

Article

Why Shared Bikes of Free-Floating Systems Were Parked Out of Order? A Preliminary Study based on Factor Analysis

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Abstract: Free-floating bicycle-sharing systems are an important component of sustainable transport. China's bicycle-sharing schemes have experienced ups and downs in the past three years, and there are a lot of related studies, but there are relatively few studies on the causes of disorderly parking of shared bikes. In this study, an open questionnaire is used to widely collect the causes of the disorderly parking of shared bicycles from users. Through factor analysis, six factors and 32 criteria for the causes of disorderly parking are constructed. Factor 1 'supervision and management of enterprises'; factor 2 'supervision and management of users'; factor 3 'parking space'; factor 4 'guidance of parking shared bikes'; factor 5 'user self-discipline'; factor 6 'operation and maintenance'. It requires the cooperation of multiple parties to solve the problem of disorderly parking of shared bicycles.

Keywords: Free-Floating Bike-sharing Systems; causes of disorderly parking; factor analysis

1. Introduction

As global warming intensifies, countries around the world have begun to save energy and reduce emissions to slow down global warming. At the Copenhagen Summit (2009 United Nations Climate Change Conference), the Chinese government made commitment to reduce carbon emissions and then opened the curtain for sustainable development. Alonso et al. [1] stated that in urban areas, where pollutants and consequently the impacts generated by unsustainable transport structure exist in a concentrated way, the sustainable mobility is a prerequisite of achieving sustainable cities. Transport systems are key elements of urban areas. Therefore, their sustainability has a pivotal role in achieving complex urban sustainability [2–4]. In China, where the population base is large, the amount of carbon dioxide produced by people in the daily transportation demand process should not be underestimated. Therefore, encouraging people to use public transport and develop a sustainable transportation system can effectively reduce carbon emissions.

Since the 1960s, Western countries have gradually realized the adverse factors such as traffic congestion, air pollution, and noise pollution caused by excessive motor vehicles, and they gradually began to realize the importance of bicycles in the transportation system. In the 1970s, the Dutch government improved bicycle transportation facilities in order to create a good bicycle traffic environment and return bicycles to people's lives. In the 1980s, the Federal Ministry of Transport and the Federal Ministry of Regional Planning, Building and Urban Development jointly promoted environmentally friendly traffic management strategies, including the integration of bicycles and public transportation systems [5]. In 2010, a National Cycling Plan has been drawn out with a vision of developing a cyclist-friendly, well-connected network, providing safe and healthy cycling for all [6]. Bicycle-sharing schemes are also called "Public-Use Bicycles" (PUBs), "Bicycle Transit", "Bikesharing"

or “Smart Bikes”, bicycle-sharing schemes comprise short-term urban bicycle rental schemes that enable bicycles to be picked up at any self-serve bicycle station and returned to any other bicycle station, which makes bicycle-sharing ideal for point-to-point trips [7,8]. China used to be named the “Kingdom of Bicycles” due to the nation’s heavy reliance on cycling for mobility given the relatively low income of its citizens, compact urban development, and short trip distances in the 1970s [9]. However, China’s bicycle ownership has declined year by year with its economic growth, popularity of motor vehicles, the longer distance of travel and the deterioration of the riding environment. For instance, average bicycle ownership in Chinese cities declined from 197 bikes/hundred households in 1993 to 113 bikes/hundred households in 2007 [10]. In light of growing traffic congestion and environmental concerns, the Chinese Ministry of Housing and Urban-Rural Development opposed bicycle use restrictions and supported tackling cycling barriers since 2007 [9]. The development of bicycle-sharing schemes in China has gone through three generations. The first-generation bicycle-sharing schemes were provided and managed by various local governments. It is required to apply for the designated IC card, and all fleets should be picked up and return to fixed stations. Most of the second-generation bicycle-sharing schemes were public-private partnership projects, the bicycle was used in a similar way to the first generation and the representative was Yonganxing. The third-generation bicycle-sharing schemes started since 2015. In addition to the advantages of flexible mobility, emission reductions, physical activity benefits, reduced congestion and fuel use, individual financial savings and support for multimodal transport connections [11], it also has the convenience features of digital registration, mobile payment, low cost and refundable deposit at any time. It provided a better solution to the problem of first/last mile of people’s travel and became a popular travel mode in a short time (Figure 1 [12]).

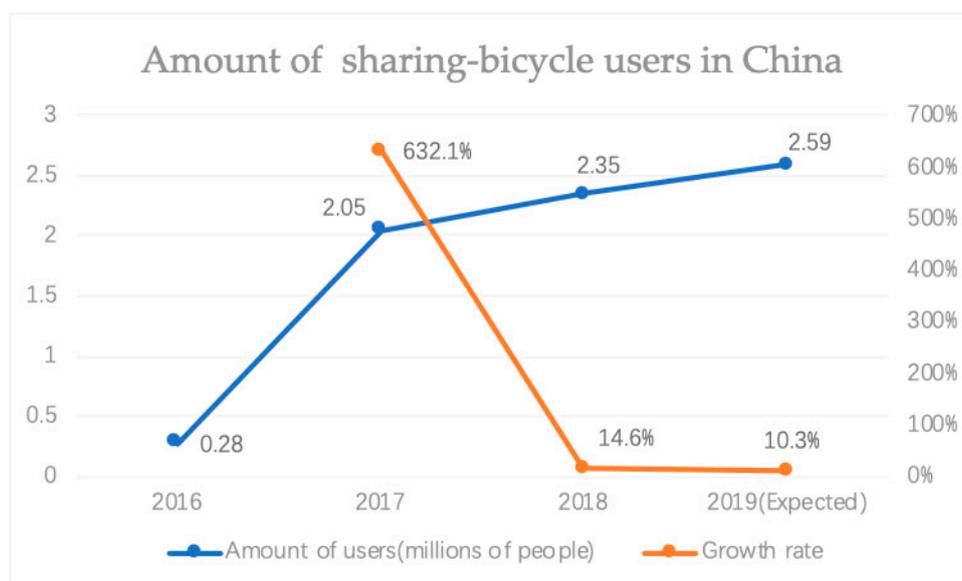


Figure 1. Amount of sharing-bicycle users in China [12].

