

Study on Bicycle Parking in Sharing Economy: Trilateral Cooperation Game and Collaborative Governance

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Abstract. While sharing bicycles brings convenience to people's lives, the public's illegal parking takes up public roads, making the game between local government and the public more prominent. In the past, most of the studies considered that the public, local government, and enterprises should be co-governated, but the measures were same, and did not find out the intrinsic mechanism and effective measures for the collaborative management. This paper uses the method of cooperative game model and concludes that the tripartite cooperation will lead to a significant reduction in the costs of each party. It also proposes a new idea for governance—"local government guide and encourage, enterprises cooperate and respond, and the public participate actively", so that the public can consciously put shared bicycles in the specific place, whether or not the governments supervise.

1. Introduction

In recent years, the large number of shared bicycles has brought convenience to the public, but also greatly changed the face of the city. The fierce competition among many companies has caused a serious overload of bicycles in society, leading to illegal parking and piles of mountains everywhere. This phenomenon not only affects the urban management of local government, but also causes great waste of resources. If the government blindly adopts restrictive measures against enterprises, it is very likely to cause the emerging sharing economy of this area to die, and it is not easy for the government to rely on its own efforts to reverse the situation, public understanding and corporate technology innovation are very important as well. So it is necessary to require three-way collaborative governance to solve the problem of shared bicycles parking. However, each party can be viewed as a rational economic man and they all hope that their own interests will be maximized. Therefore, if it can be shown that the benefits of tripartite cooperation are much higher than those of individual actions, or the cost of tripartite cooperation is far lower than the cost of individual actions, then it can provide theoretical support for collaborative governance.

On the surface, the problem of illegally parking is caused by the lack of moral awareness of the public. Local government have to strictly do its job for urban governance. The game between the two parties has always been on the stage, and it has been proved by practice that companies should also become the party that participates in the collaborative governance to solve the problem through the innovation of information technology. In order to find out the internal mechanism behind collaboration, this paper analyzes the cost range undertaken by the three parties through game tools, provides a reliable basis for cooperation of the public, local government, and enterprises, and also derives a solution framework for the problems of shared bicycle parking.

2. Theoretical basis

Shared bikes belong to a tangible derivative under the sharing economy, so it is important to understand the sharing economy. Sharing economic theory began in the 1980s. In 1986, Martin Weitzman, a professor of economics at the Massachusetts Institute of Technology in the United States, first mentioned "sharing economy" in the book "Sharing the Economy". He believed that the phenomenon of economic stagflation was mainly due to the fact that the internal fixed wage system

was not linked to operating conditions. As a result, the idea that “profit sharing system” replaced the original wage system was proposed by Martin L. Weitzman (1986) [1], which allows employees and capitalists to obtain reward-sharing results based on the share of company earnings (Dai Ming, et al., 2014)[2] so as to increase employee motivation. Chinese scholar Li Bingyan's view approximately coincides with his points. He started with the issue of enterprise costs under the socialist system, proposed that a net income sharing system can replace the wage system, and distributed net income to countries, enterprises, and employees based on the rules of distribution according to work. Li Bingyan and Weitzman's research focus on the micro level of "profit-sharing," however, the current sharing economy is based on "resource sharing" in a macro-environment. Especially with the rapid development of information technology in the background of Internet, sharing economy are constantly given new connotations and elements.

From the perspective of the three main components, the sharing economy includes demander, supplier, and sharing platforms (Zhao Sihui, 2015) [3]. The supplier and demander realize various transactions or sharing through a shared platform, especially with the rapid development of sharing platforms such as mobile Internet, big data, cloud computing, and the Internet of Things, the transaction costs between the supplier and demander are greatly reduced, and the efficiency of resource connection has also increased rapidly. Therefore, it is put forward that the sharing economy refers to the economic form in which the supplier provides idle resources or services on the Internet sharing platform, and the demander acquires the right to use these resources or services and gives them a certain return. This point can be described in Fig. 1.

