Research on the Development of Bicycle-Sharing Based on Conflict Analysis

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Abstract: In recent years, a lot of manpower, material resources and financial resources have been invested in urban planning and road expansion in our country. But the fact shows that the problems of urban traffic accidents and traffic congestion in China are still outstanding. Since the bicycle-sharing is in line with the concept of low-carbon travel, it also has solved the problem of "the last kilometer" for citizens to travel to some extent. Therefore, the bicycle-sharing is favored by the general public. The addition of a large number of bicycle-sharing has further complicated the urban traffic, posing a new challenge to the government. This paper is based on game theory, using the conflict analysis method to study the existence and development of bicycle-sharing in the city. Through analyzing the research results, the countermeasures and suggestions, such as adding bicycle lanes and improving the quality and maintenance efficiency of bicycle-sharing, are given in order to provide the basis for the rational decision of the government and the bicycle-sharing enterprises and the urban innovation, green and sustainable development.

1. Introduction

Rapidly developing bicycle-sharing has become the fourth most popular way to travel after cars, buses and subways. The development of city bicycle-sharing has effectively solved the problem of the "last kilometer" of citizens' travel, which is the main reason for the government's friendly observation in the early stage of bicycle-sharing development. But with the development of the past year, a series of problems, such as free parking, using driveway and the traffic accidents caused by the bicycle-sharing, have been highlighted. While bicycle-sharing has brought convenience to people's daily life, the clamor for government and other related departments to regulate the bicycle-sharing has become increasingly louder. Given the positive and negative effects of bicycle-sharing on people's lives, the government is expected to impose appropriate fines on cyclists and enterprises for parking and traffic violations or to seize illegal bikes to put pressure on the enterprises of bicycle-sharing, in order to force the enterprises of bicycle-sharing to reach an agreement and take effective measures to standardize the use of bicycle-sharing. While the enterprises of bicycle-sharing want to maintain the status quo and continue developing because at present they have a large number of users and good benefits. And the enterprises of bicycle-sharing don't want to put money in place to limit the use of bicycle-sharing users, because it will reduce their interest and efficiency. Some potential users are likely to give up using the incommodious bicycle-sharing if parking is inconvenient or the prescribed carriageway is not what you want to go and so on. This will result in the loss of bicycle-sharing users and reduce the company's earnings. Meanwhile, bicycle-sharing companies also do not want users to abuse their bikes and avoid fines or seizures. The game between the government and the bicycle-sharing companies is born. Therefore, it is necessary to study the existence and development of bicycle-sharing.

Although the development time of bicycle-sharing is shorter. As a new way of transportation combining "Internet plus" technology and traditional bicycle, it has caused many scholars to carry out relevant researches. S.Y. Yang and others analyzed the development situation and negative impact of bicycle-sharing by using the data in the white paper on bicycle-sharing and urban development of