In the past few decades, bicycle-sharing schemes around the world have been constantly evolving, but researches relative to bicycle-sharing schemes began roughly after 2000. The development of bicycle-sharing schemes is divided into four generations, their study sums the characteristics, problems and development process of the first three generations of shared bikes [11,13,14]. Then they point out the characteristics that the fourth generation shared bikes should have. DeMaio believes that the problems encountered by the first three generations of shared bikes include theft, inappropriate private use and anonymity. So the fourth generation bicycle-sharing schemes can put more effort into distribution of bikes, installation, powering of stations, tracking, offering pedelec (pedal assistance) bikes and new business models to improve efficiency, sustainability and usability [13]. Shasheen says that new bicycle-sharing schemes must pay attention to theft and vandalism, bicycle redistribution, information

systems, insurance and liability consideration, and prelaunch consideration. The future bicycle-sharing schemes should focus more on: (a) flexible, clean docking stations; (b) bicycle redistribution innovations; (c) smartcard integration with other transportation modes, such as public transit and carsharing; and (d) technological advances including Global Positioning System (GPS) tracking, touch screen kiosks, and electric bikes [11]. Both of the seniors' researches gave suggestions on the macro direction and the detailed procedure as a development reference for the future bicycle-sharing schemes.

DeMaio [13] and Bührmann [15] divide bicycle-sharing schemes into different models depending on the business entity. The six business entities are: government, transport agency (quasi-governmental), university, non-profit organizations (e.g., foundation or advocacy group), advertising company, for-profit organizations. These business models can be divided into two orientations: public orientation and private orientation, the for-profit model is the most private one (Figure 2). In this model, service provided by private companies should have limited or no government involvement. But if the private company used a fixed, versus flexible, system, it would need to have the local government's support to use the public space. This model is widely adopted by Chinese bicycle-sharing companies.

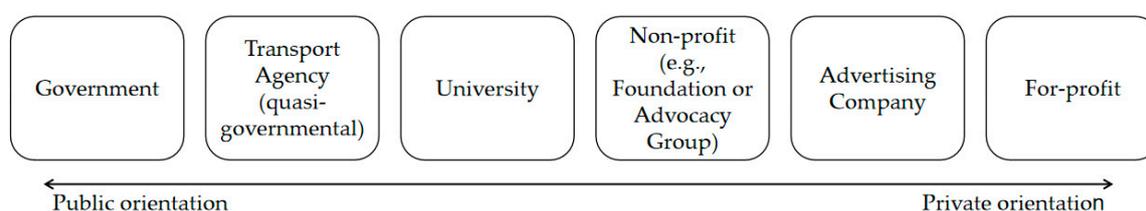


Figure 2. Different business models of bicycle-sharing schemes [13].

With the experience of previous bicycle-sharing schemes, China's bicycle-sharing schemes should be planned according to the standards of the fourth generation shared bicycles. However, the market results showed that China's shared bicycle-sharing schemes still encountered various problems in previous schemes. Due to social media's frequent exposure of disorderly parking, vandalism, theft, and wasting resources, the bicycle-sharing industry was pushed to the forefront and aroused the attention of all sectors of society. Among these problems, some of the problems have been analyzed by previous researchers and the corresponding countermeasures and suggestions are given. However, the problem of disorderly parking is rarely mentioned by scholars. Due to the failure of 'White Bikes' in Holland in 1965, most of the bicycle-sharing systems developed in early Europe and North America had parking stations, so they seldom encountered the problem of disorderly parking. In China, where free-floating bike-sharing systems are a big part of recent bicycle-sharing schemes, the problem of disorderly parking is particularly acute. In this research, the disorderly parking can be understood as users park the shared bikes out of the designated parking space. Therefore, the purposes of this study are as follows:

1. To widely collect the reasons for disorderly parking of shared bikes through the questionnaire survey of users, the results of the questionnaires are collated and analyzed as a basis for the subsequent research;
2. To construct the structure and factors of disorderly parking of shared bikes through factor analysis, and propose suggestions for improvement according to the results.

2. Methods

The first phase of the study focused on collecting the reasons for the disorderly parking of shared bikes as much as possible. Since the disorderly parking situation of shared bikes has appeared in China in recent years, and there are no foreign cases for reference, so the related research we can find is very limited. Therefore, this study used an open-ended questionnaire to ask respondents to fill in five reasons they thought would cause the disorderly parking of shared bikes in the first phase. During the period from December 20, 2018 to January 8, 2019, the users with experience of using shared bikes were invited to fill in an online questionnaire. The second online questionnaire was conducted

between 8 May 2019 and 11 May 2019. The questionnaire design includes two parts: the reasons for disorderly parking of shared bikes and basic information of respondents. There are a total of 42 items of reasons, which are obtained from result of the first-phase questionnaire. Basic information of respondents includes gender, age, education level, city, area of use (downtown, outside the downtown but within the suburbs, the suburbs), frequency of using shared bikes [16], motivation of using shared bikes (commuting, leisure and social activities “outing, group travel, etc.,” exercise, personal affairs “shopping, eating, etc.,” and others) [17], time of using shared bikes (weekdays or weekends), whether have the experience of disorderly parking, the frequency of disorderly parking. The 5-point scale was used in the questionnaire, with 1 being strongly disapproving and 5 being strongly approving. The respondents of both questionnaires are users who have the experience of using shared bikes in China. The respondents in this study are invited by the authors and their classmates. Respondents filled in the answers through the hyperlink of the online questionnaire. The basic variables of the questionnaire also investigated the frequency of using shared bikes, and the results showed that all respondents had experience in using shared bikes.

3. Results and Discussion

3.1. Descriptive Analysis of the First-Phase Questionnaire

A total of 240 questionnaires were collected, and 235 of them were valid questionnaires, the effective rate is 97.9%. The questionnaires with too many missing values and obvious deviation from the topic were considered as invalid. A total of 1004 valid items were obtained after collecting all the responses of respondents, 118 initial items were obtained after merging the similar-expression items. In the discussion part, all the items will be shown in the format of ‘item description (frequency)’. All the items are sorted directly from the original content of the respondents’ questionnaires.

