (LLR) is selected as the principle of classification statistics. LLR can generate high-quality clusters with intra-class similarity and low inter-class similarity (Chen, 2010).

In this study, 208 articles were clustered and divided into nine highlighted research clusters based on their keywords. Fig. 8 shows the clustering results and the relative importance rank through the LLR test. The maximum cluster number is #0, whereas the minimum cluster number is #8. Here, modularity $Q = 0.5677$ (>0.3), which shows that the overall clustering results are significative. Mean silhouette $= 0.5418$ (>0.5) shows that the cluster members have certain similarity and homogeneity. Fig. 8 shows that these clusters intersect. This means that although nine clusters have different label names, some parts between them overlap.

Table 3 benefits from the visualization of the grouping structure and lists the nine largest clusters in terms of group size. The silhouette scores for the clusters ranges from 0.55 to 0.90, which shows that the members (i.e., alternative labels) of the cluster fall well within their group (Ding et al., 2001; Olawumi and Chan, 2018). Among them, the largest cluster, #0 (natural experiment), represents a method that is widely used in scientific research. This alternative labels of this cluster include physical activity, walking, health, behavior, built environment, infrastructure, and so on. These subjects have applied the natural experiment method. For instance, Campbell and Brakewood (2017) quantified the impact of bike sharing system on bus passengers through a phased natural experiment and a difference-in-differences identification strategy. Cluster #1 (bicycle) represents the collective name for bike sharing. This cluster ranks second because most studies on bike sharing will include a keyword, that is, bike sharing, or bike share, or bicycle sharing. As mentioned in Section 3.4, these stop-words have no obvious analysis value.

Since the third generation of bike sharing has been introduced on the market, the most urgent problem is the imbalance between the demand for bicycles and the stock of the station. In these bike sharing systems, the user arrives at the station, unlocks the bicycle, uses it for a period of time and then returns it to another station at the user's destination. However, each station has a limited capacity and cannot accommodate more bicycles. This can lead to either a lack of or a saturation of bicycles in stations (Fricker and Gast, 2012). Therefore, operators need to spend a large amount of time and money to periodically rebalance the number of bicycles at all stations, in order to provide better services to users. To solve the

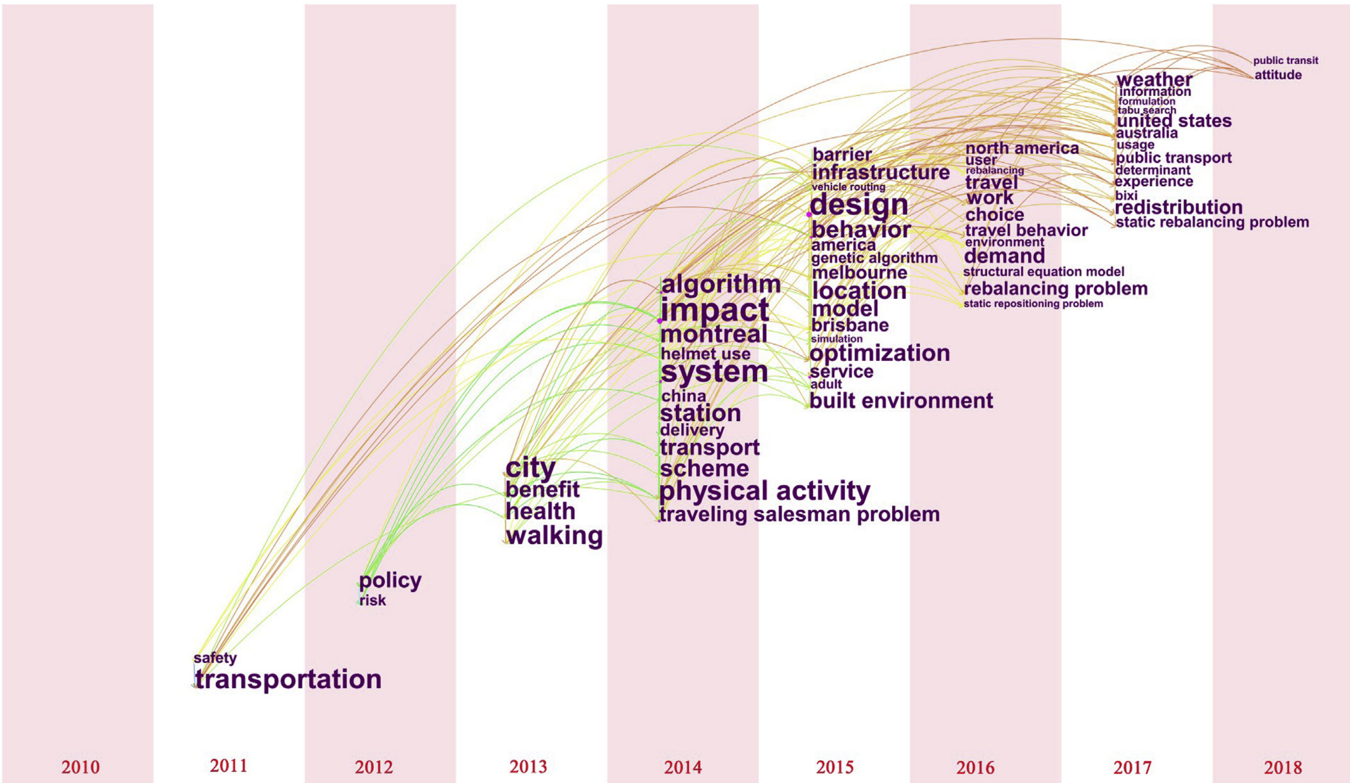

Fig. 7. A timezone view of keyword occurring more than twice: 2010–2018 (stop-words are excluded).