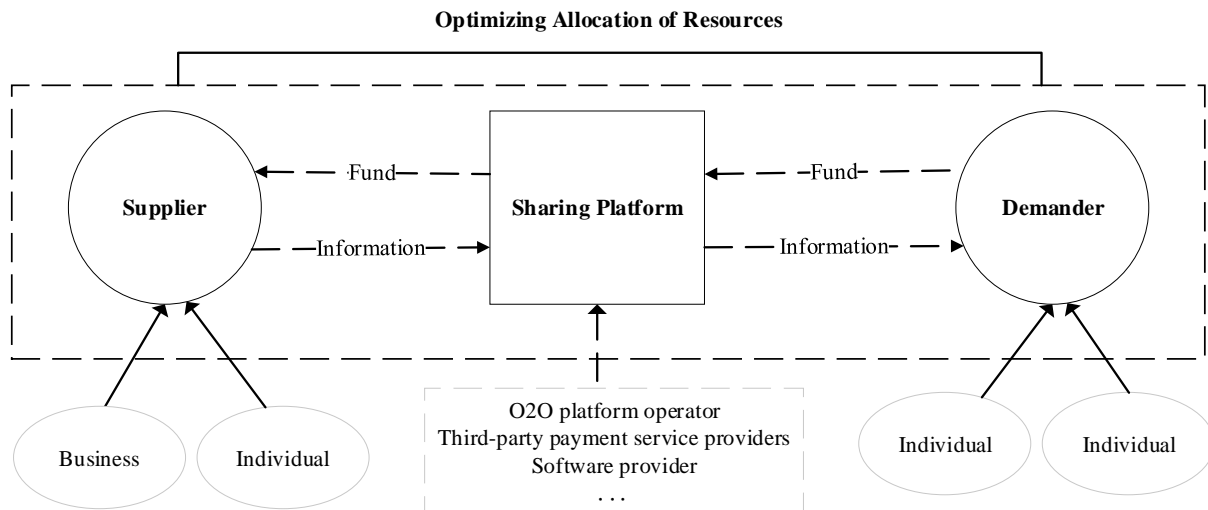


Fig. 1. The operating mechanism of the sharing economy.

The operating mode of the sharing economy is not only one. Fig. 1. shows that the demander is always an individual, and the supplier can be a business or an individual. The attribution of the resources is also distinct, including the alienation of right to use and ownership (Qin Yi, Wang Qin, 2017) [4]. Therefore, a two-dimensional matrix can be established to subdivide the patterns of sharing economy as shown in Table 1.

Table 1. Four patterns of sharing economy.

Heading level	Right to use	Ownership
Business	Capital Type I	Platform Type II
	Sharing Type III	Transfer Type IV
Individual		

- Capital type: Business transfers the right of use to individual. Enterprises produce products and build a platform, provide resources for the demanders and benefit from it. Such as Mo-bike, ofo and Airbnb.

- Platform type: Business transfers the ownership to individual. Enterprise only provide a platform for the individuals to trade resources, and individuals have the ownership of resources that maybe unused, such as T-mall.
- Sharing type: Individual transfers the right of use to individual. One side provides idle resources, and the other side obtains the right to use resources within a certain time. The platform companies facilitate the transaction between the two sides. Such as Didi, Uber.
- Transfer type: Individual transfers the ownership to individual. Once the idle products are taken over by others, the ownership will be transferred to new owners. In this case, the transaction object is generally used idle resources that are no longer needed, and the sharing platform can match supply and demand efficiently and accurately. Such as Guazi, Idlefish.

This article mainly research the shared bicycles that belong to a capital-typed sharing economy. At present, scholars at home and abroad have focused on sharing economy in the aspects of nature, problems, and countermeasures. The parking problem of shared bicycles is only a small part of the research. The measures given are basically collaborative governance of governments, companies, and the public. However, there is no explanation for the internal mechanism of why the three parties should coordinate governance, and no effective measures for solving the parking problems. Therefore, this article first analyzes the game between the public and local government on the issue of shared bicycles parking and determines the cost range of the public for legal parking, and adopts a tripartite cooperative game model to prove that cooperation is more effective than individual action. At the time, everyone's costs are greatly reduced, thus providing a theoretical basis for the collaborative management of the three parties.

