# A Study on Benefit Allocation in Joint Distribution of Last-Mile Delivery

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**Abstract.** The establishment of a benefit allocation mechanism for last-mile joint delivery alliances aims to stabilize cooperative relationships within the alliance. Based on the traditional Shapley value method, this study extends the approach by incorporating four influencing factors: risk-sharing, resource input, delivery volume, and customer satisfaction. An improved Shapley value-based benefit allocation model is developed for joint delivery alliances to address the issue of simplistic and averaged benefit distribution, providing member enterprises with fair and reasonable allocations. Finally, a case analysis is conducted to validate the improved Shapley value method, demonstrating that the enhanced benefit allocation model facilitates the adjustment of member relationships within the alliance, thereby ensuring the sustainability of cooperative partnerships.

**Keywords:** benefit allocation; joint distribution; improved Shapley value method; entropy method.

## 1. Introduction

In recent years, with the widespread adoption of internet technology and the rapid growth of e-commerce, the online shopping market has exhibited unprecedented vitality. As the final link in the supply chain, last-mile delivery plays a crucial role in shaping consumers' experience with courier services. Currently, last-mile delivery is primarily undertaken by postal and courier companies. However, the lack of courier service outlets in remote towns and villages has resulted in the inability to achieve door-to-door delivery. This not only diminishes consumer satisfaction but also constrains the development of the logistics industry. According to the *Courier Market Management Regulations*, effective March 1, 2024, couriers are prohibited from placing parcels in delivery stations or smart lockers without prior consent from recipients, imposing higher service requirements on courier companies for last-mile delivery.

This study focuses on the benefit allocation among courier enterprises, aiming to explore how to establish a stable cooperative joint distribution alliance under the framework of the newly revised “Courier Market Management Regulations”. The core of the research lies in addressing the benefit allocation problem to ensure stable collaboration among enterprises and developing a rational and efficient benefit allocation mechanism for last-mile joint distribution alliances. The proposed mechanism seeks to guarantee door-to-door delivery services while reducing operational costs, improving courier service quality, and expanding the coverage of logistics and delivery networks. The study aspires to provide theoretical support and practical guidance for optimizing e-commerce logistics and distribution systems.

## 2. Principles of Benefit Allocation

### 2.1 Principle of Fairness

Considering the differences in market position, scale, and other factors among enterprises participating in the last-mile joint distribution alliance, the roles and rights of courier companies within the alliance vary. If leading courier companies with strong market positions exploit their advantages to excessively expand their own benefits, it may reduce the benefits of small- and medium-sized courier companies with weaker market positions, ultimately undermining the stability of the alliance. Therefore, ensuring fairness in benefit allocation is essential to prevent dominant enterprises from over-expanding their advantages.

### 2.2 Principle of Shared Benefits

The principle of shared benefits emphasizes resource sharing and collaboration among enterprises in the joint distribution process. By reducing redundant resource investments, it aims to achieve maximum efficiency and minimum costs. This principle ensures that all enterprises receive appropriate returns, thereby avoiding imbalances in benefit distribution.

### 2.3 Principle of Risk Sharing

The last-mile joint distribution alliance should adhere to the fundamental principle of "risk sharing" in its operations. It is essential to consider the risks borne by alliance members and provide corresponding risk compensation, ensuring that those taking on higher risks receive greater benefits.

### 2.4 Principle of Overall Benefit

When implementing joint distribution in various regions, the total benefits of the joint distribution alliance should not be less than the sum of the independent operational benefits of individual courier companies under solo delivery. Additionally, the alliance should not allocate benefits to non-contributors, thereby safeguarding the overall interests of the alliance.

### 2.5 Principle of Individual Benefit

In the implementation of last-mile joint distribution, each participating courier enterprise should receive a final allocation of benefits no less than the profits they would achieve through independent delivery. Otherwise, enterprises would lack motivation to participate in joint distribution. Moreover, all benefits generated by the last-mile joint distribution alliance must be allocated exclusively to the member courier enterprises within the alliance.

### 2.6 Principle of Dynamism

Given the short time since the implementation of the revised Courier Market Management Regulations, the development trajectory of last-mile joint distribution alliances may vary with changes in market dynamics and courier industry trends. Additionally, collaborative efforts among last-mile courier enterprises in China are still in the pilot stage, with few established cases. Considering the evolving market and policy environment, the alliance should dynamically adjust its benefit allocation plan based on actual circumstances.

## 3. Benefit Allocation Model

The cooperative establishment of a last-mile joint distribution alliance by courier enterprises operating in remote areas provides a groundbreaking solution to the “last mile” delivery problem. The key to ensuring the stable operation of such an alliance lies in designing a fair and equitable benefit allocation model. This model should protect the legitimate interests of member enterprises in the alliance, motivate participating companies to collaborate, and attract additional courier enterprises to join. The benefit allocation within last-mile joint distribution alliances adheres to the principles of shared benefits and risk sharing. Member enterprises are treated as equals, sharing both benefits and risks. Furthermore, the greater the risks undertaken by a member enterprise, the larger its share of allocated benefits. Thus, a benefit-sharing model is particularly suitable for this study.

