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Construction of Cross Border E-commerce Cooperation Alliance based on Cloud Platform and Interest Game

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Abstract: The development of cross-border e-commerce is crucial in establishing the new pattern of domestic and international double circulation. Currently, the issue of 'information islands' within the cross-border e-commerce supply chain and the problem of conflicting interests are hindering the further development of cross-border e-commerce. This paper describes the establishment of a horizontal alliance between cross-border e-commerce manufacturers and platforms through the construction of a cloud platform. Subsequently, a vertical alliance was formed with cross-border e-commerce platforms, domestic logistics service providers, international carriers, and foreign logistics service providers as the main components. To ensure effective information coordination and benefit sharing among cross-border e-commerce partners, the traditional single benefit distribution model has been replaced. The benefits of horizontal and vertical alliances in cross-border e-commerce are now distributed using Stackelberg game theory and an improved Raiffa model, resulting in a more equitable distribution among alliance members.

Keywords: cross border e-commerce alliance, Stackelberg game, Raiffa model

1 Introduction

Cross-border e-commerce imports and exports facilitate the global flow of commodity factors, which is closely related to the formation of a new development pattern of domestic and international double circulation. According to the E-commerce Research Center, China's cross-border e-commerce transaction scale reached 15.7 trillion yuan in 2022, representing a year-on-year growth of 11.81%. Cross-border e-commerce is expected to continue its rapid development trend in the future, playing a crucial role in both domestic and international double cycle systems.

Cross-border e-commerce involves the crossing of national boundaries, and the links from supply to final consumer can be complex and scattered. In addition, consumers' expectations for products and logistics services are constantly increasing, making it challenging for a single enterprise to efficiently complete the entire cross-border e-commerce transaction. To address this, enterprises have explored new development modes and built various forms of cross-border e-commerce cooperation alliances. Martin

Christopher proposed that in the 21st century, competition is no longer between enterprises, but between supply chains. The future of cross-border e-commerce will also move towards a resource-intensive and integrated development model. However, the information standards of different countries and enterprises are inconsistent, making it difficult to share and transfer information in real-time. The issue of information islands and the problem of conflicting interests between them is a significant obstacle to the efficiency of cross-border e-commerce. Therefore, it is essential to establish a cross-border e-commerce alliance that involves multiple parties, industries, and regions, and promotes information coordination and benefit sharing[1] (Du & Gong, 2018).

Regarding cooperative alliances,information sharing through cloud computing, cloud platforms, and other technologies can effectively enhance the management performance of cooperative alliances[2](Chan et al,2017). With respect to the distribution of alliance benefits, the importance of establishing a reasonable distribution and coordination mechanism to maintain a stable alliance relationship[3-4](He et al,2012; Nikkhoo & Bozorgi,2018). Based on previous studies, this paper presents a comprehensive design for a cross-border e-commerce alliance, focusing on two key aspects: the organizational model and the benefit distribution model. The aim is to address the significant issues of 'information islands' and conflicting interests.

2 Construction of cross border e-commerce cooperation alliance based on cloud platform

Cross-border e-commerce involves multiple subjects and complex links, including supply, transportation, customs clearance, distribution, and final consumers. To enhance the efficiency of cross-border e-commerce and integrate all resources, a cross-border logistics alliance led by major cross-border e-commerce platforms (such as Alibaba and Dunhuang) has emerged. The company has integrated domestic and foreign logistics service providers, international carriers, and other intermediaries to optimize the entire cross-border logistics process. The existing cross-border e-commerce platform not only sells its own products but also provides a sales platform and logistics services for other manufacturers. However, the mutual substitution and competition between cross-border e-commerce platforms and manufacturers' products affect the prices of goods and logistics services, making it challenging to increase the total revenue of cross-border e-commerce. Scholars have discussed the relationship between e-commerce platforms and manufacturers. They propose that manufacturers can become product suppliers of cross-border e-commerce platforms through alliances with them to improve their earnings[5] (Wang et al,2017). This paper presents a model for a cross-border e-commerce cooperation alliance based on a cloud platform, with the cross-border e-commerce platform at its core. The model involves manufacturers, domestic logistics service providers, international carriers, and foreign logistics service provider, as shown in Fig.1.