3. The construction of tripartite cooperative game model

3.1. Analysis of bimatrix game between the public and local government

- It is assumed that both the public and local government are boundedly rational. In the process of pursuing maximized benefits, they will also consider protecting public facilities.
- It is assumed that the public (P) and local government (G) are the two side of game and in the complete information environment. The public's strategy set is $S_p = \{\text{illegal parking}, \text{legal parking}\}$. The local government's strategy set is $S_g = \{\text{regulation}, \text{non-regulation}\}$;
- When the public wants to save time and effort (marked as R_{pt}) to illegally dispose a shared bicycle, the local government will fine it (marked as F , and $F \geq R_{pt} > 0$), and the direct cost will be ignored. When parking legal is required, the fixed parking area needs to be found, especially when it is far away from where it is going, the time and currency cost to be paid is more (marked as C_{pt}), and of course many local government will reward the citizens who parking the bicycles correctly (marked as R_{pm}).
- Whether the public illegally or legally parking, the local government needs to supervise the parking of shared bicycles due to its obligation. The regulatory cost here is recorded as C_{gm} . When it is found that there is unlawful behavior of citizens, fines can be collected (marked as F). If without supervision, the local government will be punished by the central government. The cost of this part is recorded as C_{gn} .

Therefore, the action choices and payments of the public and local government are shown in Table 2:

Table 2. Action choices and payment of the public and local government.

Participants	Pure strategy choices	Costs	Revenue
The public	Illegal parking	Fine(F)	Saved time and money (R_{pt})
	Legal parking	Time and money costs (C_{pt})	Rewards (R_{pm})
Local Governments	Regulation	Regulatory costs (C_{gm})	Fines collected (F)
	Non-regulation	Superior punishment (C_{gn})	None

The payment matrix for the game between the public and local government is established, as shown in Table 3:

Table 3. Game matrix of public and local government.

		The Public	
		Illegal parking (F-Cgm, Rpt-F)	legal parking (-Cgm, Rpm-Cpt)
Local Government	Regulation	(-Cgn, Rpt)	(-Cgn, Rpm-Cpt)
	Non-regulation	(-Cgn, Rpt)	(-Cgn, Rpm-Cpt)

Table 3 shows that when the local government supervises, the public’s action choice depends on the value of Rpt-F and Rpm-Cpt. When the local government is unsupervised, the choice of the public’s actions depends on the value of Rpt and Rpm-Cpt. This process of game can be shown by Fig. 2.

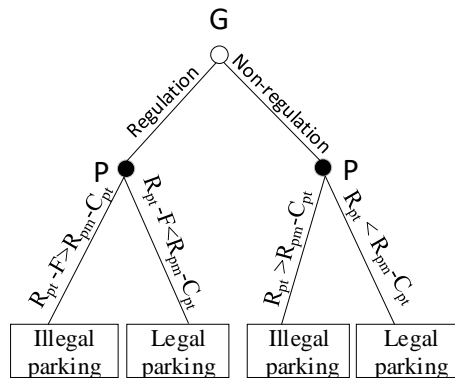


Fig. 2. Game process of the public and local government.

Obviously, there is no pure strategic Nash equilibrium in the game, which belongs to the mixed strategic Nash equilibrium. It is assumed that γ is used to indicate the probability of illegal parking of the public, and that θ indicates the probability of regulation of local government. Then, the probability of legal parking is $(1-\gamma)$ and that of non-regulation is $(1-\theta)$. Therefore, the expected revenue of local government is:

$$E_g = \theta[\gamma(F - C_{gm}) + (1-\gamma)(-C_{gm})] + (1-\theta)[\gamma(-C_{gn}) + (1-\gamma)(-C_{gn})]. \tag{1}$$

The expectation payoff of the public is:

$$E_p = \gamma[\theta(R_{pt}-F) + (1-\theta)R_{pt}] + (1-\gamma)[\theta(R_{pm}-C_{pt}) + (1-\theta)(R_{pm}-C_{pt})]. \tag{2}$$

In Equation (1) and Equation (2), compute the partial derivatives of θ , γ and make them equal to zero.

$$\frac{\partial E_g}{\partial \theta} = \gamma F - C_{gm} + C_{gn} = 0. \tag{3}$$

$$\frac{\partial E_p}{\partial \gamma} = -\theta F + R_{pt} - (R_{pm}-C_{pt}) = 0. \tag{4}$$

