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Travel behaviours, user characteristics, and social-economic impacts of shared transportation: a comprehensive review

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Abstract

Shared transportation is playing an increasingly important role in sustainable urban transportation planning and control. Because it significantly affects people's daily life, socio-economic development, and the environment, shared transportation has attracted attention from scholars and practitioners alike. For the former, the large number of articles published on the topic reveals the growing interest. Of interest are the articles that focus on travel behaviours, user characteristics, and social-economic impacts of shared transportation. Herein, we review 356 peer-reviewed articles on the topic that were published between January 2003 and September 2017. We employ a bibliometric method to investigate the overall characteristics, research methodology, research highlights, and research areas of these articles. Our analysis explores and discusses user travel behaviours, traffic satisfaction, key determinants, impact, development planning, and policies. Finally, we provide a detailed discussion on the future research challenges and new research directions for shared transportation.

Keywords

Shared transportation, bike sharing, car sharing, bibliometric review

Comments

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ABSTRACT

Shared transportation is playing an increasingly important role in sustainable urban transportation planning and control. Because it significantly affects people's daily life, socio-economic development, and the environment, shared transportation has attracted attention from scholars and practitioners alike. For the former, the large number of articles published on the topic reveals the growing interest. Of interest are the articles that focus on travel behaviors, user characteristics, and social-economic impacts of shared transportation. Herein, we review 356 peer-reviewed articles on the topic that were published between January 2003 and September 2017. We employ a bibliometric method to investigate the overall characteristics, research methodology, research highlights, and research areas of these articles. Our analysis explores and discusses user travel behaviors, traffic satisfaction, key determinants, impact, development planning, and policies. Finally, we provide a detailed discussion on the future research challenges and new research directions for shared transportation.

KEYWORDS

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Introduction

As the world economy developed, cities expanded rapidly. With the growing urban footprint, population, and economy, most cities struggled to meet the demand for urban transportation. At the same time, a series of negative externalities, such as traffic pollution, congestion, and noise

emerged to make the challenge even more intractable. One way to meet this challenge is with shared transportation, which allows people to use personal transport resources more wisely, thereby alleviating, at least to some degree, traffic pollution, congestion, and noise. The development of shared transportation dates back to the 1940s. However, in recent years, shared transportation has entered into a rapid development period and has become a standard transport mode in the daily life of many people. For example, as of June 2018 the Chinese car sharing enterprise Didi covered more than 400 cities in China (Guangming Online 2018).

Shared transportation does not have a single, uniform definition, as shown in Table 1. Some scholars define shared transportation as a mode in which vehicle ownership should be shared (Le Vine, Adamou, and Polak 2014; Le Vine and Polak 2015; Shaheen et al. 2016). According to this definition, shared transportation should include, but not be limited to, private vehicle sharing (Correia and Viegas 2011), taxi ridesharing (Ma, Zheng, and Wolfson 2014), carpooling (Berlingerio et al. 2017), vanpooling (VTPI 2013), scooter sharing, short-term car rental, (Shaheen et al. 2015), public bike sharing (Basch et al. 2015), closed campus bike sharing, and p2p bike sharing (Shaheen and Chan 2016).

Grounded in the extant literature, we define shared transportation in this paper as the temporary allocation of a transportation resource on an as-needed basis (Le Vine, Adamou, and Polak 2014; Le Vine and Polak 2015; Shaheen et al. 2016). In our study, shared transportation resources are divided into two types: bike sharing and car sharing. Bike sharing includes fixed station bike sharing and free-floating bike sharing. Car sharing includes ridesharing (carpooling and vanpooling) as well as short-term car rental (fixed-station car sharing and free-floating car sharing). There are few studies on free-floating bike sharing, vanpooling, and free-floating car

sharing in the literature, so this paper makes only a few references to them. Instead, our primary focus is on the research of fixed station bike sharing, ridesharing, and fixed station car sharing.

Scholars have analyzed and evaluated the impact of shared transportation from numerous perspectives. Huwer (2004) studied the mobility behaviors and customer satisfaction of shared services. They found that car-sharing is suitable as a supplement to public transport and may encourage individuals to use cars more efficiently. For example, rather than buying a car, an individual may decide to share a car as needed thereby reducing pollution. Indeed, Chen and Kockelman (2016) found that car sharing could reduce average individual transportation energy use and greenhouse gas (GHG) emissions by approximately 51%. These energy and emissions savings can be primarily attributed to mode shifts, which has the added benefit of reducing fuel consumption and the demand for parking infrastructure.

It is also worth noting that bike sharing is not only replacing conventional cycling it is even replacing journeys made by car. Shaheen, Guzman, and Zhang (2012) note that users can save money because bike sharing reduces automobile-related expenses. Bullock, Brereton, and Bailey (2017) noted that much of the benefit to individuals is the time savings that result from the ability to use bike sharing for short trips or combine bike sharing with public transportation for longer trips. Unfortunately, the benefit of time savings has not been estimated in economic terms (Bullock, Brereton, and Bailey 2017). Shared transportation can have a further impact as noted by El-Geneidy, Lierop, and Wasfi (2016) who found that the houses, which was closed to a bike sharing stations, were approximately increased value by 2.7%.

To date, studies that review shared transportation typically focus on car sharing (Agatz et al. 2012; Chan and Shaheen 2012) or bike sharing (Fishman and Schepers 2016; Fishman 2016; Fishman, Washington, and Haworth 2013; DeMaio 2009) separately. While some authors have

reviewed both, their work has been limited to either a specific region or one type of shared transportation (Shaheen, Chan, and Gaynor 2016; Laporte, Meunier, and Calvo 2015). Shaheen, Chan, and Gaynor (2016) reviewed the findings from practices deploying shared mobility across North America to aid public policy development. Laporte, Meunier, and Calvo (2015) classified the relevant literature about shared mobility systems. Most of the studies focused on the view of bike sharing or car sharing but did not provide an overall holistic review of shared transportation involving different types of shared transportation and multiple areas of shared transportation's impacts.

Thus, this study aims to conduct a comprehensive review of shared transportation studies from the perspectives of economy, transportation, urban studies, geography, and environment; however, the study intentionally excluded the engineering and technology perspectives. This study explored the research highlights and possible topic areas for future research using three main steps. First, the literature regarding shared transportation was collected from the Web of Science using the keywords shared-mobility, bike-sharing, bike-share, bicycle-sharing, shared-bike, shared-bicycle, ride-sharing, ridesharing, car-sharing, car-pooling and carpooling. Second, the statistical characteristics of the collected literature, including the overall characteristics, research methodology, description of research areas, and research highlights were explored using bibliometric analysis. Based upon our bibliometric analysis, the results of our shared transportation review were divided into the following: travel behavior characteristics, travel satisfaction, key determinants, impact, development of plans and policies, and governance. Lastly, from the bibliometric analysis and discussions of the research highlights, the study presents the main conclusions and other possible topic areas for future research.

Table 1. Definitions of shared transportation

Year	Definition
Wikipedia (2014)	Shared transport is a term for describing a demand-driven vehicle-sharing arrangement, in which travelers share a vehicle either simultaneously (e.g. ride-sharing) or over time (e.g. carsharing or bike sharing), and in the process share the cost of the journey, thereby creating a hybrid between private vehicle use and mass or public transport.
Wikipedia (2014)	Shared-mobility systems include 'round-trip' carsharing, 'one-way' or 'point-to-point' carsharing. liftsharing (provision of car passenger travel in another person's private car), bikesharing (short-term rental of bicycles, typically point-to-point), and peer-to-peer carsharing (provision of one's personal car for other drivers to rent), as well as traditional car rental, etc.
Le Vine and Polak (2015)	Rather than individual physical items being purchased, owned, controlled, maintained and used solely by their owner, in shared-mobility systems the physical assets (bicycles, automobiles, small aircraft, etc.) are accessed sequentially by multiple users on a pay-per-use basis.
Shaheen et al. (2015)	Shared mobility - the shared use of a vehicle, bicycle, or other mode - enables users to gain short-term access to transportation modes on an "as-needed" basis. Shared mobility includes carsharing, bikesharing, ridesharing, and on-demand ride services. It can also include alternative transit services, such as paratransit, shuttles, and private transit services.
Shaheen et al. (2016)	Shared mobility the shared use of a vehicle, bicycle, or other mode is an innovative transportation strategy that enables users to gain short-term access to transportation modes on an as-needed basis. The term shared mobility includes various forms of carsharing, bikesharing, ridesharing (carpooling and vanpooling), and on-demand ride services. It can also include alternative transit services, such as paratransit, shuttles, and private transit services (called microtransit), which can supplement fixed-route bus and rail services.
TDM (2013)	Shared Mobility refers to various modes and services that increase transportation system efficiency by sharing vehicles, including Public Transit, Ridesharing, Taxi, Ridehailing (such as Uber and Lyft), Carsharing and Bikesharing.
Shaheen et al. (2016)	Shared mobility the shared use of a vehicle, bicycle, or other mode, includes various forms of carsharing, bikesharing, ridesharing (carpooling and vanpooling), and on-demand ride services. It can also include alternative transit services, such as paratransit, shuttles, and private transit services (called microtransit), which can supplement fixed-route bus and rail services.

Statistical characteristics of the literature

We employed bibliometric analysis to explore the overall characteristics, research methodology, research highlights, and research areas regarding shared transportation using the software BibExcel. BibExcel is an open-source and widely applied bibliometric toolbox developed by Persson, Danell, and Schneider (2009). It can read academic bibliographic data from the Web of Science (Davis 2014).With the help of BibExcel, we extracted necessary information from published papers such as author names and keywords for further research trend analysis, research methodology analysis, research area analysis, and research highlights analysis (Wu et al. 2018).

Our data were sourced from the Web of Science Database, which provides comprehensive and standardized information from the literature (AghaeiChadegani et al. 2013). The keywords, shared mobility, ride-sharing, shared bicycle, ridesharing, car-sharing, car-pooling, and carpooling were

used to search on September 20, 2017. Initially, 1,382 papers were identified, which included 729 articles, 571 meetings, and 82 papers that were listed as other. We further screened the 729 articles and found that only 370 articles were related to shared transportation. There were just 14 articles published before 2003, most of which were not available from the Web of Science. Thus, we chose the time frame 2003–2017 because it included several years of moderate research before the linear growth that began around 2009. The remaining 356 full-text articles were included in our dataset.

Overall characteristics

Figure 1 depicts the publication timeline of our dataset. According to the total number of publications, the study of shared transportation can be divided into three periods: stable development (2003–2008), linear growth (2009–2013), and exponential development (2014–2017). From 2003 to 2008, the number of publications is relatively small and increases slowly with only 2 or 3 new releases per year. The total number of articles increased rapidly from 2009 to 2013. This is likely because of the expansion of shared transportation in Europe and North America after 2009. The number of articles have seen a dramatic increase between 2014 and 2017 as other regions of the world are beginning to experience an increase in shared transportation (e.g., China after 2014).