To establish an effective organizational mode, it is recommended to form a horizontal alliance between cross-border e-commerce platform enterprises and manufacturers. Manufacturers, as the suppliers of the cross-border e-commerce platform, should provide products at a lower price and ensure timely delivery. Meanwhile, cross-border e-commerce platform enterprises should provide manufacturers with a sales platform, cross-border payment, after-sales service, market information, logistics, and other necessary support services. The cross-border e-commerce platform sells products from various manufacturers in a unified manner, eliminating the previous situation where manufacturers independently sold their products on the platform. This approach ensures that the prices of goods and services are unified, thereby avoiding market chaos. Additionally, the platform can monitor commodity inventory in real-time, shorten procurement lead times, and further improve cross-border e-commerce efficiency. Based on the horizontal alliance, a vertical alliance is established among cross-border e-commerce platforms, domestic logistics service providers, international transport carriers, and foreign logistics service providers. Domestic logistics service providers are responsible for procuring, transporting, warehousing, and managing inventory of domestic commodities. International transport carriers are responsible for completing customs clearance and cross-border transport business. Foreign logistics service providers are responsible for the transportation, warehousing, and distribution of overseas goods. The cross-border e-commerce cooperation alliance mode of horizontal and vertical integration is established based on the mode of 'manufacturer + cross-border e-commerce platform enterprise + logistics service provider' to achieve the division of labour.

To address the issue of information asymmetry and 'information islands' among alliance members, a cloud platform for cross-border e-commerce alliances has been developed. This platform integrates the information systems of each member, creating an alliance database that records supply, business, market, financial, and logistics information. All members of the alliance can access the alliance database through the cloud platform, ensuring coordination of information across all links of cross-border e-commerce. This facilitates collaboration between logistics, information flow, capital flow, and business flow generated by all links in the operation process of cross-border logistics alliance members, forming a 'four-flow integration' mode.

However, the alliance is likely to involve the issue of interest distribution. To ensure stability within the cross-border e-commerce alliance, it is essential to establish a fair and reasonable profit distribution mechanism that considers the interests of all members. This paper uses Stackelberg game theory and an improved Raiffa model to explore the problem of benefit distribution in cross-border e-commerce horizontal and vertical alliances. The research presented here aims to provide decision-making support for the establishment of a profit distribution mechanism for cross-border e-commerce alliances.

3 Benefit distribution model of cross border e-commerce horizontal alliance

3.1 Model construction and hypothesis

(1)The cross-border e-commerce horizontal alliance comprises manufacturers and cross-border e-commerce platforms. The platform, being the dominant player, integrates resources from all links of cross-border e-commerce and provides technical and service support for the sale of cross-border commodities. The manufacturers, as followers, provide products to the platform. Both parties are rational economic actors. Both parties aim to maximise their own interests through cooperation. The variable w represents the wholesale price of the product, while c represents the unit production costs for manufacturers. The variable p represents the product prices on the cross-border electric platform, and K represents the maintenance costs of the cross-border electric business platform, where $w > c$ and $p > w$.

(2)Demand Function D: Assume that the demand of market is determined by the price of the product level and the logistics service level. Market demand is negatively correlated with product price and positively correlated with logistics service level, and demand is a linear function of commodity price and logistics service[6-7] (Chen et al,2013; Lejarza et al,2022). Demand of the market is: $D = \beta - b_1 p + b_2 s$, among them, the β as market size, s as logistics service level, b1 as the sensitive of consumer to commodity prices and b_2 respectively the sensitive of consumer to logistics services, and $b_i \geq 0$. It can be seen that in order to obtain the largest market share, manufacturers and cross border e-commerce platform enterprises need to make joint decisions to determine the optimal commodity price and logistics service level.

(3)The logistics service cost C(s) is assumed to be a quadratic function of the logistics service level, with $C(s) = \gamma_1 s^2/2$, where γ_1 is the coefficient for logistics service costs[8](Zhao et al,2022). There is an inherent conflict between logistics service cost and logistics service level. In order to reduce logistics costs, logistics service providers tend to maintain logistics service levels at a medium to low level, which can negatively impact consumers' experience. Therefore, it is essential to establish a horizontal alliance for cross-border e-commerce to unify the level of logistics services and improve the efficiency of cross-border logistics.