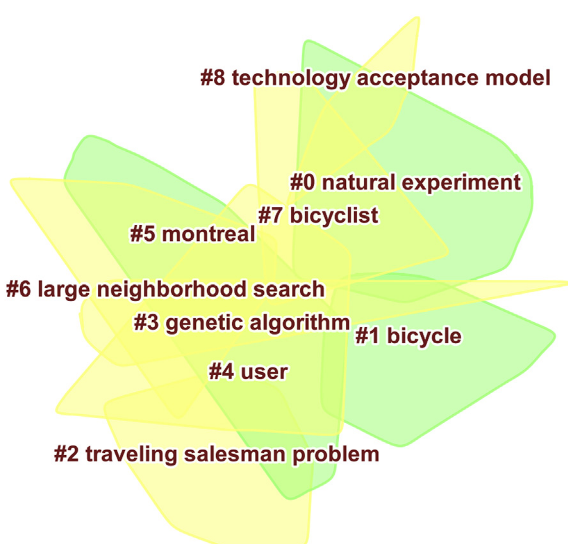

Fig. 8. Cluster analysis in the bike sharing field: 2010–2018.

problems of the rebalancing and repositioning of bike sharing systems, the academic community has carried out a considerable amount of optimization research through different methods, including the cluster #2 (traveling salesman problem), #3 (genetic algorithm) and #6 (large neighborhood search). For example, Cruz et al. (2017) and Schuijbroek et al. (2017) proposed two heuristic algorithms to address the problem of inventory rebalancing and optimal vehicle routing in the third-generation bike sharing system. The new-generation dockless bike sharing programs allow bikes to be parked in almost any place where parking is permitted. However, the rapid increase in supply scale has led to reduced efficiency of the bicycle usage. Caggiani et al. (2018) and Pal and Zhang (2017) proposed two new bicycle redistribution procedures from the dynamic and static point of view to solve the rebalancing problem of large-scale numbers of vehicles.

Clusters #4, #7 and #8 are related to usage behavior and benefits, which can be illustrated through their alternative labels, including safety, usage, behavior, barrier, and benefit. For this cluster, Fishman et al. (2014c, 2014d, 2012) focused on investigating the barriers and facilitators of the use of bike sharing in Australia. Fuller et al. (2014, 2013b) and Woodcock et al. (2014) concentrated on the health benefits of bike sharing. Interestingly, the label of Cluster #5 is a city name “Montreal”. A large amount of research have been conducted from 2010 to 2018 for the Bixi program (e.g., Bachand-Marleau et al., 2012; Bernatchez et al., 2015; El-Geneidy et al., 2016; Faghih-Imani et al., 2014; Faghih-Imani and Eluru, 2016; Fuller et al., 2013a), which is one of the most successful and typical bike sharing programs in the world (Bernatchez et al., 2015). Bixi was launched in Montreal in May 2009, and operates with 6250 bicycles and 540 docking stations. Bixi has also been providing free operational data for research on their official website. The above analysis may be the reason that a large number of researchers take Bixi or Montreal as a case. In addition, Cluster #5 (Montreal) also includes alternative labels such as impact, infrastructure and route choice because some studies conducted in the case of Montreal have investigated these three aspects (e.g., Faghih-Imani et al., 2014; Faghih-Imani and Eluru, 2016; Hyland et al., 2018).

4. Discussion

An explanation should be provided to distinguish different

Table 3
The eight research clusters in the bike sharing field.

Cluster ID	Label (LLR)	Size	Silhouette	Alternative labels
#0	natural experiment	27	0.55	physical activity, walking, health, behavior, built environment, infrastructure, determinant, work, risk, demand forecasting
#1	bicycle	26	0.63	bike share, bicycle sharing, bike sharing system, cyclist, citycycle, transport, public bicycle sharing program, helmet use
#2	traveling salesman problem	18	0.71	station, redistribution, delivery, static rebalancing problem, simulation, static repositioning problem, Stackelberg game
#3	genetic algorithm	13	0.78	system, design, model, gender, accessibility, data mining
#4	user	13	0.60	usage, weather, barrier, North America, public transit, pattern
#5	montreal	12	0.80	bixi, impact, bicycle infrastructure, route choice, ridership, Canada
#6	large neighborhood search	11	0.85	optimization, rebalancing problem, formulation, tabu search, time window, vehicle routing problem, Europe
#7	bicyclist	10	0.78	travel behavior, safety, information, management, mobility, driver
#8	technology acceptance model	7	0.90	planned behavior, structural equation model, experience, emotion, benefit, network, urban transport

generations of bike sharing. Some researchers have divided the evolution of bike sharing systems into four generations; the first two generations were considered less successful (Midgley, 2011; Parkes et al., 2013; Shaheen et al., 2010). The third generation of program based on IT systems was the first large-scale promotion and popular bike sharing program around the world. This generation integrates advanced technologies for bicycle reservations, pick-up, drop-off and information tracking. Shaheen et al. (2010) defined the fourth-generation bike sharing as demand-responsive and multi-modal systems based on new features such as redistribution systems, GPS tracking and smartcard integration with public transit. In 2016, the new generation of dockless bike sharing programs (e.g., ofo and mobike) emerged and gained popularity in Chinese cities. These large-scale data driven commercial bike sharing operations have brought new cycling booms in hundreds of cities around the world. In this study we extend Shaheen's generation model to define China's new bike sharing and other similar dockless bike sharing programs in the world as the fifth generation. The following discussion will be based on this definition. In this section, we will focus on identifying the evolutionary trends and division of knowledge areas for bike sharing over the past nine years based on the timezone view and cluster analysis of keywords.

4.1. Evolutionary trends

According to the keyword timezone view and previous analysis, the evolutionary trends of bike sharing research can be summarized into four stages. The first stage from 2010 to 2012, focused on “safety and policy” issues for third and fourth generation programs. The second stage, from 2013 to 2014, began to investigate the “benefit, system and impact” of bike sharing programs. Furthermore, the topics of “system and impact” were subdivided into “optimization, behavior, built environment, design, and infrastructure”, which are main research themes in the third stage of 2015. Not surprisingly, the research that emerged in the fourth stage (2016–2018) seem to deepen and subdivide previous topics, which are “demand, rebalancing, redistribution, choice, weather, usage, public transit and attitude”. These detailed topics covered third, fourth and fifth generation of bike sharing programs. The fifth-generation programs were especially afforded new attention.

The research trends tended to move from macro to micro, and from foundation to complexity. The segmenting trends have led to the maturity of the research of traditional bike sharing programs. The effect of technological progress on bike sharing research is also significant. For instance, an increasing number of topics focus on bike sharing system optimization, design and integration with public transit, such as redistribution, repositioning and rebalancing. Unlike previous summary of (Fishman, 2016), scientometric analysis found that research on various kinds of benefits and impacts of bike sharing decreased. External impacts, barriers and behavior on bike sharing usage remain attractive, especially for the fifth generation of bike sharing programs.