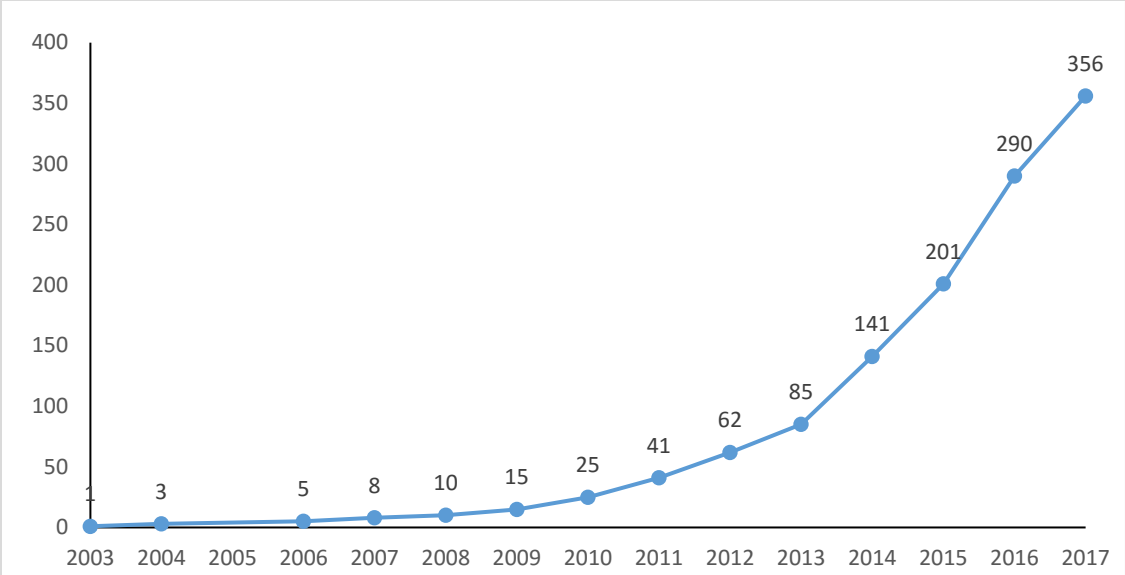

Figure 1. Cumulative number of publications.

The distribution of journals in which the selected papers were published indicates that shared transportation is a growing topic of interest. The articles in our dataset were published in 154 different journals. The Top 16 journals are presented in Table 2. Among these journals, three were more active than the others in shared transportation: *Transportation Research Record* (23 articles), *Transportation Research Part A: Policy and Practice* (17 articles), and the *Journal of Transport Geography* (15 articles).

Table 2. Distribution of literature based on the source of publication.

Publication	Year of publication															
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
Transportation Research Record	-	-	-	-	2	-	2	3	1	3	1	3	4	4	-	23
Transportation Research Part A: Policy and Practice	-	-	-	-	-	-	-	-	1	-	-	-	3	5	8	17
Journal of Transport Geography	-	-	-	-	-	-	-	-	-	1	-	7	2	3	2	15
Transportation Research Part B: Methodological	-	-	-	-	-	-	-	-	1	-	1	2	6	2	1	13
Transportation Research Part C: Emerging Technologies	-	-	-	-	-	-	-	-	-	1	-	1	1	5	4	12
Transport Policy	-	-	-	-	-	-	-	-	1	2	2	2	1	4	-	12
Transportation	-	-	-	-	1	-	-	1	1	1	-	2	2	1	1	10
IEEE Transactions on Intelligent Transportation Systems	-	-	-	-	-	-	-	-	1	1	-	3	1	3	-	9
Transportation Research Part D: Transport and Environment	-	-	-	-	-	-	1	1	-	1	1	1	1	1	1	8
International Journal of Sustainable Transportation	-	-	-	-	-	-	-	-	-	-	-	-	2	2	4	8
Transportation Planning and Technology	-	-	-	-	-	-	-	2	-	-	2	-	2	1	-	7
Sustainability	-	-	-	-	-	-	-	-	-	-	-	-	2	2	3	7
Transport Reviews	-	-	-	1	-	-	-	-	-	1	1	-	-	2	-	5
Journal of Transport Research	-	-	-	-	-	-	1	-	-	1	1	1	1	-	-	5
European Journal of Operational Research	-	-	-	-	-	-	-	-	-	-	-	1	2	1	1	5
Computers & Industrial Engineering	-	-	-	-	-	-	-	-	1	-	1	1	-	1	1	5
Others	1	2	-	1	-	2	1	3	9	9	13	32	30	52	40	195
Total	1	2	0	2	3	2	5	10	16	21	23	56	60	89	66	356

Research methodology

Within our dataset, researchers used a wide array of methods (see Table 3). Specifically, 89.3% of articles were quantitative, and the remaining 10.7% were qualitative. The most commonly used method for quantitative research on shared transportation was logit and logistic regression (13.6%). Simulation modeling (13.2%), descriptive analyses (11.2%), heuristic method (9.2%), mixed-integer program (4.8%), linear regression model (4%), and nonlinear programming methods (3.2%) were also popular quantitative approaches. Notably, retail gravitation models, equilibrium sorting models, and analytic hierarchy process were also used in the context of shared transportation (Wuerzer and Mason 2016; Bento, Hughes, and Kaffine 2013). Researchers primarily used these methods to explore the travel behaviors or the impacts of shared transportation on the economy, environment, social welfare, or travel mode choice. However, these articles do not provide a comprehensive evaluation of shared transportation's overall impact.

Description of research areas

Approximately 35% of the articles involve a case study of shared transportation in a city or in several cities. The statistical characteristics of research areas were obtained by counting the number of occurrences in the selected literature. When a paper involves several cities or regions, it is recorded separately. Table 4 lists the Top 19 countries with the number of studies about shared transportation and their corresponding early shared transportation system (car sharing or bike sharing). The table also lists the Top 19 cities in descending order with the number of studies that looked at shared transportation.

Table 4 indicates that, at the country level, most studies took place in the U.S., China, South Korea, Australia, France, and Canada due to the emergence and development of shared

transportation. The United States (U.S.) was the first country to have shared transportation and the country with the most significant number of studies on shared transportation. Although the shared transportation began to appear in China around 2005, China ranked second in the number of studies on shared transportation.

Table 3. Research methodologies

Research methodologies	Numbers	Percentage
Logit model and logistic regression	34	13.60%
Simulation modeling	33	13.20%
Descriptive analyses	28	11.20%
Heuristic methods	23	9.20%
Mixed integer program	12	4.80%
Linear regression models	10	4.00%
Nonlinear programming methods	8	3.20%
Network sciences	7	2.80%
Time-space network and spatial-temporal analysis	7	2.80%
Structural equation modeling	6	2.40%
Cluster analysis	5	2.00%
Sensitivity analyses	5	2.00%
Discrete choice mode and hybrid choice models	5	2.00%
Spatial analyses	4	1.60%
Multiple regression analysis	4	1.60%
Technology acceptance models and modified technology acceptance models	3	1.20%
Markov decision process	3	1.20%
Game theory	3	1.20%
Bayesian models	3	1.20%
Factors analysis	3	1.20%
Discrete choice models	2	0.80%
Probit models	2	0.80%
Difference in difference models	2	0.80%
Life cycle analysis	2	0.80%
Bottleneck models	2	0.80%
Ethnographic study	2	0.80%
Other approaches	32	12.80%

Table 4. Research locations and the early shared transportation systems of different countries (representative sample).

Rank	Country (number of studies)	Year opened (early shared transportation system)	Rank	City (number of studies)
1	United States(65)	1942(carpooling: Car-Sharing Club)	1	San Francisco Bay Area(8)
2	China(21)	2005(fixed-station bike sharing: Bicycle Rental)	2	Washington(8)
3	South Korea(18)	2008(fixed-station bike sharing: NUBIJA)	3	New York City(7)
4	Australia(18)	2010(fixed-station bike sharing: Melbourne Bike Share)	4	Beijing(6)
5	France(12)	1971(one-way car sharing: Procotip)	5	Brisbane(6)
6	Canada(11)	1994(personal vehicle sharing: Auto-Com)	6	California(5)
7	Italy(9)	2004(fixed-station bike sharing: Bicincittà)	7	London(5)
8	United Kingdom(8)	1977(short-term car rental: Green Cars)	8	Lisbon(4)
9	Belgium(8)	2002(carpooling: EU MOSES)	9	Nanjing(4)
10	Germany(6)	1998(short-term car rental: Bundesverband)	10	Taiwan(4)
11	Spain(6)	2005(short-term car rental: Catalunya Carsharing SA)	11	Montreal(3)
12	Portugal(5)	2000(fixed-station bike sharing: Buga)	12	Lyons(3)
13	Ireland(4)	1998(short-term car rental: Pay-As-You-Drive Carsharing)	13	Rome(3)
14	Brazil(4)	2008(fixed-station bike sharing: UseBike)	14	Hangzhou(3)
15	Denmark(3)	1991(fixed-station bike sharing:A2nd generation bike-sharing program)	15	Changwon(3)
16	Singapore(3)	1997(short-term car rental: Car Coop)	16	Daejeon(3)
17	Netherlands(2)	1965(free bike systems: WhiteBikes)	17	Melbourne(3)
18	Austria(2)	1997(short-term car rental)	18	Los Angeles(2)
19	Japan(2)	1997(short-term car rental: Intelligent Community Vehicle System)	19	Philadelphia(2)

Research highlights

Keywords are widely used to grasp the essence of the articles, which can reveal trends over time of hot research topics. The entropy of keywords represents the probability-weighted statistical mean of the amount of information, which reflects the order and disorder of the keyword co-appearance network of each period (Chen et al. 2014). The higher value of entropy, the more diverse the keywords are. The entropy value of the literature about shared transportation, as shown in Figure 2, has been increasing since 2003, reflecting the continuous expansion and deepening of the research on the shared transportation field. To further examine the research highlights, we select the Top 10 most cited keywords per year, as shown in Table 5.

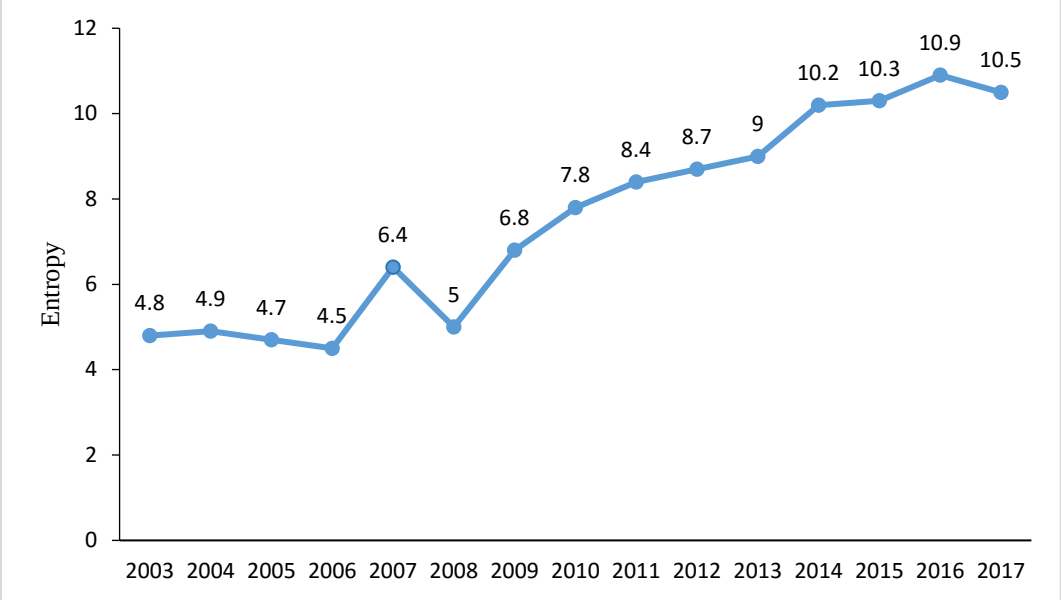

Figure 2. Entropy.

Table 5. Top 10 citied keywords and their cited times.