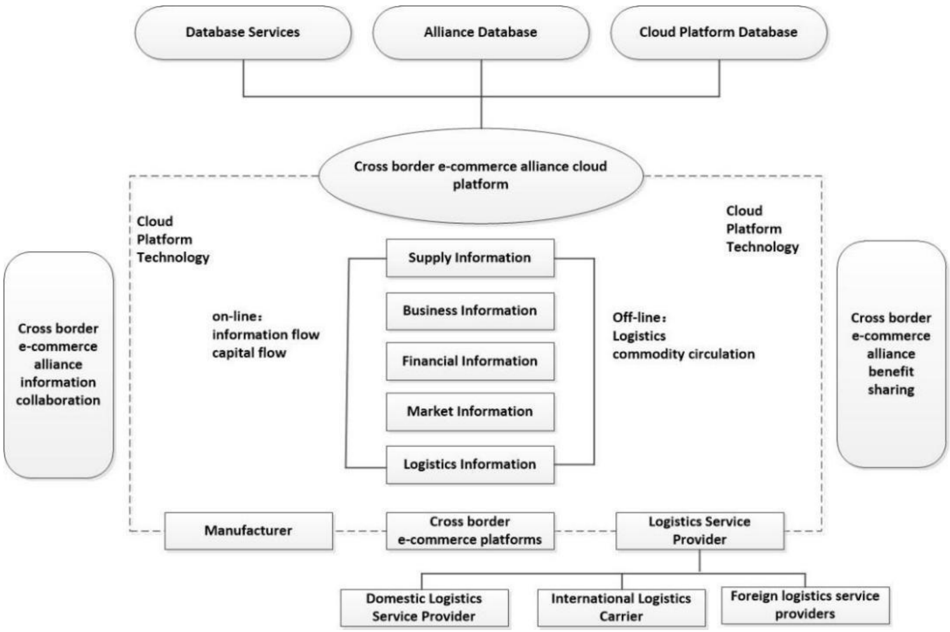

Fig. 1. Cross border e-commerce cooperation alliance model based on cloud platform

3.2 Stackelberg game model dominated by cross border e-commerce platform

In a market dominated by cross-border e-commerce platforms, the price of goods p and logistics service level s are determined by the platforms. Manufacturers, as followers, then determine the wholesale price of their products w based on the decisions made by the cross-border e-commerce platforms. This constitutes a Stackelberg game model[9-10] (Wen et ali,2019; Li et al,2022). In asymmetric competition, strong leaders make decisions to maximize their own profits, while weak followers choose strategies based on the leader's decisions. This results in a decentralized decision-making process. It is important to note that this is a technical text and therefore, technical terms such as 'asymmetric competition' and 'decentralized decision-making process' have been retained. The cross-border e-commerce platform and the manufacturer's profit functions are denoted as π_1 and π_2, respectively.

$$\pi_1 = (p-\omega)(\beta - b_1 p + b_2 s) - \frac{1}{2}\gamma_1 s^2 - K \quad (1)$$

$$\pi_2 = (\omega - c)(\beta - b_1 p + b_2 s) \quad (2)$$

Proposition 1: when $2\gamma_1 b_1 - {b_3}^2 > 0$, cross border e-commerce platform of the profit function is about commodity prices p and logistics service level s joint concave function. The manufacturer's profit function is about the wholesale price of w strictly concave function.

Proof: In equation (1), respectively count π_1 about p and s second order mixed partial derivative of the Hessian matrix:

$$H(p,s) = \begin{bmatrix} -2b_1 & b_2 \\ b_2 & -\gamma_1 \end{bmatrix} \quad (3)$$

If the Hessian matrix is negative qualitative, its corresponding function is concave. Owing to $|H_1| = \frac{\partial^2 \pi_1}{\partial p^2} = -2b_1 < 0$, to make the profit function of the cross border e-commerce platform as p and s joint concave function, need to satisfy $|H(p,s)| = \frac{\partial^2 \pi_1}{\partial p^2} * \frac{\partial^2 \pi_1}{\partial s^2} - \left(\frac{\partial^2 \pi_1}{\partial p \partial s}\right)^2 = 2\gamma_1 b_1 - {b_3}^2 > 0$. And then, according to $\pi_2 = (\omega - c)(\beta - b_1 p + b_2 s)$, assume $p = \omega + x$, among them, x as mark-up for cross border e-commerce platform, the manufacturer's profit function can be turned into equation (4):

$$\pi_2 = (\omega - c)(\beta - b_1\omega - b_1 x + b_2 s) \quad (4)$$

In equation (4), calculating the second derivative of π_2 with respect to ω, result as $\frac{\partial^2 \pi_2}{\partial \omega^2} = -2b_1 < 0$. Therefore, the manufacturer's profit function π_2 is strictly concave function about the wholesale price w. Proof completed.

In conclusion, the cross border e-commerce platform of the profit function π_1 and the manufacturer's profit function π_2 have the maximum, which both sides can make optimal decisions, make to maximize their own profits.

Proposition 2: According to Proposition 1, cross border e-commerce platform can develop the optimal commodity prices p and logistics service level s. On the basis of cross border e-commerce platform decision-making, the manufacturer can determine the optimal wholesale price w.

