Shared Bicycle Governance Based on Enterprise Benefit Distribution

Xiaodi Fan *

Liaoning Technical University, Huludao, Liaoning, 125105, China

*18338918665@163.com

Abstract. In order to make the bike-sharing enterprises carry out more reasonable benefit distribution and safe operation, a tripartite collaboration form of recycling and remanufacturing is proposed to grasp the economies of scale of bike-sharing. To study the issue of tripartite benefit distribution, the Shapley value is used to construct a profit distribution model, and the Shapley value method is improved by introducing three influencing factors: investment risk, resource input and product quality. Research results: Shapley value method not only fully reflects the contribution of all parties in the recycling and remanufacturing model of shared bicycle, but also reduces the subjectivity of the model, makes the distribution of benefits more scientific and reasonable, and is conducive to motivating the participants to make more efforts to realize the value-added benefits, which has practical value.

Keywords: Bicycle Sharing, Benefit Distribution, Corporate Governance, Shapley Value Approach

1 STATUS

In recent years, the attention of the new energy industry has continued to increase, with China's “dual-carbon” goal, the recycling of used shared bicycles this issue has aroused people's attention. More than 95% of the materials of shared bicycles can be recycled, but due to the high cost of recycling, narrow profit margins, coupled with the limited mobilization capacity and warehousing capacity of many operators, shared bicycle operators are reluctant to assume the responsibility of recycling. According to the research and analysis of scholars at home and abroad[1], it can be seen that the scrapping and regeneration of shared bicycles are constrained by two major factors: economic and environmental[2], so exploring the efficient recycling mode of decommissioned shared bicycles is the key to the sustainable development of the current shared bicycle industry.

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2 THREE-PARTY COLLABORATION CLOSED-LOOP SUPPLY CHAIN MODEL

Shared bicycle scrapping and regeneration are constrained by low-carbon environmental factors, so exploring the efficient recycling mode of retired shared bicycles is the key to the sustainable development of the current shared bicycle industry. In order to improve the high-value utilization level of used shared bicycles, to realize the closed-loop supply chain formed by operators, manufacturing enterprises, and dismantling enterprises [3], as shown in Figure 1, the recycling of shared bicycles is carried out throughout the entire supply chain, and the operators start from the design and production of bicycles with the "whole-life-cycle environmental protection theory"[4]],entrusted to the manufacturing enterprise is responsible for the design of the product architecture and operation and maintenance.Customer reporting process (with GPS function):

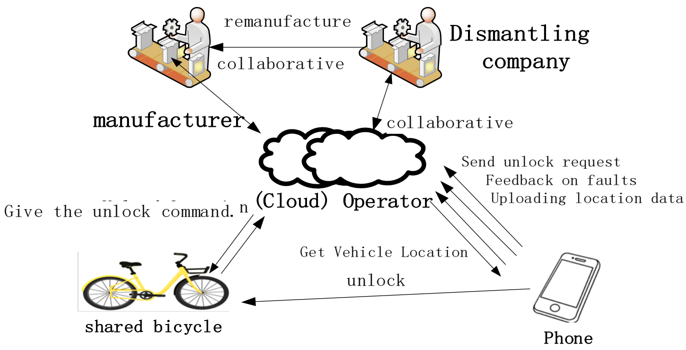

Fig. 1. Closed-loop management model for tripartite recycling and remanufacturing

3 CONSTRUCTING PROFIT ALLOCATION MODEL BASED ON SHAPLEY VALUE

3.1 Shapley Value Initial Profit Distribution Model Construction

The cooperative game model involves multiple players, set the set N={1,2,.... ,n} to denote each player, and S is the set of all subsets of N that contain firm i. Denote that several operators, manufacturing firms, and dismantling firms form a coalition portfolio among these n. The initial profit that firm i earns in the coalition is $X_i(V)$, denoted as:

$$X_i(V) = \sum_{S\subset N} w(|S|)[V(S) - V(S\backslash i)] \tag{1}$$

where w(|s|) is a weighting factor satisfying $\sum_{S\subset N} w(|S|) = 1$; V(S) denotes the revenue of subset S, and V(S/i) denotes the revenue gained by subset S without considering the firms, and then $V(S) - V(S\backslash i)$ means the contribution of the firms to i that coalition. Where:

$$w(|S|) = \frac{(n-|S|)!(|S|-1)!}{n!} \quad (2)$$

As a result, the Shapley value method determines the initial profit distribution scheme for the shared bicycle recycling and remanufacturing consortium as: $X = \{X_1(V), X_2(V), \ldots X_n(V)\}$.

It can be seen that the Shapley value method that each enterprise are with a probability of 1/n! , free permutations and combinations to form an alliance. Firm i forms an alliance S with the preceding (|S|-1) firms, S\i with S\N firms successively sorted into (n-|S|)! (|S|-1)! species, whose probability of occurrence is (n-|S|)! (|S|-1)! /n!. Based on the idea of traditional Shapley's value method[5], the result obtained can be expressed as the expectation of enterprise i's contribution to the alliance, but Shapley's value method defaults the contribution of each enterprise to the alliance to be the same in profit distribution, but in reality there are differences in many factors, so the traditional Shapley's value method has certain limitations, and it needs to be corrected and adjusted on this basis.