Year	2004	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1	carpool (1)	behavior (1)	car share(1)	carpooling (2)	carpooling (4)	carpooling (7)	carpooling (8)	car share (6)	bicycle sharing (16)	bicycle sharing systems (10)	bike share (21)	ride sharing (10)
2	ICT technologies (1)	exploration (1)	lift share (1)	transport (2)	car sharing (3)	car sharing (4)	bike sharing (3)	sustainable (4)	car sharing (9)	bike share (10)	carpool (10)	car sharing (9)
3	routing and scheduling (1)	Francisco Bay area (1)	location-aware (1)	travel(2)	ridesharing (1)	multiple commodity network flow problem (3)	location (3)	survey (2)	carpooling (7)	car sharing (9)	ridesharing (8)	bicycle sharing system (9)
4	GIS(1)	Greater Montreal Area (1)	user requirements (1)	car-sharing(2)	HOT lanes (1)	lagrangian relaxation (3)	bicycle (2)	carpooling (2)	ride sharing (7)	ridesharing (8)	sustainable mobility (7)	bike sharing (8)
5		habit (1)	user trial (1)	behavior (1)	HOV lanes (1)	commuting (3)	commuting (2)	dynamic ridesharing (2)	dynamic networks (5)	sustainable (6)	public bicycle(7)	carpooling (8)
6		income (1)		car ownership (1)	a-gps(1)	transport planning (2)	optimization (2)	transport (2)	Bicycle sharing system (5)	public bike sharing (5)	bicycle share systems(6)	sharing economy (6)
7		individuals adapt (1)		conceptual model (1)	car locating(1)	transport management (2)	travel demand management (2)	bicycle sharing system (2)	one-way car sharing (4)	carpooling (4)	demand (6)	social networks (6)
8		land-use (1)		demand management (1)	commute (1)	transport demand management (2)	bike-sharing programs (1)	bike share (2)	transport (4)	functional data (4)	bicycle (5)	collaborative (4)
9		mode choice (1)		driving cessation (1)	congestion pricing (1)	time-space network (2)	bike-station location (1)	inventory (2)	routing (3)	location based services (4)	location (5)	public bike system (4)
10		origin-destination surveys (1)		fuel consumption (1)	cycling (1)	bicycle sharing (2)	car-sharing (1)	parking demand (2)	sharing economy (3)	taxi sharing (3)	car sharing (5)	system (3)

Numbers in parentheses represent the frequency of keywords.

Car sharing related keywords (e.g., car sharing, ridesharing, carpooling, and vanpooling) appeared most frequently between 2004 and 2013. Also, the research on shared transportation first started with car sharing because it was the first mode of shared transportation. Bike sharing related keywords appeared in the Top10 in 2011 and replaced car sharing related keywords to be the highest cited keywords in 2014, which reflected that the research interest in bike sharing had surpassed that of car sharing. That was likely caused by the popularity and increased investment in bike sharing in recent years.

The diversity of research topics is increasing according to the keywords. Between 2003 and 2008, the study of shared transportation emerged and developed stably. Moreover, the research topics mainly concentrated on car sharing system design and user's travel behavior characteristics. Between 2009 and 2013, topics about the residents' living (commuting), urban transportation planning(high-occupancy toll [HOT] lanes, high occupancy vehicle [HOV] lanes, transport planning, and management), and environment protection(fuel consumption, sustainable transport, sustainable) had garnered the attention of researchers. From 2014 to 2017, dynamic networks, routing, location problem, social network, and collaborative consumption have become important research topics of shared transportation. The studies of dynamic networks, routing, and location problems provided further evidence of the ongoing development of shared transportation system. The highly cited keywords "social network" and "collaborative consumption" show that the social attributes of shared transportation have gained considerable attention since the development of technical internet platforms. Of note, sustainability and the demand for shared transportation are still the focused areas for many scholars.

Detailed analyses of the literature

Travel behavior characteristics of shared transportation

The behavior characteristics of shared transportation users mainly include travel purpose (Curto et al. 2016), travel time (Mateo-Babiano et al. 2016; Murphy and Usher 2015; Shaheen, Chan, and Gaynor 2016; Caulfield et al. 2017), travel distance (Bachand-Marleau, Lee, and El-Geneidy 2012; Campbell et al. 2016), as well as travel models (Krueger, Rashidi, and Rose 2016; Vine, Adamou, and Polak 2014; Zhou 2012; Martin and Shaheen 2011; Kopp, Gerike, and Axhausen 2015).

Travel purpose

The purpose of shared transportation travel most commonly includes commuting (Curto et al. 2016; Basch et al. 2015; Yang et al. 2015; Fishman and Schepers 2016; Martin and Shaheen 2011), recreational (Mateo-Babiano et al. 2016; Basch et al. 2015), shopping (Vine, Adamou, and Polak 2014), tourist (Zaltz et al. 2013), social (Zhang et al. 2015), fitness (Romanillos et al. 2016), and healthy lifestyle (Castillo-Manzano, Castro-Nuño, and López-Valpuesta 2015). Generally, people use shared transportation mainly for commuting and entertainment. Additionally, the travel purpose is largely influenced by the temporal dimension with travelers using bike sharing on work days, particularly during rush hour, for commuting purposes. However, during non-peak hours and on the weekends, travelers use bike sharing more for entertainment purposes (Mateo-Babiano et al. 2016; Murphy and Usher 2015).

Travel time

Travel time is affected by many factors, such as travel purpose, the natural environment, and the built environment. When using bike sharing, the average traveler's travel time is less than 30

minutes with leisure trips generally lasting longer (Mateo-Babiano et al. 2016). On weekdays travelers use bike sharing more frequently in the three peak periods of the morning, lunchtime and evening (Mateo-Babiano et al. 2016). In addition, the travel time of bike sharing may be influenced by pricing (Mateo-Babiano et al. 2016), commuter benefits (Zhou 2012), weather (Gebhart and Noland 2014), rental frequency (Zhang et al. 2016), as well as city size and compactness of the bike (Caulfield et al. 2017). With the availability of HOV (high occupancy vehicle) lanes, travelers who carpool generally have a shorter commute than solo drivers (Xiao, Liu, and Huang 2016). Seasonality is also a significant factor as summer use exceeds winter use of shared transportation (Zhou 2015).

Travel distance

Travel distance is largely influenced by travel purpose and travel time. Travelers who use bike sharing typically take shorter distance trips, for example, more than half of the origin-destination (OD) pairs in New York City in 2014 were less than 3km (Faghih-Imani et al. 2017). The mean journey length made by bike sharing is shorter than the private bicycle (Castillo-Manzano, López-Valpuesta, and Sánchez-Braza 2016) and e-bike share (Campbell et al. 2016). Research has shown that the effect of carpooling and non-carpooling are similar in distance to their workplace or schools/universities for drivers in France (Delhomme and Gheorghiu 2016). Also, the travel distance of bike sharing is influenced by travel time, with travelers commonly riding shorter distances at slower speeds on weekends than they do on weekdays in Brisbane (Mateo-Babiano et al. 2016).

The development of shared transportation has largely changed individual travel behaviors. The changes in travel behaviors caused by shared transportation directly determine whether the

shared transportation can achieve the original intention of energy conservation, emission reduction, and promotion of the sustainable development of urban traffic. In addition, travel behavior could also reflect the decision-making mechanism of an individual's employment location and residential location. That is, the spatial and temporal characteristics of travel behavior can reflect the distribution, spatial organization, and efficiency of urban occupations and housing.

Travel satisfaction of shared transportation

Travel satisfaction is an abstract concept and a subjective feeling, which is generally difficult to define in quantitative terms. Within our dataset, the articles were primarily focused on three fields of study: the effect of the characteristics of shared transportation or the user on the level of travel dissatisfaction (Kaspi, Raviv, and Tzur 2017; Nakamura and Abe 2014; Efthymiou, Antoniou, and Waddell 2013), the effect of user dissatisfaction on the likelihood of the user to adopt shared transportation (Kim, Rasouli, and Timmermans 2017; Yang et al. 2015), and the effect of transportation sharing system design on customer satisfaction (Alfian et al. 2015). Kaspi, Raviv, and Tzur (2017) found that the presence of unusable bicycles had a significant effect on user dissatisfaction. Efthymiou, Antoniou, and Waddell (2013) administered an online survey in Greece that focused on the data from young drivers. They found that satisfaction was high when the user's purpose was to commute or shop and that users 26 to 35 years of age were typically less satisfied than younger users (Efthymiou, Antoniou, and Waddell 2013). While Nakamura and Abe (2014) found that almost all of the users were satisfied with the bike sharing service of a small-scale, non-profit organization in Kitakyushu City, Japan, regardless of their travel purpose. As with bike sharing, Kim, Rasouli, and Timmermans (2017) found that the enjoyment of car sharing services had a positive relation to the user's transportation purpose. Yang et al. (2015) found that male

motorist commuters who have unpleasant travel experiences were more likely to be attracted to bike sharing services to access the metro. Alfian et al. (2015) developed a strategy for an open one-way service that could increase revenue and customer satisfaction.

Most of the previous studies on travel satisfaction of shared transportation used theoretical models or empirical research based on a regional questionnaire. The assumptions of these theoretical models have many limitations in practical applications. Additionally, the difficulty in the design and biased results of the questionnaire might also influence the practical applications. There are few studies that use big data gathered from shared transportation systems to make cross-comparison of different shared transportation programs. The explosion of big data and information technology has definitely changed the system and research on shared transportation by providing more and more abundant usable resources for the academic study of shared transportation. The user-generated big data help to explore more applications of shared transportation and provide new research opportunities that may help to make research findings more generalizable to shared transportation systems around the world.

Key determinants of shared transportation

The key determinants of shared transportation refer to all the factors that influence the level of user likelihood, travel frequency, and passenger flow of shared transportation. To create an analytical framework of influence factors of different shared transportation modes, we divide the influencing factors into three categories: the characteristics of shared transportation, user characteristics, and external factors considering the shared transportation itself, the users, and the other factors. Based on these categories, Table 6 summarizes the key determinants of three types of shared transportation, bike sharing (station-based bike sharing), ride sharing, and fixed-station car sharing.

Table 6. Key determinants of bike sharing, free-floating car sharing, and fixed-station car sharing.

