sustainability

Article

Research on Profit Allocation of Agricultural Products Co-Delivery Based on Modified Interval Shapley Value

Chenglin Wang, Zhicheng Zhou, Xiaohui Yu, Jintao Chen, Pengnan Li and Ziqi Wang *

School of Logistics, Beijing Wuzi University, Beijing 101149, China
* Correspondence: wangziqi991201@126.com

Abstract: Most of the domestic wholesale markets have many operating entities, and the level of organization and scale is not high; therefore, at this stage, building a shared business platform and carrying out common distribution is an important way to improve the overall efficiency of the wholesale market distribution operations and the level of the intensive utilization of key resources such as vehicles. Carrying out common distribution requires the formation of a good synergy mechanism among the participating subjects, in which the design of a scientific and reasonable benefit distribution scheme, especially in balancing the relationship between government resources and social resources, is particularly important. As the benefit distribution of cooperation is affected by the dynamic changes of the resource input ratio, the distribution operation scale, the risk taking, and other factors, this paper establishes a multi-weight interval Shapley value method benefit distribution model, which reflects the effect of the key parameter variables. Through the empirical analysis of Beijing's wholesale markets for agricultural products, the results show that the revised benefit distribution is more in line with the interest demands among multiple subjects and is positively correlated with the contribution degree among the participating subjects, which can better mobilize the cooperation enthusiasm of the participating enterprises and provide a new methodological path to solve the problem of common distribution in wholesale markets. The distribution model constructed in this paper further enriches the relevant research content in the field of common distribution and is of reference value for the benefit distribution problem that requires comprehensive consideration of the dynamic change in the multiple parameters affecting the relationship.

Keywords: profit allocation; cooperative game; interval Shapley value; joint distribution

Citation: Wang, C.; Zhou, Z.; Yu, X.; Chen, J.; Li, P.; Wang, Z. Research on Profit Allocation of Agricultural Products Co-Delivery Based on Modified Interval Shapley Value. *Sustainability* **2023**, *15*, 3303. https://doi.org/10.3390/su15043303

Academic Editors: Yuan-Wei Du, Man Qin and Alvaro Labella

Received: 23 December 2022
Revised: 1 February 2023
Accepted: 8 February 2023
Published: 10 February 2023

1. Introduction

According to the "Beijing-Tianjin-Hebei Synergistic Development Plan Outline", Beijing has started to gradually decentralize non-capital functions. Agricultural wholesale markets are indispensable in the city but urgently need to be upgraded and transformed to meet the requirements of the new era in Beijing. In response, the Beijing Logistics Special Plan emphasizes the need to make full use of informationization, standardization, and intelligence to develop common distribution and to achieve resource integration and optimization. This paper takes this as the starting point and proposes a unitized common distribution model for agricultural products logistics in professional wholesale markets by studying the insights of domestic and foreign scholars on the common distribution models. By introducing the Beijing Fresh and Live Agricultural Products Circulation Center as a practical case, the Shapley value method is used to study the benefit distribution of the integrated business community of agricultural products co-distribution led by the park enterprises and to increase the consideration of resource input, distribution operation, and risk bearing.

The essence of the integrated business community for common agricultural products distribution is to establish a shared and cooperative information platform to gather core resources such as sites, vehicles, and pallets; this needs to be based on resource sharing and information interconnection among multiple agricultural products logistics and distribution enterprises. Multiple agricultural products logistics and distribution enterprises jointly finance the introduction of information technology equipment to improve efficiency. The members of these enterprises form a community with a close integration of interests, and they jointly allocate benefits and bear risks. Finally, the supply chain integration services, such as distribution and processing, refrigerated storage, common distribution, and financial services, are realized. The Beijing Fresh and Live Agricultural Products Circulation Center, located in Hei Zhuang Du Township, is a new agricultural products logistics complex newly built under the guidance of Beijing Logistics Special Planning. Its function is positioned as an important core node of the capital city logistics system, a cornerstone for the livelihood of the capital city's agricultural products, and an innovation base in the field of the modern supply chain for agricultural products. In this case, Company A, namely Shounong Group, is the actual operator of the distribution center, while Companies B, C, and D are the commercial enterprises stationed in the distribution center and have their own large agricultural products logistics and distribution businesses. Company A takes the lead in gathering the commercial enterprises with strong agricultural logistics and distribution capabilities in the distribution center to form a comprehensive business community for the common distribution of agricultural products, and Company A uses new energy distribution vehicles as the carriers to carry out the unitized common distribution of agricultural products. The main three reasons for choosing trade enterprises with their own logistics and distribution businesses in the distribution center are the following: firstly, the trade enterprises have certain sources of goods, which can be used as the basic sources of goods at the initial stage of the community; secondly, the trade enterprises in the park have an interest-binding relationship with the park itself, which makes the cooperation more stable; thirdly, the trade enterprises in the park know more about the basic situation of distribution in and around the park than the third-party logistics companies, and they have more professional agricultural products distribution ability.

After forming an integrated business community for the common distribution of agricultural products, Company A will focus on maintaining the logistics site operations and distribution business within the park. Companies B, C, and D will focus on investing in the labor and logistics facilities, such as vehicles and pallets, to complete the shared distribution business outside the park. To realize the integrated supply chain operations, the four companies will also jointly invest in the construction of basic logistics facilities, such as a shared distribution information service platform, a shared pallet dispatch center, new energy vehicles, charging piles, and sorting and operation systems. The final benefit distribution will be decided based on the enterprises' dedication to the business community.

A shared distribution information service platform is established to instantly transmit incoming goods information, logistics information, and order information to fresh produce suppliers and fresh produce e-commerce platforms, and operational information is fed back to the members of the integrated business community in the application of the shared distribution business in the park. The shared pallet dispatch center will send planning instructions to the service outlets at the origin and provide pallet rental and recycling business for the fresh produce suppliers. At the same time, the operation information will be fed back to the members of the integrated business community. Finally, the physical business process of "unified storage, unified distribution and unified service" is realized in the Beijing Fresh Agricultural Products Distribution Center.

When multiple fresh produce suppliers choose to adopt transportation with boards, it greatly reduces the workload of the intermediate turnover link. Under the role of a unitized shared distribution information service platform, the merchant order resources are integrated. Then, the unified agricultural products are jointly distributed by the integrated business community through the transportation with boards. They are transported to the demand points such as e-commerce stores and farmers' markets. This model can effectively promote the efficient operation of logistics, capital flow, and information flow and can realize modern distribution services. The specific distribution model is shown in Figure 1.

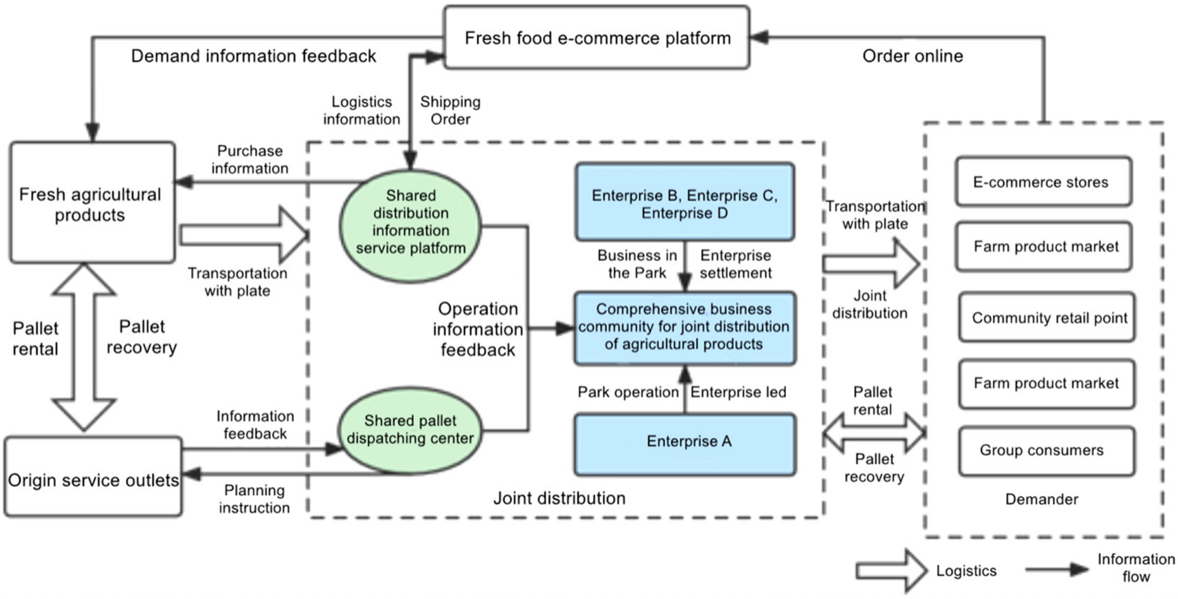

Figure 1. Beijing Fresh Agricultural Products Circulation Center unit sharing distribution mode.