4.2. Existing knowledge domains

As discussed in Section 3.5, the results of the cluster analysis are intersecting, which can present several research clusters. However, the results cannot accurately reflect the division of the existing knowledge domain. In terms of the results of cluster analysis and combining with high-frequency keywords, we have manually divided the knowledge domains of bike sharing from 2010 to 2018. Similar clusters and high-frequency keywords are integrated into one category. The final result is shown in Fig. 9. The different generations of programs are discussed separately.

The existing knowledge domain for the third and fourth generation programs can be divided into four large categories. The first category is factor and barrier, which consists of Cluster #0 (natural experiment) and many high frequency keywords (see Fig. 9). These factors and barriers include but are not limited to the built environment, infrastructure, weather, college campus, number and location of docking stations and the sign-up process (e.g., Fishman et al., 2014d, 2012; Godavarthy and Rahim Taleqani, 2017; Hamilton and Wichman, 2018; Mateo-Babiano et al., 2016; Mattson and Godavarthy, 2017; Médard de Chardon et al., 2017). The second category is system optimization, which consists of Cluster #2 (traveling salesman problem), #3 (genetic algorithm), #6 (large neighborhood search) and corresponding high frequency keywords. The pressing problem that needs to be addressed in bike sharing system is the imbalance between bicycle demand and station inventory levels. The usual strategy is to reposition, redistribution, and rebalance the bicycles during off-peak hours (static or dynamic). This type of algorithm-based research has appeared in large numbers since 2016 and was mostly published in journals of *Transportation Research* and *Operations Research* series (e.g., Alvarez-Valdes et al., 2016; Chemla et al., 2013; Cruz et al., 2017; Ghosh et al., 2017; Ho and Szeto, 2017, 2014; Park and Young Sohn, 2017; Scarinci et al., 2017; Zhang et al., 2017).

The third category is behavior and impact, which consists of Cluster #4 (user), #7 (bicyclist), #8 (technology acceptance model) and relevant frequency keywords (such as “impact”). Bike sharing provides many benefits, such as improved health, better traffic options and convenience, reduced travel time and costs (Fuller et al., 2013a; Ricci, 2015; Shaheen et al., 2013, 2010). In addition, as discussed in Section 3.4, some impacts of bike sharing benefit the

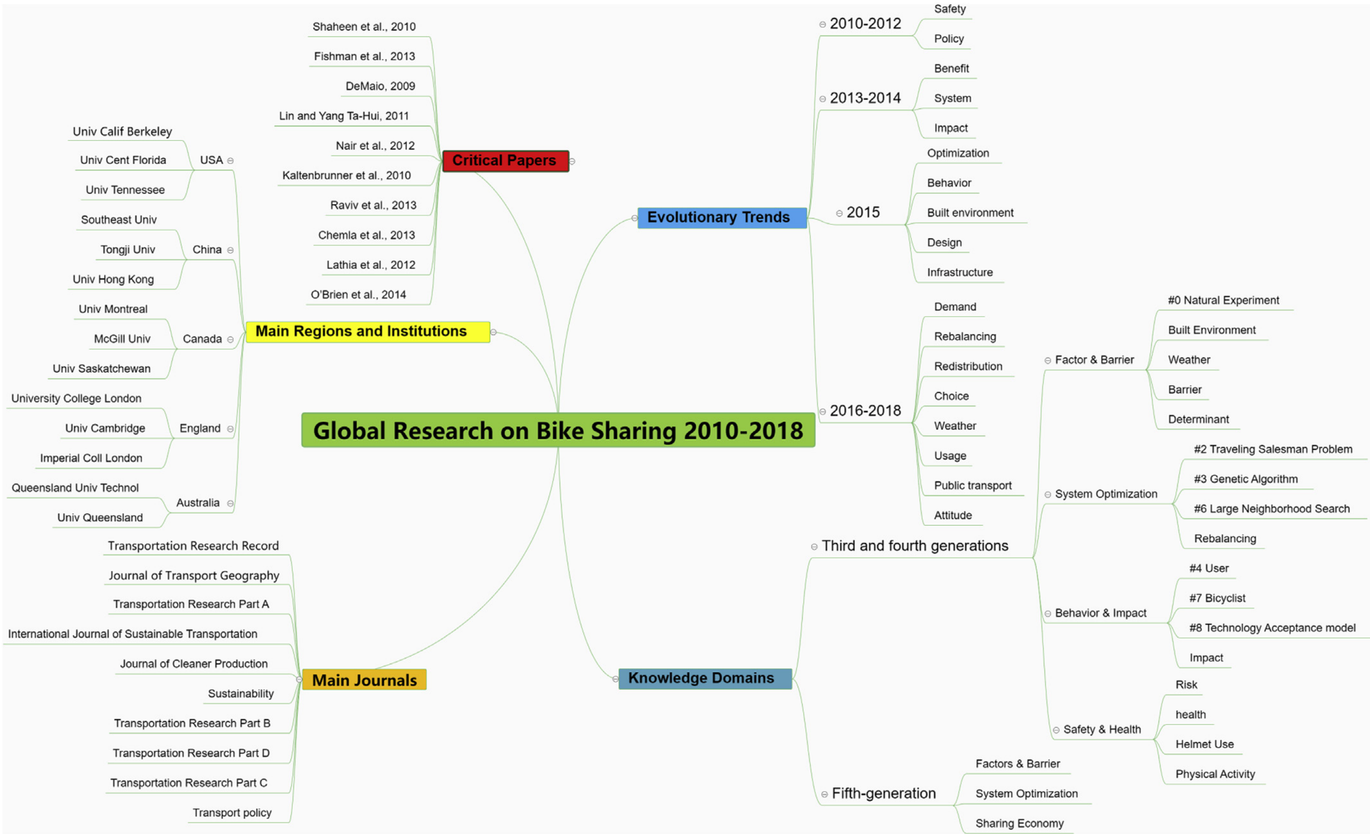

Fig. 9. A comprehensive knowledge map in the bike sharing field: 2010–2018.