Impact	Shared transportation	Shared transportation characteristics	User characteristics		External factors		
			Psychological variables	Social demographic characteristics	Natural environment	Temporal characteristics	Built environment
Positive	Bike sharing	● Comfort (Campbell et al. 2016), Higher density catchment design (Fishman and von Wyss 2017), Number of stations (Faghih-Imani et al. 2014), Suitable bicycle infrastructure (Fishman et al. 2012), Trendy status and theft prevention (Bachand-Marleaul 2012)	● Car driver attitudes (Fishman et al. 2012), Environmental concern (Kim et al. 2017), Environmental responsibility (Yang and Long 2016), Health considerations (Yang and Long 2016; Kim et al. 2017), Safety considerations (Yang and Long 2016),	● Age (median age: 30) (Vogel et al. 2014), Educational attainment (Bernatchez et al. 2015), Gender (male) (Vogel et al. 2014; Murphy and Usher 2015), Income (Efthymiou et al. 2013; Gavin et al. 2016)	● Air quality (Campbell et al. 2016), Hours of sunshine (Caulfield et al. 2017), Weather (Faghih-Imani et al. 2014; Corcoran et al. 2014; Caulfield et al. 2017; Gebhart and Noland 2014; Faghih-Imani et al. 2014)	● Peak hour (Mateo-Babiano et al. 2016), Public holidays and weekends (Corcoran et al. 2014), Workday (Faghih-Imani et al. 2014)	● Branch roads (Zhang et al. 2017), Density of bicycle lanes (Mateo-Babiano et al. 2016; Sun et al. 2017), Length of bicycle lanes (Sun et al. 2017; Zhang et al. 2017), Number of restaurants (Faghih-Imani et al. 2014), Population density (Zhang et al. 2017; Faghih-Imani et al. 2014), Public transport facilities (Yang and Long 2016), Usage at nearby stations (Zhang et al. 2017),
	Ridesharing	● Availability, Flexibility of travel times, Socializing (Nielsen et al. 2015)	● Environmental attitudes (Delhomme and Gheorghiu 2016), Positive attitudes toward public transport (Delhomme and Gheorghiu 2016), Safety (Nielsen et al. 2015)	● Cost savings (Nielsen et al. 2015; Shaheen et al. 2016), Distance traveled to work (Belz and Lee 2012), Employment density (Belz and Lee 2012), Full employment (Shaheen et al. 2016), Have children (Delhomme and Gheorghiu 2016), Hispanics and Asians co-ethnic neighborhood (Shin 2017), Income (Shaheen et al. 2016), Neighborhood (Charles and Kline 2012), Time savings (Shaheen et al. 2016)	-	-	-
	Short-term car rental	● Convenience (Joo 2017), Car availability and Satisfaction (Kim, J. et al. 2017)	● Compatibility, enjoyment, innovative tendencies of car-sharing services, and perceived reliability, (Kim et al. 2017), Environmentally conscious (Efthymiou et al. 2013)	● Income (between 15 K and 25 K Euros) (Efthymiou et al. 2013), Time savings (Joo 2017)	-	-	● Public transportation availability (Jeong 2015)
Negative	Bike sharing	● Sign-up process (Fishman et al. 2012)	● Environmental crisis consciousness (Yang and Long 2016)	-	● Elevation (Mateo-Babiano et al. 2016), High temperatures (Campbell et al. 2016), Rainfall (precipitation, humidity) (Caulfield et al. 2017; Campbell et al. 2016; Corcoran et al. 2014; Gebhart, and Noland 2014; Faghih-Imani et al. 2014), Wind speed (Corcoran et al. 2014)		● Congestion (Fishman and von 2017), Violent crime (Sun et al. 2017)
	Ridesharing	-	● Social awkwardness (Nielsen et al. 2015)	● Gender (male) (Delhomme and Gheorghiu 2016; Belz and Lee 2012)	-	-	-
	Short-term car rental	-		● Age (in the 26–35 years age group being more reluctant than younger ones). (Efthymiou et al. 2013)	-	-	-
Insignificant	Bike sharing	-	-	● User demographics (Campbell et al. 2016; Yang and Long 2016)	-	● School holidays (Corcoran et al. 2014)	● Congestion (Sun et al. 2017), Cycling culture (Caulfield et al. 2017), Land use (Sun et al. 2017), Public transport facilities (Zhang et al. 2017), Traffic accidents (Sun et al. 2017)
	Ridesharing	-	● Environmentally conscious (Shaheen et al. 2016)	● Age (Shin 2017), Black neighborhood residency (Shin 2017), Cost savings (Belz and Lee 2012), Educational attainment (Shaheen et al. 2016), Gender (male) (Shaheen et al. 2016), Neighborhood (Shaheen et al. 2016)	-	-	-
	Short-term car rental	-	-	● Privacy concern and perceived cost of using the services (Kim et al. 2017), Social value (Joo 2017),	● Cost savings (Joo 2017)	-	-

Characteristics of shared transportation

The characteristics of shared transportation include the variables concerning the quality and quantity of vehicles and infrastructure (e.g. stations or lanes). According to previous studies, bike sharing is susceptible to convenience and comfort. Different from private bicycles, the use of fixed-station bike sharing is restricted by parking stations and cannot be parked everywhere, but there is no need to worry about theft. Therefore, factors related to convenience such as the number of stations (Faghih-Imani et al. 2014), higher density catchment design (Fishman and von Wyss 2017), and theft prevention (Bachand-Marleau, Lee, and El-Geneidy 2012) have a positive impact on the usage of bike sharing, while the lengthy long sign-up process (Fishman et al. 2012) has a negative effect. Suitable (Fishman et al. 2012) and comfortable (Campbell et al. 2016) bicycle infrastructure has positive effects on bike sharing, as bike riders are more sensitive to their comfort than car passenger. The flexibility of travel times (Nielsen et al. 2015) is positively related to ridesharing. Convenience (Joo 2017), satisfaction, and car availability (Kim J. et al. 2017) also have an important influence on fixed-station car sharing, since the user needs to reach a fixed parking location before and after use.

User characteristics

The user characteristics (social demographic variables, including cost savings, age, gender, and educational attainment) have different effects on bike sharing, ride sharing, and fixed-station car sharing. The positive impact of income on shared transportation has been widely recognized by scholars (Efthymiou et al. 2013; Gavin et al. 2016; Shaheen et al. 2016). The impact of cost savings on ridesharing and short-term car rental is controversial. Nielsen et al (2015) and Shaheen et al (2016) found that cost savings had positive effect on ridesharing taking the case of Denmark and San Francisco Bay Area, while an insignificant influence of cost savings on ridesharing was found

by Belz and Lee (2012) taking the case of Vermont and Joo (2017) considering the short-term car rental in South Korea. Age is a concern of both bike-sharing and car-sharing researchers. For bike sharing, age is significant to bike sharing, and the median age of active subscribers is 30 (Vogel et al. 2014). For ridesharing, age maybe insignificant to ridesharing and negative to short-term car rental (Shin 2017; Efthymiou et al. 2013). The impact of gender is varied based upon the conclusions of different studies. Vogel et al. (2014) and Murphy and Usher (2015) found that males are more likely to use bike sharing, while Delhomme and Gheorghiu (2016), as well as Belz and Lee (2012), found that males are more likely to use ridesharing. Interestingly, Shaheen et al. (2016) found that gender was insignificant to ridesharing. Educational attainment may be positively related to bike sharing, but has been found to be insignificant with respect to ridesharing (Bernatchez et al. 2015; Shaheen et al. 2016). Employment density (Belz and Lee 2012), distance traveled to work (Belz and Lee 2012), as well as income and full employment (Shaheen et al. 2016) have a positive impact on ridesharing, possibly because commuters are a large group of people who use carpooling.

Psychological variables include the users' consciousness and considerations for privacy, environment, safety, health, transport-related factors (e.g., reliability, compatibility), which generates different influence on the usage of shared transportation. According to the literature, the privacy concern and perceived cost by shared transportation of users have insignificant influence on the usage of short-term car rental (Kim, H. et al. 2017). The influence of users' environmental consciousness on the usage of bike sharing (Kim et al. 2017; Yang and Long 2016) and ridesharing (Delhomme and Gheorghiu 2016; Shaheen et al. 2016) is unclear, but the influence on the adoption of fixed-station car sharing is positive (Efthymiou et al. 2013). Safety factors, such as mandatory helmet legislation, poor road awareness of riders, and imperfect cycling facilities, may influence

the decision to use bike sharing (Yang and Long 2016). Safety factors may also influence the decision to use ride sharing by incorporating people who tend to be unafraid of meeting strangers and more tolerant and trusting of others (Nielsen et al. 2015). Additionally, health considerations in relation to bike sharing (Yang and Long 2016; Kim et al. 2017) and car driver attitudes to bike sharing (Fishman et al. 2017) have appreciable impacts upon the willingness to participation in bike sharing. For ridesharing, carpoolers are more likely to have positive attitudes toward public transport (Delhomme and Gheorghiu 2016). Social awkwardness has the potential to afflict the efficacy of ridesharing. (Nielsen et al. 2015). For short-term car rental, perceived reliability, compatibility, and enjoyment of short-term car rental services, as well as users' innovative tendencies, are positively associated with usage intention (Kim et al. 2017). However, users' privacy concern and perceived cost of using the services are found to have no significant effects on the adoption of the services (Kim et al. 2017). Social value did not significantly influence the intention to use short-term car rental (Joo 2017).

External factors

The external factors include natural environment variables, the variables concerning the date, and build environment variables. In the natural environment variables, bike sharing is greatly affected by seasonal changes and weather conditions. Factors such as good weather (Faghih-Imani et al. 2014; Corcoran et al. 2014; Caulfield et al. 2017; Gebhartand and Noland, 2014; Faghih-Imani et al. 2014), hours of sunshine (Caulfield et al. 2017), and air quality (Campbell et al. 2016) have a positive relationship with bike sharing, while wind speed (Corcoran et al. 2014), rainfall (precipitation, humidity) (Caulfield et al. 2017; Campbell et al. 2016; Corcoran et al. 2014; Gebhartand and Noland 2014; Faghih-Imani et al. 2014), high temperatures (Campbell et al. 2016), and elevation (Mateo-Babiano et al. 2016) have a negative relationship with bike sharing.

The variables concerning the date such as public holidays and weekends (Corcoran et al. 2014), workday (Faghih-Imani et al. 2014), and peak hours (Mateo-Babiano et al. 2016) have been confirmed by some studies to influence usage positively. School holidays have been shown to have an insignificant impact on the use of bike sharing (Corcoran et al. 2014).

Built environment variables, such as the high frequency of public transport availability, increase people's willingness to use fixed-station car sharing (Jeong 2015). Factors such as the length of bicycle lanes (Sun et al. 2017; Zhang et al. 2017), the density of bicycle lanes (Mateo-Babiano et al. 2016; Sun et al. 2017), and branch roads (Zhang et al. 2017) are positively related to bike sharing. However, there is some controversy over whether the land use (Faghih-Imani et al. 2014; Sun et al. 2017) and public transport facilities (Yang and Long 2016; Zhang et al. 2017), have a significant impact on the bike sharing.

The impact of shared transportation

Table 7 shows the evidence to date from shared transportation research and the applications and limitations for transport policy according to the results and findings of our review. According to the bibliometric results from the collected literature, the research hotspots about the impacts of shared transportation could be summarized from several aspects: optimization effect on traffic, competition and cooperation effects, economic effects, environmental effects, and social effects. The convenience of shared transportation influences people's travel method and lifestyles. It creates new competition-cooperation relationships between different modes of transportation. However, there is no consensus on the economic, environmental, and social effects of shared transportation necessitating further research and evaluation.

Table 7. Main viewpoints of shared transportation's impact.

Impacts		Evidence from studies	The implication for related transport policy and applications
Traffic optimization	**Bike sharing**	● Promote sustainable development	● Combining bicycle sharing system with traditional public transport system could promote sustainable urban transport development (Jäppinen, Toivonen, and Salonen, 2013).
		● Cost efficiency	-
	Car sharing	● Save travel time	● Reduce in-vehicle times while longer door-to-door times(Bahat and Bekhor 2015).
		● Increase vehicle utilization	● Improved urban mobility can be attained through more efficient vehicle usage and better road network utilization, namely through increased vehicle occupancy and new operation modes (D'Orey and Ferreira 2014).
		● Alleviating congestion	● Traffic restriction scheme is possible to enhance carpooling and alleviate congestion (Ding and Shuai 2017).
Competition	**Bike sharing**	● Walk	● Bike sharing primarily substitute for walking of short trips.(Murphy and Usher 2015).
		● Private bicycle	● Users are more likely to use bike sharing for short distances, and use private bicycles for long distances. (Castillo-Manzano, Castro-Nuño, and López-Valpuesta 2015)
		● Taxi	● Bike sharing is more competitive on the travel distance less than 3km during weekdays' AM, Midday and PM time period(Faghih-Imani et al. 2017)s.
		● Bus	● Bike sharing and transit may short-term substitutes but act as complements in the long-term(Campbell and Brakewood 2017).
		● Private car	● It is necessary to encourage mode shifts from car, taxi and public transport to bikesharing for improve the impact of bike sharing on active travel levels(Fishman, Washington, and Haworth 2015).
	Free-floating bike sharing	● Station-based bike sharing	-
	For-profit ridesharing	● Traditional ridesharing	-
Corporation	**Bike sharing**	● Rail transit	● Chinese cities to equitably boost public bicycle integration with rail transit (Ji et al. 2017).
Economic	**Bike sharing**	● Generated advertising value	● The uneven distribution of bicycles caused by the ever-changing usage and supply can give different advertising value to the public bicycle system (Meng , 2017).
		● Required government-led investment and subsidies	● The government led investment and subsidized business model is more efficient than attracting advertising (Zhang et al., 2015).
		● Increase the home sale prices	● Public bike-sharing has wider economic benefits for the urban economy which is commensurate with the investment of it (El-Geneidy, Lierop, and Wasfi , 2016).
	Car sharing	● Save users' travel costs	-
Environmental	**Environmental benefits**	● Reduced carbon emissions	-
		● Reduced gasoline consumption	-
		● Reduced the public's willingness to buy new cars	-
		● Reduced the use of the cars	-
	Limited environmental benefits	● Does not affect climate change or environmental sustainability	-
Social	**Bike sharing**	● Traffic safety	● Bike share bicycles were involved in fewer crashes than private bicycles(Fishman and Schepers 2016).
		● Social equity	● Low cost of sharing bicycles mayconducive to social equity(Goodman and Cheshire 2014).
		● Rich data	● The big data of shared transportation provide insights for traffic development(O'Brien, Cheshire, and Batty 2014).
	Car sharing	● Traffic safety	● Not all ride-sharing services had the same effect.
		● User privacy	● Risks of divulging user privacy (Greenwood and Wattal 2017).