The remainder of this paper is organized as follows. In Section 2, we review some studies about agricultural products and the joint distribution model. In Section 3, a profit distribution model is built based on the interval profits, and the multi-weight interval Shapley value is proposed. In Section 4, a numerical case is given, where the costs are computed based on equipment costs, vehicle expenses, manpower costs, and risk costs. Finally, special attention is paid to the profit distribution scheme based on the proposed multi-weight interval Shapley value.

2. Literature Review

Domestic and foreign scholars generally believe that joint distribution can bring certain social benefits. Aminoff [1] and Osorio et al. [2] believe that the implementation of common distribution can integrate the main resources in each link of the supply chain and make the relationship between cooperative enterprises closer and closer and can realize the goal of reducing costs and increasing efficiency, and at the same time, it can relieve urban traffic pressure. Lu Hua et al. [3] established the dynamic model of the urban freight transportation system in urban joint distribution and performed a dynamic simulation and concluded that the overall benefit of joint distribution is optimal and that there is the potential for energy saving and emissions reduction.

The current research on the construction of a common distribution mode mainly considers the regional common distribution mode under different environments from the terminal point of view. Based on the idea of common distribution, Leon Pretorius et al. [4] conducted a specific study on the terminal logistics distribution problem of the urban regional logistics center and established a common distribution node. Hao Zhang et al. [5] designed a common distribution mode of daily necessities led by large-scale agricultural product wholesale enterprises from the perspective of supply chain integration. Considering the fragile and perishable characteristics of fresh agricultural products, the common distribution of agricultural products needs to solve the problem of the cold chain. Zhiguo Wang [6] put forward the strategic concept of the establishment of a rural common distribution system based on a new type of rural cooperative economic organization, with cold chain logistics services as the carriers and regions as the link. Wenzhao Tao et al. [7] proposed the urban food cold chain 2B/2C business integration and co-location model and established a pricing game model between third-party logistics companies and fresh food e-commerce.

As most of the merchants operating fresh agricultural products in the market are small and medium-sized, they often lack a professional independent logistics system and need to use the third-party logistics industry to realize resource integration. Hou Bin et al. [8] and Maozeng Xu et al. [9] study, respectively, the joint distribution operation mode of the eco-city led by third-party logistics companies and the four common distribution modes of third-party logistics companies under different conditions of resource sharing. Liuxin Chen et al. [10] constructed a retailer–TPL–supplier three-level agricultural product supply chain profit model and found that the profits of the supply chain and its members would increase with the increase in the TPL preservation level. In this regard, Jun Ye et al. [11] incorporated the decision making of the cold chain logistics service level of third-party logistics companies into the cross-border trade operation of the fresh agricultural product supply chain and constructed the Stackelberg game model of the fresh agricultural product supply chain.

With the deepening of the research, the insightful domestic scholars have found that pallets are the basic tools for urban common distribution and that pallet sharing can greatly save costs and ensure the standardization of item packaging. CARRANO A L et al. [12] believe that pallet sharing can reduce carbon emissions and improve the efficiency of logistics operations. The study of ELIA V et al. [13] found that a pallet logistics network and exchange system are the key factors in realizing a closed-loop pallet management system. Guanghua Zhao et al. [14] proposed four common distribution operation modes based on shared logistics and believed that a logistics information platform had to be established to ensure the organic combination and sharing of the various areas of information. Zhengyu Wang et al. [15] studied the problem of a multi-service station, multi-cycle, multi-pallet model of the urban common distribution of common pallet scheduling and constructed a stochastic planning model of common pallet scheduling.

In addition to model research, the issue of the profit allocation of common distribution is also of great research significance. In combination with the existing research, some scholars have improved and innovated the traditional Shapley value method with consideration of different influencing factors, perspectives, and fields in order to study the profit allocation of common distribution. With regard to the different influencing factors, Wang Y [16] studied the distribution profit allocation of shared distribution centers and shared end nodes, considered cost factors, and revised the Shapley value model. Xuanfei Wang et al. [17] introduced factors such as resource investment, risk sharing, and innovation ability to improve the Shapley value method and obtained the comprehensive quantitative value of each participant in the mobile payment business model. Xiaojuan Bai et al. [18] revised the traditional Shapley value method from the three factors of risk taking, business execution, and innovation resource investment and constructed an improved profit allocation model of the Shapley value method. Considering different perspectives and fields, Jie Yang [19] et al., based on the perspective of contribution degree, obtained the cost coordination strategy of alliance members according to the difference in contribution degree through the marginal contribution distribution and contribution difference modification of the Shapley value. Yefu Zhou [20] considered the information sharing and benefit sharing among the consortium subjects and distributed the benefits between the horizontal and vertical supply chain alliance subjects through Stackelberg game theory and the Shapley value model. From the perspective of the cooperative game, Ke Xu [21] used the optimized Shapley value method to analyze the cost-benefit composition and profit distribution of each link of a Beijing dairy industry chain. From the perspective of the cooperative game, the optimized Shapley value method was used to analyze the cost-benefit composition and profit distribution of each link of the Beijing dairy chain. Zhenxiang Gao et al. [22] analyzed the cost-benefit composition of the production, marketing, and transportation entities in the supply chain when they operated independently. Mingke He et al. [23] and Yong Wang et al. [24] studied, respectively, the common distribution problem between large retailers and vehicle sharing centers and used the improved Shapley value model to study the profit allocation problem of the alliance.

Yong Wang, Fangfang Guo, and other scholars consider the use of various methods to construct models in different environments to solve the problem of the profit allocation of common distribution. Yong Wang et al. [25] constructed a linear programming model for multi-center common distribution at the same level and applied the improved GA–PSO hybrid algorithm to solve it to improve the stability of multi-center cooperation alliance. Fangfang Guo et al. [26] studied the profit allocation problem in the process of an urban common distribution alliance based on the evaluation model of the AHP-entropy weight method. Xin Peng et al. [27] adopted the two-stage common distribution profit allocation model of the Nash negotiation method to solve the problem of the task-oriented common distribution alliance profit allocation. Yanning Jiang et al. [28] constructed a two-level programming mathematical model of a common distribution operation mode under the conditions of a multi-distribution center and a type of multi-cargo and solved the problem of joint distribution operation and cost allocation.

In summary, scholars at home and abroad have fully recognized the significance of common distribution and have proposed many regional common distribution models and profit allocation methods. However, the existing model research lacks the integration of shared factors and practical case studies on the joint distribution of agricultural products, and it lacks the research on the distribution of profit among the members of the shared distribution, and most models allocate the total income as an accurate value, without considering the actual application scenarios. This paper proposes a new model for the unitized logistics of the shared distribution of agricultural products based on the core enterprise as the leader and the integrated business community of agricultural products co-distribution and takes the Beijing Fresh and Live Agricultural Products Distribution Center as a practical case to study the benefit distribution mechanism under this model.

3. Research Methods

The common distribution revenue of the Beijing Fresh and Live Agricultural Products Distribution Center is the result of the joint cooperation between the park enterprises and the trade enterprises. This can be regarded as a benefit distribution problem of cooperative response. Due to the long cost recovery period of the common distribution project of the Beijing Fresh and Live Agricultural Products Distribution Center, each participating enterprise cannot be accurately informed of the benefits generated by the cooperation. This makes the traditional Shapley value method limited. Therefore, this paper treats the benefits obtained by each participating enterprise as an interval number and determines the weights of the influencing factors. In this paper, the multi-weight interval Shapley value method is used to conduct a study on the benefit distribution of the common distribution in the Beijing Fresh and Live Agricultural Products Distribution Center [29].

3.1. The Influencing Factors of Joint Distribution of Benefits

There are many factors that affect the profit distribution in the implementation of the agricultural product joint distribution mode. Through field investigation and analysis, this is carried out from the perspectives of resource input, distribution operation, and risk taking so as to lay a good foundation for the construction of the profit allocation model.

3.1.1. Resource Investment

Resource input includes the human, material, and financial resources invested by participating enterprises during the implementation of an agricultural products co-distribution business, and it also includes tangible assets, such as initial capital, infrastructure, new energy distribution vehicles, unitization apparatus, manpower, and intangible assets such as the service capability, social influence, and innovation capability of the participating enterprises. It is the guarantee of the operation of the joint distribution mode, and its influence on the profit distribution occupies a large proportion [30].

3.1.2. Distribution Operation

The distribution operation includes factors such as the volume of co-distribution of the agricultural products, the volume of broken agricultural products, the cold chain distribution situation, the application of green packaging, the application of logistics technology, the cooperation among participating companies, and customer satisfaction. The distribution operation of the agricultural products is the direct influence factor in the obtaining of benefits. Usually, the greater the number of agricultural products co-distribution completed by the members of the integrated business community of agricultural products, the more the profit that is created for the enterprise, which is more favorable to the development of the co-distribution mode.