After sorting out respondents’ answers, we found that although some respondents’ answers were different in expressions, they essentially described the same problem, so it is necessary to further combine such items. For better analysis of the items, we classified the items according to the main content discussed by the items after the semantic judgment of the items. All items were divided into six categories, including ‘user-related problems’, ‘rules and regulations’, ‘rewards and punishment for users’, ‘supervision and management issues’, ‘parking facilities’ and ‘social advocacy’, and the rest were discussed separately. The detailed process is as follows.

The first category is about users, including: for users’ own convenience (75 times), users tended to follow the trend and crowd (45 times), users’ didn’t have time to find parking area(79 times), user quality problem(128 times), users don’t care (6 times), personal habits (11 times), users are not conscious (12 times), no awareness of parking or no public awareness (29 times), users put shared bikes down stairs (once), laziness (15 times), bikes aren’t their owns, so users don’t care (8 times), users were not responsible (12 times), users forgot to park bikes in order (once), high user arbitrariness (twice), users were not familiar with the rules of parking (12 times), moral deficiency (13 times), users(who parked bikes out of order) were not punished (twice), user deliberate (16 times), users were not satisfied with the service of the bicycle-sharing companies, so they deliberately retaliated (once), parking bikes was inconvenient (twice), users didn’t obey the regulations (once), without damaging the bikes, it was users’ right and freedom to decide where and how to park the bike (once), users thought it was unnecessary to park bikes in order (twice), park nearby (once), and users were worried about shared bikes will be taken away by others, so they hid shared bikes for their own use (five times).

- a. For users’ own convenience is a statement covered a lot, so a lot of other items can be incorporated into it. In this study, ‘parking bikes was inconvenient’, ‘park nearby’, ‘put shared bikes down stairs’, and ‘users were worried about shared bikes will be taken away by others, so they hid shared bikes for their own use’ are all incorporated into for users’ own convenience.

- b. Users' didn't have time to find parking area. In addition to the situation that the users are really in a hurry, it may also be because the user is unwilling to find a parking area or users can't find the parking area in a short time.
- c. Users tended to follow the trend and crowd. This is one of the important factors that respondents believe to cause disorderly parking of shared bikes. Lots of users saw or felt that other users didn't park their shared bikes according to the regulations, so they imitated them, which eventually led to a large range of disorderly parking of shared bikes.
- d. Shared bicycle users also need to bear certain responsibilities while enjoying the convenience brought by shared bicycles. The responsibilities can be divided into legal responsibility and moral responsibility. Bicycle-sharing schemes are newly developed things, and the development of corresponding laws and regulations is impossible to keep up with the development of the industry in a short time, which means the self-discipline of enterprises and users is required. 'Bikes don't belong to users', 'so users don't care', 'users were not responsible', and 'users thought it was unnecessary to park bikes in order' indicate that users subjectively believe that the shared bikes are no longer their business after use, and they don't need to bear corresponding responsibility. 'High user arbitrariness' and 'users forgot to park bikes in order' also reflect that users didn't pay enough attention to parking shared bikes in order after use. This study merges the above items into 'users don't attach enough importance to parking shared bikes in order'.
- e. User quality problem. Bicycle-sharing schemes have been described by the media as the mirror for the quality of the civil, a large number of disorderly parking does reflect the national quality need to be improved.
- f. Personal habits indicate that users may not change the old parking habits and they won't follow the current parking specifications of shared bikes. The habit of parking in order didn't fully spread indicates that the normative parking behavior of shared bicycles is not yet widespread, and users need some time to adapt to the new parking specifications. These two items are integrated into 'users need time to get rid of the old parking habits'.
- g. No awareness of parking, no public awareness. Users themselves do not have the awareness to park shared bikes in order, nor have they been trained to do so, leading to a weak awareness of parking shared bikes in order.
- h. Laziness. In many cases, users are not willing to park shared bikes in order just because they are lazy.
- i. Users were not familiar with the rules of parking. On the one hand, it reflects that users, as the subject, didn't not take the initiative to understand the relevant rules of parking shared bikes; on the other hand, the bicycle-sharing companies didn't effectively promote the rules of parking shared bikes to users, or the rules of parking shared bikes were not perfect. This study focuses on the former here, and the latter will be discussed in a later section. So, this item is changed to 'users didn't take the initiative to understand the relevant rules of parking shared bikes'.
- j. Users who parked bikes out of order were not punished. This item indicates that the punishment for users' illegal parking behavior was not completely implemented, and also reflects that users have some fluke mind. In this section, we focus on the latter, so this item is modified to 'users were not punished, so they had fluke mind'.
- k. Without damaging the bikes, it was users' right and freedom to decide where and how to park the bike. Users of shared bikes must take corresponding responsibilities when obtaining the right to use shared bikes, so users should use and park shared bikes according to the regulations. Therefore, this item won't be discussed separately in this study.
- l. Users couldn't find parking area. The reasons why users can't find the parking area can be roughly divided into the following categories. Firstly, there is no parking area near users' destination; secondly, the guidance system of parking area is not clear, which will be discussed

in the latter section; thirdly, users own reasons such as: lack of time, laziness or some other reasons. Therefore, this item is divided to discuss in other items.

After discussion, the first category reasons for disorderly parking are shown in Table 1.

Table 1. First category reasons for disorderly parking.

No.	Items
a	For users' own convenience
b	Users tended to follow the trend and crowd
c	Users' didn't have time to find parking area
d	User quality problem
e	Users need time to get rid of the old parking habits
f	No awareness of parking, no public awareness
g	Laziness
h	Users don't attach enough importance to parking shared bikes in order
i	Users didn't take the initiative to understand the relevant rules of parking shared bikes
j	Users were not punished, so they had fluke mind

The second category is about rules and regulations. Due to the rapid development of the bicycle-sharing industry, many local governments were unable to develop management regulations, and there were also no related regulations of parking shared bikes provided by bicycle-sharing companies. Items of second category are as follows: no relevant constraints (once), integrity system was not established completely (three times), lack of government management practice (three times), there was no corresponding management mechanism (13 times), insufficient regulations binding (once), there were no clear parking specifications (12 times), incomplete laws (8 times).

- a. 'Lack of government management practice' was included in 'there was no corresponding management mechanism', so they were discussed together. To solve the problem of disorderly parking of shared bikes, the government needs to guide both bicycle-sharing companies and users of shared bikes, and bicycle-sharing companies also need to restrain users [18]. Therefore, these two items are divided into 'the government lacks enterprises management regulations' and 'bicycle-sharing companies lacks user management regulations'.
- b. Same as above, 'insufficient regulations binding' can be divided into 'government's management regulations for enterprises has insufficient binding force' and 'bicycle-sharing companies' management regulations for users has insufficient binding force'.