Optimization effect on traffic

Shared transportation is widely considered a useful measure to reduce traffic congestion as well as travel time. Several valuable studies have analyzed the optimization effect of shared transportation on traffic. Two important areas of study included design optimization of shared transportation system (Berlingerio et al. 2017; Zhou et al. 2017; Ding and Shuai 2017; Xu, Ordóñez, and Dessouky 2015; D'Orey and Ferreira 2014; Dimitrakopoulos, Demestichas, and Koutra 2012; Correia and Viegas 2011; Liu and Li 2017; Regue, Masoud, and Recker 2016; Bahat and Bekhor 2015; Ji et al. 2014; Jäppinen, Toivonen, and Salonen 2013) and the evaluation of current sharing systems (Stiglic et al. 2016; Abrahamse and Keall 2012).

Some studies focus on the convenience of car sharing such as analyzing the impact of sharing cars on saving travel time (Bahat and Bekhor 2015), increasing the private car seat utilization or vehicle occupancy (Zhou et al. 2017; D'Orey and Ferreira 2014), minimizing the number of cars needed (Berlingerio et al. 2017), and alleviating traffic congestion (Ding and Shuai 2017; Liu and Li 2017). The matching rate of shared transportation plays a significant role in expanding market coverage and improving the operation efficiency. Therefore, some scholars have studied how to improve the matching rate of shared transportation. Regue, Masoud, and Recker (2016) developed a shared mobility system modeled as a pure binary problem and solved with an exact solution method. Dimitrakopoulos, Demestichas, and Koutra (2012) studied the novel management functionality for dynamic ride matching. Stiglic et al. (2016) studied the impact of different types of traveler flexibility and found that increased flexibility can increase the expected matching rate. Correia and Viegas (2011) studied assessing carpooling time-space potential. Bike sharing is usually used to solve the “last kilometer” problem. Therefore, some studies are dedicated to the convenience of bike sharing. Ji et al. (2014) presented a cost-constrained e-bike sharing system

design based on a pilot project at the University of Tennessee. They concluded that it is important for each electric bicycle to have multiple replaceable batteries to meet a high demand scenario and that travel time has the greatest impact on the availability of electric bicycles. Jäppinen, Toivonen, and Salonen (2013) studied the effect of bike sharing systems on public transport travel time based on a hypothetical shared bike system modeled in the Greater Helsinki area in Finland. They found that combining a bike sharing system with a traditional public transport system could promote sustainable urban transport development.

Competition and cooperation effects

This section provides an overview of the competition and cooperation effects between shared transportation and the other transport modes as reported in the literature. As new travel modes emerge in the modern traffic system, there are areas of competition and cooperation between the shared modes of transportation and other transport modes (Anderson 2014; Faghih-Imani et al. 2017; Campbell and Brakewood 2017; Castillo-Manzano, Castro-Nuño, and López-Valpuesta 2015; Fishman, Washington, and Haworth 2015; Murphy and Usher 2015; Yang and Long 2016; Ji et al. 2017), as well as between different shared transportation modes (Pal and Zhang 2015; Anderson 2014). Among them, the substitution of shared transportation for traditional transport attracts significant researcher attention. Some studies found that there are significant substitution effects of bike sharing to walking (Murphy and Usher 2015), private bicycle (Castillo-Manzano, Castro-Nuño, and López-Valpuesta 2015), taxi (Faghih-Imani et al. 2017), bus (Campbell and Brakewood 2017) and private car (Fishman, Washington, and Haworth 2015). For example, Murphy and Usher (2015) found that 45.6% of respondents used a shared ride as a substitute for walking. Campbell and Brakewood (2017) found that shared ride use led to a 2.42% fall in daily

unlinked bus trips. In addition, bike sharing is widely considered in conjunction with public transport modes (Yang and Long 2016; Ji et al. 2017; Murphy and Usher 2015). For example, Murphy and Usher (2015) found that 39.0% of respondents used Dublin bikes in conjunction with at least one other mode to complete their trip. In terms of different forms of shared transportation, free-floating bike sharing, as compared to station-based bike sharing, has lower start-up costs (Pal and Zhang 2015). At present, for-profit ridesharing is more popular than traditional ridesharing (Anderson 2014). Thus, the competition and cooperation of the various methods of shared transportation in an urban traffic system offer both challenges and opportunities in the sustainable development of cities.

The existing research on competition and cooperation effects between shared transportation and others typically considers the substitution effects of shared transportation on one of the other transport modes. Consequently, little attention has been paid to the multimodal operations between car sharing and public transit. A multimodal system will likely become necessary and represents a significant area for future research. It will not be just sharing a bike, car, or bus that solves the accumulated transportation problem. Instead, a mixture of multiple transportation modes will actually allow urban mobility to reach its full potential.

Shared transportation is, in essence, the resource reallocation of current traffic network in a real-time manner, which is suitable for multimodal cooperation and competition. Shared transportation may provide possible answers needed to build an efficient multimodal traffic network by offering transit able ridership on an as-needed basis. Shared transportation will influence the traditional travel modes by both substituting and complementing them internally and externally.

Economic effect

Shared transportation is widely thought to have economic benefits for users (Wang, Winter, and Ronald 2017), companies (Li et al. 2017; Frade and Ribeiro 2015; Meng 2017), and societies (El-Geneidy, Lierop, and Wasfi 2016; Bullock, Brereton, and Bailey 2017; Zhang et al. 2015; Nakamura and Abe 2014; Murphy and Usher 2015). From the user perspective, scholars have found that the use of shared cars saves travel costs (Zhou et al. 2017; D'Orey and Ferreira 2014; Regue, Masoud, and Recker 2016). Interestingly, carpooling with strangers does not significantly increase travel costs as compared to carpooling with acquaintances (Wang, Winter, and Ronald 2017). From the company perspective, Li et al. (2017) found that the income of bike sharing systems is relative to GDP based on the dynamic programming model they proposed. Shared transportation could also generate economic benefits from the advertising. Meng (2017) studied the advertising value of the public bicycle system and proposed an evaluation algorithm of advertising value. While Zhang et al. (2015) found that the government-led investment model is more efficient than the attracting advertising model. From the societal perspective, Bullock, Brereton, and Bailey (2017) concluded that public bike sharing generates wider economic benefits for the urban economy, which is commensurate with the investment of public transport schemes. El-Geneidy, Lierop, and Wasfi (2016) studied the impacts of bike sharing systems on property value in Montreal, Canada. They found that the presence of a bike sharing system may have had a positive relationship with increased home sale prices.

Overall, shared transportation could generate positive economic impacts for the users, companies, and society at large, by saving significant travel costs for users, bring advertising and government-led investment for companies, and increase the home sale prices for some areas. However, little attention has been paid to the potentially negative impacts of shared transportation on the economy, mainly caused by the vicious competition between the companies of shared

transportation or between shared transportation and other transport modes. Thus, future research should pay much attention to the negative influence of shared transportation.

Environmental effect

At present, there is not a unanimous opinion about whether shared transportation can bring environmental benefits. Some scholars believe that car sharing including carpooling (Bruck et al. 2017; Minett and Pearce 2011), ridesharing (Jacobson and King 2009; Yu et al. 2017) and organised car sharing (Rabbitt and Ghosh 2013) may change people's behavior patterns there by reducing carbon emission and gasoline consumption. The competition between shared transportation and traditional means of transportation, such as the replacement of the private car by the car sharing including car (park) sharing (Hwang and Jeon 2014; Kent and Dowling 2016) and carpooling (Baldacci, Maniezzo, and Mingozzi 2004) can reduce the use of cars achieving some measurable environmental benefits. The convenience of ridesharing, such as reduced mileage, reduced road traffic, and less traffic congestion, will also result in energy savings and emission reduction (Rodier, Alemi, and Smith 2016). Also, ridesharing may change people's travel mode and reduce people's willingness to buy new cars (Yu et al. 2017). Some scholars have stated that the environmental benefits of shared transportation are limited. For example, Nielsen et al. (2015) thought that it unlikely that carpool efforts focused on climate change or environmental sustainability would be successful in Denmark.

Generally speaking, studies about the environmental impact of shared transportation mainly concentrated on reduced mileage, reduced carbon emission, and gasoline consumption, and reduced people's willingness to buy new cars. However, there is no unified measurement standard yet. Moreover, the existing research rarely involves the impact of increasing abandoned bicycles

on the environment. Future research could seek to establish scientific and reasonable evaluation criteria as well as reasonable scrapping and recycling mechanism.

Social effect

Academic research has been mixed regarding the positive and negative social effects of shared transportation. Those social effects include traffic safety (Fishman and Schepers 2016; Greenwood and Wattal 2017), social equity (mainly related to bike sharing) (Goodman and Cheshire 2014; Karki and Liu 2016; Murphy and Usher 2015), user privacy (mainly related to car sharing) (Caballerogil et al. 2017; Friginal et al. 2014), and the source of data (O'Brien, Cheshire, and Batty 2014). The safety of shared transportation has received a significant acknowledgment by scholars. Fishman and Schepers (2016) analyzed the impact of bike sharing programs on cycling safety and found that bike sharing is less risky in bicycle crashes than private bicycles. Greenwood and Wattal (2017) analyzed the influence of ride-sharing services on alcohol-related motor vehicle fatalities. They concluded that introducing Uber X had significantly reduced the rate of alcohol-related motor vehicle fatalities in California. However, not all ride-sharing services have had the same effect. Regarding social equity, some scholars believe the low cost of bike sharing is conducive to social equity (Goodman and Cheshire 2014), but other scholars believe it has a limited impact. Karki and Liu (2016) found that lower-income people were less likely to take advantage of public bike sharing programs in Suzhou, China. While big data related to shared transportation provides insights for traffic development (O'Brien, Cheshire, and Batty 2014), there are risks of infringing on user privacy. To combat those risks, Caballerogil et al. (2017) and Friginal et al. (2014) developed carpool systems for preserving a user's privacy.

In the existing literature, the impacts of shared transportation on traffic safety and social equity in studies are quite different, which might be related to the different research perspectives, research objects, and research areas of these studies. Future research should pay much attention to the cross-comparison regarding the impacts of shared transportation among the countries and regions with different development levels and cultural backgrounds.

Development of plans and policies

Formulating traffic management plans and improving related policies of shared transportation are of great significance for the orderly sustainable development of shared transportation. At present, studies that focus on shared transportation policies are mainly about subsidization policies, accommodation lanes, parking-related policies, and regulations.

Planning for how cities will operate today and in the future is an intricate process. In the long term, analyzing and planning the suitability of shared transportation for a city are considered helpful for the introduction and rational planning of shared transportation programs (Fishman and von Wyss 2017; Godavarthy and Taleqani 2017). Fishman and von Wyss (2017) analyzed the ability of Adelaide, Australian to support a bike sharing program. They developed a Bike Share Propensity Index and then proposed the prerequisites and development time. Godavarthy and Taleqani (2017) analyzed the factors that influence the willingness to use bike sharing in locations with harsh winters such as Fargo, North Dakota. They gathered the operational data from bike sharing programs in those cities and found evidence to support a positive attitude towards winter use of bike sharing.