3.1.3. Risk Taking

Risk taking includes market risk, time risk, information sharing risk, tray loss risk, cooperative management moral risk, management style difference risk, and other factors. At present, the competition of agricultural logistics enterprises is seriously homogenized. The strong third-party logistics enterprises can better cope with the market changes, while the weak enterprises cannot adapt to the market changes and face the risk of bankruptcy. Therefore, the risk-bearing capacity is also an important criterion for profit distribution [31].

3.2. Profit Distribution Model Based on Multi-Weight Interval Shapley Value Method Is Constructed

3.2.1. Initial Shapley Value Method Profit Allocation Model

The Shapley value method was proposed by Shapley L.S. in 1953 to solve the problem of multiple insiders conflicting over the distribution of benefits in the process of cooperation; the method belongs to the field of cooperative games [32]. One of the major advantages of applying Shapley value is to distribute the benefits according to the marginal contribution of a member to the coalition, i.e., the benefit shared by member i is equal to the average of the marginal benefits created by that member for the coalition in which he participates. Sakawa and Nishizaki extended the payment function in classical cooperative countermeasures from real numbers to fuzzy numbers and proposed fuzzy payment cooperative countermeasures [33]. Let n participants voluntarily join the common distribution alliance organization in order to reduce costs and optimize resource allocation. The binary group $(N, \overline{v})$ is the cooperative response with the interval payment on the set of stakeholders of the benefit distribution of the Beijing Fresh Produce Distribution Center $N = \{1, 2 \ldots, n\}$, where $\overline{v}$ is a fuzzy payment function whose values are on the power set $P(N)$, defined as N $\overline{\Re}$, $\overline{v} : P(N) \to \overline{\Re}$, and $\overline{v}(\varnothing) = 0$. In this paper, we assume that the distribution subject of the common distribution benefit of the Beijing Fresh Agricultural Products Circulation Center consists of black dealer enterprises and three third-party trade enterprises, which can be represented by $N = \{1,\ 2,\ 3\}$. The fuzzy payment function refers to the total revenue obtained by each stakeholder in the common distribution of Hei Zhuangtou's agricultural products logistics.

As the cooperative game $P(N)$ has a corresponding interval pay function, there is a unique interval Shapley function $\overline{\phi}_i(\overline{v}) : P(N) \to \overline{\Re}$ that accords with the three axioms of interval symmetry, interval validity, and interval additive, which are shown below.

Axiom 1. *(Interval validity) If S is carrying on the* $(N, \overline{v})$*, the*$\sum_{i\in N} \phi_i^+(\overline{v}) = \sum_{i\in S} \phi_i^+(\overline{v}) \geq v^+(N)$, $\sum_{i\in N} \phi_i^-(\overline{v}) = \sum_{i\in S} \phi_i^-(\overline{v}) \leq v^-(N)$*, If* $i \notin S, \overline{\phi}_i(\overline{v})(S) = 0$*;*

Axiom 2. *(Interval symmetry) If the player in the game* $i \in N$*.* π *being any displacement over* N*,*$\overline{\phi}_{\pi(i)}(\pi\overline{v}) = \overline{\phi}_i(\overline{v})$*;*

Axiom 3. *(Interval additivity) For any two cooperation countermeasures,*$(N, \overline{v}_1)$ *and* $(N, \overline{v}_2)$*, if there is a cooperation countermeasure,* $(N, \overline{v}_1 + \overline{v}_2)$ *for* $\forall S \in P(N)$*, there are always* $(\overline{v}_1 + \overline{v}_2)(S) = \overline{v}_1(S) + \overline{v}_2(S)$*; then,* $\overline{\phi}_i(\overline{v}_1 + \overline{v}_2) = \overline{\phi}_i(\overline{v}_1) + \overline{\phi}_i(\overline{v}_2)$*,* $i \in N$*.*

The definition 1 interval numbers satisfy the addition and subtraction operations: given two interval numbers, the following equation holds. Thus, the value range of the ambiguous expected benefit of the Beijing Fresh Agricultural Product Circulation Center joint distribution cooperation solution with the remit $\overline{\phi}_i(\overline{v})$ can be represented as:

$$\begin{array}{c} \overline{a} + \overline{b} = [a^- + b^-, a^+ + b^+] \\ \overline{a} - \overline{b} = [a^- - b^+, a^+ - b^-] \\ \overline{\phi}_i(\overline{v}) = \sum_{i \in S \in P(N)} \gamma_S(\overline{v}(S) - \overline{v}(S \backslash \{i\})) \end{array} \quad (1)$$

For $\forall i \in N$, there are:

$$\gamma_s = \frac{(n-s)!(s-1)!}{n!} \quad (2)$$

$$\begin{cases} \overline{\varphi}_i(\overline{v}) = \left[\varphi_i^-(\overline{v}), \varphi_i^+(\overline{v})\right] \\ \phi_i^+(\overline{v}) = \sum_{i \in S \in P(N)} \gamma_S(v^+(S) - v^-(S \backslash \{i\})) \\ \phi_i^-(\overline{v}) = \sum_{i \in S \in P(N)} \gamma_S(v^-(S) - v^+(S \backslash \{i\})) \end{cases} \quad (3)$$

where γ_s is the weighting factor; S is the number of people in the joint distribution alliance of the Beijing Fresh Agricultural Products Circulation Center; n is the number of stakeholders; $\overline{v}(S)$ is the total revenue of alliance S; $\overline{v}(S \backslash \{i\})$ is the revenue that participating enterprise i can obtain without consideration; $\overline{v}(S) - \overline{v}(S \backslash \{i\})$ refers to the contribution value of participating enterprise i in the joint distribution alliance of the Beijing Fresh Agricultural Products Circulation Center; $v^+(S)$ refers to the maximum possible revenue for each participating enterprise in the joint distribution alliance; and $v^-(S)$ refers to the minimum possible revenue for each participating enterprise.

In the joint distribution in the league, for $\forall S \in P(N)$, $v(S) \in R$ with $(S) \in \overline{v}(S) = [v^-(S), v^+(S)]$ was established, namely the Beijing Fresh Agricultural Products Distribution Center, the Beijing Fresh Agricultural Products Circulation Center unitized distribution mode of the cooperative game (N, v), and the initial Shapley value distribution of interests of $\phi_i(v) \in \overline{\phi}_i(\overline{v}) = \left[\phi_i^-(\overline{v}), \phi_i^+(\overline{v})\right]$.

3.2.2. Multi-Weight Interval Shapley Value Method Profit Distribution Model

The traditional interval Shapley value method determines the same weight of the participants in the profit allocation without considering the difference in contributions brought by different factors [34]. Therefore, on the basis of considering the three factors of resource input, distribution operation, and risk bearing, this paper constructs the profit allocation model of the multi-weight interval Shapley value method. The main steps are as follows.

(1) Obtain the initial profit allocation of the Beijing Fresh Agricultural Product Distribution Center based on the Shapley value method and determine the initial profit allocation range of the contributor enterprise $\phi_i(v)$.

(2) The analytic hierarchy process [35] was used to draw the hierarchical model and construct the judgment matrix. The group decision-based calculation method was used to obtain the values of the influencing factors C_{ik}, such as resource input, distribution operation, and risk taking, according to the scores of each expert.

$$C_{ik} = C_{ik} / \sum_{i=1}^{n} C_{ik} \quad (4)$$

(3) Determine the contribution of participating organization i to the organization: $\varphi_i = \lambda_i C_{ik}$:

φ_i is said to participate in the enterprise i contribution to the alliance, satisfying $\sum\limits_{i=1}^{n} \varphi_i = 1$, $1/i$ in the said cooperation organization in the enterprise average contribution. λ_i represents the importance degree of each influencing factor to profit distribution; C_{ik} represents the value of each influencing factor.

(4) Determine the comprehensive contribution limit of participating enterprise: $\Delta\varphi_i = \varphi_i - 1/i$:

$\Delta\varphi_i$ indicates the comprehensive contribution of the participating enterprise i in the joint distribution alliance organization.

(5) Determine the benefit compensation value of the contributing enterprise i: $\Delta\phi_i(v) = \phi_i(v)\mu\Delta\varphi_i$, where $\mu(\mu \in [0,1])$ is the adjustment coefficient, which is determined by the participating enterprises of the Beijing Fresh Agricultural Products Circulation Center. The co-distribution enterprises discuss and decide that the adjustment coefficient is to be 0.3 on the basis of consultation with the industry experts and the consideration of the initial input resources, actual operation situation, risk situation, and market demand situation.

According to the contribution of logistics enterprise i in the cooperation of the distribution alliance, the corresponding benefit compensation will be made. $\Delta\phi_i(v) \geq 0$ indicates that the participating logistics enterprise i has positive compensation. $\Delta\phi_i(v) \leq 0$ indicates that the participating logistics enterprise i has negative compensation.

(6) Determine the range of benefits in the participation of enterprise i: $\phi_i{}'(v) = \phi_i(v) + \Delta\phi_i(v)$.

