The Impact of Bike Sharing on Urban Transportation

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Abstract: In recent years, with the advent of low-carbon life, shared bicycles have continuously entered people's field of vision and become an indispensable part of people's lives. Sharing bicycles facilitates people to go to work, supermarket shopping, fitness and fitness, and also effectively protect the environment. This paper studies the impact of shared bicycles on cities from four aspects: transportation and society.

Keywords: shared bicycle; hierarchical analysis; comparison matrix

1. Introduction

1.1. The meaning of shared bicycle

Sharing bicycles, as the name implies, is a bicycle that everyone can use together. The concept of belonging in economics has changed from a single to a common form, and this possibility is realized through the Internet. In today's society, short-distance travel pursues convenience, flexibility, efficiency, and low cost, and sharing bicycles just fills these demands. With the concept of "green, low-carbon travel" and the goal of "solving the last mile of people's travel", the effective connection between the registration of the Internet APP and the physical bicycle will realize the management of the Internet of Things and make people's travel more. Convenient, richer experience, and loved by people.

1.2. The impact of shared bicycles on the city

Sharing bicycles brings convenience to people, but it also brings many problems to urban management. We analyze the impact of shared bicycles on cities from four aspects: urban transportation, economy, society and environment.

Table 1. Definitions and Symbols.

Symbols	Definitions
CR	Daily average concentration of several pollutants for monitoring air quality
CI	An indicator that measures the degree of inconsistency in a pairwise comparison matrix
RI	Average random consistency indicator
w	Weighted average
W_i	Combined weight value
α_i	Index weight vector determined by AHP method
β_i	Index weight vector determined by entropy method
K	Total impact index
b_i	The proportion of each part of the economy to the total
w_i	Weight of each component
k_i	Component influence index

2. Models

2.1. The Foundation and solution of Traffic impact model

The city's public transportation system is further developed and re-improved, and it is impossible to solve the problem of the "last mile" of the citizens. Bicycles that have an advantage in short-distance travel can just make up for the shortcomings at the end of the traffic. The emergence of shared bicycles not only provided great convenience for the citizens' lives, but also solved the problem of the citizens' "last mile" travel.

The emergence of shared bicycles has also had a great impact on the lives of urban residents, and there is a choice in the way of travel. The following will establish a hierarchical analysis model to analyze its impact.

First, for the five modes of bicycles, private cars, taxis, buses, and hikers, the four factors that influence the way of travel are: time, cost, comfort and convenience, constitute the following hierarchical analysis model (Figure 1):

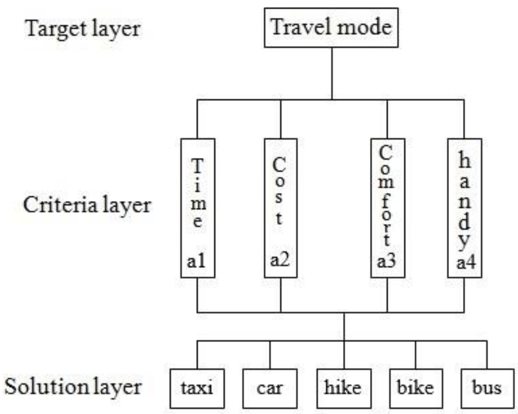

Figure 1. Analysis Model.

Then, constructing a pairwise comparison matrix, comparing the importance of the *i* element to the *j* element relative to a factor above, is described using a quantified relative weight a_{ij}. Let a total of *n* elements participate in the comparison, then $A=(a_{ij})_{n\times n}$ is called a pairwise comparison matrix.