Although shared transportation “adds value for consumers” and offers alternative methods of travel, it has blurred the lines between personal and commercial activities, which is effectively

challenging regulations. Therefore, some cities have implemented new regulations and bylaws for shared transportation. Policy research on shared transportation includes: helmet-wearing (mandatory helmet legislation) (Friedman et al. 2016; Fischer et al. 2012; Fishman, Washington, and Haworth 2012), subsidization policies (Wang 2011), accommodation lanes (Wang 2011; Burris et al. 2014), parking-related policies (Kent and Dowling 2016; Kaspi et al. 2016; Dowling and Kent 2015) and regulations (Posen 2015). In terms of helmet-wearing, Fishman, Washington, and Haworth (2012) found that mandatory helmet legislation may reduce spontaneous use. Indeed, Fischer et al. (2012) found that many bike sharing users do not use helmets. Friedman et al. (2016) found that it is typically younger males who do not wear helmets and they concluded that mandatory helmet legislation could improve helmet usage, but would likely reduce cycling. Regarding subsidization policies, Wang (2011) thought it is unreasonable to give subsidies to people who carpool. Of note, most bike sharing systems in the world rely on some form of government subsidy. In the studies of accommodation lanes, Wang (2011) found that it was more beneficial to convert general motor vehicle lanes to bus lanes rather than HOV lanes in China. Likewise, Burris et al. (2014) found there is a negative impact of converting HOV lanes to HOT lanes on carpooling in the U.S. Parking-related policy is also considered an important field with respect to car sharing (Dowling and Kent 2015). Kaspi et al. (2016)demonstrated the validity of the complete parking reservation policy in theory based on two case studies of real-world systems. However, Kent and Dowling (2016) found parking policies could affect car sharing both positively and negatively in Sydney, Australia. Posen (2015) argued that reasonable regulators should rely on experimental regulations for safety rather than set entry controls or price-fixing.

Although scholars have done a lot of research on the development plans and policies of shared transportation, many problems still remain, such as problems of bike sharing deposit refund, illegal

parking, quantity control, damage and theft, and safety problems of car sharing. Many governments of countries and cities have introduced relevant policies to solve. For the deposit management, for example, on 16 May 2019, China has issued a new rule to platforms operating within the country's sharing economy that car- and bike-sharing operators should no longer collect user deposits in principle (Ministry of Transport of China 2019). With respect to illegal parking, the San Diego City Council on 23 April 2019 unanimously approved new regulations that require dockless bike sharing companies to pick up and relocate bikes that are parked illegally (Andrew 2019). For quantity control, Beijing has capped the total number of shared bicycles at 1.91 million since 2018 (YNET 2018). In 2019, the Karnataka Government asked taxi aggregators to withdraw carpooling services in Bengaluru to ensure passenger safety (Chaitra 2019). The studies about the performance evaluation and effects of these policies might give some suggestions for the sustainable development of shared transportation.

Governance

The shared transportation research literature is just beginning to investigate the various governance models, and the consistent and transparent monitoring and evaluation framework have not yet been formed. Some governance models have been adopted in shared transportation. For instance bike sharing business models include partnerships between local government and advertising agencies, public agency funding, and not-for-profit models (Mateo-Babiano 2015). As an emerging key policy issue, many scholars have discussed the governance issue of companies based on different theoretical frameworks. Bardhi and Eckhardt (2012)examined the nature of access in the context of car sharing and found that the negative reciprocity of car sharing resulting in a big-brother model of governance which can be beneficial to consumers. Hartl, Hofmann, and Kirchler

(2016) studied governance in collaborative consumption communities, which extends previous research on car sharing customers. The results of their experiment indicated that the implementation of a governance system might lead to the participation of people who choose collaborative consumption for economic reasons and the reactance of people who consider social reasons. Schor (2016) thought that the ownership and governance of the sharing economy platforms should be democratized to build a social movement centered on genuine practices of sharing and cooperation in the production and consumption of goods and services. Ricci (2015) thought that bike sharing could be delivered through multiple governance models based on a process perspective. The specific bike sharing governance model and contractual arrangements might dictate the range and quality of data that can be released in the short-term. Ma et al. (2018) examined how commercial, political, and social actors interact in addressing the emerging public problems in the free-floating bike sharing scale-up process from a collaborative governance perspective based on a case study.

Conclusion

Shared transportation has made a significant, positive impact on the everyday lives of many individuals while at the same time providing benefits to the economy, environment, and society at large. However, our study found that even as more articles on the topic are being published, there is not a core group of journals dedicated to the study of shared transportation. Additionally, researchers are only now beginning to pay attention to the impact of shared transportation on travel behaviors, user characteristics, and social-economic impacts.

In this paper, we analyzed the research on shared transportation published between 2003 and 2017. The two major research topics in the field of shared transportation were car sharing and ride

sharing. We found that research on this topic could be divided into nine main areas: travel behavior characteristics; transit satisfaction; influential factors; the impact of shared transportation on convenience; competitive-cooperative mechanism; economic effect; environmental effect; social effect; as well as development planning and policies. The main conclusions and the other possible topic areas that would increase our collective understanding of shared transportation are summarized as follows:

The changing travel behaviors and its impacts. The existing research has done much work on the impacts of shared transportation on travel behaviors from the perspectives of individual travel time, travel distance, and travel purpose, which to date have neglected the potential impacts of the changing travel behaviors regarding energy saving, emission reduction, sustainable development of urban traffic, and even the separation between jobs and residential locations. All of these would provide a practical and interesting direction for research.

Analysis of multimodal operations concerning shared transportation. The existing research on multimodal operations typically considers the substitution effects of shared transportation on other transport modes concerning the travel time and travel satisfaction. However, little attention has been paid to cooperation and competition between shared transportation and public transit. Shared transportation has emerged to provide the public with varied transportation options to fill the gaps in their travel journey (e.g., bike sharing might solve "the last mile" problem). It will be a more practical and interesting direction to investigate how those inter-and intra-model relationships affect the sustainable, balancing, and coupling development of the urban traffic system.

Scientific and reasonable evaluation of the system itself and the external effect of shared transportation. According to the existing literature, as noted above, shared transportation could

bring economic benefits to include, but not limited to, reduced travel costs and increased property value. Additionally, shared transportation could spawn environmental benefits which include reduced carbon emissions, reduced fuel consumption, reduced traffic congestion, reduced personal car ownership, and reduced willingness to buy new cars. However, the external effects of shared transportation are complex and hard to calculate, and few scholars have done this work. For example, how to build a uniform standard for the effective empirical evaluation of these impacts of shared transportation. Thus, how to formulate a scientific and reasonable evaluation system for shared transportation itself and to evaluate the external effects of shared transportation comprehensively will be a continuing challenge for the policymakers and researchers.

Formulate reasonable development planning and policies. Shared transportation has generated many problems that need urgent attention, such as increasing regulatory hurdles, safety, and social problems, illegally parked bikes, as well as economic and environmental problems. While researchers have made much work regarding policy of safety problems (e.g., helmet-wearing), parking, subsidies, accommodation lanes, and regulations, there is still much room for further research. The regulations about the technical specifications of shared transportation to reduce hidden dangers are also important. In addition, the policies about how to improve the corresponding legal system, clarify accident liability, protect personal information, and solve the problem of deposit refunds need to be further perfected. The relative merits of different transport systems in differing urban contexts also need further study.

Room for contributions in research methods and big data analysis. With the development of information technologies, especially the mobile computing technology, mobile shared transportation apps like Uber, Didi, Mo-bike, and taxi recommendation systems have generated abundant data (also named “big data”), including the trajectory data and the social-economic

attribution of the users. The trajectory data generated by shared transportation apps could reflect the whole trip chain of urban travel and the social-economic attribution of each traveler could be used to explore the travel behavior in terms of individual heterogeneity. All of these data could be implemented in both directly related fields such as traffic management and network optimization, as well as in indirectly related fields such as urban functional area identification, city planning, and policy evaluation. In addition, by combining the "big data" and "small data" (e.g., SP data), the travel scope, as well as time and spatial patterns of individuals, could be further analyzed. Thus, future research on shared transportation should comprehensively explore the influencing factors of individual travel choice and travel behaviors.

A significant limitation of our study was our reliance on one database, Web of Science, which limited the number of articles that we analyzed. Future studies should consider using additional academic literature databases and possibly a more structured evaluation of those articles.

References

Abrahamse, W., and M. Keall. 2012. "Effectiveness of a web-based intervention to encourage carpooling to work: A case study of Wellington, New Zealand." *Transport Policy* 21 (4):45–51.

Agatz, N., A. Erera, M. Savelsbergh, and X. Wang. 2012. "Optimization for dynamic ride-sharing: A review." *European Journal of Operational Research* 223 (2):295–303.

AghaeiChadegani, A., H. Salehi, M. Yunus, H. Farhadi, M. Fooladi, M. Farhadi, and N. Ale Ebrahim. 2013. "A comparison between two main academic literature collections: Web of Science and Scopus databases." *Asian Social Science* 9 (5):18–26.

Andrew Bowen. 2019 "The new regulations require bike and scooter sharing companies to limit speeds in high-pedestrian areas and to respond to reports of abandoned or illegally parked devices." Retrieved from https://www.kpbs.org/news/2019/apr/23/city-council-regulations-dockless-scooters-bikes/ (retrieved 08.17.19)

Alfian, G., J. Rhee, Y. S. Kang, and B. Yoon. 2015. "Performance comparison of reservation based and instant access one-way car sharing service through discrete event simulation." *Sustainability* 7 (9):12465–89.

Anderson, D. N. 2014. ""Not just a taxi"? For-profit ridesharing, driver strategies, and VMT." *Transportation* 41 (5):1099–117.

Bachand-Marleau, J., B. H. Y. Lee, and A. M. El-Geneidy. 2012. "Better understanding of factors influencing likelihood of using shared bicycle systems and frequency of use." *Transportation Research Record* 2314 (1):66–71.

Bahat, O., and S. Bekhor. 2015. "Incorporating ridesharing in the static traffic assignment model." *Networks and Spatial Economics* 16 (4):1–25.

Baldacci, R., V. Maniezzo, and A. Mingozzi. 2004. "An exact method for the car pooling problem based on lagrangean column generation." *Operations Research* 52 (3):422–39.

Bardhi, F., and G. M. Eckhardt. 2012. "Access-based consumption: The case of car sharing." *Journal of Consumer Research* 39 (4):881–98.

Basch, C. H., D. Ethan, P. Zybert, S. Afzaal, M. Spillane, and C. E. Basch. 2015. "Public bike sharing in New York City: Helmet use behavior patterns at 25 Citi Bike™ stations " *Journal of Community Health* 40 (3):530–3.

BEIJING YOUTH DAILY. 2018 "Beijing Limits Shared Bicycles to 191,000." Retrieved from http://www.xinhuanet.com/tech/2018-08/03/c_1123216141.htm (retrieved 08.17.19)

Belz, N. P., and B. H. Lee. 2012. "Composition of vehicle occupancy for journey-to-work trips: Evidence of ridesharing from 2009 National Household Travel Survey Vermont Add-On Sample." *Transportation Research Record* 2322 (1):1–9.

Bento, A. M., J. E. Hughes, and D. Kaffine. 2013. "Carpooling and driver responses to fuel price changes: Evidence from traffic flows in Los Angeles." *Journal of Urban Economics* 77 (1):41–56.

Berlingerio, M., B. Ghaddar, R. Guidotti, A. Pascale, and A. Sassi. 2017. "The GRAAL of carpooling: GReen and sociAL optimization from crowd-sourced data." *Transportation Research Part C: Emerging Technologies* 80:20-36.

Bernatchez, A. C., Gauvin, L., Fuller, D., Dubé, A. S., and Drouin, L. 2015. " Knowing about a public bicycle share program in Montreal, Canada: are diffusion of innovation and proximity enough for equitable awareness?" *Journal of Transport & Health* 2(3): 360–368.