external environment, such as public transport networks (Yang et al., 2018), bus ridership (Campbell and Brakewood, 2017), car use (Fishman et al., 2014a), urban economy and policy (Pelechrinis et al., 2017). According to the previous review of Ricci (2015), no evidence indicates that bike sharing can significantly reduce traffic congestion and carbon emissions. Hamilton and Wichman (2018) and Wang and Zhou (2017) provided new evidence that bike sharing can alleviate traffic congestion. Some scholars concluded that the lack of supporting infrastructure and corresponding laws for bike sharing have threatened users' health and safety (e.g., Buck et al., 2013; Fishman, 2016; Friedman et al., 2016; Qi, 2016). This issue leads to the fourth category of the research topic, namely, safety and health. This topic consists of many frequency keywords (such as risk, health, helmet use and physical activity). Numerous studies have attempted to quantify the impact of bike usage on user's physical activity. For example, cycling instead of sedentary movement creates more physical activity, but when walking is replaced by a bicycle, the level of physical activity of the user is actually reduced (Fishman et al., 2014b; Fuller et al., 2013c). In addition, some statistics on traffic accidents cited the involvement of bike sharing. These studies emphasize the importance of the mandatory wearing of helmets and supporting infrastructure (e.g., Graves et al., 2014; Walker et al., 2014).

The number of studies that examined the fifth generation of bike sharing is relatively small and has mainly occurred after 2017. Fifth generation systems have been introduced only two years ago. Considering that researchers take time to collect data, research, write results and submit to journals, it may not be published yet in journals since many high-quality journals have a “time-to-publication” period of one to two years to allow a thorough review. Most existing studies on the fifth generation of bike sharing aim to help understand the influence “factors and barrier” of bike sharing usage in cities, especially in China (e.g., Du and Cheng, 2018; Jia et al., 2018; Shen et al., 2018). Although the fifth generation of bike sharing programs addresses the problem of station restrictions through the use of GPS positioning and electronic anti-theft locks, the excessive delivery of new services is causing bicycles to be used less efficiently. Moreover, the contradiction between vehicle supply and demand still exists. A few studies (e.g., Caggiani et al., 2018; Pal and Zhang, 2017) focused on the issue of “system optimization” for fully-dockless bike sharing. In addition, as the sharing economy thrives worldwide, the fifth-generation bike sharing programs gradually become the iconic programs of the sharing economy. An increasing number of scholars are using bike sharing programs as cases to discuss the business model of the “sharing economy” (e.g., Lan et al., 2017; Ma et al., 2018, 2018b).

Overall, the above topics summarize the main research of bike sharing from 2010 to 2018, which advances our understanding of the knowledge body of bike sharing. Compared with the prior review of Ricci (2015) and Fishman (2016), knowledge domains discussed in this study complement new evidence on the topics of barrier, impact and system optimization (balancing). Emerging research themes on fifth-generation programs are also elaborated. Besides, major journals, institutions and papers in the field of bike sharing have been identified and analyzed based on the scientometric analysis. As a result, a comprehensive knowledge map of the bike sharing field is presented in Fig. 9.

5. Conclusion and future directions

Efficient traffic flow directly affects urban economic growth, social well-being and residents' happiness. To solve the problems of the "last mile" and urban traffic congestion, various bike sharing programs have popped up worldwide. As a green and sustainable way to travel, bike sharing offers financial savings, health benefits and a low-carbon lifestyle for the users. An increasing number of countries and regions have implemented bike sharing systems to promote sustainable transportation and reduce carbon emissions since 2010. A large number of studies associated with bike sharing were conducted from diverse perspectives.

The present study reviewed bike sharing research in the past nine years and covers three generations of programs, through a scientometric analysis of 208 articles. Firstly, an advanced search of WoS core database combined with manual screening was conducted to summarize the bike sharing research published from 2010 to 2018. Then, the network of countries, institutions, co-cited articles and the keyword co-occurrence and cluster analysis were conducted to help understand the overall research status. Grounded in the above analysis, an integrated knowledge map of the bike-sharing field was presented, including main journals, regions and institutions, critical papers, evolutionary trends and knowledge domains.

Results reveal that *Transportation Research Record*, *Journal of Transport Geography*, *Transportation Research Part* A: *Policy and Practice*, *International Journal of Sustainable Transportation* and *Journal of Cleaner Production* are the main five journals that published bike sharing core research from 2010 to 2018. In terms of countries/regions and institutions, the US, China, Canada, England, Australia and France all make major contributions in the field of bike sharing research. The University of California, Berkeley, McGill University, University of Montreal, Southeast University, University of Central Florida, University of Queensland, University of Toronto and University of Saskatchewan can be regarded as the most productive institutions for bike sharing research in recent decade. Chemla et al. (2013), DeMaio (2009), Fishman et al. (2013), Kaltenbrunner et al. (2010), Lathia et al. (2012), Lin and Yang Ta-Hui (2011), Nair et al. (2012), O'Brien et al. (2014), Raviv et al. (2013) and Shaheen et al. (2010) are the 10 most important and critical highly cited articles in the field of bike sharing research.

According to the timezone view of keywords, evolutionary trends of bike sharing research are identified into four stages. The first stage from 2010 to 2012, focused on "safety and policy" issues. From 2013 to 2014, the second stage began to investigate the "benefit, system and impact" of bike sharing programs. Furthermore, the topics were subdivided into "optimization, behavior, built environment, design, and infrastructure", which are main research themes in the third stage of 2015. The research topics that emerged in the fourth stage (2016–2018) are "demand, rebalancing, redistribution, choice, weather, usage, public transport and attitude". In terms of knowledge domains, core studies on bike sharing that published from 2010 to 2018 are summarized and classified into five categories in view of different generations of programs. As for the third and fourth generations of programs, the main knowledge domains are divided into: 1) factor & barrier; 2) system optimization; 3) behavior & impact; 4) safety & health. With regard to the fifth generations of programs, the main knowledge domains are divided into: 1) factor & barrier; 2) system optimization; 3) sharing economy.