The benefit-sharing model requires the last-mile joint distribution alliance to adopt a benefit allocation mechanism agreed upon by all member enterprises. The alliance itself retains no profits, with all benefits being allocated among its members. This approach encourages enterprises to create more value while requiring alliance members to adhere to the principles of shared benefits and risk sharing. This model is widely used in most alliances for benefit allocation.

In the specific allocation process, the first step is to develop a pre-optimized benefit allocation model for rural last-mile joint distribution based on the Shapley value method, under the premise of clearly defined benefit allocation principles. This initial allocation model takes into account the

differences in the contributions of various members to the alliance's overall benefits, effectively avoiding egalitarianism in distribution. It makes the benefit allocation process more logical and reasonable, enhances member acceptance of the allocation scheme, and reflects the bargaining dynamics among alliance members.

Second, the Shapley value method is refined by incorporating additional influencing factors, such as risk undertaken, resource investment, delivery volume, and customer satisfaction. The basic Shapley value-based allocation model assumes that only the contributions of member enterprises to the alliance's benefits vary, while other influencing factors are implicitly treated as equal. However, to ensure the stable operation of the alliance, it is essential to comprehensively consider these factors in the benefit allocation process.

Finally, the pre- and post-optimized benefit allocation schemes are compared to evaluate the effectiveness of the improved model. This step ensures that the allocation model is robust, logical, and capable of supporting the sustainable operation of the alliance.

## 4. Benefit Allocation Based on the Improved Shapley Value Method

### 4.1 Shapley value method

The Shapley value method was first proposed by Lloyd Shapley, a professor at the University of California, Los Angeles, to address the cooperative game theory problem of conflicts arising from benefit allocation in multi-party cooperation. It is a fair and effective mathematical approach widely applied in cooperative game theory.

Regarding the foundational theory and allocation principles, assume that there are n enterprises in the last-mile joint distribution alliance, represented as N={1，2，…，n}, which denotes the set of alliance members. Let S represent a new subset formed by the members of the alliance, where S∈N is any subset. V(N) represents the total benefits of the alliance, V(S) represents the benefits of subset S, V(i) denotes the individual benefits of courier enterprise i when operating independently, and $\varphi i$(v) represents the allocable benefits for member enterprise i in the alliance.

For the Shapley value calculation formula, $|S|$ represents the number of members in subset S, w($|S|$) represents the weight of enterprise i's share of the total benefits of the alliance, i.e., the probability of each combination occurring. $V(S-i)$ represents the cooperative benefits of the alliance excluding enterprise i, while $V(S)-V(S-i)$ represents the contribution of member i to subset S in the alliance.

Assume that the last-mile joint distribution alliance S is composed of three courier enterprises: A, B, and C. The Shapley value of member enterprise A under different cooperation scenarios and its specific calculation process are shown in the table. The benefit allocation value for member enterprise A can be calculated based on the above formula. Similarly, the benefit allocation values for members B and C can be obtained. Finally, the benefit allocation scheme for the three enterprises based on the traditional Shapley value method is determined.

Table 1 Traditional Shapley value method for benefit distribution

| S | {A} | {A, B} | {A, C} | {A, B, C} |
|---|---|---|---|---|
| remainder | {B, C} | {C} | {B} | ∅ |
| V(S) | a11 | a12 | a13 | a14 |
| V(S-i) | a21 | a22 | a23 | a24 |
| V(S)-V(S-i) | a11- a21 | a12- a22 | a13- a23 | a14- a24 |
| \|S\| | 1 | 2 | 2 | 3 |
| (\|S\|−1)!(n−\|S\|)! | 2 | 1 | 1 | 2 |
| W(\|S\|) | 1/3 | 1/6 | 1/6 | 1/3 |

### 4.2 Analysis of Influencing Factors for the Improved Shapley Value

The sustainable development of a last-mile joint distribution alliance requires the implementation of a benefit allocation scheme that is unanimously accepted by its member enterprises. This involves clearly defining the contribution levels of each member enterprise to the alliance and thoroughly analyzing the factors influencing benefit allocation. These steps form the foundation and prerequisite for conducting benefit allocation in rural last-mile joint distribution. Through a review and analysis of existing research, it is evident that "risk undertaken", "resource investment", "delivery volume", and "customer satisfaction" are the most critical factors influencing benefit allocation. In the process of benefit allocation within the joint distribution alliance, these factors must be considered in conjunction with real-world conditions and the unique characteristics of rural courier services. Consequently, the Shapley value is improved and adjusted by incorporating these four factors into the allocation scheme.