The value of a_{ij} in the pairwise comparison matrix can be evaluated by Satty's proposal and scaled as follows. a_{ij} takes the value between 1-9 and its reciprocal. a_{ij} = 1, element *i* factor; and element j have the same importance to the previous level

a_{ij} = 3, elemen *i* is slightly a little more important than element *j*;

a_{ij} = 5, element *i* is slightly more important than element *j*;

a_{ij} = 7, element is slightly much more important than element *j*;

a_{ij} = 9, element *i* is extremely more important than element *j*;

$a_{ij} = 2n$, n = 1,2,3,4, the importance of element *i* ;and *j* is between $a_{ij} = 2n-1$ and $a_{ij} = 2n+1$

The selection method of travel considers four conditions: time $a1$, comfort $a2$, convenience $a3$, and cost $a4$. According to the traffic travel mode and the green travel survey report of urban residents in Xi'an, the percentage of influencing factors can be known. Using the pairwise comparison method, the pairs are compared as follows:

$$\begin{pmatrix} 1 & 2 & \frac{1}{3} & 1 \\ \frac{1}{2} & 1 & \frac{1}{4} & \frac{1}{2} \\ 3 & 4 & 1 & 3 \\ 1 & 2 & \frac{1}{3} & 1 \end{pmatrix}$$

$a_{31}=3$ indicates that the ratio of convenience to time is 3, that is, urban residents, think that convenience is slightly more important than time.

After the paired matrix is constructed, a consistency check should be performed to determine the acceptability of the matrix. Theoretically, if A is a completely consistent pairwise comparison matrix, there should be:

$$a_{ij}a_{jk}=a_{ik},\ 1\le i,j,k\le n$$

However, it is actually impossible to satisfy the above-mentioned numerous equations when constructing a pairwise comparison matrix. Therefore, it is required to have a certain consistency in the pairwise comparison matrix, that is, a certain degree of inconsistency may be allowed in the pairwise comparison matrix.

It can be seen from the analysis that for a completely consistent pairwise comparison matrix, the eigenvalue with the largest absolute value is equal to the dimension of the matrix. For the consistency requirement of the pairwise comparison matrix, the eigenvalue with the largest absolute value of the required matrix is not much different from the dimension of the matrix.

The steps to verify the consistency of the pairwise comparison matrix A are as follows:

Calculate the index CI that measures the degree of inconsistency of a pairwise comparison matrix A (n>1 matrix):

$$CI=\frac{\lambda_{\max}(A)-n}{n-1}$$

RI is the average random consistency indicator, which is only related to the matrix order n, and its value is shown in Table 2.

Table 2. *RI* Value Table.

n	1	2	3	4	5	6	7	8	9
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45

The random consistency ratio *CR* is calculated as follows:

$$CR = \frac{CI}{RI}$$

The judgment method is as follows: When CR <0.1, it is determined that the paired comparison array A has satisfactory consistency, or the degree of inconsistency is acceptable; otherwise, the pairwise comparison matrix A is adjusted until satisfactory consistency is achieved.

The maximum eigenvalue of the pairwise comparison matrix using MATLAB to calculate the influencing factors is 4.0206, and the index of inconsistency is 0.007.

$$CR = \frac{CI}{RI} = \frac{0.007}{0.9} = 0.0078 = 0.1$$

This means that A is not consistent, but A has satisfactory consistency and A 's degree of inconsistency is acceptable. The normalized eigenvector U of A is calculated using MATLAB (= 0.1894 0.1054 0.5158 0.1894)Z. This vector is called a weight vector after normalization. Here it reflects the most important convenience when residents choose travel mode, followed by time and cost, and finally comfort. The relative importance of each factor is determined by the components of the weight vector U.

According to the above method, one of the five modes of travel is selected to be the most suitable for affecting the conditions of the travel factor. Therefore, for the five travel modes taxi, car, hike, bike, and bus, respectively, the four influencing factors of time $a1$, comfort $a2$, convenience level $a3$, and cost $a4$ are obtained, and the pairwise comparison matrix is as follows:

$$B1 = \begin{pmatrix} 1 & \frac{1}{5} & 6 & 4 & \frac{1}{5} \\ 5 & 1 & 8 & 6 & 1 \\ \frac{1}{6} & \frac{1}{8} & 1 & \frac{1}{4} & \frac{1}{8} \\ \frac{1}{4} & \frac{1}{6} & 4 & 1 & \frac{1}{6} \\ 5 & 1 & 8 & 6 & 1 \end{pmatrix} B2 = \begin{pmatrix} 1 & \frac{1}{5} & 4 & 3 & \frac{1}{5} \\ 5 & 1 & 7 & 5 & 2 \\ \frac{1}{4} & \frac{1}{7} & 3 & 1 & \frac{1}{4} \\ \frac{1}{3} & \frac{1}{5} & 3 & 1 & \frac{1}{4} \\ 5 & \frac{1}{2} & 6 & 4 & 1 \end{pmatrix}$$