After discussion, the second category reasons for disorderly parking are shown in Table 2.

Table 2. Second category reasons for disorderly parking.

No.	Items
a	There were no relevant constraints on parking shared bikes
b	Integrity system was not established completely
c	The government lacks enterprises management regulations
d	Bicycle-sharing companies lacks user management regulations
e	Government's management regulations for enterprises has insufficient binding force
f	Bicycle-sharing companies' management regulations for users has insufficient binding force
g	There were no clear parking specifications
h	Incomplete laws

The third category is about rewards and punishment for users, including the following: violation cost was low (twice), no punishment (39 times), the accountability of users was not well investigated and affixed (once).

a. 'No punishment' is a representation of 'violation cost was low'. These two items are combined into 'The penalty for users' violation of parking is not enough'.

After discussion, the third category reasons for disorderly parking are shown in Table 3.

Table 3. Third category reasons for disorderly parking.

No.	Items
a	The penalties for users' violation of parking is not enough
b	The accountability of users was not well investigated and affixed

The fourth category is supervision and management issues, including: No supervision and management (50 times), inadequate participation of managers (11 times), the government didn't pay enough attention (3 times), carrier management problem (10 times), the city administration is not in place (7 times), little follow-up guarantee was invested in bicycle-sharing schemes (3 times), no specific management staff (4 times), city management (once), governments' and bicycle-sharing companies' administration was not in place (12 times), disordered management (once), insufficient municipal management (twice), there were none staff managing parking area (4 times), lack of forward-looking for new things (once), immature management system (manual management and system management) (once), poor planning by providers (once), there were too many shared bikes (18 times), bicycle-sharing companies were not good at vehicle management (repair of damaged vehicle) (9 times), concentrated parking in certain periods (especially at noon and night near the school) (once), intense industry competition (4 times).

- a. The expression of 'No supervision and management' is too succinct. The government has the responsibility to supervise and manage the bike-sharing companies, bike-sharing companies have the responsibility to supervise and manage users of shared bikes, and the government has a duty of supervision over the users of shared bikes. Insufficient municipal management, the government didn't pay enough attention, the city administration is not in place, city management, insufficient municipal management, carrier management problem, governments' and bicycle-sharing companies' administration was not in place, all these items are about government and business management and supervision. Three new items derived from the above items are as follows: The government has no supervision and management of bike-sharing companies, bike-sharing companies have no supervision and management of users of shared bikes, the government has no supervision of users of shared bikes.
- b. 'Inadequate participation of managers' can be understood as there are not enough managers and managers in 'inadequate participation of managers' can be divided into managers in government and managers in enterprises. In addition, 'there were none staff managing parking area' also shows the problem of insufficient number of managers in government or bicycle-sharing companies. Therefore, this study will discuss this problem from the perspective of insufficient number of managers, which can be divided into 'insufficient number of government managers' and 'insufficient number of bicycle-sharing company managers'.
- c. The meaning of 'little follow-up guarantee was invested in bicycle-sharing schemes' is the maintenance and management of shared bikes is not in place, which is consistent with the content of 'bicycle-sharing companies were not good at vehicle management (repair of damaged vehicle)' and 'concentrated parking in certain periods (especially at noon and night near the school)'. Therefore, the above items are sorted as follows: 'The bicycle-sharing companies can't maintain the damaged bikes in time' and 'the vehicle distribution policy of bicycle-sharing companies is unreasonable'.
- d. 'Disordered management' and 'immature management system (manual management and system management)' not only point out the management of government and bicycle-sharing companies isn't in place, but also vaguely reveal that the division of responsibility for management of shared

bikes within the government is not clear. 'No specific management staff' is catered to the content of previous items. Therefore, these two parts are sorted into 'the division of responsibility for management of shared bikes within the government is not clear'.

- e. The providers in 'poor planning by providers' can be the government or bicycle-sharing companies. If the provider referred to the government, it can be understood that the government's control measures for the scale of the bicycle-sharing market are not in time, which is consistent with 'lack of forward-looking for new things'. If the provider referred to bicycle-sharing companies, it can be understood combined with 'there were too many shared bikes' and 'intense industry competition' that bicycle-sharing companies put excessive amount of shared bikes in order to gain more market share. In this study, the items above are summarized as 'the government's control measures for the scale of the bicycle-sharing market are not in time' and 'bicycle-sharing companies put excessive amount of shared bikes'.

After discussion, the fourth category reasons for disorderly parking are shown in Table 4.

Table 4. Fourth category reasons for disorderly parking.

No.	Items
a	The government has no supervision and management of bike-sharing companies
b	Bike-sharing companies have no supervision and management of users of shared bikes
c	The government has no supervision of users of shared bikes
d	Insufficient number of government managers
e	Insufficient number of bicycle-sharing companies managers
f	The bicycle-sharing companies can't maintain the damaged bikes in time
g	The vehicle distribution policy of bicycle-sharing companies is unreasonable
h	The division of responsibility for management of shared bikes within the government is not clear
i	The government's control measures for the scale of the bicycle-sharing market are not in time
j	Bicycle-sharing companies put excessive amount of shared bikes

The fifth category of reasons center on parking facilities, including: no dedicated parking area (82 times), parking area was full (12 times), the bicycle-sharing companies didn't provide parking space (twice), there was little parking area (33 times), the parking area is far away (17 times), there were no more reasonable parking areas allocated (5 times), unreasonable setting of parking area (9 times), the parking space was occupied (once), street vendors occupied the parking area (once), poor design of bicycle parking (3 times), lack of fixed parking area (twice), the parking area was not clearly defined (5 times), the parking area was narrow (5 times), there were no suitable places for parking bikes (once), the parking area was too concentrated (3 times), the place was inappropriate for parking bikes (once), there was no specific position for parking bikes (once), urban planning problem (twice), the place was remote (twice), the sidewalk was narrow (once), the signs of parking area were not eye-catching (5 times), irregular parking area arrangement (once), the parking area is not big enough (twice), there was no electronic fence (once), the parking space was little (twice), parking facility (once), limitation of road conditions (once). In China, most cities take bicycle parking space into consideration at the beginning of planning. A small number of bicycles would be parked on the sidewalk when there is no bicycle parking space. Although it would not cause too much trouble when the amount of shared bikes is small, the original bicycle parking space in the city cannot meet the parking demand of users of shared bicycles after the rapid growth of bicycle-sharing industry, so a large number of Shared bicycles are parked out of order. Shared bicycle is actually a kind of private goods with public properties, whose ownership belongs to the for-profit bicycle-sharing company. However, shared bicycles play an active role in the public transportation system, especially in the slow traffic transportation system, which makes it have certain public attributes. Therefore, the government and bicycle-sharing companies should work together to solve the problems of facilities and parking area of shared bikes instead of either of them taking all the responsibilities.

