

The Use and Improvement Suggestions of Shared Bicycles in Beijing

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Abstract. In response to the call for cleaner and greener mobility, the shared bicycle has developed rapidly in Beijing. However, such development has also brought a series of problems such as management chaos and private occupation by residents, which in turn has led to the decline of the shared bicycle market. Based on Beijing's basic geographic information and Mobike riding data, the article finds that ①Bike-sharing has obvious time variation characteristics, with a clear morning and evening peak period on weekdays and a more balanced distribution on the weekend. ②There is an apparent concentration of shared bicycle use during the morning peak period on weekdays, with the central Xicheng District, Dongcheng District, western Chaoyang District, northeastern Fengtai District, and southeastern Haidian District being the peak areas of bicycle use.

Keywords: Bike-sharing, Time distribution, Spatial distribution, Management suggestions.

1. Introduction

In recent years, the shared bicycle has become popular among residents as a convenient and fast way of transportation, featuring low cost of use and the convenience to borrow and return bicycles. Besides, the emergence of shared bicycles responds to the development trend of the green environment and plays a vital role in solving urban congestion and urban pollution. According to statistics, the transaction volume of China's sharing economy was 2,842 billion yuan in 2018, and the number of shared bicycle numbers was 235 million in 2018. In this way, bike-sharing has rapidly developed in China [1].

However, it is impossible to ignore that a series of problems also accompany the development of bike-sharing. The competition of capital for profit has led to an unlimited expansion of bike-sharing, resulting in a big change in the bike-sharing market now, which also has a particular impact on the sharing economy market in China. In addition, bike-sharing has also brought certain problems to urban management, such as the conflict between the profit and urban managers [2]. Besides, there are still some distinct problems such as untimely management and private occupation or damage to bicycles [3], which have led to the withdrawal of bike-sharings from the Chinese market in recent years.

As the political and cultural center of China, Beijing is also one of the most developed regions of the sharing economy. During the last six months of 2019, the city's average daily bike-sharing ridership was 1.272 million, with a total of about 900,000 shared bikes. However, one single bike's average daily turnover rate is only 1.4 times [4]. The excessive bicycle investment, low turnover rate, and uneven distribution of bicycles have led to the chaotic situation of bike-sharings in Beijing, which has seriously affected the daily travel and life of residents. Recently, Beijing has issued regulations jointly with bike-sharing companies to reduce the number of shared bikes in the central city to less than 500,000[5]. In this context, this paper analyzes the distribution and usage of shared bikes in Beijing, hoping to make some suggestions for the distribution of shared bikes in Beijing.

2. Study area and STUDY DATA

2.1 Study Area

As China's political and cultural center, Beijing has a highly prosperous economy, high traffic pressure, and highly dense population distribution, which presents tremendous pressure to residents.

Therefore, public transportation in Beijing has to play an essential role in urban transportation construction. In addition, Beijing has strong talent resources and innovative strength, making it the founding point of many bike-sharing companies and one of the most prosperous regions for the sharing economy in China. At the end of 2020, the resident population density is 1334 people per square kilometer, facing a huge pressure of transportation [6].

2.2 Study Data

2.2.1. Beijing Geographic Information Data

The geographic information data of Beijing used in this paper include road network data and administrative division data of Beijing.

2.2.2. Bike-sharing usage data

This article uses the riding data of Mobike in Beijing ‘s central urban area from May 10 to May 24 in 2017 for analysis. The data includes order number, user id, bike id, bike type, riding start time, and code coordinated by geohash of the start and end positions.

The article first selects May 18-May 24 as a complete week for data classification and gets a total of 1383996 riding data. The data were sorted and analyzed separately to think about changes during the week and weekday and weekend periods. Since the data is sampled before, there will be some error in using single-day data for analysis. Therefore, this article sample 1% data of rides on weekdays and weekends for calculating the mean value, which is on behalf of weekdays and weekends, respectively. Since the longitude and latitude information of the original data was encoded by geohash, the article sampled 1% of data in the peak period to decode to obtain the longitude and latitude information. Finally, the article used the obtained information on longitude and latitude to analyze the bike-sharing migration status during the weekday peak.