$$B3 = \begin{pmatrix} 1 & \frac{1}{4} & \frac{1}{3} & \frac{1}{8} & \frac{1}{2} \\ 4 & 1 & \frac{1}{3} & \frac{1}{5} & 3 \\ 3 & 3 & 1 & \frac{1}{4} & 2 \\ 8 & 5 & 4 & 1 & 7 \\ 2 & \frac{1}{3} & \frac{1}{2} & \frac{1}{7} & 1 \end{pmatrix} B4 = \begin{pmatrix} 1 & \frac{1}{4} & \frac{1}{5} & \frac{1}{4} & 5 \\ \frac{1}{4} & 1 & \frac{1}{7} & \frac{1}{6} & 2 \\ 5 & 7 & 1 & 2 & 7 \\ 4 & 6 & \frac{1}{2} & 1 & 6 \\ \frac{1}{5} & \frac{1}{2} & \frac{1}{7} & \frac{1}{6} & 1 \end{pmatrix}$$

For the consistency test of $B1, B2, B3$ and $B4$, the random consistency ratios are: 0.0902, 0.0754, 0.0739, and 0.0648, and the results are all less than 0.1. Therefore the degree of inconsistency of these four matrices is acceptable.

After calculation, the weight vectors of $B1, B2, B3$ and $B4$ are respectively.

$$\omega_{a1} = (0.1354, 0.3847, 0.0306, 0.0646, 0.3847)^Z$$

$$\omega_{a2} = (0.1241, 0.4415, 0.0398, 0.0758, 0.3188)^Z$$

$$\omega_{a3} = (\ 0.0475, 0.1363, 0.1945, 0.5481, 0.0736)^Z$$

$$\omega_{a4} = (0.1364, 0.0540, 0.4577, 0.3119, 0.1400)^Z$$

Finally calculate the weight of each travel mode ωz(taxi).

$$\omega_Z(taxi) = \sum 4\, j = \varepsilon_j \omega_{aj}(taxi) = 0.1894 \times 0.1354 + 0.10540 \times 0.1$$

It can be seen from the calculation formula that the total score ω(taxi) of taxi is actually the weighted average of the conditions ωa1(taxi), ωa2(taxi), ωa3(taxi), ωa4(taxi) of the taxi, and the weight is an important condition. Sex. Calculate the total score of a travel mode as shown in Table 3.

Table 3. Comparison of Travel Mode.

	0.1894	0.1054	0.5158	0.1894
Taxi	0.1354	0.1241	0.0475	0.1364
Car	0.3847	0.4415	0.1363	0.0540
Hike	0.0306	0.0398	0.1945	0.4577
Bike	0.0646	0.0758	0.5481	0.3119
Bus	0.3847	0.3188	0.0736	0.0400

According to the calculation results in Table 3, we can finally compare and sort the available bike > car > hike > bus > taxi, sharing bicycles become the first choice for urban residents to travel daily, so the promotion of shared bicycles will greatly ease urban traffic.

2.2. The Foundation and Solution of Social Impact Model

The development of shared bicycles is a new benchmark for enterprise innovation, in line with the development concept of “public entrepreneurship and innovation” proposed by the government; people from all walks of life are guided by the trend of the times and use Internet technology to promote the optimization and upgrading of industrial structure. The development of shared bicycles has injected new functions into industrial transformation and upgrading. In addition to the substantial increase in production capacity and orders, the rapid development of shared bicycles has formed a comprehensive integration of traditional manufacturing companies in product design, technology research and development, production processes, service systems and safety performance. Impact, in the case of the decline in domestic bicycle sales, the development of the spurt of the shared bicycle market has brought new hope to the development of the bicycle industry. At the same time, sharing the Internet technology of bicycle use has forced the comprehensive upgrade of the traditional bicycle manufacturing industry. The process, eliminating backward production capacity, has brought the entire industry to a “subversive” upgrade, which can greatly promote the development of society.