- a. 'No dedicated parking area', 'the bicycle-sharing companies didn't provide parking space', 'lack of fixed parking area', 'there were no suitable places for parking bikes', and 'there was no specific position for parking bikes' all show that 'there was no dedicated parking space for shared bikes'.
- b. 'Parking area was full', 'there was little parking area', 'there were no more reasonable parking areas allocated', 'the parking area was narrow', 'the parking area is not big enough', and 'the parking space was little' all indicate that 'the capacity of shared bikes parking space is insufficient'.
- c. 'The parking area is far away', 'poor design of bicycle parking', 'the parking area was too concentrated', 'the place was inappropriate for parking bikes', 'urban planning problem', 'the place was remote', and 'irregular parking area arrangement' all show that 'the setting of shared bikes parking area is unreasonable'.
- d. 'Street vendors occupied the parking area' and 'the parking space was occupied' are telling the same truth.
- e. 'The sidewalk was narrow' and 'limitation of road conditions': In those areas without designated parking space, it is customary for users to park shared bikes on sidewalks. These two items contains two aspects: on the one hand, the parking area has not been set up, on the other hand, the capacity of parking space is in sufficient.
- f. The parking space of shared bikes should not only have clear mark of margin on the ground, but also have eye-catching guiding signs for users to find it. 'The signs of parking area were not eye-catching' is modified to 'the guiding signs of parking space is not eye-catching' for better understanding.
- g. The meaning of 'parking facility' is vague, which is limited to the parking facilities of shared bikes in this study. Parking facilities of shared bicycle mainly include shared bicycle parking space, guiding signs of parking space, etc., which are similar to the above items. Therefore, this item will not be repeated in the follow-up study.

After discussion, the fifth category reasons for disorderly parking are shown in Table 5.

Table 5. Fifth category reasons for disorderly parking.

No.	Items
a	There was no dedicated parking space for shared bikes
b	The capacity of shared bikes parking space is insufficient
c	The setting of shared bikes parking area is unreasonable
d	The parking space was occupied
e	The parking area was not clearly defined
f	The guiding signs of parking space is not eye-catching
g	There was no electronic fence

The sixth category is about social advocacy, including: social atmosphere (3 times), influence of users' surrounding environment (twice), users are affected by people who have previously parked bikes out of order (twice), influence of the disorderly parking of bicycles and motorcycles (4 times), the habit of parking in order hasn't fully spread (twice), ineffective social supervision (once), the whole society doesn't care (once), the user wasn't discouraged by others (once), people turn a blind eye to the phenomenon of disorderly parking (twice), insufficient government and media promotion (26 times), insufficient education of parking in order (twice), bicycle-sharing schemes firstly promoted as 'shared bikes can be picked up and parked anywhere and anytime' (5 times), the bicycle-sharing companies didn't explicitly remind users to park in order (3 times), lack of reporting platform for easy reporting (once).

- a. Wikipedia defines social atmosphere as the sum of the customs, cultural traditions, behavioral patterns, moral values, and fashion elements of a given society. In the past period of time, the phenomenon of disorderly parking of shared bikes can be seen everywhere, which is indeed a kind of behavior jointly presented by the whole society. ‘Influence of users’ surrounding environment’, ‘users are affected by people who have previously parked bikes out of order’ and ‘influence of the disorderly parking of bicycles and motorcycles’ are incorporated into ‘social atmosphere’ due to similar meaning.
- b. ‘The whole city didn’t care’ is consistent with ‘people turn a blind eye to the phenomenon of disorderly parking’, which reflects the ‘lack of social supervision’. Also, ‘lack of reporting platform for easy reporting’ is one of the causes of lack of social supervision.
- c. After using shared bikes, users tend to park shared bikes in the place according to their old habits. They would park shared bikes in the place they thought right, they would also park the shared bikes nearby for their convenience. However, the users of shared bicycles do not have the ownership of the bicycles. Instead, they have obtained the right to use the shared bicycles within a certain period of time from the bicycle-sharing companies according to the rules of use, so they shall comply with the corresponding rules. The government, social media and bicycle-sharing companies should work together to carry out propaganda on parking shared bikes in order to help regulate users parking behavior. Therefore, ‘insufficient government and media promotion’ is modified to ‘government’s, social media’s and bicycle-sharing companies’ propaganda on parking shared bikes in order is not in place’.
- d. “Bicycle-sharing schemes firstly promoted as ‘shared bikes can be picked up and parked anywhere and anytime’” reflects the advantages of shared bikes for short trips, but there are limits to ‘park anywhere and anytime’, so there is misleading in initial propaganda of bicycle-sharing companies.

After discussion, the sixth category reasons for disorderly parking are shown in Table 6.

Table 6. Sixth category reasons for disorderly parking.

No.	Items
a	Influence of social atmosphere
b	Lack of social supervision
c	Lack of reporting platform for easy reporting
d	Government’s, social media’s and bicycle-sharing companies’ propaganda on parking regulations is not in place
e	The bicycle-sharing companies didn’t explicitly remind users to park in order
f	There is misleading in initial propaganda of bicycle-sharing companies

‘Bikes were moved away by others’ (4 times), ‘there was something wrong with bicycle positioning’ (once), ‘the bicycle-sharing market was not optimistic’ (once), ‘weather problems such as strong winds’ (4 times), ‘users didn’t put shared bikes back in place’ (once), ‘the bike was not parked in order at the beginning’ (twice), accidental situation (once), ‘the bike fleet was broken’ (12 times), ‘the bike was not comfortable to ride’ (once), ‘the bike is hard to ride and need to be changed’ (twice), ‘shared bikes are easy to get’ (once), ‘no cohesion’ (once), “users’ destinations were diverse” (once), ‘the allocation of road rights of shared bikes was not clear’ (once), ‘limitation of road conditions’ (once), ‘the security guard was not responsible enough, so users could park the shared bikes in the community’ (once), ‘temporary parking’ (once), ‘poor traffic condition’ (once), ‘the bike was not parked steadily, then it toppled’ (once), ‘the market was not mature and perfect in all aspects’ (once), ‘the bikes should set reminders for users’ (once) are difficult to be classified into one of the above categories, so they are discussed separately.