The result is the revised multi-weight-range Shapley value method for the Beijing Live Agricultural Product Distribution Center, with the profit allocation scheme being $\phi' = (\phi_1{}'(v), \phi_2{}'(v), \ldots, \phi_n{}'(v))$. At the same time, due to the overall operating environment of the market, the operating cost often fluctuates within a certain range. Therefore, based on the multi-weight fuzzy Shapley value method, it has good applicability in the analysis of the revenue distribution problem of the Beijing Fresh and Live Agricultural Products Distribution Center using fuzzy numbers. A scientific and reasonable profit distribution is conducive to the attraction of more companies to the logistics industry [36].

4. Case Study

4.1. Data Exporting

This is a case study of the co-distribution model of agricultural products, as constructed in Section 2. In this paper, B, C, and D, the three large and representative logistics enterprises in the joint distribution alliance led by the black dealer enterprise (A), are selected as the research objects, and the joint distribution business of the four enterprises within a fixed time is selected for calculation and analysis in order to realize the case analysis of the joint distribution profit allocation by the interval Shapley value method under multiple weights. A, B, C, and D form a comprehensive joint distribution business community. Enterprise A is responsible for specific operations and has an experienced operation and management team. As the government gives strong support to its development, it has the right to use all the resources, such as space facilities, operation equipment, distribution vehicles, and auxiliary equipment. With the operating income as the return of the input of enterprise A, and with certain public welfare attributes, the three enterprises B, C, and D are to provide the distribution services. In this shared distribution mode, the public resources are the core resources.

4.1.1. Sharing the Operating Cost of the Distribution Site

The shared distribution center mainly includes the sorting area, office area, parking area, and other functional areas. Each area is charged according to the gradient of the area it occupies. The specific gradient cost is shown in Table 1.

Table 1. Venue fee schedule.

Area	Area Range (Unit: Square Meters)	Fee (Unit: RMB/Square Meter)
Shared distribution center	$[0, 1000]$	$[1.97, 2.11]$
	$[1001, 2000]$	$[1.89, 1.97]$
	$[2001, 3000]$	$[1.83, 1.89]$
	$[3001, 4000]$	$[1.75, 1.83]$
	$[4001, 5000]$	$[1.68, 1.75]$
	$[5001, 6000]$	$[1.61, 1.68]$
	$[6001, 7000]$	$[1.53, 1.61]$

The three enterprises B, C, and D accounted for the site area of 3000 m^2, 2000 m^2, and 1300 m^2. The annual site expense of the shared distribution center is expressed as $\overline{C_1}$. See (5) for the calculation formula of the site operation cost. The specific cost is shown in Table 2.

$$\overline{C_1} = S_1 \times \overline{P_1} \times 365 \tag{5}$$

S_1: Shared distribution center area;
$\overline{P_1}$: Rental fee per unit area.

Table 2. Site fee cost table.

Enterprise	Site Cost (Ten Thousand RMB/Year)
A, B	$[200, 207]$
A, C	$[138, 144]$
A, D	$[90, 93]$
A, B, C	$[307, 319]$
A, B, D	$[264, 275]$
A, C, D	$[211, 220]$
A, B, C, D	$[370, 386]$

4.1.2. Equipment Costs

The equipment of the common distribution center mainly includes the sorting subsystem, the operation control subsystem, the other working tools, the DC quick charging pile, etc. The specific procurement costs are shown in Table 3.

Table 3. Equipment cost of shared distribution center (unit: RMB ten thousand).

Details of Equipment	Technical Parameters	Unit	Amount	The Unit Price
Sorting out system	Number of stations $\leq$ 220	Set	1	$[37.9, 38]$
Operating system	Ability to manage data	Set	1	$[7.4, 7.6]$
Other operation tools	Loading, unloading, handling, packaging equipment, etc.	Set	1	$[13.73, 22.13]$
DC quick charging pile	Wall-mounted type	Pile	1	$[15.6, 18.7]$

The amount of equipment required under the different enterprise cooperation modes is shown in Table 4.

Table 4. Required quantity of equipment.

Enterprise	Sorting out System	Operating System	Other Working Equipment	DC Quick Charging Pile
A, B	1	1	4	8
A, C	1	1	3	6
A, D	1	1	2	4
A, B, C	1	1	6	13
A, B, D	1	1	5	11
A, C, D	1	1	4	10
A, B, C, D	1	1	8	17

The service life of the equipment is calculated as 7 years, and the total annual equipment maintenance cost is calculated as RMB 26,000. The calculation formula of the annual equipment cost is shown in (6), and the specific cost is shown in Table 5.

$$\overline{C_2} = (\sum_{V=1}^{K} \overline{P} \times T)/R + Y \tag{6}$$

$\overline{P}$: Unit price of equipment of certain specifications;
T: Number of devices of a certain specification;
Y: Total annual equipment maintenance cost;
R: Service life of equipment.

Table 5. Equipment cost table.

Enterprise	Equipment Cost (Ten Thousand RMB/Year)
A, B	[35, 43]
A, C	[28, 35]
A, D	[22, 26]
A, B, C	[50, 63]
A, B, D	[43, 54]
A, C, D	[39, 48]
A, B, C, D	[63, 80]

4.1.3. Vehicle Expenses

After the establishment of the shared distribution center, the Geely Remote RE500 Standard Edition new energy refrigerated truck was used as the delivery vehicle, with consideration of the restrictions on trucks around and inside the area. The rated load capacity was 850 kg. The distribution quantity of the B, C, and D enterprises is shown in Table 6.

Table 6. Partial distribution information of three logistics enterprises on a certain day.

Enterprise B		Enterprise C		Enterprise D	
Point of Distribution	Delivery Volume (kg)	Point of Distribution	Delivery Volume (kg)	Point of Distribution	Delivery Volume (kg)
B1	816	C1	710	D1	1360
B2	632	C2	880	D2	897
B3	762	C3	1589	D3	694
B4	1560	C4	950	D4	1075
B5	1280	C5	859	D5	820
B6	518	C6	538	D6	756
B7	846	C7	865	-	-
B8	952	C8	1130	-	-
B9	425	C9	458	-	-
B10	658	-	-	-	-
B11	1335	-	-	-	-

According to Table 6, the number of vehicles after the shared distribution is known, and the specific number of vehicles is shown in Table 7.

Table 7. Number of vehicles after shared distribution.

Enterprise	Number of Vehicles
A, B	$[14, 15]$
A, C	$[12, 15]$
A, D	$[8, 9]$
A, B, C	$[26, 30]$
A, B, D	$[22, 24]$
A, C, D	$[20, 24]$
A, B, C, D	$[34, 39]$

According to national regulations, the average service life of trucks is 15 years, but it is known through research that they are used frequently and carry a large amount of cargo. Therefore, based on industry experience, the service life of trucks is set at 10 years, and the salvage value rate is 6%. According to the state regulations, the power consumption of the new energy vehicles for 100 km is not more than 10 kw/h. According to the average speed of the new energy vehicles, at 65 kw/h for 8 h a day, the electric charge of the Beijing industrial electricity is calculated from 1.1 RMB/kwh. The specific vehicle parameters are shown in Table 8. The calculation formula of the vehicle cost is shown in (7), and the specific cost is shown in Table 9.

$$\overline{C_3} = \sum_{j=1}^{m} V \times (D + \overline{M}) \times 12 \tag{7}$$

V: Sum of quantities of vehicle specification j;
D: Monthly depreciation of vehicle specification j;
$\overline{M}$: Monthly fuel/electricity bill for vehicle specification j.

Table 8. Specific vehicle parameters.

Specifications	Purchase Cost (Ten Thousand RMB/Car)	Depreciation Fee (RMB/Month)	Fuel/Electricity (RMB/Month)
4.02 m of new energy	28.88	$[2262, 2262]$	$[2300, 2500]$

Table 9. Vehicle fees.

Enterprise	Number of Vehicles
A, B	$[77, 80]$
A, C	$[66, 69]$
A, D	$[44, 46]$
A, B, C	$[142, 149]$
A, B, D	$[120, 126]$
A, C, D	$[109, 114]$
A, B, C, D	$[186, 194]$

4.1.4. Manpower Costs

The staff of the shared distribution center includes sorters, drivers, administrative staff, and so on. According to the survey, the average sorter sorted 700 kg of products every day; the drivers are assigned according to the principle of one person per car. The number of post-delivery workers is shown in Table 10. See (8) for the calculation formula of the vehicle cost.

Table 10. The number of staff after shared distribution.