Proof: In equation (4), according to the Stackelberg game model, using backward induction, calculate the first order partial derivative of manufacturers profit function π_2 with respect to w, result as $\frac{\partial \pi_2}{\partial \omega} = -2b_1\omega + \beta + b_2 s + b_1 c - b_1 x$, make $\frac{\partial \pi_2}{\partial \omega} = 0$ and x=p-ω, result as equation (5):

$$\omega = \frac{\beta + b_2 s}{b_1} + c - p \quad (5)$$

Substitute equation (5) into equation (1), and calculate the first order partial derivative with respect to p and s, result as $p^{1*} = \frac{3(\beta + b_2 s)}{4b_1} + \frac{c}{4}$, $s^{1*} = \frac{(3p-c)b_1 b_2 - 2b_2\beta}{b_1\gamma_1 + 2{b_2}^2}$. And then, substitute p^{1*} and s^{1*} into equation (5), result as the manufacturer's optimal wholesale price $\omega^{1*} = \frac{\beta + b_2 s^{1*}}{b_1} + c - p^{1*}$. Proof completed.And then, substitute p^{1*} and s^{1*} into equation (1) and equation (2), result as ${\pi_1}^*$ and ${\pi_2}^*$, respectively representing the maximum profit of cross border e-commerce platform and manufacturer.

3.3 Profit distribution model of cross border e-commerce horizontal alliance under centralized decision-making

In the case of centralized decision-making, the cross border e-commerce platform and the manufacturer reach an alliance in the true sense. Instead of maximizing their own interests, they are committed to maximizing the overall interests of the cross border e-commerce alliance. According to the above model assumption, cross border e-commerce alliance union overall profit function π as follows:

$$\pi = \pi_1 + \pi_2 = (p - c)(\beta - b_1 p + b_2 s) - \frac{1}{2}\gamma_1 s^2 - K \tag{6}$$

In equation (6), calculate respectively the first order partial derivative of overall profit function π with respect to p and s, then make it zero. Joining $\frac{\partial\pi}{\partial p} = 0$ and $\frac{\partial\pi}{\partial s} = 0$, calculate the best price and optimal logistics service level as p^{2*} and s^{2*}, so as to maximize the overall benefit of the cross border e-commerce alliance, among them $p^{2*} = \frac{\beta\gamma_1 + b_1\gamma_1 c - c{b_2}^2}{2b_1\gamma_1 - {b_2}^2}$, $s^{2*} = \frac{b_2}{\gamma_1}(\frac{\beta\gamma_1 + b_1\gamma_1 c - c{b_2}^2}{2b_1\gamma_1 - {b_2}^2} - c)$. And then substituting p^{2*} and s^{2*} into equation (6) can obtain the overall maximum profit of cross border e-commerce alliance as π^*.

3.4 Profit distribution of cross border e-commerce horizontal alliance based on revenue sharing model

In order to promote the centralized decision-making of cross border e-commerce platform and manufacturers, improve the efficiency of cross border e-commerce and increase their respective profits, refer to [11], this paper uses the contract model of revenue sharing to coordinate the behaviors and interests of both parties. The cross border e-commerce platform determines the optimal commodity price and logistics service level from the perspective of the overall profit maximization of cross border e-commerce, while manufacturers provide products for the cross border e-commerce platform at a lower wholesale price. Cross border e-commerce platform share revenue from the sale of goods with manufacturers, among them, the cross border e-commerce platform accounted for the proportion of sales revenue for λ, the proportion of manufacturers as $1 - \lambda$. Under a revenue sharing, cross border e-commerce platform of the profit function is $\pi_1(\lambda)$.

$$\pi_1(\lambda) = \lambda p(\beta - b_1 p + b_2 s) - \omega(\beta - b_1 p + b_2 s) - \frac{1}{2}\gamma_1 s^2 - K \tag{7}$$

In equation (6), calculate respectively the first order partial derivative of $\pi_1(\lambda)$ with respect to p and s. Joining $\frac{\partial\pi_1(\lambda)}{\partial p} = 0$ and $\frac{\partial\pi_1(\lambda)}{\partial s} = 0$, the following results can be obtained.

$$p^*(\lambda) = \frac{\lambda{b_2}^2\omega - \lambda\gamma_1\beta - b_1\gamma_1\omega}{\lambda^2{b_2}^2 - 2\lambda b_1\gamma_1} \tag{8}$$

$$s^*(\lambda) = \frac{(\lambda p^*(\lambda) - \omega)b_2}{\gamma_1} \tag{9}$$

Under a revenue sharing, in order to achieve the effect of centralized decision-making, set $p^*(\lambda) = p^{2*}$, the following results can be obtained.