Based on the review of bike sharing research for the past nine years, this study seeks to identify gaps and find some possible directions that need further investigation. Firstly, a large amount of system research has focused on inventory optimization at the station. However, only a few studies considered the issue of broken bikes that cannot meet the needs of users. Broken bikes in the system not only mean a waste of resources, but also lead to user dissatisfaction (Kaspi et al., 2017). The breakdown and recycling issues of station-based and dockless bike sharing programs therefore need further attention. Second, although the fifth generation of programs has only emerged in the two years, the traditional programs have experienced unprecedented competition and squeeze, especially in Chinese cities. The coexistence of these programs with fifth-generation programs is an important and relevant consideration. Third, as bike sharing systems worldwide have undergone several generations of updates and developments, various barriers and constraints have also been challenging their sustainable development. A comprehensive evaluation framework and indicator system should be constructed for researchers and operators to improve the sustainability performance of bike sharing in practice.

This study provides valuable information to researchers, operators and transport policy makers. In particular, major published journals, regions, institutions and papers present a clear, valuable and crucial guide for follow-up research. The knowledge domains and evolutionary trends enable in-depth understanding of the research status quo of bike sharing worldwide. This study also contributes to updating the existing body of knowledge of bike sharing, which in turn could lay a significant foundation for the sustainable development of the three generations of programs.

It is appreciated that the data used in this study were retrieved only from the core database of WoS. Although WoS is considered the most authoritative source of data for most publications, some literature included in other databases may have been overlooked. In addition, the co-author network, journal co-citation and author co-citation network were not presented in this study because existing studies related to bike sharing are relatively few and dispersed. Future studies can extend the boundaries of this study by taking into account other types of databases and documents to integrate a more comprehensive knowledge map for bike sharing.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jclepro.2018.12.157.

References

Alvarez-Valdes, R., Belenguer, J.M., Benavent, E., Bermudez, J.D., Muñoz, F., Vercher, E., Verdejo, F., 2016. Optimizing the level of service quality of a bike-sharing system. Omega (United Kingdom) 62, 163–175. https://doi.org/10.1016/j.omega.2015.09.007.
Bachand-Marleau, J., Lee, B., El-Geneidy, A., 2012. Better Understanding of Factors Influencing Likelihood of Using Shared Bicycle Systems and Frequency of Use. Transp. Res. Rec. J. Transp. Res. Board 2314, 66–71. https://doi.org/10.3141/2314-09.
Bernatchez, A.C., Gauvin, L., Fuller, D., Dubé, A.S., Drouin, L., 2015. Knowing about a public bicycle share program in Montreal, Canada: Are diffusion of innovation and proximity enough for equitable awareness? J. Transp. Heal. 2, 360–368. https://doi.org/10.1016/j.jth.2015.04.005.
Borner, K., Chen, C., Boyack, K.W., 2003. Visualizing knowledge domains. Annu. Rev. Inf. Sci. Technol. 37, 179–255.
Buck, D., Buehler, R., Happ, P., Rawls, B., Chung, P., Borecki, N., 2013. Are Bikeshare Users Different from Regular Cyclists? A First Look at Short-Term Users, Annual Members, and Area Cyclists in the Washington DC Region. In: Transp. Res. Board 92nd Annu. Meet, vol. 436, pp. 265–279. https://doi.org/10.3141/2387-13.
Bullock, C., Brereton, F., Bailey, S., 2017. The economic contribution of public bike-share to the sustainability and efficient functioning of cities. Sustain. Cities Soc. 28, 76–87. https://doi.org/10.1016/j.scs.2016.08.024.
Caggiani, L., Camporeale, R., Ottomanelli, M., Szeto, W.Y., 2018. A modeling framework for the dynamic management of free-floating bike-sharing systems. Transport. Res. C Emerg. Technol. 87, 159–182. https://doi.org/10.1016/j.trc.