Enterprise	Driver	Sorting Officer	Administrative Staff
A, B	[14, 15]	14	4
A, C	[12, 15]	11	3
A, D	[8, 9]	8	2
A, B, C	[26, 30]	25	7
A, B, D	[22, 24]	22	6
A, C, D	[20, 24]	29	5
A, B, C, D	[34, 39]	33	9

$$\overline{C}_4 = (E_{\mathrm{n}} \times \overline{W_1} + B_n \times \overline{W_2} + F_n \times \overline{W_3}) \times 12 \quad (8)$$

E_n: Sum of drivers;
$\overline{W_1}$: Average driver's salary;
B_n: Total number of sorters and administrative staff;
$\overline{W_2}$: Average salary of sorters and administrative staff;
F_n: Sum of drivers;
$\overline{W_3}$: Average driver's salary.

According to the survey, the average salary of the drivers is [8700, 9200] RMB/month; the average salary of the sorters is [6500, 6800] RMB/month; and the average salary of the administrative staff is [5700, 6200] RMB/month. According to formula (8), the labor cost can be calculated, and the specific cost is shown in Table 11.

Table 11. Manpower costs.

Enterprise	Labor Cost (Unit: Millions/Year)
A, B	[283, 299]
A, C	[232, 245]
A, D	[160, 168]
A, B, C	[514, 543]
A, B, D	[442, 467]
A, C, D	[469, 495]
A, B, C, D	[674, 712]

4.1.5. Risk Cost

According to the survey, the risk cost of the shared distribution center includes the security cost and the insurance cost. The current security cost of the shared distribution center is 37,000 RMB/year, and the average insurance cost is [6.23, 6.42] RMB/ton. The calculation formula of the risk cost is shown in (9), and the specific cost is shown in Table 12.

$$\overline{C_5} = R + \overline{Q} \times Z \quad (9)$$

R: Cost of safety facilities;
$\overline{Q}$: Average insurance cost;
Z: Total distribution per unit time.

Table 12. Risk cost table.

Enterprise	Cost of Labor
A, B	[5.9, 6.0]
A, C	[5.5, 5.6]
A, D	[5.0, 5.1]
A, B, C	[7.7, 7.9]
A, B, D	[7.2, 7.3]
A, C, D	[6.8, 6.9]
A, B, C, D	[9.0, 9.2]

4.1.6. Other Costs

According to the survey, other the costs caused by factors such as unpredictable weather and overtime during holidays account for about 1.3% of the total cost. Therefore, other costs = (the sum of the above costs/98.7%) × 1.3%, as shown in Table 13.

Table 13. Cost summary table (unit: RMB).

Enterprise	Sum of the above Costs	Final Cost	Other Costs
A, B	[600, 635]	[608, 643]	[8, 8]
A, C	[469, 497]	[475, 504]	[6, 7]
A, D	[320, 339]	[324, 343]	[4, 4]
A, B, C	[1021, 1082]	[1034, 1096]	[13, 14]
A, B, D	[877, 929]	[889, 941]	[12, 12]
A, C, D	[835, 885]	[846, 896]	[11, 12]
A, B, C, D	[1302, 1381]	[1319, 1399]	[17, 18]

4.1.7. Sharing Distribution Revenue

According to the survey, the actual operation cost of the shared distribution center is [2.13, 2.36] RMB/kg at present. The benefits of the shared distribution center are shown in Table 14.

Table 14. Income statement of each party (unit: RMB ten thousand).

Enterprise	Shared Pre-Delivery Charges	Shared Post-Delivery Costs	Final Revenue
A, B	[761, 843]	[608, 643]	[118, 234]
A, C	[620, 687]	[475, 504]	[117, 212]
A, D	[436, 483]	[324, 343]	[92, 158]
A, B, C	[1381, 1530]	[1034, 1096]	[285, 496]
A, B, D	[1196, 1325]	[889, 941]	[255, 437]
A, C, D	[1056, 1170]	[846, 896]	[159, 323]
A, B, C, D	[1817, 2013]	[1319, 1399]	[417, 694]

4.2. Initial Profit Allocation

According to Equation (3), we can calculate the interval Shapley value of the profits obtained by the participating enterprises in the whole cooperative organization process of the Beijing Fresh Agricultural Products Circulation Center. The specific benefits are shown in Table 15.

Table 15. Profit value of each enterprise in all sub-strategies under sharing mode (unit: RMB ten thousand).

$\overline{\varphi}(\overline{V})(W)$	A	B	C	D
$\overline{\varphi}(\overline{V})(\{A\})$	0	0	0	0
$\overline{\varphi}(\overline{V})(\{B\})$	0	0	0	0
$\overline{\varphi}(\overline{V})(\{C\})$	0	0	0	0
$\overline{\varphi}(\overline{V})(\{D\})$	0	0	0	0
$\overline{\varphi}(\overline{V})(\{A,B\})$	[59, 117]	[59, 117]	0	0
$\overline{\varphi}(\overline{V})(\{A,C\})$	[58, 106]	0	[58, 106]	0
$\overline{\varphi}(\overline{V})(\{A,D\})$	[46, 79]	0	0	[46, 79]
$\overline{\varphi}(\overline{V})(\{A,B,C\})$	[134, 240]	[76, 134]	[75, 122]	0
$\overline{\varphi}(\overline{V})(\{A,B,D\})$	[120, 211]	[74, 132]	0	[61, 94]
$\overline{\varphi}(\overline{V})(\{A,C,D\})$	[88, 170]	0	[42, 90]	[30, 64]
$\overline{\varphi}(\overline{V})(\{A,B,C,D\})$	[190, 328]	[102, 159]	[70, 117]	[56, 89]

As shown in Table 15: $\overline{\phi}_A(\overline{v}) = [190, 328]$; $\overline{\phi}_B(\overline{v}) = [102, 159]$; $\overline{\phi}_C(\overline{v}) = [70, 117]$; $\overline{\phi}_D(\overline{v}) = [56, 89]$.

4.3. Distribution of Benefits after Modification

4.3.1. Determine the Weight of Each Influencing Factor

The AHP-based Yaahp software is an auxiliary tool for calculating weights; it can realize various functions, such as model construction and calculation analysis. By inputting the judgment matrix values, we determine the weights of each influencing factor of the common distribution of the benefit distribution of the Beijing Fresh and Live Agricultural Products Circulation Center. The specific application process is as follows:

Firstly, a hierarchical model was drawn (see Figure 2), and the hierarchical structure diagram of the influencing factors of the joint distribution profit allocation of the Beijing Fresh Agricultural Products Circulation Center was inputted.

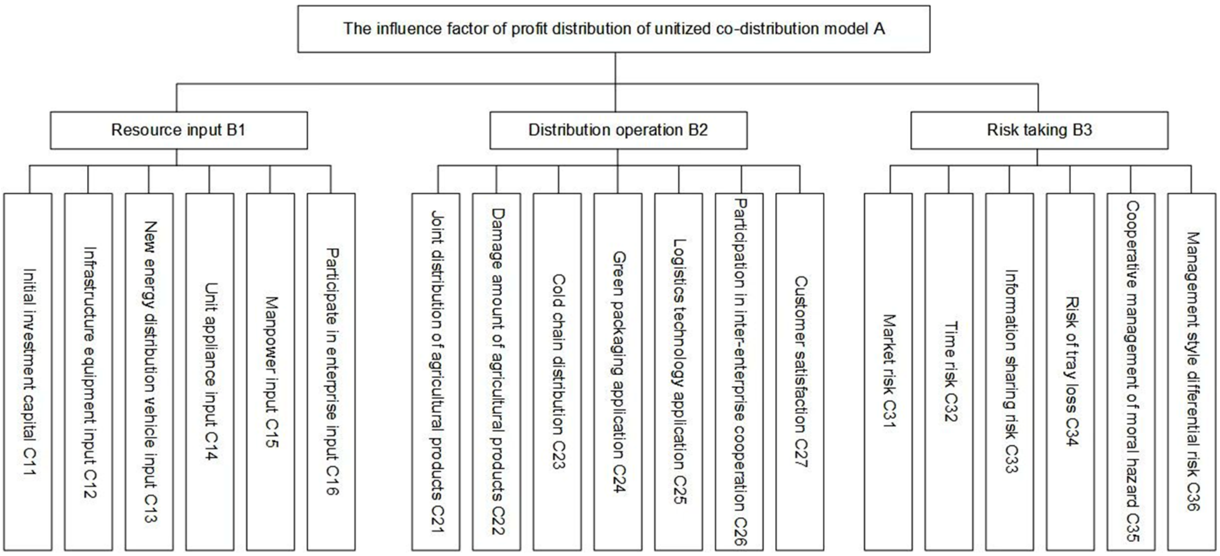

Figure 2. Hierarchical sub-structure of factors influencing profit distribution of agricultural products joint distribution.

Secondly, the input page of the judgment matrix was selected. The calculation method based on group decision making was based on the score of each expert, and the aggregation method of "weighted geometric average of expert judgment matrix" was selected to obtain the weight of each factor.

Using the relevant data output by the Yaahp software, the C_{ik} values of each influencing factor of the four enterprises A, B, C, and D were determined, as shown in Table 16.

Table 16. Weight distribution of influencing factors among enterprises (enterprise weight).