$$\omega^*(\lambda) = \frac{\left(\beta\gamma_1 + b_1\gamma_1 c - c{b_2}^2\right)({b_2}^2\lambda^2 - 2\lambda b_1\gamma_1)}{(2b_1\gamma_1 - {b_2}^2)(\lambda{b_2}^2 - b_1\gamma_1)} + \frac{\lambda\gamma_1\beta}{\lambda{b_2}^2 - b_1\gamma_1} \tag{10}$$

Substitute $\omega^*(\lambda)$ into equation (7), profit function $\pi_1(\lambda)$ of cross border e-commerce platform under revenue sharing can be calculated. In this case, the profit function of the manufacturer is $\pi_2(\lambda) = \pi - \pi_1(\lambda) = (1-\lambda)\pi$. Under the assumption of revenue sharing, the profits of both cross border e-commerce platform and manufacturer are higher than those of decentralized decision-making, and the profits of cross border e-commerce platform as the leader are higher than manufacturer. That is $\pi_1(\lambda) > \pi_1{}^*$, $\pi_2(\lambda) > \pi_2{}^*$, and $\pi_1(\lambda) > \pi_2(\lambda)$.

4 Profit distribution model of cross border e-commerce vertical alliance

Domestic and foreign logistics service providers, as well as international transport providers, play a crucial role in cross-border e-commerce by connecting enterprises and consumers. The logistics service level of these providers directly affects consumer demand. To maximize their own interests in cooperation, logistics service providers act as rational economic agents. However, it is important to note that high logistics service levels may result in higher logistics costs. To reduce these costs, logistics service providers may naturally maintain logistics services at a medium or low level. This, unfortunately, contradicts the logistics service level expected by cross-border e-commerce platforms and consumers. To enhance the efficiency of logistics and service levels in cross-border e-commerce, a vertical alliance has been established. This alliance is led by a cross-border e-commerce platform and includes domestic logistics service providers, international transport providers, and foreign logistics service providers. The cross-border e-commerce platform shares the total revenue from the horizontal alliance with the logistics service providers. The logistics service provider will adhere to the optimal logistics service level $s^*(\lambda)$ as formulated by the cross-border e-commerce platform to provide logistics services.

Most studies use the Shapley model to distribute benefits to cooperative members. However, the calculation amount of the Shapley model increases exponentially with the number of members, limiting its practical application[11-12] (Yang et al,2020; Hu et al,2023). On the other hand, the Raiffa model considers the upper and lower limits of profit distribution. On the other hand, it is easy to operate and avoids the difficult problem of collecting information data. It is also more suitable for distributing profits among multiple members. In summary, it effectively compensates for the shortcomings of the Shapley model. To ensure a fair and reasonable distribution of alliance benefits, this paper uses the improved Raiffa model to distribute the benefits of the cross-border e-commerce vertical supply chain alliance[13] (Yang et al,2023).

4.1 Raiffa profit distribution model

The set of cross-border e-commerce vertical alliances for the enterprise is N={1,2...... N}, where n=4. V(N) represents the total revenue of the cross-border e-commerce vertical alliance. This paper sets V(N) as the total revenue of cross-border e-commerce under optimal decision-making. In other words, V(N) is the total revenue obtained under the revenue-sharing contract between the cross-border e-commerce platform, $\mathrm{V(N)} = \pi_1(\lambda)$. x_i represents the profit gained by member i from V(N), and $\sum_{i=1}^{n} x_i = \mathrm{V(N)}$. When the remaining number of n-1 enterprises establish a cooperative alliance, their profits is $\mathrm{V}(\mathrm{N}/i) = \mu_i$, where $i = 1,2\ldots\ldots n$.