Bruck, B. P., V. Incerti, M. Iori, and M. Vignoli. 2017. "Minimizing CO2 emissions in a practical daily carpooling problem." *Computers & Operations Research* 81:40–50.

Bullock, C., F. Brereton, and S. Bailey. 2017. "The economic contribution of public bike-share to the sustainability and efficient functioning of cities." *Sustainable Cities & Society* 28:76–87.

Burris, M., N. Alemazkoor, R. Benz, and N. S. Wood. 2014. "The impact of hot lanes on carpools." *Research in Transportation Economics* 44 (1):43–51.

Caballerogil, C., P. Caballerogil, J. Molinagil, F. Martínfernández, and V. Loia. 2017. "Trust-based cooperative social system applied to a carpooling platform for smartphones." *Sensors* 17 (2):245.

Campbell, A. A., C. R. Cherry, M. S. Ryerson, and X. Yang. 2016. "Factors influencing the choice of shared bicycles and shared electric bikes in Beijing." *Transportation Research Part C: Emerging Technologies* 67:399–414.

Campbell, K. B., and C. Brakewood. 2017. "Sharing riders: How bikesharing impacts bus ridership in New York City." *Transportation Research Part A: Policy and Practice* 100:264–82.

Castillo-Manzano, J. I., M. Castro-Nuño, and L. López-Valpuesta. 2015. "Analyzing the transition from a public bicycle system to bicycle ownership: A complex relationship." *Transportation Research Part D: Transport and Environment* 38:15–26.

Castillo-Manzano, J. I., L. López-Valpuesta, and A. Sánchez-Braza. 2016. "Going a long way? On your bike! Comparing the distances for which public bicycle sharing system and private bicycles are used." *Applied Geography* 71:95–105.

Caulfield, B., M. O'Mahony, W. Brazil, and P. Weldon. 2017. "Examining usage patterns of a bike-sharing scheme in a medium sized city." *Transportation Research Part A: Policy and Practice* 100:152–61.

Chaitra v. 2019 “It is the responsibility of the taxi aggregators to ensure passenger safety. Monitoring app-based services is essential for accountability” Retrieved from https://www.dailypioneer.com/2019/columnists/a-regulatory-approach.html (retrieved 08.17.19)

Chan, N. D., and S. A. Shaheen. 2012. "Ridesharing in north america: Past, present, and future." *Transport Reviews* 32 (1):93–112.

Charles, K. K., & Kline, P. 2006. "Relational costs and the production of social capital: evidence from carpooling." *The Economic Journal, 116(511), 581-–604.*

Chen, T. D., and K. M. Kockelman. 2016. "Carsharing’s life-cycle impacts on energy use and greenhouse gas emissions." *Transportation Research Part D: Transport and Environment* 47:276–84.

Chen, Y., C. Chen, Z. Hu, and X. Wang. 2014. "Principles and applications of analyzing a citation space." *Science and Technology Press*.

Corcoran, J., T. Li, D. Rohde, E. Charles-Edwards, and D. Mateo-Babiano. 2014. "Spatio-temporal patterns of a public bicycle sharing program: The effect of weather and calendar events." *Journal of Transport Geography* 41:292–305.

Correia, G., and J. M. Viegas. 2011. "Carpooling and carpool clubs: Clarifying concepts and assessing value enhancement possibilities through a Stated Preference web survey in Lisbon, Portugal." *Transportation Research Part A: Policy and Practice* 45 (2):81–90.

Curto, A., A. De Nazelle, D. Donaire-Gonzalez, T. Cole-Hunter, J. Garcia-Aymerich, D. Martínez, E. Anaya, D. Rodríguez, M. Jerrett, and M. J. Nieuwenhuijsen. 2016. "Private and public modes of bicycle commuting: A perspective on attitude and perception." *European Journal of Public Health* 26 (4):717–23.

D'Orey, P. M., and M. Ferreira. 2014. "Can ride-sharing become attractive? A case study of taxi-sharing employing a simulation modelling approach." *IET Intelligent Transport Systems* 9 (2):210–20.

Davis, K. 2014. "Different stakeholder groups and their perceptions of project success." *International Journal of Project Management* 32 (2):189–201.

Delhomme, P., and A. Gheorghiu. 2016. "Comparing French carpoolers and non-carpoolers: Which factors contribute the most to carpooling?" *Transportation Research Part D: Transport and Environment* 42:1–15.

DeMaio, P. 2009. "Bike-sharing: History, impacts, models of provision, and future." *Journal of public transportation* 12 (4):41–56.

Dimitrakopoulos, G., P. Demestichas, and V. Koutra. 2012. "Intelligent management functionality for improving transportation efficiency by means of the car pooling concept." *IEEE Transactions on Intelligent Transportation Systems* 13 (2):424–36.

Ding, D., and B. Shuai. 2017. "A traffic restriction scheme for enhancing carpooling." *Discrete Dynamics in Nature and Society* 2017:1–9.

Dowling, R., and J. Kent. 2015. "Practice and public–private partnerships in sustainable transport governance: The case of car sharing in Sydney, Australia." *Transport Policy* 40:58–64.

Efthymiou, D., C. Antoniou, and P. Waddell. 2013. "Factors affecting the adoption of vehicle sharing systems by young drivers." *Transport Policy* 29:64–73.

El-Geneidy, A., D. V. Lierop, and R. Wasfi. 2016. "Do people value bicycle sharing? A multilevel longitudinal analysis capturing the impact of bicycle sharing on residential sales in Montreal, Canada." *Transport Policy* 51:174–81.

Faghih-Imani, A., S. Anowar, E. J. Miller, and N. Eluru. 2017. "Hail a cab or ride a bike? A travel time comparison of taxi and bicycle-sharing systems in New York City." *Transportation Research Part A: Policy and Practice* 101:11–21.

Faghih-Imani, A., N. Eluru, A. M. El-Geneidy, M. Rabbat, and U. Haq. 2014. "How land-use and urban form impact bicycle flows: Evidence from the bicycle-sharing system (BIXI) in Montreal." *Journal of Transport Geography* 41:306–14.

Fischer, C. M., C. E. Sanchez, M. Pittman, D. Milzman, K. A. Volz, H. Huang, S. Gautam, and L. D. Sanchez. 2012. "Prevalence of bicycle helmet use by users of public bikeshare programs." *Annals of Emergency Medicine* 60 (2):228–31.

Fishman, E. 2016. "Bikeshare: A review of recent literature." *Transport Reviews* 36 (1):92–113.

Fishman, E., and P. Schepers. 2016. "Global bike share: what the data tells us about road safety." *Journal of Safety Research* 56:41–5.

Fishman, E., and M. von Wyss. 2017. "Bike share in the Australian city: Assessing the feasibility of a future bike share program for Adelaide." *Road & Transport Research: A Journal of Australian and New Zealand Research and Practice* 26 (2):1–16.

Fishman, E., S. Washington, and N. Haworth. 2012. "Barriers and facilitators to public bicycle scheme use: A qualitative approach." *Transportation research part F: traffic psychology and behaviour* 15 (6):686–98.

Fishman, E., Washington, S., and Haworth, N. 2013. "Bike share: A synthesis of the literature." *Transport Reviews* 33 (2):148–65.

Fishman, E., Washington, S., and Haworth, N. 2015. "Bikeshare's impact on active travel: Evidence from the United States, Great Britain, and Australia." *Journal of Transport & Health* 2 (2):135–42

Frade, I., and A. Ribeiro. 2015. "Bike-sharing stations: A maximal covering location approach." *Transportation Research Part A: Policy and Practice* 82:216–27.

Friedman, S. M., M. Adamson, P. Cleiman, T. Arenovich, K. Oleksak, I. M. Mohabir, R. Ta, and K. Reiter. 2016. "Helmet-wearing practices and barriers in Toronto bike-share users: A case-control study." *Canadian Journal of Emergency Medicine* 18 (1):28–36.

Friginal, J., S. Gambs, J. Guiochet, and M. O. Killijian. 2014. "Towards privacy-driven design of a dynamic carpooling system." *Pervasive and Mobile Computing* 14:71–82.

Gebhart, K., and R. B. Noland. 2014. "The impact of weather conditions on bikeshare trips in Washington, DC." *Transportation* 41 (6):1205–25.

Gavin, K., Bennett, A., Auchincloss, A. H., and Katenta, A. 2016. "A brief study exploring social equity within bicycle share programs. " *Transportation Letters*, 2016, 8(3): 177–180.

Godavarthy, R. P., and A. R. Taleqani. 2017. "Winter bikesharing in US: User willingness, and operator's challenges and best practices." *Sustainable Cities and Society* 30:254–62.

Goodman, A., and J. Cheshire. 2014. "Inequalities in the London bicycle sharing system revisited: Impacts of extending the scheme to poorer areas but then doubling prices." *Journal of Transport Geography* 41 (2):272–9.

Greenwood, B. N., and S. Wattal. 2017. "Show me the way to go home: An empirical investigation of ride sharing and alcohol related motor vehicle homicide." *MIS Quarterly* 41 (1):163–88.

Guangming Online. 2018 . "Didi obtained Tai'an city online car-hailing business license."Retrieved from http://it.gmw.cn/2018-08/13/content_30500703.htm (retrieved 06.01.19).
Hartl, B., E. Hofmann, and E. Kirchler. 2016. "Do we need rules for “what's mine is yours”? Governance in collaborative consumption communities." *Journal of Business Research* 69 (8):2756–63.
Huwer, U. 2004. "Public transport and car-sharing—benefits and effects of combined services." *Transport Policy* 11 (1):77–87.
Hwang, K. Y., and H. J. Jeon. 2014. "Applying sharing economy principle on transport with focus on car sharing practice and research." *Journal of Transport Research* 21 (1):35–49.
Jacobson, S. H., and D. M. King. 2009. "Fuel saving and ridesharing in the US: Motivations, limitations, and opportunities." *Transportation Research Part D: Transport and Environment* 14 (1):14–21.
Jäppinen, S., T. Toivonen, and M. Salonen. 2013. "Modelling the potential effect of shared bicycles on public transport travel times in greater helsinki: An open data approach." *Applied Geography* 43:13–24.
Ji, S., C. R. Cherry, L. D. Han, and D. A. Jordan. 2014. "Electric bike sharing: Simulation of user demand and system availability." *Journal of Cleaner Production* 85:250–7.
Ji, Y., Y. Fan, A. Ermagun, X. Cao, W. Wang, and K. Das. 2017. "Public bicycle as a feeder mode to rail transit in China: The role of gender, age, income, trip purpose, and bicycle theft experience." *International Journal of Sustainable Transportation* 11 (4):308–17.
Joo, J. 2017. "Motives for participating in sharing economy: Intentions to use car sharing services." *Journal of Distribution Science* 15 (2):21–6.
Jeong, K. B., Cho, G. B., and Kim, S. W. 2015. "The study of availability and factor analysis on car-sharing for sharing economy." *Korean Comparative Government Review* 19(3), 105-124.
Karki, T. K., and T. Liu. 2016. "How accessible and convenient are the public bicycle sharing programs in China? Experiences from Suzhou City." *Habitat International* 53:188–94.
Kaspi, M., T. Raviv, and M. Tzur. 2017. "Bike-sharing systems: User dissatisfaction in the presence of unusable bicycles." *IISE Transactions* 49 (2):144–58.
Kaspi, M., T. Raviv, M. Tzur, and H. Galili. 2016. "Regulating vehicle sharing systems through parking reservation policies: Analysis and performance bounds." *European Journal of Operational Research* 251 (3):969–87.
Kent, J. L., and R. Dowling. 2016. "“Over 1000 cars and no garage”: How urban planning supports car (park) sharing." *Urban Policy and Research* 34 (3):1–13.
Kim, H., K. H. Choi, K. J. Kim, and E. Park. 2017. "From owning to sharing: Understanding the emergence of social sharing services." *Program* 51 (2):102–15.
Kim, J., K. Choi, S. Kim, and S. Fujii. 2017. "How to promote sustainable public bike system from a psychological perspective?" *International Journal of Sustainable Transportation* 11 (4):272–81.
Kim, J., S. Rasouli, and H. Timmermans. 2017. "Satisfaction and uncertainty in car-sharing decisions: An integration of hybrid choice and random regret-based models." *Transportation Research Part A: Policy and Practice* 95:13–33.
Kopp, J., R. Gerike, and K. W. Axhausen. 2015. "Do sharing people behave differently? An empirical evaluation of the distinctive mobility patterns of free-floating car-sharing members." *Transportation* 42 (3):449–69.