2017. She pointed out that it is necessary for bicycle-sharing companies, bicycle-sharing users and government working together to solve the development bottleneck of bicycle-sharing [1]. J. Zhou demonstrated the effect of bicycle-sharing in the urban traffic system and traffic transportation from the perspective of resource utilization efficiency and pointed out that the bicycle-sharing is superior comparing with the traditional bicycle with a pile. The government needs to adjust measures to local conditions to guide its development [2]. K.H. Li analyzed the internal and external factors of bicycle-sharing comprehensively by using PEST model and SWOT-PEST matrix and summarized the influence factors in the government environment, economic environment, social environment and technical environment, such as the bicycle-sharing strengths, weaknesses, opportunities and threats etc. The countermeasures are put forward from the aspects of government, bicycle-sharing companies and users [3]. Y. Guo and others analyzed the utilization rate and customer satisfaction through collecting the data and using the BOP model. Suggestions for the improvement of bicycle-sharing utilization rate were put forward based on the study conclusion [4]. Y. Sun and others studied the impact of environment factors on bicycle-sharing. The paper pointed out that high road safety, low crime rate and convenient transportation can improve bicycle usage [5]. As can be seen from the above analysis, it is necessary for the government to make public policy. H.J. Wang analyzed various factors including satisfaction standard, choose difficulties, preferential policy and public policy but not public factors and so on. The paper explained that each stakeholder took the necessary action to realize interest coordination based on fighting for maximizing their own interest in the process of policy making [6]. Bicycle-sharing chaos caused the conflict between the government and bicycle-sharing companies. The government represents the interest of broad masses of the people. But, the bicycle-sharing companies expect to maximize their own interests. Conflict analysis technology is the scientific methodology on conflict resolution and decision-making, and it also can help government and bicycle-sharing companies to solve such contradiction effectively. S.L. Xue and others demonstrated conflict contradiction among the city manager by using static and dynamic conflict analysis means. For more players, in order to compare and weigh each smooth outcome, the concept of stability was put forward. In stability analysis, stability can be used to determine the final stability outcome easily [7]. Bicycle-sharing makes cities become a sharing system to some extent. J.W. Zhang studied the individual trip prediction problem for bicycle-sharing systems from individuals' bike usage behaviors. Inferring the potential destinations and arriving time of each individual trip beforehand can help bicycle-sharing users travel conveniently [8].

From what has been discussed above, most of the existing literature has simply pointed out the bicycle chaos caused by the development of bicycle-sharing and gives some suggestions. There is no detailed explanation for the transformation process of the conflict between the government and the enterprises of bicycle-sharing. In this paper, the conflict model is established to combine the two sides well and makes the process of resolving the conflict resolution between the enterprises of bicycle-sharing and the government clarified. The second part of the article is to establish the conflict analysis model and the stability analysis process of the model. The third part is the analysis of the global stability of the conflict analysis model. The fourth part summarizes the full text and gives the suggestions to support the decision of both sides.

2. Conflict analysis process

2.1 Background

The traffic problem caused by bicycle-sharing is becoming more and more serious as it brings convenience to people. In order to effectively govern the bicycle chaos, the government departments decided to act. The government is committed to maximizing the collective interests of the society, forcing the bicycle-sharing companies to take measures to regulate the use of bicycle-sharing. The bicycle-sharing companies want to maintain the status quo so that they do not suffer losses.

2.2 Modeling

1) Time

The time is December 2017. It has been about a year since bicycle-sharing develops. The traffic problems caused by bicycle-sharing stand out. And the parties concerned decide to act.

2) Players

The government is concerned for city dwellers to a large degree because the government wants to formulate policies or to let bicycle-sharing companies make necessary measures to curb the occurrence of bicycle chaos and regulate the use of bicycle-sharing in order to ensure people's personal safety and property safety. While the bicycle-sharing companies want to continue its development in accordance with the current situation, so as to reduce users' using cost and increase their profit stably on the basis of low investment and maintenance funds. Therefore, government and bicycle-sharing companies are contradictory subjects.

3) Actions

The government may take two actions: seize the bicycle-sharing or impose a fine. There are also two strategies for bicycle-sharing companies, namely formulating measures to regulate the development of bicycle-sharing or removing the bicycle-sharing.

4) Expression of outcome

For the sake of convenient analysis, the result is represented by binary array according to Howard's convention. Using "1" and "0" respectively indicates the "take" and "give" of an action. For example, the basic outcome (1,0|0,0) indicates that the government has taken the seizure of illegal bikes, and the bicycle-sharing companies have not taken any actions, which means maintaining the status quo.

In artificial analysis, it is convenient to express the ending with a decimal number. The conversion formula is

$$Q=X_0\cdot 2^0 \quad X_1\cdot 2^1 \quad \dots \quad X_L\cdot 2^L \qquad (1)$$

In addition, $L=\sum_1^n(Ki-1)$, Xi=1, 0 (the elements of the (i +1) action line in the basic outcome table) According to the above, 16 (2^{2+2}=16) basic outcomes of the bicycle-sharing chaos can be obtained, as shown in table 1.