3.2 Benefit Distribution Model Based on Improved Shapley Value Method

From the above model, it can be seen that the traditional Shapley value method does not take the influencing factors such as resource input, risk sharing and service quality into account in the distribution of benefits, in order to achieve a more scientific and reasonable distribution of benefits, the cloud center of gravity method is modified to improve the benefit distribution model by drawing on the idea of TOPSIS. its mathematical expression is:

$$\varphi_k(v) = \sum_{S \in U} \varpi(|s|)[v(S) - v(S\{k\})], k = 1,2, \ldots, n \quad (3)$$

$$\varpi(|S|) = \frac{(n-|s|)!(|s|-1)!}{n!} \quad (4)$$

In the formula, $\varphi k(v)$ denotes the benefit shared by the kth member in the total benefit of cooperative alliance U; $\varpi(|s|)$ is the weighting factor; s is the number of elements contained in the subset S of cooperative alliance; $v(S)$ is the benefit gained from subset S; and $v(s\backslash\{k\})$ is the benefit gained in subset S after removing the kth member.

The cloud center of gravity theory[6] is a conversion model of uncertainty between qualitative concepts and quantitative numerical representations, which is mainly expressed by three numerical features: E_x (expected value), E_n (entropy) and H_e (hyperentropy). Based on the cloud center of gravity theory, it is known that a cloud model can be constructed foer each influential factor. Its expression is: $T = a \times b$, where a is the location of the center of gravity of the cloud, the expected value E_x; b is the height of the center of gravity of the cloud, the weight of the influencing factors.

M experts are invited to evaluate and assign values to 10 secondary indicators of 3 major influencing factors, namely, risk magnitude, degree of resource input and product quality, and their exact values are expressed as E_{x_1}~E_{x_m}.

The numerical characteristics E_x、E_n of each indicator cloud model can be expressed as:

$$E_x = \frac{(E_{x_1}+E_{x_2}+\cdots+E_{x_m})}{m} \tag{5}$$

$$E_n = \frac{[max(E_{x_1},E_{x_2},\ldots,E_{x_m})-min(E_{x_1},E_{x_2},\ldots,E_{x_m})]}{6} \tag{6}$$

Calculate the modified value of each subject's gain

The weighted deviationΨof each subject of the participant is normalized to obtain the weighted deviation $\Psi^*$of each subject, and thereturn modification $\Delta\Phi_i(V)$ of each subject is:

$$\begin{cases} \Phi_i(V) = V(n)\Delta R_i \\ \Delta R_i = -\frac{1}{n+\Psi^*} \end{cases} \tag{7}$$

The revised actual income distribution $\Phi_i(V)^*$ is:

$$\Phi_i(V)^* = \Phi_i(V) + \Delta\Phi_i(V) \tag{8}$$

Take resource input α as an example to study the impact of resource input on system evolution, in the case of other values remain unchanged, so that the value of α were 0.1, 0.5, 0.9, to explore the evolution of the three parties under different strengths, the evolution game trajectory is shown in Figure 2 , within a certain range of values, as the operator's resource input is increased, the manufacturing company evolves in the direction of assuming the responsibility for the extension of the remanufacturing, and the dismantling company advances in the direction of active input, and as shown in Figure 3, the model runs well.

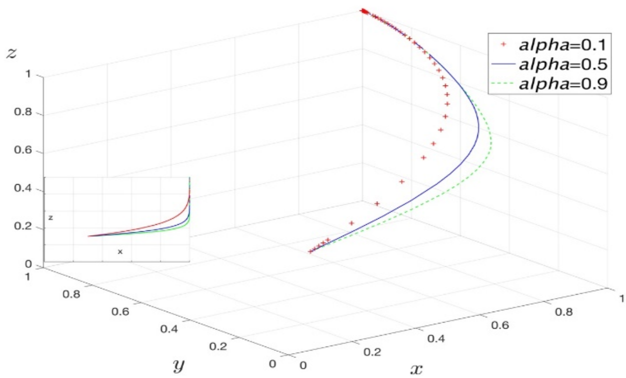

Fig. 2. Impact of resource inputs on system evolution

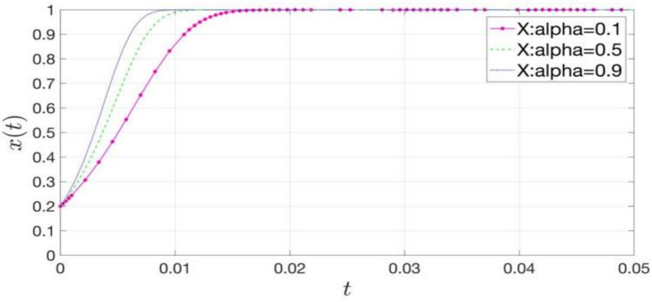

Fig. 3. Resource input impact on operators

3.3 Summary

In summary, the modified Shapley value method fully considers the risk bearing, resource input and product quality of each participant of the shared bicycle, and in the process of modification, the cloud center of gravity evaluation method is used to solve the randomness and ambiguity in the evaluation process, so as to make the distribution of the benefits of recycling and remanufacturing of shared bicycles more reasonable. At the same time, the reasonable distribution is conducive to motivating each participant to put more efforts to realize the value-added recycling and remanufacturing benefits.

4 CONCLUSION

This paper mainly applies the Shapley value method to allocate the recycling and remanufacturing benefits of shared bicycles under the coordination of industrial chain. By analyzing the main factors affecting the distribution of the recycling and remanufacturing benefits of shared bicycles, the three factors of risk, resource input and product quality are introduced on the basis of the Shapley value method, and the cloud center of gravity method is used to improve the original Shapley value method. The results show that the Shapley value method based on cloud center of gravity not only fully reflects the contributions of all parties in the shared bicycle recycling and remanufacturing model, but also reduces the subjectivity in the process of model correction, makes the benefit distribution results more fair and scientific, closer to reality, and has practical value. The shortcoming of this paper is that the model is static, but the actual participants and the environment are dynamic, the model does not take into account the impact of the actual changes, the future will be committed to enhance the adaptability of the model to the dynamic changes in the data.

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