Krueger, R., T. H. Rashidi, and J. M. Rose. 2016. "Preferences for shared autonomous vehicles." *Transportation Research Part C: Emerging Technologies* 69:343–55.
Laporte, G., F. Meunier, and R. W. Calvo. 2015. "Shared mobility systems." *4OR: A Quarterly Journal of Operations Research* 13 (4):341–60.
Le Vine, S., O. Adamou, and J. Polak. 2014. "Predicting new forms of activity/mobility patterns enabled by shared-mobility services through a needs-based stated-response method: Case study of grocery shopping." *Transport Policy* 32:60–8.
Le Vine, S., and J. Polak. 2015. "Introduction to special issue: New directions in shared-mobility research." *Transportation* 42 (3):407–11.
Li, L., M. Shan, Y. Li, and S. Liang. 2017. "A dynamic programming model for operation decision-making in bicycle sharing systems under a sustainable development perspective." *Sustainability* 9 (6):895.
Liu, Y., and Y. Li. 2017. "Pricing scheme design of ridesharing program in morning commute problem." *Transportation Research Part C: Emerging Technologies* 79:156–77.
Ma, S., Zheng, Y., and Wolfson. 2014 " Real-time city-scale taxi ridesharing"*IEEE Transactions on Knowledge and Data Engineering* 27(7): 1782–1795.
Ma, Y., J. Lan, T. Thornton, D. Mangalagiu, and D. Zhu. 2018. "Challenges of collaborative governance in the sharing economy: The case of free-floating bike sharing in Shanghai." *Journal of Cleaner Production* 197 (1):356–65.
Martin, E., and S. Shaheen. 2011. "The impact of carsharing on public transit and non-motorized travel: An exploration of North American carsharing survey data." *Energies* 4 (11):2094–114.
Mateo-Babiano, I. 2015. "Public bicycle sharing in Asian cities." *Journal of the Eastern Asia Society for Transportation Studies* 11:60–74.
Mateo-Babiano, I., R. Bean, J. Corcoran, and D. Pojani. 2016. "How does our natural and built environment affect the use of bicycle sharing?" *Transportation Research Part A: Policy and Practice* 94:295–307.
Meng, H. 2017. "Research on evaluation algorithm of public bicycle system advertising value based on the mobility modeling and prediction." *AGRO Food Industry Hi-Tech* 28 (3):1573–8.
Minett, P., and J. Pearce. 2011. "Estimating the energy consumption impact of casual carpooling." *Energies* 4 (1):126–39.
Ministry of Transport of China. 2019.” Measures for the management of user funds in emerging forms of transportation shall come into effect in June.” Retrieved from http://www.gov.cn/xinwen/2019-05/16/content_5392142.htm (retrieved 08.17.19)
Murphy, E., and J. Usher. 2015. "The role of bicycle-sharing in the city: Analysis of the Irish experience." *International Journal of Sustainable Transportation* 9 (2):116–25.
Nakamura, H., and N. Abe. 2014. "The role of a non-profit organisation-run public bicycle-sharing programme: The case of Kitakyushu City, Japan." *Journal of Transport Geography* 41:338–45.
Nielsen, Jesper Riber, Harald Hovmøller, Pascale-L Blyth, and Benjamin K Sovacool. 2015. "Of “white crows” and “cash savers:” A qualitative study of travel behavior and perceptions of ridesharing in Denmark." *Transportation Research Part A: Policy and Practice* 78:113–23.
O’Brien, O., J. Cheshire, and M. Batty. 2014. "Mining bicycle sharing data for generating insights into sustainable transport systems." *Journal of Transport Geography* 34 (219):262–73.
Pal, A., and Y. Zhang. 2015. "Free-floating bike sharing: Solving real-life large-scale static rebalancing problems." *Transportation Research Part C: Emerging Technologies* 80:92–116.

Persson, O., R. Danell, and J. W. Schneider. 2009. "How to use BibExcel for various types of bibliometric analysis." In *Celebrating scholarly communication studies: A Festschrift for OllePersson at his 60th Birthday*, 9–24. Lund University.

Posen, H. A. 2015. "Ridesharing in the sharing economy: Should regulators impose Uber regulations on Uber?" *Iowa Law Review* 101 (1):405–33.

Rabbitt, N., and B. Ghosh. 2013. "A study of feasibility and potential benefits of organised car sharing in Ireland." *Transportation Research Part D: Transport and Environment* 25 (8):49–58.

Regue, R., N. Masoud, and W. Recker. 2016. "Car2work: shared mobility concept to connect commuters with workplaces." *Transportation Research Record: Journal of the Transportation Research Board* 2542:102–10.

Ricci, M. 2015. "Bike sharing: A review of evidence on impacts and processes of implementation and operation." *Research in Transportation Business & Management* 15:28–38.

Rodier, C., F. Alemi, and D. Smith. 2016. "Dynamic ridesharing: Exploration of potential for reduction in vehicle miles traveled." *Transportation Research Record: Journal of the Transportation Research Board* 2542:120–6.

Romanillos, G., M. Z. Austwick, D. Ettema, and J. D. Kruijf. 2016. "Big data and cycling." *Transport Reviews* 36 (1):114–33.

Schor, J. 2016. "Debating the sharing economy." *Journal of Self-Governance and Management Economics* 4 (3):7–22.

Shaheen, S. A., N. D. Chan, and T. Gaynor. 2016. "Casual carpooling in the San Francisco Bay Area: Understanding user characteristics, behaviors, and motivations." *Transport Policy* 51:165–73.

Shaheen, S., A. Cohen, I. Zohdy, and B. Kock. 2016. "Smartphone applications to influence travel choices: practices and policies." https://trid.trb.org/view/1415732.

Shaheen, S., & Chan, N. 2016. "Mobility and the sharing economy: Potential to facilitate the first- and last-mile public transit connections." *Built Environment* 42(4): 573–588.

Shaheen, S., Chan, N., Bansal, A., and Cohen, A. 2015. "Definitions, Industry Developments, and Early Understanding" Berkeley, CA: University of California Berkeley Transportation Sustainability Research Center. http://innovativemobility. org/wp-content/uploads/2015/11/SharedMobility_WhitePaper_FINAL. pdf.

Shaheen, Susan A, Nelson D Chan, and Helen Micheaux. 2015. "One-way carsharing's evolution and operator perspectives from the Americas." *Transportation* 42 (3):519–36.

Shaheen, Susan, Stacey Guzman, and Hua Zhang. 2012. "Bikesharing across the globe." In *City cycling*, edited by John Pucher and Ralp Buehler, 183–210. Cambridge, MA: The MIT Press.

Shin, Eun Jin. 2017. "Ethnic neighborhoods, social networks, and inter-household carpooling: A comparison across ethnic minority groups." *Journal of Transport Geography* 59:14–26.

Stiglic, M., N. Agatz, M. Savelsbergh, and M. Gradisar. 2016. "Making dynamic ride-sharing work: The impact of driver and rider flexibility." *Transportation Research Part E: Logistics and Transportation Review* 91:190–207.

Sun, Y., A. Mobasheri, X. Hu, and W. Wang. 2017. "Investigating impacts of environmental factors on the cycling behavior of bicycle-sharing users." *Sustainability* 9 (6):1–12.

Victoria Transport Policy Institute, 2013. "Online TDM Encyclopedia, updated March 2013." Retrieved from http://www.vtpi.org/tdm/index.php (retrieved 06.01.19).

Vine, S. L., O. Adamou, and J. Polak. 2014. "Predicting new forms of activity/mobility patterns enabled by shared-mobility services through a needs-based stated-response method: Case study of grocery shopping." *Transport Policy* 32 (32):60–8.

Vogel, M., R. Hamon, G. Lozenguez, L. Merchez, P. Abry, J. Barnier, P. Borgnat, P. Flandrin, I. Mallon, and C. Robardet. 2014. "From bicycle sharing system movements to users: A typology of Vélo'v cyclists in Lyon based on large-scale behavioural dataset." *Journal of Transport Geography* 41:280–91.

Wang, R. 2011. "Shaping carpool policies under rapid motorization: The case of Chinese cities." *Transport Policy* 18 (4):631–5.

Wang, Y., S. Winter, and N. Ronald. 2017. "How much is trust: The cost and benefit of ridesharing with friends." *Computers Environment and Urban Systems* 65:103–12.

Wu, F., Y. Geng, X. Tian, S. Zhong, W. Wu, S. Yu, and S. Xiao. 2018. "Responding climate change: A bibliometric review on urban environmental governance." *Journal of Cleaner Production* 204:344–54.

Wuerzer, T., and S. G. Mason. 2016. "Retail gravitation and economic impact: A market-driven analytical framework for bike share station location analysis in the United States." *International Journal of Sustainable Transportation* 10 (3):247–59.

Xiao, L. L., T. L. Liu, and H. J. Huang. 2016. "On the morning commute problem with carpooling behavior under parking space constraint." *Transportation Research Part B: Methodological* 91:383–407.

Xu, H., F. Ordóñez, and M. Dessouky. 2015. "A traffic assignment model for a rideshared transportationation market." *Journal of Advanced Transportation* 49 (7):793–816.

Yang, M., X. Liu, W. Wang, Z. Li, and J. Zhao. 2015. "Empirical analysis of a mode shift to using public bicycles to access the suburban metro: Survey of Nanjing, China." *Journal of Urban Planning and Development* 142 (2):05015011.

Yang, R., and R. Long. 2016. "Analysis of the influencing factors of the public willingness to participate in public bicycle projects and intervention strategies—A case study of Jiangsu Province, China." *Sustainability* 8 (4):1–16.

Yu, B., Y. Ma, M. Xue, B. Tang, B. Wang, J. Yan, and Y. M. Wei. 2017. "Environmental benefits from ridesharing: A case of Beijing." *Applied Energy* 191:141–52.

Zaltz, A. M., O. O'Brien, E. Strano, and M. Viana. 2013. "The structure of spatial networks and communities in bicycle sharing systems." *PLoS ONE* 8 (9):e74685.

Zhang, L., J. Zhang, Z. Y. Duan, and D. Bryde. 2015. "Sustainable bike-sharing systems: Characteristics and commonalities across cases in urban china." *Journal of Cleaner Production* 97:124–33.

Zhang, S., K. He, S. Dong, and J. Zhou. 2016. "Modeling the distribution characteristics of urban public bicycle rental duration." *Discrete Dynamics in Nature and Society* 2016 (6):1–9.

Zhang, Y., T. Thomas, M. Brussel, and M. V. Maarseveen. 2017. "Exploring the impact of built environment factors on the use of public bikes at bike stations: Case study in Zhongshan, China." *Journal of Transport Geography* 58:59–70.

Zhou, G., Z. Liu, W. Shu, T. Bao, L. Mao, and D. Wu. 2017. "Smart savings on private car pooling based on internet of vehicles." *Journal of Intelligent & Fuzzy Systems* 32 (5):1–12.

Zhou, J. 2012. "An analysis of university employee car-sharers in Los Angeles." *Transportation Research Part D: Transport and Environment* 17 (8):588–91.

Zhou, X. 2015. "Understanding spatiotemporal patterns of biking behavior by analyzing massive bike sharing data in Chicago." *PLoS ONE* 10 (10):e0137922.