Table.1. Action and basic outcomes in the bicycle-sharing chaos

Players and Actions	**Basic outcomes**															
Government	**Government actions**															
1. Seize bike	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
2. Impose a fine	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1
Bicycle-sharing company	**Bicycle-sharing companies actions**															
3. Regulation	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1
4. Removing bike	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
Decimal number	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Particularly, in the above 16 basic outcomes, it is impossible for the bicycle-sharing companies to formulate measures to regulate people's use of bicycle-sharing and at the same time remove the bicycle-sharing and no longer operate. So, the last four endings are logically unworkable and should be deleted. The remaining 12 outcomes are all possible outcomes, as shown in table 2.

Table.2. The feasible outcomes of the bicycle-sharing chaos

Players and Actions	**Feasible outcomes**											
Government	Government actions											
1. Seize bike	0	1	0	1	0	1	0	1	0	1	0	1
2. Impose a fine	0	0	1	1	0	0	1	1	0	0	1	1
Bicycle-sharing company	Bicycle-sharing companies actions											
3. Regulation	0	0	0	0	1	1	1	1	0	0	0	0
4. Removing bike	0	0	0	0	0	0	0	0	1	1	1	1
Decimal number	0	1	2	3	4	5	6	7	8	9	10	11

5) Prioritize

In the priority sequence, the most advantageous outcome is the leftmost, and the most unfavorable result is at the far right. After repeated studies by both government and bicycle-sharing companies, the priority sequence was determined, as shown in table 3and table 4.

In the priority sequence, it is the principle of the two parties to avoid bicycle-sharing chaos and to regulate people's rational use of bicycle-sharing. On this basis, the government has made efforts to establish measures to regulate the use of bicycle-sharing and the enterprises of bicycle-sharing hope to maintain the status quo.

Table.3. The priority of government in the bicycle-sharing chaos

Players and Actions	**Priority**											
Government	Government actions											
1. Seize bike	0	0	1	1	0	1	1	0	1	1	0	0
2. Impose a fine	0	1	0	1	1	0	1	0	1	0	1	0
Bicycle-sharing company	Bicycle-sharing companies actions											
3. Regulation	1	1	1	1	0	0	0	0	0	0	0	0
4. Removing bike	0	0	0	0	0	0	0	0	1	1	1	1
Decimal number	4	6	5	7	2	1	3	0	11	9	10	8

Explanation: The government expects that bicycle-sharing companies reach an agreement to encourage users to use bike normatively and tries to avoid bicycle-sharing chaos.

Table.4. The priority of bicycle-sharing companies in the bicycle-sharing chaos

Players and Actions	**Priority**											
Government	Government actions											
1. Seize bike	0	0	0	0	1	1	1	1	1	1	0	0
2. Impose a fine	0	0	1	1	0	0	1	1	1	0	1	0
Bicycle-sharing company	Bicycle-sharing companies actions											
3. Regulation	0	1	1	0	1	0	1	0	0	0	0	0
4. Removing bike	0	0	0	0	0	0	0	0	1	1	1	1
Decimal number	0	4	6	2	5	1	7	3	11	9	10	8

Explanation: Bicycle-sharing companies expect to maintain the status quo in order to have a high benefit based on a low cost.

And they also don’t want to removing bike that have been put on the market and don’t want to see the government act.

2.3 Stability analysis

Stability analysis solves the problem of balancing outcome from all possible outcomes. In the

analysis process, there are three prerequisites. a) Each player will continue to change their strategy in the most favorable direction. b) In deciding their own choices, player will consider the possible reactions of others and their impact on themselves. c) The balance outcome must be accepted by all players. The stability analysis of the model is described as follows.

1) Unilateral improvement (UI)

Unilateral improvement is the basic state of stability analysis and the first step of stability analysis. The unilateral improvements of each feasible outcome are listed below the corresponding outcome (q) of the priority number. And rank them from top to bottom in terms of priority.