3. Analysis OF the Results

3.1 Analysis of the time distribution

3.1.1. Analysis of bike-sharing use time

The data obtained this time range from May 10, 2017, 00:00:09 to May 24, 2017, 19:00:16, a total of 3,214,096 pieces of riding data. The article selected riding data from May 18 to May 24 to profile a whole week's rides to facilitate analysis and comparison. After classification, the amount of data for each day of the study interval is as follows:

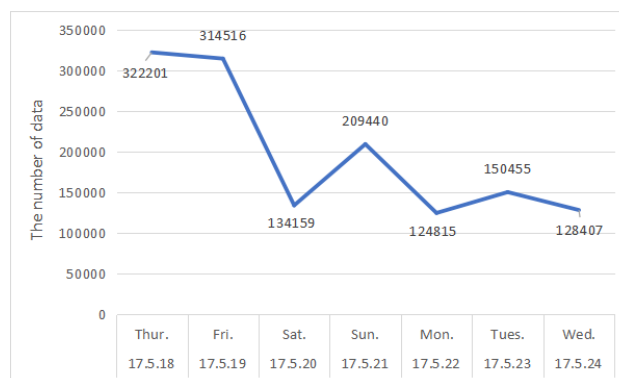


Figure 1 Riding Data for A Week

In fact, since the data itself is sample ones, there may be some bias when analyzing data on a single day. In order to reduce the bias, the article averages the data of weekdays and weekends. It is found that the average number of shared bikes per day on weekdays was 208,078.8, accounting for 55% of the average usage on weekdays and weekends; while the average number of shared bikes per day on

weekends was 171,799.5, accounting for 45% of the average usage on weekdays and weekends. This indicates that Beijing residents use bike-sharing services more during weekdays.

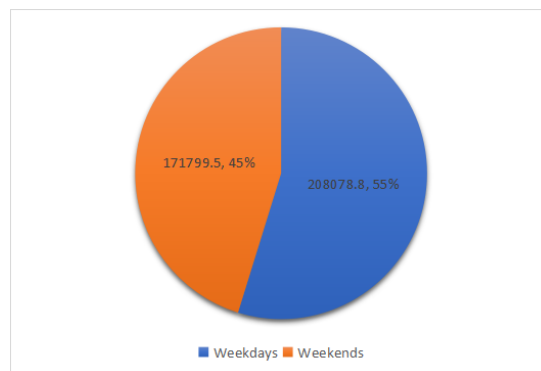


Figure 2 Shared Bikes Use Distribution by Weekdays and Weekends

3.1.2. Temporal analysis of bike-sharing usage

For the same reason as mentioned in 3.1.1, the Mobike ride data obtained in this paper are sampled data, and there is a gap of a few hours missing in the data on a certain day. So when analyzing and comparing the ride status of a single day, this article chooses to discuss weekdays and weekends separately, and randomly sample 1% of the data every day. Then, add up this data and divide the results by the corresponding number of days to obtain the mean distribution of travel conditions for a day corresponding to a weekday/weekend.

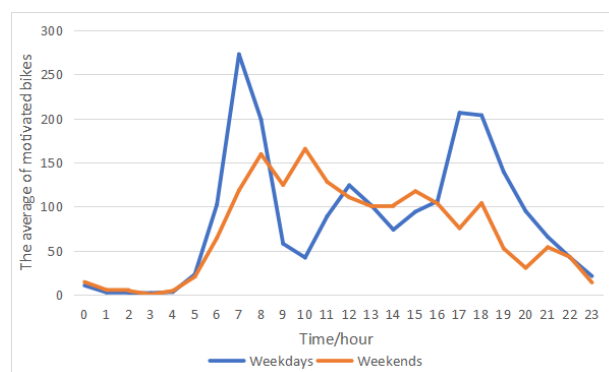


Figure 3 Shared Bikes Use Distribution by Chronological Order

In terms of the time distribution of bike-sharing use, it showed prominent temporal variation characteristicson both weekdays and weekends. Comparing the overall distribution of weekday data with that of weekend data, it is easy to find that there are obviously busy and idle periods in bike-sharings during weekday periods, while the use of bike-sharings on weekends varies more moderately. This indicates that the daily variation of bike-sharing use is larger on weekdays, while the daily variation of contributed bicycle use is smaller on weekends. This also matches with the reality of commuting peak in the morning and evening on weekdays.