- a. ‘Weather problems such as strong winds’ do cause trouble for users to use and park shared bikes. In addition to strong winds, heavy rains and snow weather will cause the same problem.

Therefore, this item is adjusted to ‘weather condition, which makes it impossible for users to use the shared bike as usual’.

- b. ‘The bike fleet was broken’, ‘there was something wrong with bicycle positioning’, ‘users didn’t put shared bikes back in place’, and ‘the bike is hard to ride and need to be changed’ can be summarized as ‘the shared bike is damaged, so users can’t park it in order’.
- c. ‘Temporary parking’ is a common scenario when users using shared bikes.
- d. The remaining items of this category will not be discussed in this study due to their trivial content and low relevance to the content of this paper.

After discussion, the seventh category reasons for disorderly parking are shown in Table 7.

Table 7. Seventh category reasons for disorderly parking.

No.	Items
a	Weather condition, which makes it impossible for users to use the shared bike as usual
b	The shared bike is damaged, so users can’t park it in order
c	Temporary parking

In addition to the internal reasons for users cause the disorderly parking of shared bikes, the above part also discusses the external factors that lead to disorderly parking of shared bikes. In the special case of disorderly parking of shared bikes in China, Qin Zheng and Wang Qin [18] put forward the model of collaborative governance of government, market and society. They propose that the government should guide the market and society, and the market should restrain society, among which the market society respectively refer to bicycle-sharing companies and users. Therefore, this study firstly integrates and classifies the questions based on the content of the questions, and then reintegrates the answers of the interviewees through the relationship of the government, enterprises and users to remove the repeated content in the repeated questions, so as to construct the next questionnaire.

- a. Considering that the bicycle-sharing industry is a recent development industry, ‘insufficient number of government managers’ can be recognized as the result of ‘the division of responsibility for management of shared bikes within the government is not clear’. Therefore, these two items are merged into ‘the division of responsibility for management of shared bikes within the government is not clear’.
- b. ‘The bicycle-sharing companies can’t maintain the damaged bikes in time’ are modified to ‘the bicycle-sharing companies can’t maintain the damaged vehicle properly’ for better understanding.
- c. Laws can be understood as stricter regulations. Thus, the meaning of ‘incomplete laws’ is included in ‘the government lacks enterprises management regulations’. ‘The government has no supervision and management of bike-sharing companies’ has two scenarios. Firstly, the government has no rules to follow. Secondly, the government has rules to follow, but the enforcement is weak. Therefore, it is modified to ‘the government’s enforcement of business regulations is weak’.
- d. ‘The government has no supervision of users of shared bikes’, ‘incomplete laws’, ‘the government has no supervision of users of shared bikes’ can be included in ‘there were no relevant constraints on parking shared bikes’, which is too vague for respondents to understand. So, ‘there were no relevant constraints on parking shared bikes’ is replaced by the three more specific items.
- e. ‘Bike-sharing companies have no supervision and management of users of shared bikes’ was removed from this study because the content of this item is a summary of other items, such as ‘bicycle-sharing companies lacks user management regulations’, ‘the bicycle-sharing companies didn’t explicitly remind users to park in order’ and so on.

All reasons for disorderly parking of shared bikes are shown in Table 8.

Table 8. All reasons for disorderly parking of shared bikes.

No.	Items
VAR1	For users' own convenience
VAR2	Users tended to follow the trend and crowd
VAR3	Users' didn't have time to find parking area
VAR4	User quality problem
VAR5	Users need time to get rid of the old parking habits
VAR6	No awareness of parking, no public awareness
VAR7	Laziness
VAR8	Users don't attach enough importance to parking shared bikes in order
VAR9	Users didn't take the initiative to understand the relevant rules of parking shared bikes
VAR10	Users were not punished, so they had fluke mind
VAR11	The division of responsibility for management of shared bikes within the government is not clear
VAR12	The government's control measures for the scale of the bicycle-sharing market are not in time
VAR13	The government lacks enterprises management regulations
VAR14	Government's management regulations for enterprises has insufficient binding force
VAR15	The government's enforcement of business regulations is weak
VAR16	Incomplete laws
VAR17	The government has no supervision of users of shared bikes
VAR18	The government's propaganda on parking shared bikes in order is not in place
VAR19	Insufficient number of bicycle-sharing companies managers
VAR20	The bicycle-sharing companies can't maintain the damaged vehicle properly
VAR21	The vehicle distribution policy of bicycle-sharing companies is unreasonable
VAR22	Bicycle-sharing companies put excessive number of shared bikes
VAR23	Bicycle-sharing companies lacks user management regulations
VAR24	There were no clear parking specifications
VAR25	The penalties for users' violation of parking is not enough
VAR26	The accountability of users was not well investigated and affixed
VAR27	The bicycle-sharing companies didn't explicitly remind users to park in order
VAR28	There is misleading in initial propaganda of bicycle-sharing companies
VAR29	There was no dedicated parking space for shared bikes
VAR30	The capacity of shared bikes parking space is insufficient
VAR31	The setting of shared bikes parking area is unreasonable
VAR32	The parking space was occupied
VAR33	The parking area was not clearly defined
VAR34	The guiding signs of parking space is not eye-catching
VAR35	There was no electronic fence
VAR36	Influence of social atmosphere
VAR37	Lack of social supervision
VAR38	Lack of reporting platform for easy reporting
VAR39	Social media's propaganda on parking regulations is not in place
VAR40	Weather condition, which makes it impossible for users to use the shared bike as usual
VAR41	The shared bike is damaged, so users can't park it in order
VAR42	Temporary parking