First Order Factor	First Order Factor	Enterprise A	Enterprise B	Enterprise C	Enterprise D
Input of resources B_1	Initial capital input C11	0.317	0.535	0.104	0.044
	Infrastructure equipment input C12	0.245	0.537	0.108	0.11
	New energy vehicle input C13	0.012	0.635	0.17	0.183
	Unit appliance input C14	0.375	0.454	0.095	0.076
	Manpower input C15	0.000	0.421	0.342	0.237
	Participation in corporate image C16	0.310	0.343	0.175	0.172
Distribution operation B_2	Agricultural products joint distribution quantity C21	0.000	0.419	0.341	0.240
	Breakage rate of agricultural products distribution C22	0.000	0.304	0.341	0.355
	Cold chain distribution of agricultural products C23	0.000	0.413	0.257	0.330
	Application of green packaging C24	0.000	0.393	0.340	0.267
	Application of logistics technology C25	0.000	0.434	0.240	0.326
	Participation in inter-enterprise cooperation C26	0.313	0.431	0.129	0.127
	Customer satisfaction C27	0.302	0.229	0.273	0.196

Table 16. *Cont.*

First Order Factor	First Order Factor	Enterprise A	Enterprise B	Enterprise C	Enterprise D
Assumption of risk B_3	Market risk C31	0.196	0.263	0.307	0.234
	Time risk C32	0.239	0.274	0.326	0.161
	Information-sharing risk C33	0.228	0.275	0.314	0.183
	Risk of tray loss C34	0.283	0.335	0.198	0.184
	Cooperative management of moral hazard C35	0.248	0.372	0.164	0.216
	Management mode difference risk C36	0.379	0.281	0.144	0.196

Combined with the above table, it can be seen that the overall weight of each influencing factor of the Beijing Fresh Agricultural Products Circulation Center is shown in Table 17:

Table 17. Overall weight of each influencing factor.

Name of Influencing Factor	Weight λ_i	Name of Influencing Factor	Weight λ_i
Initial capital input C_{11}	0.1021	Application of logistics technology C_{25}	0.0328
Infrastructure equipment input C_{12}	0.0576	Participation in inter-enterprise cooperation C_{26}	0.0217
New energy vehicle input C_{13}	0.0969	Customer satisfaction C_{27}	0.0352
Unit appliance input C_{14}	0.0328	Market risk C_{31}	0.0251
Manpower input C_{15}	0.0549	Time risk C_{32}	0.0335
Participation in corporate imageC_{16}	0.0436	Information-sharing risk C_{33}	0.0534
Agricultural products joint distribution quantity C_{21}	0.1267	Risk of tray loss C_{34}	0.0229
Breakage rate of agricultural products distribution C_{22}	0.0945	Cooperative management of moral hazard C_{35}	0.0362
Cold chain distribution of agricultural products C_{23}	0.0783	Management mode difference risk C_{36}	0.0252
Application of green packaging C_{24}	0.0266	Total	1

4.3.2. Profit Distribution of Multi-Weight Interval Shapley Value Method

On the basis of obtaining the initial profit allocation interval, the comprehensive contribution degree containing the correction factor $\Delta\varepsilon'_i$ is introduced to obtain the benefit compensation value of each enterprise.

(1) Calculation of contribution coefficient

The contribution of each enterprise to the joint distribution income of the Beijing Fresh Agricultural Products Circulation Center is determined by the distribution value of the secondary evaluation index C_{ik} (enterprise weight) in each enterprise and the overall weight of the secondary evaluation index λ_i, namely $\theta_I = C_{ik}\ \lambda_i$. Through the analytic hierarchy process, the weight of each influencing factor on the profit distribution can be obtained. Combined with Tables 16 and 17, the contribution of each enterprise to the joint distribution income of the Beijing Fresh Agricultural Products Circulation Center can be obtained.

The contribution of enterprise A is: $\theta_A = C_{1k}\lambda_i = 0.141$.

The contribution of enterprise B is: $\theta_B = C_{2k}\lambda_i = 0.415$.

The contribution of enterprise C is: $\theta_C = C_{3k}\lambda_i = 0.237$.

The contribution of enterprise D is: $\theta_D = C_{4k}\lambda_i = 0.207$.

(2) Determine the comprehensive contribution degree $\Delta\theta_i$ of A, B, C, and D enterprises.

The comprehensive contribution degree is the difference between the contribution degree of each enterprise and the average contribution degree, among which the average contribution degree of each enterprise in the cooperation is 1/4; so, the comprehensive contribution degree is:

$$\Delta\theta'_A = \theta_A - 1/4 = 0.233 - 0.25 = -0.109.$$

$$\Delta\theta'_B = \theta_B - 1/4 = 0.323 - 0.25 = -0.165.$$

$$\Delta\theta'_C = \theta_C - 1/4 = 0.237 - 0.25 = -0.013.$$

$$\Delta\theta'_D = \theta_D - 1/4 = 0.207 - 0.25 = -0.043.$$

(3) Determine the benefit compensation values $\Delta X_i(V)$ of A, B, C, and D enterprises. On the basis of obtaining the initial profit allocation value, the comprehensive contribution degree containing the correction factor $\Delta\theta'_i$ is introduced, and then, the benefit compensation value of each enterprise is found. The adjustment factor is 0.3, which is negotiated among the enterprises in the common distribution alliance of the Beijing Fresh and Live Agricultural Products Distribution Center.

Under the co-distribution mode of the Beijing Fresh Agricultural Products Circulation Center, the benefit compensation value of each participant is:

$$\Delta\overline{\phi}_A(\overline{v}) = \overline{\phi}_A(\overline{v}) \times \mu\Delta\theta'_A = [417, 694] \times 0.3 \times (-0.017) = -[14, 23].$$

$$\Delta\overline{\phi}_B(\overline{v}) = \overline{\phi}_B(\overline{v}) \times \mu\Delta\theta_B = [417, 694] \times 0.3 \times 0.073 = [21, 34].$$

$$\Delta\phi_C(V) = \phi_C(V) \times \mu\Delta\theta_C = [417, 694] \times 0.3 \times (-0.013) = -[2, 3].$$

$$\Delta\phi_D(V) = \phi_D(V) \times \mu\Delta\theta_D = [417, 694] \times 0.3 \times (-0.049) = -[5, 9].$$

(4) Determine the profit allocation value of participating enterprises i.

The profit distribution value of the Beijing Fresh Agricultural Products Circulation Center is as follows:

$$\overline{\phi}'_A(\overline{v}) = \overline{\phi}_A(\overline{v}) + \Delta\phi_\mathrm{A}(\mathrm{V}) = [176, 306].$$

$$\overline{\phi}'_B(\overline{v}) = \overline{\phi}_B(\overline{v}) + \Delta\overline{\phi}_B(\overline{v}) = [122, 193].$$

$$\overline{\phi}'_C(\overline{v}) = \overline{\phi}_C(\overline{v}) + \Delta\overline{\phi}_C(\overline{v}) = [68, 115].$$

$$\overline{\phi}'_D(\overline{v}) = \overline{\phi}_D(\overline{v}) + \Delta\overline{\phi}_D(\overline{v})$$

Therefore, the interest distribution interval of the participants in the joint distribution of the Beijing Fresh Agricultural Products Circulation Center after modification is: $\overline{\phi}'_A(\overline{v}) = [176, 306]$, $\overline{\phi}'_B(\overline{v}) = [122, 193]$, $\overline{\phi}'_C(\overline{v}) = [68, 115]$, and $\overline{\phi}'_D(\overline{v}) = [50, 80]$.

4.4. Result Analysis

The comparison between the initial profit distribution interval and the revised profit distribution interval is shown in Table 18. It can be seen that enterprise B obtains positive benefit compensation in the cooperation of the joint distribution organization. This is because enterprise B invested more funds, facilities, and equipment during the cooperation period of the uniformed joint distribution mode in the circulation center of the fresh agricultural products in Beijing, which contributed a lot to the normal operation of the joint distribution mode. Therefore, enterprise B gets more positive benefit compensation after modification. However, enterprises A, C, and D have less resource input, and enterprises A, C, and D are compensated with negative returns when considered together.

Table 18. Comparison of profit distribution interval of joint distribution after modification (unit: RMB).

Joint Distribution Participating Enterprises	A	B	C	D
Initial interval Shapley value	[190, 328]	[102, 159]	[70, 117]	[56, 89]
Multi-weight correction of Shapley values	[176, 306]	[122, 193]	[68, 115]	[50, 80]

To sum up, the revenue obtained by each participating enterprise in the cooperative distribution organization of the Beijing Fresh and Live Agricultural Products Circulation Center should be reasonably considered from various aspects, such as resource input, distribution operation, and risk bearing of the enterprise. The distribution of the benefits of the common distribution should be improved and rationalized through different degrees of contribution. It is helpful to improve the fairness and stability of the participating enterprises in the cooperative organization.