2018.01.001.
Campbell, K.B., Brakewood, C., 2017. Sharing riders: How bikesharing impacts bus ridership in New York City. Transport. Res. Part A Policy Pract 100, 264–282. https://doi.org/10.1016/j.tra.2017.04.017.
Chemla, D., Meunier, F., Wolfler Calvo, R., 2013. Bike sharing systems: Solving the static rebalancing problem. Discrete Optim. 10, 120–146. https://doi.org/10.1016/j.disopt.2012.11.005.
Chen, C., 2015. CiteSpace : Visualizing Trends and Patterns in Scientific Literature Outline • What can we learn from scientific.
Chen, C., 2006. CiteSpace II: Detecting and visualizing emerging trends and transient patterns in scientific literature. J. Am. Soc. Inf. Sci. Technol. 57, 359–377.
Chen, C., Chen, Y., 2005. Searching for clinical evidence in CiteSpace. In: AMIA Annu Symp Proc, pp. 121–125.
Chen, C., Chen, Y., Horowitz, M., Hou, H., Liu, Z., Pellegrino, D., 2009. Towards an explanatory and computational theory of scientific discovery. J. Informetr. 3, 191–209. https://doi.org/10.1016/j.joi.2009.03.004.
Chen, C., Ibekwe-SanJuan, F., Hou, J., 2010. The structure and dynamics of cocitation clusters: A multiple-perspective cocitation analysis. J. Am. Soc. Inf. Sci. Technol. 61, 1386–1409. https://doi.org/10.1002/asi.21309.
Chen, C.F.I.J.H., 2010. The structure and dynamics of cocitation clusters: A multiple-perspective cocitation analysis. J. Am. Soc. Inf. Sci. Technol. 61, 1386–1409.
Chen, J., Su, Y., Si, H., Chen, J., 2018. Managerial Areas of Construction and Demolition Waste: A Scientometric Review. Int. J. Environ. Res. Publ. Health 15, 2350. https://doi.org/10.3390/ijerph15112350.
Cruz, F., Subramanian, A., Bruck, B.P., Iori, M., 2017. A heuristic algorithm for a single vehicle static bike sharing rebalancing problem. Comput. Oper. Res. 79, 19–33. https://doi.org/10.1016/j.cor.2016.09.025.
de Castro e Silva Neto, D., Cruz, C.O., Rodrigues, F., Silva, P., 2016. Bibliometric Analysis of PPP and PFI Literature: Overview of 25 Years of Research. J. Construct. Eng. Manag. 142, 06016002. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001163.
DeMaio, P., 2009. Bike-sharing : History , Impacts , Models of Provision , and Future. J. Public Transp. 12, 41–56.
Ding, Y., Chowdhury, G.G., Foo, S., 2001. Bibliometric cartography of information retrieval research by using co-word analysis. Inf. Process. Manag. 37, 817–842. https://doi.org/10.1016/S0306-4573(00)00051-0.
Du, M., Cheng, L., 2018. Better understanding the characteristics and influential factors of different travel patterns in free-floating bike sharing: Evidence from Nanjing, China. Sustain 10. https://doi.org/10.3390/su10041244.
El-Geneidy, A., van Lierop, D., Wasfi, R., 2016. Do people value bicycle sharing? A multilevel longitudinal analysis capturing the impact of bicycle sharing on residential sales in Montreal, Canada. Transport Pol. 51, 174–181. https://doi.org/10.1016/j.tranpol.2016.01.009.
Faghih-Imani, A., Eluru, N., 2016. Determining the role of bicycle sharing system infrastructure installation decision on usage: Case study of montreal BIXI system. Transport. Res. Part A Policy Pract. 94, 685–698. https://doi.org/10.1016/j.tra.2016.10.024.
Faghih-Imani, A., Eluru, N., El-Geneidy, A.M., Rabbat, M., Haq, U., 2014. How land-use and urban form impact bicycle flows: Evidence from the bicycle-sharing system (BIXI) in Montreal. J. Transport Geogr. 41, 306–314. https://doi.org/10.1016/j.jtrangeo.2014.01.013.
Fishman, E., 2016. Bikeshare: A Review of Recent Literature. Transport Rev. 36, 92–113. https://doi.org/10.1080/01441647.2015.1033036.
Fishman, E., Washington, S., Haworth, N., 2014a. Bike share's impact on car use: Evidence from the United States, Great Britain, and Australia. Transport. Res. Transport Environ. 31, 13–20. https://doi.org/10.1016/j.trd.2014.05.013.
Fishman, E., Washington, S., Haworth, N., 2014b. Bikeshare's impact on active travel: Evidence from the United States, Great Britain, and Australia. J. Transp. Heal. 2, 135–142. https://doi.org/10.1016/j.jth.2015.03.004.
Fishman, E., Washington, S., Haworth, N., 2013. Bike Share: A Synthesis of the Literature. Transport Rev. 33, 148–165. https://doi.org/10.1080/01441647.2013.775612.
Fishman, E., Washington, S., Haworth, N., 2012. Barriers and facilitators to public bicycle scheme use: A qualitative approach. Transport. Res. F Traffic Psychol. Behav. 15, 686–698. https://doi.org/10.1016/j.trf.2012.08.002.
Fishman, E., Washington, S., Haworth, N., Mazzei, A., 2014c. Barriers to bikesharing: An analysis from Melbourne and Brisbane. J. Transport Geogr. 41, 325–337. https://doi.org/10.1016/j.jtrangeo.2014.08.005.
Fishman, E., Washington, S., Haworth, N., Watson, A., 2014d. Factors influencing bike share membership: An analysis of Melbourne and Brisbane. Transport. Res. Part A Policy Pract. 71, 17–30. https://doi.org/10.1016/j.tra.2014.10.021.
Fricker, C., Gast, N., 2012. Incentives and Redistribution in Homogeneous Bike-Sharing Systems with Stations of Finite Capacity. EURO J. Transp. Logist. 261–291. https://doi.org/10.1007/s13676-014-0053-5.
Friedman, S.M., Adamson, M., Cleiman, P., Arenovich, T., Oleksak, K., Mohabir, I.M., Ta, R., Reiter, K., 2016. Helmet-wearing practices and barriers in Toronto bike-share users: A case-control study. Can. J. Emerg. Med. 18, 28–36. https://doi.org/10.1017/cem.2015.22.
Fuller, D., Gauvin, L., Dubï¿½, A.S., Winters, M., Teschke, K., Russo, E.T., Camden, A., Mee, C., Friedman, S.M., 2014. Evaluating the impact of environmental interventions across 2 countries: The International Bikeshare Impacts on Cycling and Collisions Study (IBICCS) Study protocol. BMC Public Health 14, 1–6. https://doi.org/10.1186/1471-2458-14-1103.
Fuller, D., Gauvin, L., Kestens, Y., Morency, P., Drouin, L., 2013a. The potential modal shift and health benefits of implementing a public bicycle share program in Montreal, Canada. Int. J. Behav. Nutr. Phys. Activ. 10, 2–7. https://doi.org/10.1186/1479-5868-10-66.