First of all, according to profit which created by number of $n-1$ alliance enterprises, we can calculate $\underline{x_i}$, where $\underline{x_i}$ is the lower limit of distribution for the interests of all parties benefit.

$$\begin{cases} \sum_{i=1}^{n} x_i - x_1 = \mu_i \\ \\ \sum_{i=1}^{n} x_i - x_n = \mu_n \end{cases} \quad (11)$$

According to equation (11), we can calculate $x_i = \frac{1}{n-1}\sum_{i=1}^{n}\mu_i - \mu_i$. Revenue will increase when the enterprise j establish an alliance with the number of $n-1$ alliance enterprises. We treat the increase in revenue as the ideal upper limit of profit distribution, where $\overline{x_j} = B - \mu_i$. $\overline{x_j}$ is divided equally by member party j and n-1, and they distribute profits based on $\underline{x}_i$. The following results can be calculated.

$$x_j = \frac{\overline{x_j}}{2},\ x_i = \underline{x}_i + \frac{\overline{x_j}}{2(n-1)}\ ,\ i = 1,2\ldots n,\ i \neq j \quad (12)$$

Finally, j takes 1,2... n. we repeat the above average, then substitute $\overline{x}$ and $\underline{x}$ into equation (12). Profit distribution of the vertical alliance of cross border e-commerce can be calculated. The results is as follow:

$$x_i = \frac{V(N)}{n} + \frac{2n-3}{2(n-1)}\left[\frac{1}{n}\sum_{i=1}^{n}\mu_i - \mu_i\right] \quad (13)$$

4.2 Raiffa benefit allocation model modification based on services undertaken by alliance members

The Raiffa model presented above is considered ideal. However, for it to be applicable, the services provided by members of cross-border e-commerce vertical alliances must be consistent, namely $F = \frac{1}{n}$ [14](He et al,2018). In reality, the service content undertaken by the vertical alliance members of cross-border e-commerce differs, as do their contributions to the business. As a result, there is some discrepancy between the ideal model and the actual profit distribution. The cross-border e-commerce platform, as the leading party, is responsible for integrating and coordinating all resources involved in cross-border e-commerce and providing a range of supporting services. Domestic logistics service providers are responsible not only for transferring commodities to international carriers but also for commodity procurement, warehousing, transportation, and inventory management. International carriers are responsible for transporting goods across borders, while foreign logistics service providers are responsible for the warehousing and distribution of overseas goods. This paper revises the Raiffa model based on the services undertaken by alliance members.

It is assumed that the services undertaken by the vertical alliance members of cross border e-commerce are reflected in three aspects. On the one hand, costs φ_i incurred by alliance members for providing corresponding services. On the other hand, the service level s_i provided by the alliance members. And in addition, the business level θ_i provided by enterprise alliance. M_i is corresponding weights of three the above three. Therefore, the services F_i undertaken by alliance member i is as follow.

$$F_i = M_1\frac{\varphi_i}{\sum\varphi_i} + M_2\frac{\boldsymbol{s_i}}{\sum\boldsymbol{s_i}} + M_3\frac{\theta_i}{\sum\theta_i} \quad (14)$$

It can be seen that the difference between the actual service undertaken by each alliance member and the original assumed model is $\Delta F_i = F_i - \frac{1}{n}, where \sum \Delta F_i = 0$. At this point, given the interests of the members actual correction as $\Delta x_i^* = \Delta F_i V(N)$. As a result, according to improved Raiffa model, the actual distribution of benefits among alliance members i is as follow:

$$x_i^* = x_i + \Delta x_i^* = \frac{V(N)}{n} + \frac{2n-3}{2(n-1)}\left[\frac{1}{n}\sum_{i=1}^{n}\mu_i - \mu_i\right] + (F_i - \frac{1}{n}) * V(N) \qquad (15)$$

5 Numerical simulation

To verify the correctness and scientificity of the proposed benefit distribution method, this paper conducts numerical simulations on the benefit distribution of alliance members. The simulations are carried out under three different situations: decentralized decision making, centralized decision making, and revenue sharing. This analysis aims to identify the optimal revenue sharing coefficient and decision-making process among alliance members by examining the changes in benefit distribution and decision-making under different coefficients.

5.1 Profit distribution of cross border e-commerce horizontal alliance

The benefit distribution model for cross-border e-commerce horizontal alliance members assumes specific values for each parameter: $K = 10, \gamma_1 = 1, c = 10, \beta = 200, b_1 = 2, b_2 = 1$. By substituting each parameter into the equations for p^{1*}, s^{1*} and ω^{1*}, the best commodity prices and logistics services for alliance members can be calculated in the context of decentralized decision-making. By substituting each parameter into the equations for p^{1*}, s^{1*} and ω^{1*}, the best commodity prices and logistics services for alliance members can be calculated in the context of decentralized decision-making. Specifically, the calculated values are $p^{1*} = 87.14$, $\omega^{1*} = 35.71$, $s^{1*} = 25.71$. Therefore, cross-border e-commerce platforms and manufacturers can maximise the benefits of decentralised decisions, namely $\pi_1{}^* = 2304.54$, $\pi_2{}^* = 1322.27$. Under centralised decision-making, the overall profit of cross-border e-commerce is 5390, namely π = 5390. By implementing revenue sharing, an ideal income sharing coefficient can be obtained when $\pi_1(\lambda) > \pi_1{}^*$, $\pi_2(\lambda) > \pi_2{}^*$ and $\pi_1(\lambda) > \pi_2(\lambda)$, with a range of 0.71 ⩽ λ ⩽ 0.88. If the revenue sharing coefficient λ is below 0.71 or above 0.89, cross-border e-commerce platforms and manufacturers will not adopt the profit distribution mode of sharing under centralized control in order to ensure their maximum interests. When the benefit sharing coefficient λ takes different values, decision parameters and profit changes of cross-border e-commerce horizontal alliances can be calculated with a step change of 0.02. Refer to Table 1 for details.