3.2. Results and Discussion of the Second-Phase Questionnaires

3.2.1. Descriptive Analysis of the Second-Phase Questionnaire

A total of 254 questionnaires were collected in the second phase, 245 of which are valid after screening, the effective rate was 96.5%. The questionnaires with too many missing values were considered as invalid. The sample size has met the requirement of factor analysis [19,20]. The Cronbach's α value is 0.951, 42 items have high internal consistency. Commuting (32.1%), personal affairs (27.7%) and leisure and social activities (24.2%) are the most common use scenarios, and the percentage of total cases showed that the respondents use shared bikes in various situations. Among the respondents, 156 of them are in the downtown area, accounting for 63.7%. 76 of them are in the suburbs outside the downtown area, accounting for 31%; 13 of them are in the suburbs, accounting for 5.3%. There are

209 users whose frequency of use is 5 times or less per week, accounting for 85.3%. 26 users' frequency of use between 6 to 10 per week, accounting for 10.6%; 10 users' frequency of use is 11 or more per week, accounting for 4.1%. Among the respondents, 96 have experience of disorderly parking, accounting for 39.2%, 149 of them don't, accounting for 60.8%.

3.2.2. Item Analysis of the Second-Phase Questionnaire

Since the items in this study are derived from the results of the previous questionnaire survey, it is necessary to judge whether the questions are relevant by item analysis before conducting factor analysis. The principal component analysis method is used to extract a factor. Using the common identity of 'composition matrix' less than 0.3 as standard, VAR1, VAR2, VAR3, VAR4, VAR5, VAR6, VAR22, VAR36, VAR38, and VAR41, a total of 10 questions are deleted. The remaining 32 items are used for factor analysis.

3.2.3. Factor Analysis of the Second-Phase Questionnaire

In this study, principal component analysis (PCA) and maximum axis method are used to extract and name the causes of disordered parking of Shared bicycles. Six factors are extracted from 32 items by factor analysis, factor 1 has 7 items, factor 2 has 8 items, factor 3 has 5 items, factor 4 has 5 items, factor 5 has 4 items, and factor 6 has 3 items. After the maximum rotation axis method, the eigenvalue of factor 1 is 4.409, factor 2 is 4.19, factor 3 is 3.572, factor 4 is 3.05, factor 5 is 2.877, and factor 6 is 2.459. Six factors explain the variable variation of 13.778%, 13.095%, 11.162%, 9.532%, 8.99% and 7.684% respectively, and the total explained variable is 64.241%. As can be seen from the table, the integrality of the factors after the rotation axis increases and the proportion of the factors that can be explained changes: factor 1 (39.375% 13.778%), factor 2 (6.727% 13.095%), factor 3 (6.282% 11.162%), factor 4 (4.605% 9.532%), factor 5 (3.801% 8.99%), factor 6 (3.451% 7.684%). The explainable specific gravity of factor 1 decreases, while the explainable specific gravity of factor 2, factor 3, factor 4, factor 5 and factor 6 increase. The commonality and relative positions of the six factors remain unchanged, and the synthesis of the characteristic values and the overall cumulative total variation remain unchanged, remaining at 64.241%. The Barrett sphericity test, KMO value, and the result of factor analysis is shown in Tables 9 and 10.

Table 9. Barrett sphericity test and KMO value.

Barrett Sphericity Test and KMO Value		
KMO sampling fitness measure		0.921
Bartlett sphericity test	The approximate chi-square	4795.757
	Degrees of freedom	496
	Significance	0

After extraction, the criteria of factor 1 include: 'the government lacks enterprises management regulations', 'government's management regulations for enterprises has insufficient binding force', 'the government's enforcement of business regulations is weak', 'the government's control measures for the scale of the bicycle-sharing market are not in time', 'the division of responsibility for management of shared bikes within the government is not clear', 'the government's propaganda on parking shared bikes in order is not in place', 'there is misleading in initial propaganda of bicycle-sharing companies'. VAR13, VAR14, VAR15, VAR12, VAR11, VAR18, VAR28 are about the government's supervision and management of bicycle-sharing companies. In terms of solving the problem of disorderly parking of shared bikes, the government's management and supervision of companies are indeed an important link. Bicycle-sharing companies' misleading propaganda in the early stage can also be considered as the result of government's poor management. Therefore, factor 1 is named as 'supervision and management of enterprises'.

Table 10. Result of factor analysis.

No.	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
VAR13	0.804					
VAR14	0.757					
VAR15	0.75					
VAR12	0.737					
VAR11	0.562					
VAR18	0.508	0.494				
VAR28	0.415			0.412		
VAR37		0.765				
VAR39		0.657				
VAR26		0.598			0.458	
VAR25		0.572			0.475	
VAR23		0.571				
VAR16		0.549				
VAR17	0.49	0.542				
VAR24		0.479				
VAR31			0.779			
VAR30			0.777			
VAR29			0.648			
VAR32			0.546	0.511		
VAR27			0.41			
VAR33				0.69		
VAR42				0.681		
VAR34				0.64		
VAR40				0.549		0.508
VAR35				0.489		
VAR7					0.76	
VAR8					0.695	
VAR10					0.684	
VAR9					0.559	
VAR19						0.785
VAR20						0.716
VAR21			0.451			0.599
Eigenvalue	4.409	4.19	3.572	3.05	2.877	2.459
Extraction sums of squared loadings %	39.375	6.727	6.282	4.605	3.801	3.451
Rotation Sums of Squared Loadings %	13.778	13.095	11.162	9.532	8.99	7.684
Total explanatory variance %				64.241		
The overall-scale Cronbach's α				0.949		
Subscale Cronbach's α	0.883	0.887	0.830	0.808	0.797	0.815

The criteria of factor 2 include: 'lack of social supervision', 'social media's propaganda on parking regulations is not in place', 'the accountability of users was not well investigated and affixed', 'the penalties for users' violation of parking is not enough', 'bicycle-sharing companies lacks user management regulations', 'Incomplete laws', 'the government has no supervision of users of shared bikes', and 'there were no clear parking specifications'. VAR37 and VAR39 are about social supervision of users. After large quantities of exposure of disorderly parking of shared bikes, users began to realize the importance of parking shared bikes in order, showing the power of social supervision. VAR26, VAR25, VAR23 and VAR24 are about bicycle-sharing companies' supervision and management of users. VAR16 and VAR17 are about the government's supervision and management of users. Taking all three aspects of supervision and management into consideration, factor 2 is named as 'supervision and management of users'.