Fuller, D., Gauvin, L., Kestens, Y., Morency, P., Drouin, L., 2013b. The potential modal shift and health benefits of implementing a public bicycle share program in Montreal, Canada. Int. J. Behav. Nutr. Phys. Activ. 10, 1. https://doi.org/10.1186/1479-5868-10-66.
Fuller, D., Gauvin, L., Morency, P., Kestens, Y., Drouin, L., 2013c. The impact of implementing a public bicycle share program on the likelihood of collisions and near misses in Montreal, Canada. Prev. Med. (Baltim). 57, 920–924. https://doi.org/10.1016/j.ypmed.2013.05.028.
Ghosh, S., Varakantham, P., Adulyasak, Y., Jaillet, P., 2017. Dynamic repositioning to reduce lost demand in bike sharing systems. J. Artif. Intell. Res. 58, 387–430. https://doi.org/doi:10.1613/jair.5308.
Godavarthy, R.P., Rahim Taleqani, A., 2017. Winter bikesharing in US: User willingness, and operator's challenges and best practices. Sustain. Cities Soc. 30, 254–262. https://doi.org/10.1016/j.scs.2017.02.006.
Graves, J.M., Pless, B., Moore, L., Nathens, A.B., Hunte, G., Rivara, F.P., 2014. Public bicycle share programs and head injuries. Am. J. Public Health 104, 106–111. https://doi.org/10.2105/AJPH.2014.302012.
Haider, Z., Nikolaev, A., Kang, J.E., Kwon, C., 2018. Inventory rebalancing through pricing in public bike sharing systems. Eur. J. Oper. Res. 270, 103–117. https://doi.org/10.1016/j.ejor.2018.02.053.
Hamilton, T.L., Wichman, C.J., 2018. Bicycle infrastructure and traffic congestion: Evidence from DC's Capital Bikeshare. J. Environ. Econ. Manag. 87, 72–93. https://doi.org/10.1016/j.jeem.2017.03.007.
He, Q., Wang, G., Luo, L., Shi, Q., Xie, J., Meng, X., 2017. Mapping the managerial areas of Building Information Modeling (BIM) using scientometric analysis. Int. J. Proj. Manag. 35, 670–685. https://doi.org/10.1016/j.ijproman.2016.08.001.
Ho, S.C., Szeto, W.Y., 2017. A hybrid large neighborhood search for the static multi-vehicle bike-repositioning problem. Transp. Res. Part B Methodol. 95, 340–363. https://doi.org/10.1016/j.trb.2016.11.003.
Ho, S.C., Szeto, W.Y., 2014. Solving a static repositioning problem in bike-sharing systems using iterated tabu search. Transport. Res. Part E Logist. Transp. Rev. 69, 180–198. https://doi.org/10.1016/j.tre.2014.05.017.
Hyland, M., Hong, Z., Pinto, H.K.R. de F., Chen, Y., 2018. Hybrid cluster-regression approach to model bikeshare station usage. Transport. Res. Part A Policy Pract 115, 71–89. https://doi.org/10.1016/j.tra.2017.11.009.
Jensen, P., Rouquier, J.B., Ovtracht, N., Robardet, C., 2010. Characterizing the speed and paths of shared bicycle use in Lyon. Transport. Res. Transport Environ. 15, 522–524. https://doi.org/10.1016/j.trd.2010.07.002.
Jia, L., Liu, X., Liu, Y., 2018. Impact of different stakeholders of bike-sharing industry on users' intention of civilized use of bike-sharing. Sustain 10. https://doi.org/10.3390/su10051437.
Kaltenbrunner, A., Meza, R., Grivolla, J., Codina, J., Banchs, R., 2010. Urban cycles and mobility patterns: Exploring and predicting trends in a bicycle-based public transport system. Pervasive Mob. Comput. 6, 455–466. https://doi.org/10.1016/j.pmcj.2010.07.002.
Kaspi, M., Raviv, T., Tzur, M., 2017. Bike-sharing systems: User dissatisfaction in the presence of unusable bicycles. IISE Trans. 49, 144–158. https://doi.org/10.1080/0740817X.2016.1224960.
Krykewycz, G., Puchalsky, C., Rocks, J., Bonnette, B., Jaskiewicz, F., 2010. Defining a Primary Market and Estimating Demand for Major Bicycle-Sharing Program in Philadelphia, Pennsylvania. Transp. Res. Rec. J. Transp. Res. Board 2143, 117–124. https://doi.org/10.3141/2143-15.
Lan, J., Ma, Y., Zhu, D., Mangalagiu, D., Thornton, T.F., 2017. Enabling value co-creation in the sharing economy: The case of mobike. Sustain 9. https://doi.org/10.3390/su9091504.
Lathia, N., Ahmed, S., Capra, L., 2012. Measuring the impact of opening the London shared bicycle scheme to casual users. Transport. Res. C Emerg. Technol. 22, 88–102. https://doi.org/10.1016/j.trc.2011.12.004.
Li, X., Wu, P., Shen, G.Q., Wang, X., Teng, Y., 2017. Mapping the knowledge domains of Building Information Modeling (BIM): A bibliometric approach. Autom. ConStruct. 84, 195–206. https://doi.org/10.1016/j.autcon.2017.09.011.
Lin, J.R., Yang Ta-Hui, T.H., 2011. Strategic design of public bicycle sharing systems with service level constraints. Transport. Res. Part E Logist. Transp. Rev. 47, 284–294. https://doi.org/10.1016/j.tre.2010.09.004.
Lowry, P., Romans, D., Curtis, A., 2004. Global Journal Prestige and Supporting Disciplines: A Scientometric Study of Information Systems Journals. J. Assoc. Inf. Syst. Online 5, 29–77. https://doi.org/10.17705/1jais.00045.
Ma, Y., Lan, J., Thornton, T., Mangalagiu, D., Zhu, D., 1 October 2018. Challenges of Collaborative Governance in the Sharing Economy: The case of free-floating bike sharing in Shanghai. J. Clean. Prod. 197 (Part 1), 356–365. https://doi.org/10.1016/j.jclepro.2018.06.213.
Ma, Y., Rong, K., Mangalagiu, D., Thornton, T.F., Zhu, D., 2018b. Co-evolution between urban sustainability and business ecosystem innovation: Evidence from the sharing mobility sector in Shanghai. J. Clean. Prod. 188, 942–953. https://doi.org/10.1016/j.jclepro.2018.03.323.
Mateo-Babiano, I., Bean, R., Corcoran, J., Pojani, D., 2016. How does our natural and built environment affect the use of bicycle sharing? Transport. Res. Part A Policy Pract. 94, 295–307. https://doi.org/10.1016/j.tra.2016.09.015.
Mattson, J., Godavarthy, R., 2017. Bike share in Fargo, North Dakota: Keys to success and factors affecting ridership. Sustain. Cities Soc. 34, 174–182. https://doi.org/10.1016/j.scs.2017.07.001.
Médard de Chardon, C., Caruso, G., Thomas, I., 2017. Bicycle sharing system 'success' determinants. Transport. Res. Part A Policy Pract. 100, 202–214. https://doi.org/