4.5. Analysis of the Impact of the Change in Distribution Business Volume

Under the condition that the above basic conditions remain unchanged, due to the increase in the average daily distribution volume of the shared distribution center, the concentration of the distribution area of the drivers increases; the full load rate increases; the final distribution efficiency per unit time increases; and the per capita distribution presents a linear growth trend. At the same time, considering the economic scale of the distribution and the optimal workstation limitation of the sorting subsystem of the shared distribution center, the analysis shows that the average daily distribution of the shared distribution center varies from 23,365 kg to 163,555 kg. On this basis, the income distribution problem of A, B, C, and D is further studied when the average daily distribution volume of the shared distribution center is 23,365 kg to 163,555 kg. The specific income changes are shown in Table 19.

Table 19. Summary of income changes of four enterprises when distribution volume changes.

Average Daily Distribution	$X'_A(\overline{v})$	$X'_B(\overline{v})$	$X'_C(\overline{v})$	$X'_D(\overline{v})$
23,365	$[176, 306]$	$[122, 193]$	$[68, 115]$	$[50, 80]$
46,730	$[977, 1199]$	$[540, 663]$	$[354, 433]$	$[237, 288]$
70,095	$[1331, 1669]$	$[737, 925]$	$[480, 601]$	$[322, 399]$
93,460	$[1657, 2113]$	$[919, 1171]$	$[594, 757]$	$[400, 504]$
116,825	$[2015, 2586]$	$[1118, 1435]$	$[720, 924]$	$[484, 614]$
140,190	$[2201, 2896]$	$[1223, 1608]$	$[784, 1033]$	$[530, 688]$
163,555	$[2307, 3130]$	$[1284, 1740]$	$[819, 1114]$	$[557, 745]$

As can be seen from Table 19, this mode of the shared distribution center will bring profits to all the participating enterprises. The core is that enterprises B, C, and D reduce fixed investment and site rent and that the utilization rate of these investments is low. However, enterprise A gathers a fragmented distribution demand, forming a scale effect. The profits of enterprises B, C, and D mainly come from the return on the investment of human resources, vehicles, and other resources, while the profits of enterprise A mainly come from the return on the investment of resources such as venue facilities and logistics equipment. Therefore, there is a linear positive correlation between its profits and the daily distribution volume.

The base value (median value) of the income value of each enterprise in Table 19 is used as the specific income. The data in the above table were converted into a line graph, and a linear fitting was carried out. The results are shown in Figure 3.

With the increase in the average daily delivery volume, the four companies' profit growth rates differed, and the revenue gained increased continuously. In the early stage of the cooperation of the shared distribution center, the overall benefits increased rapidly due to the significant increase in the full load rate of the vehicles and the utilization rate of the equipment. With the increase in the number of deliveries and the saturation of the equipment utilization rate, the growth rate of each enterprise's revenue slowed down. Enterprise A contributes more to the overall benefit due to the large investment in the infrastructure of the shared distribution center, the growth rate is higher, and the benchmark value (intermediate benefit) is more; enterprises B, C, and D contribute less to the overall benefit, the growth rate is lower, and the benchmark value (intermediate benefit) is less. By reasonably adjusting the distribution and delivery mode, the economic and logistic synergistic development of Heizhuangdu enterprises can be realized.

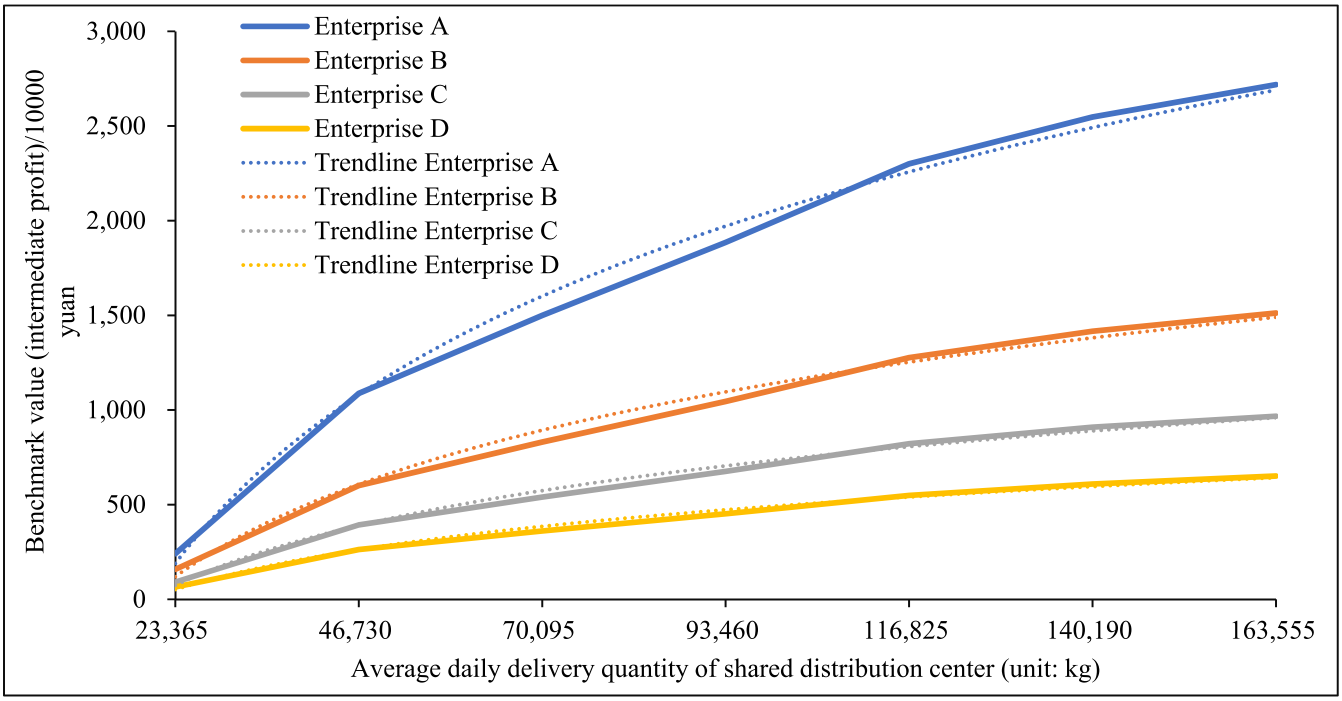

Figure 3. Income change in fresh agricultural products circulation center in Beijing.

To sum up, all the participating enterprises in the joint distribution cooperative organization of the Beijing Fresh Agricultural Products Circulation Center make different contributions to the organization, thus obtaining different benefits from the organization. Reasonable considerations should be made with regard to the resource input of the enterprises, the distribution operation, the risk bearing, and other aspects. Therefore, different contribution degrees should be used to improve the income distribution of the joint distribution to make the income distribution more reasonable and to help to improve the fairness and stability of the participating enterprises in the cooperative organization.

5. Conclusions

In this paper, a common distribution service model based on unitization is constructed for the current problem of the low efficiency of urban distribution in wholesale markets. Using cooperative game theory, a benefit allocation model with multi-weight interval Shapley values considering the resource input, distribution operation, risk taking, and other factors is established. According to the benefit allocation results, it can be seen that the interval range of the benefit allocation for each participating enterprise obtained by using the interval Shapley function gives more space for each participating enterprise to choose the benefit allocation, and the benefit allocation results are more reasonable.

The main findings of this study are as follows:

(1) The co-distribution mode of the serving wholesale markets may include infrastructure owners as important participants and may cooperate with the enterprises engaged in related businesses to form a comprehensive business community for the co-distribution of agricultural products. By introducing new energy vehicles that meet the requirements of urban distribution, each participating enterprise will jointly carry out the unitized agricultural products co-distribution business. Building a shared distribution center service system helps to reduce the operating costs of logistics enterprises, to improve distribution efficiency, and to increase enterprise revenue, which meets the development needs of green, intensive, efficient, and intelligent cities.

(2) Benefit distribution is the core element affecting the construction of the common distribution model in wholesale markets, and the key factors affecting benefit distribution mainly include resource input, distribution operation, and risk taking.

(3) The traditional interval Shapley value method determines the participating subjects with the same weights when allocating benefits, without considering the differences in the contributions from the different factors. In order to allocate benefits more reasonably, we can construct a multi-weight interval Shapley value method benefit allocation model to reasonably allocate the profits of the shared distribution centers by considering the limitations of the influencing factors of the interval value method.

(4) Based on the empirical study, it is proved that the benefit distribution of the multi-weight interval Shapley value method can meet the need for dynamic changes in parameters and is more reasonable. For example, as the average daily distribution volume increases, the profit growth of the participating companies appears to be differentiated, and the companies that invest heavily in the infrastructure of the shared distribution center have higher growth rates and receive more benchmark values (intermediate benefits) due to their higher contribution to the overall benefits.