Table 1. λ impact on cross border e-commerce horizontal alliance members

λ	$p^*(\lambda)$	$\omega(\lambda)$	$s^*(\lambda)$	$\pi_1(\lambda)$	$\pi_2(\lambda)$	π^*
0.71	70	16.68	33.02	2516.66	2509.46	5026.12
0.73	70	16.61	34.49	2654.01	2410.56	5064.57
0.75	70	16.50	36.00	2798.00	2304.00	5102.00
0.77	70	16.34	37.56	2949.07	2189.17	5138.24

0.79	70	16.13	39.17	3107.70	2065.43	5173.13
0.81	70	15.86	40.84	3274.39	1932.07	5206.46
0.83	70	15.54	42.56	3449.70	1788.30	5238.00
0.85	70	15.15	44.35	3634.23	1633.27	5267.5
0.87	70	14.71	46.19	3828.66	1466.05	5294.71
0.88	70	14.46	47.14	3929.80	1377.55	5307.35

5.2 Profit distribution of cross border e-commerce vertical alliance

The benefit distribution model for cross-border e-commerce vertical alliances includes four members: the cross-border e-commerce platform, domestic logistics service provider, international transport provider, and foreign logistics service provider (N={1,2,3,4}). To achieve the desired logistics service level, the cross-border e-commerce platform must form an alliance with a logistics service provider and share their total revenue. The revenue-sharing model for the cross-border e-commerce vertical alliance is based on the optimal decision of the cross-border e-commerce platform, denoted as V(N)=π_1 (λ), where the total revenue is calculated. This article assumes the following: V(1∪2∪3)=2200, V(1∪2∪4)=2300, V(1∪3∪4)=2000, and V(2∪3∪4)=1600. The logistics service provider should offer logistics services $s^*(\lambda)$ based on the optimal decision-making logistics service level in the horizontal alliance model. The model assumes that the service level provided by cross-border e-commerce platforms is consistent with that provided by logistics service providers. It only discusses the cost of investment φ_i and service level θ_i by alliance members. The cost of investment and service level by alliance members for the service are as follows: $\varphi = [\varphi_1, \varphi_2, \varphi_3, \varphi_4] = [20,15,8,12]$, $\theta = [\theta_1, \theta_2, \theta_3, \theta_4] = [0.7,0.5,0.4,0.6]$. The weight of cost investment φ and service level θ are 0.7 and 0.3 respectively. Formula (15) can be used to calculate the profit distribution of the cross-border e-commerce platform, domestic logistics service provider, cross-border transport provider, and foreign logistics service provider, represented by $\{x_1{}^*, x_2{}^*, x_3{}^*, x_4{}^*\}$.

Table 2 shows the profit changes of the cross-border e-commerce vertical alliance when the benefit-sharing coefficient λ takes different values, with step changes of 0.01. In the horizontal alliance benefit distribution model of cross-border e-commerce platforms under decentralized decision-making, the total income is 2304.5, denoted as V(N). According to the modified Raiffa model, the profit distribution among members of the cross-border e-commerce vertical alliance is as follows: $x_1 = 1056.59$, $x_2 = 680.42$, $x_3 = 110.35$, $x_4 = 457.19$. Table 2 shows that when λ=0.71, the benefits distributed by domestic and foreign logistics service providers are lower than those of decentralized decision-making. Therefore, it is necessary to consider the best interests of both horizontal and vertical parties in cross-border e-commerce alliances. The revenue sharing coefficient λ should be between 0.72 and 0.88.