10.1016/j.tra.2017.04.020.
Midgley, P., 2011. Bicycle-sharing schemes: enhancing sustainable mobility in urban areas (New York).
Nair, R., Miller-Hooks, E., Hampshire, R.C., Bušić, A., 2012. Large-Scale Vehicle Sharing Systems: Analysis of Vélib'. Int. J. Sustain. Transp. 7, 85–106. https://doi.org/10.1080/15568318.2012.660115.
O'Brien, O., Cheshire, J., Batty, M., 2014. Mining bicycle sharing data for generating insights into sustainable transport systems. J. Transport Geogr. 34, 262–273. https://doi.org/10.1016/j.jtrangeo.2013.06.007.
Olawumi, T.O., Chan, D.W.M., 2018. A scientometric review of global research on sustainability and sustainable development. J. Clean. Prod. 183, 231–250. https://doi.org/10.1016/j.jclepro.2018.02.162.
Olawumi, T.O., Chan, D.W.M., Wong, J.K.W., 2017. Evolution in the intellectual structure of BIM research: a bibliometric analysis. J. Civ. Eng. Manag. 23, 1060–1081. https://doi.org/10.3846/13923730.2017.1374301.
Pal, A., Zhang, Y., 2017. Free-floating bike sharing: Solving real-life large-scale static rebalancing problems. Transport. Res. C Emerg. Technol. 80, 92–116. https://doi.org/10.1016/j.trc.2017.03.016.
Park, C., Young Sohn, S., 2017. An Optimization Approach for the Placement of Bicycle-sharing stations to Reduce Short Car Trips: An Application to the City of Seoul. Transport. Res. Part A Policy Pract. 105, 154–166. https://doi.org/10.1016/j.tra.2017.08.019.
Parkes, S.D., Marsden, G., Shaheen, S.A., Cohen, A.P., 2013. Understanding the diffusion of public bikesharing systems: Evidence from Europe and North America. J. Transport Geogr. 31, 94–103. https://doi.org/10.1016/j.jtrangeo.2013.06.003.
Pelechrinis, K., Zacharias, C., Kokkodis, M., Lappas, T., 2017. Economic impact and policy implications from urban shared transportation: The case of Pittsburgh's shared bike system. PLoS One 12, 1–21. https://doi.org/10.1371/journal.pone.0184092.
Qi, I., 2016. Switching to alternative transit: Combining bicycle safety improvements with parking regulations. Chinese J. Popul. Resour. Environ. 14, 81–87. https://doi.org/10.1080/10042857.2016.1187478.
Raviv, T., Tzur, M., Forma, I.A., 2013. Static repositioning in a bike-sharing system: models and solution approaches. EURO J. Transp. Logist. 2, 187–229. https://doi.org/10.1007/s13676-012-0017-6.
Ricci, M., 2015. Bike sharing: A review of evidence on impacts and processes of implementation and operation. Res. Transp. Bus. Manag. 15, 28–38. https://doi.org/10.1016/j.rtbm.2015.03.003.
Saberi, M., Ghamami, M., Gu, Y., Shojaei, M.H., Fishman, E., 2018. Understanding the impacts of a public transit disruption on bicycle sharing mobility patterns: A case of Tube strike in London. J. Transport Geogr. 66, 154–166 (Sam). https://doi.org/10.1016/j.jtrangeo.2017.11.018.
Scarinci, R., Markov, I., Bierlaire, M., 2017. Network design of a transport system based on accelerating moving walkways. Transport. Res. C Emerg. Technol. 80, 310–328. https://doi.org/10.1016/j.trc.2017.04.016.
Schuijbroek, J., Hampshire, R.C., van Hoeve, W.J., 2017. Inventory rebalancing and vehicle routing in bike sharing systems. Eur. J. Oper. Res. 257, 992–1004. https://doi.org/10.1016/j.ejor.2016.08.029.
Shaheen, S., Cohen, A., Martin, E., 2013. Public Bikesharing in North America. Transp. Res. Rec. J. Transp. Res. Board 2387, 83–92. https://doi.org/10.3141/2387-10.
Shaheen, S., Guzman, S., Zhang, H., 2010. Bikesharing in Europe, the Americas, and Asia. Transp. Res. Rec. J. Transp. Res. Board 2143, 159–167. https://doi.org/10.3141/2143-20.
Shen, Y., Zhang, X., Zhao, J., 2018. Understanding the usage of dockless bike sharing in Singapore. Int. J. Sustain. Transp. 8318, 1–15. https://doi.org/10.1080/15568318.2018.1429696.
Shi, J., Si, H., Wu, G., Su, Y., Lan, J., 2018. Critical Factors to Achieve Dockless Bike-Sharing Sustainability in China : A Stakeholder-Oriented Network Perspective. Sustain 10, 2090. https://doi.org/10.3390/su10062090.
van der Veen, R.A.C., Kisjes, K.H., Nikolic, I., 2017. Exploring policy impacts for servicising in product-based markets: A generic agent-based model. J. Clean. Prod. 145, 1–13. https://doi.org/10.1016/j.jclepro.2017.01.016.
Walker, I., Garrard, I., Jowitt, F., 2014. The influence of a bicycle commuter's appearance on drivers' overtaking proximities: An on-road test of bicyclist stereotypes, high-visibility clothing and safety aids in the United Kingdom. Accid. Anal. Prev. 64, 69–77. https://doi.org/10.1016/j.aap.2013.11.007.
Wang, M., Zhou, X., 2017. Bike-sharing systems and congestion: Evidence from US cities. J. Transport Geogr. 65, 147–154. https://doi.org/10.1016/j.jtrangeo.2017.10.022.
Wang, Y., Szeto, W.Y., 2018. Static green repositioning in bike sharing systems with broken bikes. Transport. Res. Transport Environ. 65, 438–457. https://doi.org/10.1016/j.trd.2018.09.016.
Wilks, D.S., 2011. Cluster Analysis. Int. Geophys. 100, 603–616. https://doi.org/10.1016/B978-0-12-385022-5.00015-4.
Woodcock, J., Tainio, M., Cheshire, J., O'Brien, O., Goodman, A., 2014. Health effects of the London bicycle sharing system: Health impact modelling study. BMJ 348, 1–14. https://doi.org/10.1136/bmj.g425.
Yang, X.H., Cheng, Z., Chen, G., Wang, L., Ruan, Z.Y., Zheng, Y.J., 2018. The impact of a public bicycle-sharing system on urban public transport networks. Transport. Res. Part A Policy Pract. 107, 246–256. https://doi.org/10.1016/j.tra.2017.10.017.
Zhang, D., Yu, C., Desai, J., Lau, H.Y.K., Srivathsan, S., 2017. A time-space network flow approach to dynamic repositioning in bicycle sharing systems. Transp. Res. Part B Methodol. 103, 188–207. https://doi.org/10.1016/j.trb.2016.12.006.
Zhao, P., Li, S., 2017. Bicycle-metro integration in a growing city: The determinants of cycling as a transfer mode in metro station areas in Beijing. Transport. Res. Part A Policy Pract 99, 46–60. https://doi.org/10.1016/j.tra.2017.03.003.
Zhao, X., 2017. A scientometric review of global BIM research: Analysis and visualization. Autom. ConStruct. 80, 37–47. https://doi.org/10.1016/j.autcon.2017.04.002.