Based on the above findings, this paper draws the following policy insights:

(1) With the improvement of the level of information technology, the reform of the circulation system of the Beijing agricultural wholesale market, and the acceleration of the marketization of the agricultural wholesale industry, it is crucial to correctly handle the relationship between the market and the government and to regulate the market order.

(2) Accelerate the distribution service model innovation, take the initiative to build a common system for agricultural products, reasonably develop express delivery plans, effectively control the risk of delayed delivery, save delivery time, and improve delivery efficiency.

(3) Provide a sound assessment and evaluation system, a reasonable distribution of the interests of the participating enterprises, and the construction of a good development environment.

Author Contributions: Conceptualization, C.W. and X.Y.; methodology P.L. and Z.W.; investigation, Z.Z. and J.C.; writing—original draft preparation C.W., X.Y., Z.W., Z.Z., J.C. and P.L. All authors have read and agreed to the published version of the manuscript.

Funding: This research were funded by Beijing Wuzi University School-Level Scientific Research Project in 2021, the Beijing Municipal Education Commission and the National Natural Science Foundation of China, Grant No. 2021XJKY03, CIT&TCD20180319 and 72171024, respectively.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Aminoff, A.; Hakanen, T. Implications of product centric servitization for global distribution channels of manufacturing companies. *Int. J. Phys. Distrib. Logist. Manag.* **2018**, *48*, 10. [CrossRef]
2. Osorio, C.; Wang, C. An Analytical Approximation of the Joint Distribution of Aggregate Queue-Lengths in an Urban Network. *Procedia-Soc. Behav. Sci.* **2012**, *54*, 917–925. [CrossRef]
3. Hua, L.; Min, Y.; Yuxia, L.; Zhiping, D. Research on the benefits of Joint Distribution to Urban Freight Transportation System. *Transp. Syst. Eng. Inf.* **2019**, *19*, 6–12+19.
4. Pretorius, L.; Liu, H.; Jiang, D. Optimization of cold chain logistics distribution network terminal. *EURASIP J. Wirel. Commun. Netw.* **2018**, *2018*, 1.
5. Hao, Z.; Yan, C.; Liyu, Z.; Shuai, L. Research on Urban Daily Necessities Joint Distribution Mode led by large-scale Agricultural wholesale enterprises. *Bus. Econ. Res.* **2018**, *3*, 122–126.
6. Wang, Z.G. Research on accelerating the development of cold chain logistics of fresh agricultural products from the perspective of joint distribution. *Mod. Econ. Res.* **2017**, *1*, 55–59.
7. Wenzhao, T.; Zhenlin, W.; Baowen, L. Urban food cold chain joint distribution pricing based on non-cooperative game. *Beijing Jiaotong Univ.* **2017**, *41*, 28–33.
8. Hou, B.; Fen, W.; Huan-fang, W. Research on Formation mechanism and operation mode of eco-city co-distribution. *Hunan Soc. Sci.* **2016**, *4*, 132–135.

9. Maozeng, X.; Xiang, Z.; Li-gang, C.; Yong, L.; Guoyin, Y. Common distribution mode and benefit distribution of express delivery in low distribution density areas. *Comput. Integr. Manuf. Syst.* **2020**, *26*, 181–190. [CrossRef]
10. Liuxin, C.; Lei, H.; Li Jun, M. Study on Revenue Sharing Contract of Agricultural supply chain with TPL participation under Freight Cost Sharing. *J. Manag. Eng.* **2021**, *35*, 218–225. [CrossRef]
11. Jun, Y.; Bojun, G.; Yufang, F. Cold chain Logistics Service and pricing Decision of fresh agricultural products Supply chain under different trade modes. *China Manag. Sci.* **2021**, 1–12. [CrossRef]
12. Carrano, A.L.; Pazour, J.A.; Roy, D.; Thorn, B.K. Selection of Pallet Management Strate gies Based on Carbon Emissions Impact. *Int. J. Prod. Econ.* **2015**, *164*, 258–270. [CrossRef]
13. Elia, V.; Gnoni, M.G. Designing an Effective Closed Loop System for Pallet Management. *Int. J. Prod. Econ.* **2015**, *170*, 730–740. [CrossRef]
14. Guanghua, Z. Operation mode of rural E-commerce Joint distribution based on shared logistics. *China Circ. Econ.* **2018**, *32*, 36–44.
15. Zhengyu, W.; Jianwei, R.; Yuqi, M.; Honghong, Z. Stochastic Programming Model of Pallet Sharing Scheduling Based on City Common Distribution System. *J. Highw. Transp. Sci. Technol.* **2018**, *35*, 146–152.
16. Wang, Y.; Ma, X.; Liu, M.; Gong, K.; Liu, Y.; Xu, M.; Wang, Y. Cooperation and profit allocation in two-echelon logistics joint distribution network optimization. *Appl. Soft Comput.* **2017**, *56*, 143–157. [CrossRef]
17. Xuan-fei, W.; Ying-liang, W.; Yuan, H. Research on Profit Distribution of Mobile Payment Business Model Dynamic Alliance Based on Cooperative Game. *Oper. Res. Manag.* **2017**, *26*, 29–38.
18. Bai, X.; Zhang, Y.; Jin, J. Profit Distribution Strategy of new retail Supply Chain Based on Improved Shapley Value Method. *Math. Pract. Underst.* **2019**, *49*, 88–96.
19. Yang, J.; Zhou, Y. The coordination strategy of fresh agricultural products joint distribution cost from the perspective of contribution degree. *J. Agric. For. Econ. Manag.* **2021**, *20*, 51–58.
20. Zhou, Y. Construction and benefit game of virtual Agricultural product supply chain Cooperative Alliance. *East China Econ. Manag.* **2018**, *32*, 174–179. (In Chinese)
21. Fang, L.; Chen, W. Optimization of profit distribution mechanism of dairy industry chain in Beijing. *Chin. J. Anim. Sci.* **2016**, *52*, 6–11.
22. Gao, Z.; Zhu, H.; Shi, Y. Research on Profit Distribution Mechanism of Coal Production, Transportation and Distribution Supply Chain Based on Shapley Value Method. *Coal Eng.* **2020**, *52*, 177–182. (In Chinese)
23. He, M.; Wang, Z.; Tu, C. Game study on joint distribution of large and small retailers under Fuzzy Demand. *Bus. Res.* **2017**, *2*, 108–117.
24. Wang, Y.; Zhou, X.; Liu, Y.; Xu, M. Optimization of Multi–center Joint Distribution Alliance Based on Vehicle Sharing. *Comput. Integr. Manuf. Syst.* **2021**, *27*, 1820–1832.
25. Wang, Y.; Ren, Y.; Xu, M. Revenue Distribution Optimization Problem Based on Multi-Center Co-Distribution. *Comput. Integr. Manuf. Syst.* **2017**, *23*, 1571–1580.
26. Guo, F.; Zhong, Y. Rational Profit Distribution of Joint Distribution of Alliance E-commerce. *Jiangxi Soc. Sci.* **2018**, *38*, 201–208, 256.
27. Peng, X.; Cheng, Y. Profit Distribution Strategy of Task-Oriented Cooperative Distribution Game. *J. Railw. Sci. Eng.* **2016**, *13*, 2070–2076.
28. Jiang, Y.; Xu, Q.; Zhang, R.; Jin, Z. Optimization of Joint Distribution Operation Mode. *J. Dalian Marit. Univ.* **2017**, *43*, 53–59.
29. Tan, C.; Zhang, Q. Shapley Value of N-person game with interval alliance Value. *Chin. J. Appl. Math.* **2010**, *33*, 193–203. (In Chinese)
30. Wang, C.; Chen, J.; Wan, W. Study on Urban Co-distribution Model from the perspective of modern economies of Scale. *J. Xi'an Univ. Financ. Econ.* **2017**, *30*, 82–87.
31. Li, J.; Yang, F.; Guan, M.; Chen, Z. Joint distribution mode orders vehicles matching decision optimization research. *J. Manag. Eng.* **2021**, *35*, 259–266. [CrossRef]
32. Shapley, L.S. A value for n-persons games. *Ann. Math. Stud.* **1953**, *28*, 307318.
33. Nishizaki, I.; Sakawa, M. Fuzzy Cooperative Games Arising from Linear Production Programming Problem with Fuzzy Parameters. *Fuzzy Sets Syst.* **2000**, *114*, 11–21. [CrossRef]
34. Tsurumi, M.; Tanino, T.; Inuiguchi, M. A Shapley function on a class of cooperative fuzzy games. *Eur. J. Oper. Res.* **2001**, *129*, 596–618. [CrossRef]
35. Saaty, T.L. Highlights and critical points in the theory and application of the analytic hierarchy process. *Eur. J. Oper. Res.* **1994**, *74*, 426–447. [CrossRef]
36. Song, J.; Ma, X.; Chen, R. A profit distribution model of reverse logistics based on fuzzy DEA efficiency—Modified shapley value. *Sustainability* **2021**, *13*, 7354. [CrossRef]