#### 4.2.1 risk undertaken

By forming a joint distribution alliance, courier enterprises can achieve risk-sharing; however, this does not eliminate or reduce risks. On the contrary, the existence of cooperative relationships may give rise to new risks. The members of a last-mile joint distribution alliance include enterprises of different levels, such as leading courier companies and small- and medium-sized courier enterprises. Each enterprise differs in terms of overall competitiveness, scale, service quality, and other internal conditions, which result in varying levels of risk exposure. According to the principle of risk-sharing, assuming other influencing factors remain constant, the higher the level of risk borne by a participant, the greater the share of benefits it should receive. The risks considered in this study primarily include operational risk, collaborative risk, and informational risk.

Based on the principle of shared benefits, the level of risk undertaken by enterprises within the alliance is directly proportional to the share of benefits they should receive. During the decision-making process, enterprises can choose whether to take on risks. Therefore, if an enterprise demonstrates a stronger willingness to actively bear risks or experiences a higher frequency of potential losses within the alliance, its share of allocated benefits should be proportionately higher. Enterprises with higher risk-bearing rates should receive correspondingly greater levels of benefit compensation.

Assume there are n enterprises in the last-mile joint distribution alliance. Enterprise i faces Li potential risk losses, and Ai represents the benefit compensation factor corresponding to the normalized risk-bearing proportion of enterprise i. The calculation formula is as follows:

$$A_i = \frac{L_i}{\sum_{i=1}^{n} L_i} \tag{1}$$

#### 4.2.2 resource investment

During the construction and operation of the last-mile joint distribution alliance, member courier enterprises, adhering to the principle of sharing, contribute substantial resources to the alliance, including infrastructure resources, transportation resources, warehousing resources, financial resources, human resources, information technology, brand reputation, and customer bases. These resource contributions effectively promote the establishment of rural last-mile joint distribution alliances. However, due to differences in capacity and resource availability among enterprises, the proportion of resources contributed by each enterprise varies. This disparity impacts the benefit allocation ratios among the enterprises. Therefore, in the implementation of benefit allocation, it is essential to comprehensively consider these factors. The greater the proportion of an enterprise's resource contribution to the total resources of the alliance, the greater the share of benefits it should receive.

Assume there are n enterprises in the last-mile joint distribution alliance, contributing three categories of resources for the alliance's development. Matrix Q represents the cost values of each

type of resource contributed by each enterprise. The entropy method is used to calculate the weights of each type of resource contributed by the enterprises. The entropy method is a multi-indicator evaluation approach that determines the weight of each indicator in the evaluation system by calculating the entropy of each indicator, thereby performing a comprehensive evaluation of the subjects.

When the degree of dispersion in the indicator data is larger, the information entropy is smaller, and the amount of information provided by that indicator is greater. As a result, the importance of that indicator in the comprehensive evaluation system is also higher, leading to a larger weight for that indicator. The advantage of the entropy method lies in its ability to objectively reflect the importance of each indicator within the evaluation system, making it suitable for multi-indicator comprehensive evaluation problems. The specific calculation process is as follows:

Step 1: Perform dimensionless processing on the revised matrix Q, standardizing it into the standardized indicator data matrix M. Then, calculate the proportion of each indicator data, denoted as Pij:

$$M = \frac{N_{ij} - minN_{ij}}{maxN_{ij} - minN_{ij}} + 0.002 \tag{2}$$

Step 2: Calculate the entropy value ej of the indicator data:

$$e_j = -\frac{1}{\ln(n)} \sum_{j=1}^{n} P_{ij} lnP_{ij} \tag{3}$$

$$\frac{1}{\ln(n)} > 0 \tag{4}$$

Step 3: Calculate the indicator variation coefficient, denoted as qj:

$$q_j = 1 - e_j \tag{5}$$

Step 4: Calculate the weight of the evaluation indicator, denoted as wj:

$$w_j = \frac{q_j}{\sum_{j=1}^{n} q_j} \tag{6}$$

The subsequent weighting process using the entropy method follows the same logic.

In summary, the total value of resources contributed by enterprise i is denoted as Ri:

$$R_i = \sum_{j=1}^{3} Q_j w_j \tag{7}$$

The benefit allocation ratio of enterprise $i$ in the last-mile joint distribution alliance is represented as $Bi$, calculated using the cost aggregation method:

$$B_i = \frac{R_i}{\sum_{i=1}^{n} R_i} \tag{8}$$

### 4.2.3 delivery volume

The volume of courier business is an important indicator for measuring the contribution level of member enterprises in the last-mile joint distribution alliance. The alliance evaluates courier business based on quantity as the standard. The greater the volume of courier business, the higher the pre-delivery transportation costs borne by the member enterprises, and the more benefits they generate for the alliance as a whole.