For bike-sharing during weekday periods, the demand for bicycle use is basically concentrated in the morning and evening periods, while the demand for bicycle use at noon is smaller. The demand for bicycle use is lowest in the early morning hours and reaches its lowest value at around 3:00 a.m. There are two distinct peak hours at this time - the morning peak (7-9 a.m.) and the evening peak (17-19 a.m.). At this time, the rush hour coincides with the actual situation of residents commuting to and from work, which shows that residents have a high demand for bike-sharing. Therefore, traffic management in bike-sharing should be strengthened at this time, and the location of bike-sharing should be deployed well before the rush hour. In addition, the slope of both the rise and fall of the

morning peak is higher than the evening peak, indicating that residents are more concentrated in the morning when they go to work. More dispersed in the evening when they leave work, which leads to a less high mean value and slower linear change in the evening peak period.

For bike-sharing on weekends, the demand for bicycles is more evenly distributed between 6:00 and 20:00. With the passage of time, the demand for bicycles starts to decrease in the morning, and the demand for bicycles is less in the rest of the day. There is a more abrupt peak period at this time - the morning hours (7-10 a.m.). The peak period at this time is guessed to match the demand for leisure and recreation of the residents, so they choose to depart in the morning during the weekend break. All-day travel demand is high, indicating that the public has more space and time. Besides, the need for commuting during weekends is rare. Therefore, compared to weekdays, there is less pressure to manage shared bikes on weekends, with a more balanced need.

3.2 Analysis of the spatial distribution

All the morning peak period data of weekdays (17.5.18, 17.5.19, 17.5.22, 17.5.23, 17.5.24) are collected and then randomly selected 1% by excel for decoding. Then the article gets 2322 trips of data. After that, these data are decoded by Python 3.10. The following table shows the location of each decoded data, and a map is performed using ArcGIS 10.8.1 to do the kernel density analysis:

Table 1. Bike-sharing Data Decoding Example

Userid	Detailed time	geohashed_start_loc	geohashed_end_loc	departure longitude	departure latitude	termination longitude	termination latitude
1019509	7:59:56	wx4erby	wx4g20e	116.37	39.95	116.37	39.95
405395	8:02:10	wx4g490	wx4g474	116.48	39.91	116.47	39.92
758195	7:46:21	wx4g34j	wx4g31r	116.42	39.96	116.42	39.95
750966	8:14:24	wx4fcx7	wx4fcw3	116.44	39.90	116.44	39.89
701940	7:02:30	wx4g174	wx4g172	116.43	39.92	116.42	39.92