2) Individual stability

Three basic individual stable states can be obtained on the basis of unilateral improvement. There are rational stable outcome and sequentially sanctioned stable outcome and unstable outcome, respectively denoted by ***r*** and ***s*** and ***u***. By using the Fraser-Hipel decision criteria, the stability analysis and results of this model are shown in table 5 below.

Table.5. Stability analysis of the bicycle-sharing chaos

Global Equilibrium	**E**							**E**				
Government												
Individual stability	r	s	u	u	r	u	u	u	r	u	u	u
Priority	4	6	5	7	2	1	3	0	11	9	10	8
UI		4	4	4		2	2	2		11	11	11
			6	6			1	1			9	9
				5				3				10
Bicycle-sharing company												
Individual stability	r	s	r	u	r	u	r	u	u	u	u	u
Priority	0	4	6	2	5	1	7	3	11	9	10	8
UI		0		6		5		7	7	5	6	0
									3	1	2	4

3) Simultaneous penalty stability

When the basic individual stability has been determined, we analyze the simultaneous penalty stability. The simultaneous penalty stability is denoted by ú. The outcomes (p) that two players perform unilateral improvements simultaneously can be calculated by the formula p= (a+b)-q, a and b are respectively unilateral improvements below q. The intermediate results of the simultaneous penalty stability can be calculated by the above formula and shown in table 6 below.

Table.6. The intermediate results of the simultaneous penalty stability

q	1	3	9	10	8
p	6	6,5	7,3	7,3,5,1	2,1,3,6,5,7

4) Determine global equilibrium outcome

We call the outcome (q) as the global equilibrium outcome if the outcome (q) belongs to (r, s, ú) for each player and use E instead of this outcome (q). In this bicycle-sharing chaos, E= {4,6}, as shown in table 5.

3. Results analysis

The above results show that the global stability outcome of the conflict analysis between the government and the bicycle-sharing companies triggered by the bicycle-sharing chaos is: E = {4}. That is, in the condition of that the government didn't take any actions, the bicycle-sharing companies reached an agreement to formulate measures to regulate the development of bicycle-sharing and avoid the bicycle-sharing chaos and traffic accidents. E = {6}, that is, under the circumstance of fines imposed by the government on the bicycle-sharing companies that allow users to use the bicycle freely and don't care the bicycle-sharing chaos, the bicycle-sharing companies begin to formulate measures to regulate the development of bicycle-sharing and encourage users to jointly maintain the traffic order so as to reduce government penalties. In the early stages of the development of

bicycle-sharing, neither the government nor the bicycle-sharing companies take any measures to limit the use of bicycle-sharing. The situation is still at {0,0;0,0}. This situation is the optimal strategy for bicycle-sharing companies and from other side also illustrates that the government has a positive attitude towards the development of bicycle-sharing in the short term and hopes to develop this new thing. However, with the recent disruptions caused by the bicycle-sharing chaos, such as violations of traffic order and frequent occurrence of traffic safety accidents, the government has to rethink the development trend of bicycle-sharing in the future. From the above stable outcomes E = {4} and E = {6}, we know that there will be a steady situation between the government and the bicycle-sharing companies.

4. Conclusion

Bicycle-sharing as a new type of green transport has good prospects for development. This paper is based on game theory, using the conflict analysis method to study the existence and development of bicycle-sharing in the city. Through analyzing the research results, we give the following countermeasures and suggestions: The local governments should provide the good development environment for bicycle-sharing companies according to local conditions, such as adding bicycle lanes and subsidizing users of bicycle-sharing, etc. Bicycle companies should ensure the quality of bicycle-sharing put on the market and improve the maintenance efficiency of bicycle-sharing so that users can get quick and convenient bicycle service. By implementing the above suggestions, we can better resolve the conflict between the government and the bicycle-sharing companies in order to provide the basis for the government and the bicycle-sharing

Companies to make rational decision and urban innovation, green and sustainable development. In addition, the conflict resolution method used in this paper can get promotion. By us-

Ing conflict analysis method, we can solve such problems effectively and make problem solving process clear.

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