The impact of shared bicycles on society is mainly divided into positive externalities and negative externalities.

2.2.1. Positive externality

Sharing the development of the bicycle industry to promote employment. According to the “Research Report on the Employment of the Shared Bicycle Industry”, in the first half of 2017 alone, sharing bicycles drove 100,000 jobs. Among the 100,000 employed people, there were about 8000 platform employees; bicycle manufacturers had about 4250 workers; there are about 5000 workers in the distribution industry. The development of shared bicycles has driven more people to work, and many people who still have the ability to work but have no jobs for various reasons have a source of income for their lives, which not only reduces the social burden, but also improves the happiness of the people.

The development of shared bicycles promotes industrial transformation and upgrading. According to the product cycle theory: a new product from the beginning of entering the market to being eliminated by the market, which must undergo cycles such as formation, growth, maturity, and decline, so we can know that from the sharing of bicycles to the market to the market The whole process of elimination involves many industries, including bicycle manufacturing, smart lock and other parts manufacturing, operation and maintenance services, and resource recycling. Before the emergence of shared bicycles, many manufacturing developments have been very depressed, especially in the bicycle manufacturing industry. As early as the 1980s, China was known as the “Bicycle Kingdom”. These reflect the development of China’s economic level and the improvement of economic level, which has caused the bicycle manufacturing industry to stagnate. According to the research report of China’s shared bicycle industry in 2017, the cumulative output of bicycles in China in 2016 was 53.033 million, a cumulative year-on-year decrease of 5%. Traditional bicycles have many orders and few orders, which makes production efficiency very low, while shared bicycles are “single product”, which can easily regulate the labor technology of production workers. The bicycle manufacturing industry has initially shown scale. The development trend of industrialization has gradually shifted from labor-intensive to automatic processing.

2.2.2. Negative externalities

Excessive delivery leads to waste of resources. The sharing bicycle market has a low barrier to entry. In order to occupy the market as soon as possible, major bicycle companies have launched a large number of launches in the market, especially in the first-and second-tier cities with more types of bicycles, which quickly led to the saturation of shared bicycles in these cities. Some even want to be able to produce a large number of bicycles in a short period of time without sacrificing the quality of bicycles, resulting in a shortened bicycle service life. At the same time, excessive delivery makes a large number of bicycles unmanned, collectively stacked on open spaces with little traffic, and scrapped. Both the car and the car that can be used normally do not have normal management, which inevitably leads to a large waste of resources. On the one hand, this kind of competition without cost will cause oversupply, gradually become a sunk cost, and cause a burden on social management. On the other hand, market norms that violate fair competition will occupy the market. If this disorderly competition continues to develop, it is likely it will affect the stability of the crisis market and social security.

Occupy public resources. The biggest feature of shared bicycles is the liberation of parking piles. Users can park in the nearest position to their destination according to their own needs. It is precisely because of this that there are chaotic stops, occupied motor vehicles, blind roads and sidewalks. Even in the green belt, there are shared bicycles. Wu Weiqiang, a professor at the School of Public Administration of Zhejiang University of Technology and vice president of the Hangzhou Institute for Reform and Development, said that shared bicycle companies set up vehicles before they were approved, zero-cost occupation of sidewalk parking vehicles, and the nature of small stall vendors on the road. There is no essential difference, and the laws and regulations of urban management have been clearly violated. This behavior ignores the concept of road rights. At the same time, due to the phenomenon of chaos and arbitrage, the government departments need to send personnel for management, which has raised the cost of social governance to a certain extent.

3. Conclusions

In view of the impact of shared bicycle promotion on the city, we analyze it from four aspects: urban transportation and society.

First, we consider the impact on urban traffic and use the impact of shared bicycles on people’s travel as an entry point. According to the four indicators of time, cost, comfort and convenience, the analytic hierarchy model is established. Finally, the comprehensive solution shows that the bicycle travel mode has the highest score, so it can effectively reduce the daily usage of private cars, thus alleviating urban traffic congestion.

Then we consider the impact on society. We divide the impact of shared bicycles on society mainly into positive externalities and negative externalities, and then analyze them separately.

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