Assume that the volume of courier transportation business undertaken by member enterprise i in the last-mile joint distribution alliance is Ei, and the average revenue per courier service ticket for enterprise i is Qi. Then, considering only the courier business volume of enterprise i, the benefit allocation ratio Ci for enterprise i is:

$$C_i = \frac{E_i Q_i}{\sum_{i=1}^{n} E_i Q_i} \tag{9}$$

### 4.2.4 customer satisfaction

According to the newly revised *Courier Market Management Measures*, if a courier company fails to adequately perform its delivery tasks or provide satisfactory service quality to consumers, the company may face warnings or even fines. Therefore, the quality of courier service experienced by consumers becomes a critical factor, imposing high demands and strict constraints on courier companies' service quality and future development direction. This drives the courier industry towards intensive and comprehensive development in rural areas, with last-mile joint distribution becoming a growing trend.

However, member enterprises within the joint distribution alliance adopt different approaches and levels of effort in improving consumer satisfaction, resulting in varying benefits. Specific evaluation indicators of consumer satisfaction include transportation efficiency, delivery efficiency, the rate of home deliveries, and parcel integrity rate. The effort levels of enterprises can be measured by their level of cooperation, degree of resource coordination, and task completion levels.

To encourage enterprises to enhance service quality while balancing costs, the alliance should provide certain rewards to companies with high consumer satisfaction in its benefit distribution process. The amount of benefit distributed should be directly proportional to the level of consumer satisfaction.

Let the customer satisfaction of alliance member enterprise i in a specific aspect be Gij, and let Hi represent the weighted customer satisfaction of enterprise i. Di represents the proportion of benefits to be allocated based on the customer satisfaction level of enterprise i in the alliance. The calculation steps are as follows:

$$H_i = \sum_{j=1}^{5} G_{ij} w_j \tag{10}$$

$$D_i = \frac{H_i}{\sum_{i=1}^{n} H_i} \tag{11}$$

## 4.3 Improved Shapley Value Benefit Distribution Model with the Introduction of a Correction Factor

If the benefit distribution is calculated using the basic method, the benefits brought by a member joining the alliance will be evenly distributed among all members, making it difficult to ensure fairness and equity in the distribution. Therefore, it is necessary to consider the aforementioned influencing factors and introduce corresponding weights for risk-sharing, resource contribution, courier business volume, and customer satisfaction to adjust the Shapley value. The improved Shapley value benefit distribution method better ensures fairness within the alliance and helps to enhance the cooperative enthusiasm of alliance members.

Assume that there are n member enterprises in the last-mile joint distribution alliance. The set of correction factors for the alliance's benefit distribution is J={j}, where j = 1, 2, 3, 4. Let $x_{ij}$ represent the proportion of member i in the alliance with respect to the j-th correction factor. The correction factors are shown in the table below.

Table 2 Correction factors

| j / i | risk undertaken | resource investment | delivery volume | customer satisfaction |
|---|---|---|---|---|
| 1 | x11 | x12 | x13 | x14 |
| 2 | x21 | x22 | x23 | x24 |
| … | … | … | … | … |

| n | xn1 | xn2 | xn3 | xn4 |
|---|---|---|---|---|

The adjusted benefit distribution value for enterprise i is:

$$V_i = \varphi_i(v) + \left( \frac{z_{ij}}{\sum_{i=1}^{n} z_{ij}} - \frac{1}{n} \right) \times V(N) \tag{12}$$

In summary, the improved Shapley value method for benefit distribution in the last-mile joint distribution alliance addresses the drawback of the initial benefit distribution scheme, which averaged the impact of various influencing factors. This enhancement strengthens the fairness of the benefit distribution.

## 5. Summary

Last-mile joint distribution in courier services requires both delivery efficiency and quality. On the one hand, courier companies need to shorten delivery times; on the other hand, they must comply with the provisions of the newly revised *Courier Market Management Measures*, providing doorstep delivery services as required by consumers. Therefore, courier companies operating in rural areas should complement each other's strengths when building a last-mile joint distribution alliance, enhancing overall delivery performance and maximizing the alliance's benefits in joint delivery operations. Enterprises with different market positions and financial strengths contribute differently to the alliance. To ensure the stable operation of the alliance, a fair and reasonable benefit distribution scheme is crucial.

The benefit distribution scheme for the last-mile joint distribution alliance proposed in this paper provides a certain reference value for courier company operations under the newly revised *Courier Market Management Measures*. However, the study still has some limitations. The correction factors selected in this paper are not comprehensive enough and could be expanded with more systematic research based on practical scenarios. Additionally, the construction of last-mile joint distribution alliances is challenging, and the enforceability and binding nature of the benefit distribution mechanism for alliance members need to be improved. Therefore, future research could focus on aspects such as alliance operations and member management.

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