After solving the equation group, it is gained the value of γ and θ :

$$\gamma^* = (C_{gm} - C_{gn}) / F. \tag{5}$$

$$\theta^* = (R_{pt} - (R_{pm}-C_{pt})) / F. \tag{6}$$

Therefore, it can be concluded that the mixed strategy Nash equilibrium is: $(\theta^*, \gamma^*) = ((R_{pt} - (R_{pm}-C_{pt})) / F, (C_{gm} - C_{gn}) / F)$. It can be found that when $R_{pt} - (R_{pm}-C_{pt}) < 0$, regardless of regulation and non-regulation of local government, the public will choose to legal parking shared bicycles, and when $R_{pt} - (R_{pm}-C_{pt}) > 0$, if it’s regulated by the local government, the public will legal park, once it is not monitored, it will go illegal. In order to achieve the former ideal goal, it musts meet a condition that $C_{pt} < R_{pm} - R_{pt}$, that is, if the public consciously parking is required, the cost must be controlled the difference between the rewards of legal parking and the benefits of time and money saved in the illegal parking. Further analysis, the government's rewards to legal parking is generally fixed, while that takes some time to look for parking areas, then the resulting monetary gains and other income is almost collected by companies and local government. So in order to en-

hance the motivation for parking legal of the public, it is required to distribute the benefits among the enterprises, the public, and local government.

3.2. Analysis of trilateral cooperative game after introducing enterprises

- It is assumed that the public, enterprises, and local government form a set $N=\{1,2,3\}$, non-empty subset $S(S \in N)$ is a coalition, N is a total coalition. When the three parties are involved in the cooperation at the same time, it forms a game alliance $G = [N, v]$.
- It is assumed that $V(p) = C_p$, $V(f) = C_f$, and $V(g) = C_g$ are the costs of the independent governance of the public, enterprises, and local government, $V(p, f) = C_{pf}$ means the cost of cooperative governance between the public and enterprises, $V(p,g)=C_{pg}$ means the cost of cooperative governance between the public and local government, $V(f,g)=C_{fg}$ means the cost of cooperative governance between the enterprises and local government, and $V(N)=C_n$ is the cost of three-party cooperative governance. And these costs satisfy the quantitative relationship of $V(N) \leq \sum_{i \in N} V(i)$.

In order to simplify the study, the Shapley method can be used to solve the game $G = [N, v]$. According to the Shapley method, the average marginal contribution of person i in each assignment scheme of all game can be expressed as:

$$\Phi_i(v) = \sum_{S \in N} \frac{(n-|S|)! (|S|-1)!}{n!} [v(S) - v(S/i)] \quad i = 1,2,\dots,n. \quad (7)$$

Among them, $|S|$ represents the number of people in the coalition S .

$(n - |S|) !$ indicates the number of leagues arranged.

$(|S| - 1) !$ indicates the permutation number of alliances that exclude the players.

$n!$ indicates the permutation number of n players.

$v(S/i)$ represents the contribution of the other players after removing i in S .

$v(S) - v(S/i)$ represents the marginal contribution to the coalition of the player i .

Therefore, if the three parties cooperate in governance, then $n = 3$, and the costs they bear are:

The cost of the public:

$$\phi_p(v) = \frac{2C_p + (C_{pf} - C_f) + (C_{pg} - C_g) + 2(C_n - C_{fg})}{6} \quad (8)$$

The cost of enterprises:

$$\phi_f(v) = \frac{2C_f + (C_{pf} - C_p) + (C_{fg} - C_g) + 2(C_n - C_{pg})}{6} \quad (9)$$

The cost of Local government:

$$\phi_g(v) = \frac{2C_g + (C_{pg} - C_p) + (C_{fg} - C_f) + 2(C_n - C_{pf})}{6} \quad (10)$$