The criteria of factor 3 include: ‘the setting of shared bikes parking area is unreasonable’, ‘the capacity of shared bikes parking space is insufficient’, ‘there was no dedicated parking space for shared bikes’, ‘the parking space was occupied’, and ‘the bicycle-sharing companies didn’t explicitly remind users to park in order’. VAR31, VAR30, VAR29, VAR32 are about parking space. VAR27 are about bicycle-sharing companies’ management of users. VAR27 is not strongly related to the previous criteria. Therefore, the naming of factor 3 is mainly based on the first four criteria, and factor 3 is named as ‘parking space’.

The criteria of factor 4 include: ‘the parking area was not clearly defined’, ‘temporary parking’, ‘the guiding signs of parking space is not eye-catching’, ‘weather condition, which makes it impossible for users to use the shared bike as usual’, and ‘there was no electronic fence’. VAR33 and VAR34 are about physical guiding system of parking shared bikes. The ‘electronic fence’ of VAR35 interacts with users through the mobile APP interface to guide users to park shared bikes. Electronic fence can be recognized as a kind of digital guiding system of parking shared bikes. VAR40 and VAR42 are all very special cases, and their content are very different from the previous criteria. Taking VAR33, VAR34 and VAR35 as the reference, and the study named factor 4 as ‘guidance of parking shared bikes’.

The criteria of factor 5 include: ‘laziness’, ‘users don’t attach enough importance to parking shared bikes in order’, ‘users were not punished, so they had fluke mind’, ‘users didn’t take the initiative to understand the relevant rules of parking shared bikes’. All criteria are about users’ control of their own behavior and intention. Factor is named as ‘user self-discipline’.

The criteria of factor 6 include: ‘insufficient number of bicycle-sharing companies managers’, ‘the bicycle-sharing companies can’t maintain the damaged vehicle properly’, ‘the vehicle distribution policy of bicycle-sharing companies is unreasonable’. All criteria are about bicycle-sharing companies’ operation and maintenance of shared bikes. Factor 6 is named as ‘operation and maintenance’.

3.2.4. Influence of Users’ Basic Information on the Factors of Disorderly Parking of Shared Bikes

In this study, independent sample t test and one-way ANOVA are used to examine the influence of users’ basic variables on the factors of disorderly parking of shared bikes. Users in different areas have no significant differences in factor 1, factor 2, factor 3, factor 4, and factor 5. Shared bike users on weekdays and weekends have no significant differences in factor 1, factor 2, factor 3, factor 4, factor 5, and factor 6. Users with or without experience of disorderly parking have no significant differences in factor 1, factor 2, factor 3, factor 4, factor 5, and factor 6.

But users in different areas have significant differences in factor 6. After post-event comparison, it was found that the users in the downtown area and users outside downtown but within the suburbs have much higher recognition of factor 6 than the users in the suburbs, indicating that bicycle-sharing companies should strengthen the operation and maintenance within the suburbs.

4. Conclusions and Suggestions

In the context of reducing emissions to achieve sustainable development, the development of a complete low-carbon transport system is crucial. As an important part of low-carbon transportation system, the development trend of bicycle-sharing industry has been stable. At this stage, solving the problem of disorderly parking of shared bicycles becomes the key to ensure the long-term development of the industry. This study collected the causes of disorderly parking of shared bicycles as comprehensively as possible through two-phase questionnaire survey, and constructed the factors of the causes of disorderly parking of shared bicycles through factor analysis, so as to facilitate the decision-making of the government and enterprises for reference. The conclusions of this study are as follows:

1. This study has extensively collected the causes of disorderly parking of shared bicycles. Combined with literature discussion, it is found that the three main objects involved in disorderly parking of shared bicycles are users, bicycle-sharing companies and the government. In addition, six factors and 32 criteria for the causes of disorderly parking of Shared bicycles are obtained, which are

as follows: factor 1 ‘supervision and management of enterprises’; factor 2 ‘supervision and management of users’; factor 3 ‘parking space’; factor 4 ‘guidance of parking shared bikes’; factor 5 ‘user self-discipline’; factor 6 ‘operation and maintenance’.

2. Users lack self-discipline; the supervision and management of users by bicycle-sharing companies, government and society is not in place; the government’s management and supervision of enterprises are not in place, and bicycle-sharing companies’ operation and maintenance of shared bikes are not in place; the failure of enterprises and governments to cooperate to provide sufficient parking space and to equip them with good parking guidance system, all show that the solution of disorderly parking requires multi-party cooperation. Therefore, in the formulation of solutions, we should take multiple factors into account in order to properly solve the problem of disorderly parking of shared bicycles.
3. Based on the tripartite cooperation mechanism and six factors, we propose the following suggestions:
 1. The government needs to strengthen the supervision and management of bicycle-sharing companies. The government needs to formulate a complete, feasible and binding regulation for bicycle-sharing companies. Besides, the management responsibilities within the government should be clarified and management norms should be implemented effectively.
 2. The government, enterprises and society should strengthen the supervision and management of users. The government and society should strengthen the publicity of parking shared bikes in order. The government and enterprises shall formulate clear parking standards or regulations of parking shared bikes, and violators shall be dealt with in strict accordance with the provisions.
 3. The sharing-bicycle companies shall provide reasonable and sufficient parking space for users and shall clearly remind users to park shared bikes in accordance with parking regulations. The sharing-bicycle companies may cooperate with the government to provide parking space or adopt technical means to meet users’ parking needs.
 4. When setting up parking spaces, sharing-bicycle companies and governments should set up some guidance signs to facilitate users to find parking spaces. At the same time, the whole parking space and the single parking unit should be clearly demarcated to help users park shared bikes in order.
 5. Users also need to correct their attitude, observe the usage and parking rules of Shared bikes to create a good environment for sharing bikes.
 6. The sharing-bicycle companies should increase the investment in operation and maintenance and provide sufficient operation and maintenance personnel to ensure the good condition of vehicles. They should also constantly optimize the strategy of vehicle distribution according to users’ demand to create a good experience for users.

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