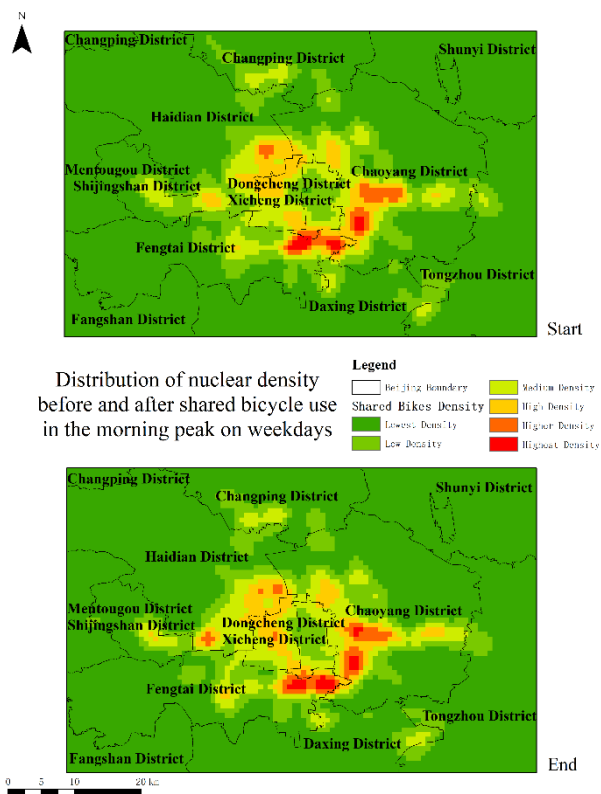


Figure. 4 Distribution of Nuclear Density Before and After Shared Bicycle Use in The Morning Peak on Weekdays

From figure 4, it can be seen that among the 1% of randomly selected trips on weekdays, the bicycle locations at the departure points and the termination points have obvious spatial clustering characteristics. Taking the map of the departure points as an example, it is obvious that the bikes are clustered in Beijing North Railway Station, Beijing Railway Station, Tiantan Park and Panjiayuan, and there is a clear "center-surrounding" radiation pattern, with more bikes distributed in the central Xicheng District, Dongcheng District, western Chaoyang District, northeastern Fengtai District and southeastern Haidian District. Shared bikes at these places are more numerous and more efficient. Compared with the departure locations, the termination locations of shared bikes change a little, with the extension to Shijingshan District and the shrinkage from Changping District.

Therefore, in the points where the number of shared bikes is high, especially in the East 2nd Ring Road and South 2nd Ring Road areas. It is suggested that more shared bikes need to be deployed in advance for use before the morning peak. In the center of Dongcheng District, the number of shared bikes needed is low due to the distribution of cultural attractions. In this way, it can be used as a mobile distribution area to migrate the bikes here to the peak area for use when the peak period comes.

4. Conclusion And Discussion

4.1 Conclusion

The article takes Beijing as an example, based on the cycling data of Mobike, combined with python and ArcGIS for composite analysis of cycling data. This article explores the average daily use of shared bikes in Beijing, the temporal and spatial changes of cycling destinations, and the study comes to the following conclusions:

4.1.1. Commuting by bike-sharing has a distinct time distribution characteristic.

Compared to weekends, Beijing residents have a greater demand for shared bikes on weekdays. There is a clear morning and evening peak period for bike demand on weekdays, with less demand for shared bikes at other times of the day, when it is easier to make space allocations for shared bikes. In contrast, the change in demand for shared bikes on weekends is smoother, indicating that the demand for shared bikes is more evenly distributed on weekends, requiring ground staff to complete the space allocation of shared bikes before 6:00 and 17:00.

4.1.2. Commuting by bike-sharing has a distinct spatial distribution characteristic.

For the morning peak period, the cycling destination tends to move to the southeast, and there is an obvious cycling peak area. Compared to the distribution of bike-sharing locations before the ride, the bike-sharing after the ride extends to the southeast, indicating the trend of people moving to the southeast at this time; in addition, there are obviously dense distribution areas of shared bikes on the map, including the central Xicheng District, Dongcheng District, western Chaoyang District, northeastern Fengtai District, and southeastern Haidian District, where there is a high demand for bicycles. This indicates that the government and enterprises should work together to do a good job of flexible relocation, coordination, and deployment of shared bikes to meet the travel requirements of residents.

4.2 Discussion

While bike-sharing has achieved development in China, it has also brought a series of problems to urban construction. According to the analysis in this paper, the following suggestions are made for the management of bike-sharing in Beijing:

Strengthen the deployment of bike-sharing use during weekday peak periods, and adjust bicycles partially to points with high travel demand through ground management staff before the arrival of peak periods to closely fit users' needs and reduce the unavailability of bicycles.

In terms of time, the use of bike-sharing fits the trend of people moving demand from residential to commercial areas in the morning peak and from commercial to residential areas in the evening

peak. Therefore, when deploying shared bikes, it is of great importance to fit the current situation of citizens' mobile needs.

5. Authors' Contributions

Dejiang Wang concluded research, performed mapping, analyzed data, and wrote the paper.

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