Since the precondition is $V(N) \leq \sum_{i \in N} V(i)$, $C_{pf} - C_f$, $C_{pg} - C_g$, and $C_n - C_{fg}$ in Equation (8) are all less than zero and $\phi_p(v) < 1/3$. It is found that in the three-party cooperative game, the cost undertaken by the public has fallen to less than 1/3 of the original cost alone. Similarly, the costs of the enterprise and local government have also fallen to less than 1/3 of the original cost. The cost has been greatly reduced, and it indicates operation can achieve win-win. In order to control the costs of the public parking legal within a certain range ($C_{pt} < R_{pm} - R_{pt}$) and realize the ideal goal, it should begin with analyzing the cost structure of the public, including the time and money it takes to find and park in the regulation area. Therefore, it is necessary to create a collaborative governance situation in which local government encourages and guides, enterprises respond to the government, and the public actively participates.

4. Conclusions and suggestion

4.1. Conclusions

This paper focuses on the issue of parking shared bicycles and uses the game theory approach to draw the following conclusions:

First, by analyzing the game between the public and local government, it is concluded that if the costs can be controlled the difference between the rewards of parking legal and the benefits of time and money saved in the illegal parking, it's very likely to achieve the goal for the public's parking shared bicycles legal and consciously, whether or not the government will supervise it.

Second, by using the cooperative game model, it is discovered that when the public, enterprises, and local government make every efforts to cooperate, the cost of each party has become less than 1/3 of the original individual governance, thus demonstrating the necessity and intrinsic mechanism of the three parties.

4.2. Suggestion

First, local government should guide and encourage the public.

The local government should incorporate parking issues of shared bicycles into the scope of market regulation. Local government can regulate the behavior of enterprises from the aspects of setting regional allocations and renovating road facilities, and standardize the behavior of the public through strengthening education and introducing a punishment mechanism. For enterprises and local government, it is necessary to negotiate the input amount of shared bicycles. After the verification, the enterprises cannot increase randomly within the specified time. When the bicycles have been significantly reduced, it will be negotiated for the second time. The Internet monitoring platform will be used to control the input of shared bicycles in real time and carry out penalties, incentives and credit management. At the same time, it can control the input ratio of districts to avoid gathering in central urban areas so that the shared bicycles occupy roadside parking spaces, sidewalks, and motor vehicle lanes, which brings about traffic congestion. In addition, the existing road network will be reconstructed for new bicycle lanes, bicycle driving regulations and penalties will be clarified, characteristic garages will be constructed, illegally parked bicycles will be confiscated in the single garage repair area, and important road sections, bus stops, and subway entrances will be set for forbidden zone. For the public, local government can make full use of the propaganda wall and Internet columns to enhance citizens' awareness of law, morality, and sharing. Any people that violates the punishment regulations will be strictly investigated, and it is possible that the uncivilized phenomenon will disappear gradually.

Second, enterprises can cooperate with and response to government.

Enterprises should standardize social behavior by introducing new technology, credit management and punishment system. Enterprises should cooperate with local government to implement various measures, cooperate with scientific research institutions to incubate scientific results, promote the technical innovation of shared bicycles, and use technical means to solve the parking problem of shared bicycles and establish a credit scoring system for users. Using positioning technology to determine whether the public parks the bicycles in the prescribed area, if illegal parking occurs many times, the users will be classified into the "blacklist" and the falling credit score and deductions will be implemented. Through the advanced positioning system and reasonable planning, the efficiency of use will improve greatly. It can be done to publicize the regulations of shared bicycles and credit information within the software. In addition, the company holds a large amount of user data, through the government-enterprise cooperation, the government can also timely realize the information of using shared bicycles, carry out evaluations of various regions, improve related facilities, and provide escort for green travel.

Third, the public is actively involved

In addition to the propaganda and restraint of local government and corporate, the most important thing is to guide the public to actively participate in the entire decision-making process. Not only can they park bicycles legal themselves, but also actively guide other users to follow the rules

and take on the monitoring functions, that is "Reporting illegal users, complaining against illegal enterprises, participating in government decision-making." The public can use mobile phone software and telephones to report illegally parking users of shared bicycles, illegally operated companies, and form a volunteer team to put illegally parked bicycles in the prescribed area to deliver positive energy. The public are supposed to give some suggestion when local government asks for advice, thereby providing solutions to participate in government decision-making.

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