Table 2. λ impact on cross border e-commerce vertical alliance members

λ	V(N)	$x_1{}^*$	$x_2{}^*$	$x_3{}^*$	$x_4{}^*$
0.71	2516.66	1235.00	672.88	164.35	444.44
0.72	2584.53	1258.75	690.46	174.96	460.36
0.74	2725.15	1307.97	726.89	196.95	493.34

0.76	2872.62	1359.58	765.10	220.01	527.93
0.78	3027.41	1413.76	805.21	244.21	564.23
0.80	3190.00	1470.67	847.33	269.63	602.37
0.82	3360.93	1530.49	891.62	296.36	642.46
0.84	3540.77	1593.44	938.22	324.48	684.64
0.86	3730.17	1659.72	987.29	354.10	729.06
0.88	3929.80	1729.60	1039.01	385.31	775.88

5.3 Comparative analysis of profit distribution of cross border e-commerce alliances under different decisions

To observe changes in interest distribution among members of cross-border e-commerce alliances under different decisions, we draw function images based on the model functions described above.

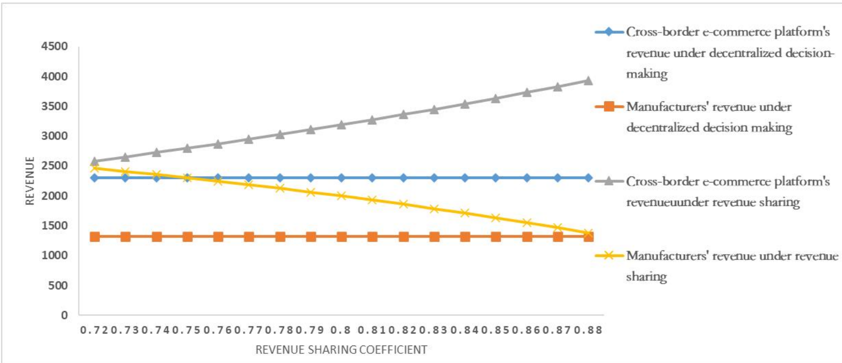

Fig. 2. benefit distribution of cross border e-commerce horizontal alliance members under different decisions

5.3.1Comparative analysis on profit distribution of cross border e-commerce alliance.

Figures 2 and 3 illustrate the distribution of benefits in a cross-border e-commerce alliance under decentralized decision-making and revenue sharing. It is evident from the figures that centralized decision-making and revenue sharing result in higher profits for all alliance members compared to decentralized decision-making. Moreover, the revenue of cross-border e-commerce alliances has shown an increasing trend compared to the decentralized decision-making situation. This is in line with Pareto improvement and validates the rationality of the benefit allocation model mentioned above. However, if the revenue sharing coefficient exceeds 0.88, the manufacturer's revenue will be lower than that of decentralized decision making, and they may terminate the revenue sharing contract of centralized decision making. Additionally, the study found that cross-border e-commerce platforms generate the highest revenue in the case of revenue sharing. This is due to their significant contribution as the leading party. In terms of revenue, domestic logistics service providers rank first among all logistics service providers, followed by foreign logistics service providers in second place, and national logistics service providers in third place. This ranking is consistent with the current industry landscape.

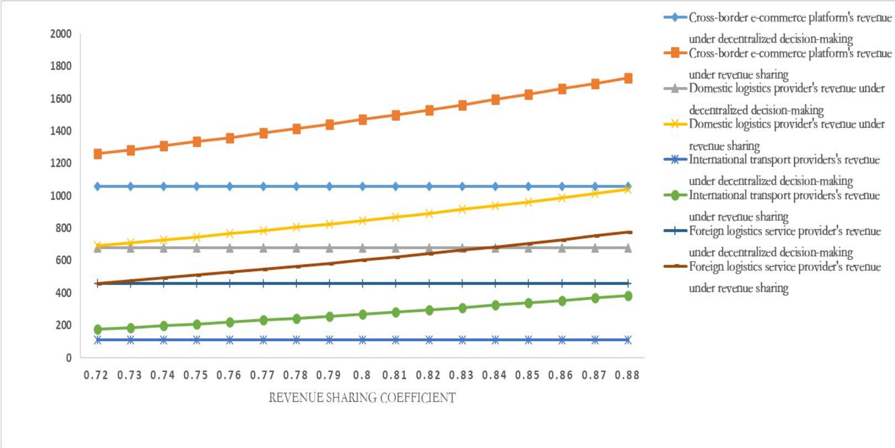

Fig. 3. benefit distribution among members of cross border e-commerce vertical alliance under different decisions

5.3.2Change analysis of decision parameters and demand under different circumstances.

Figure 4 shows the changes in logistics service level and market demand under different circumstances. The logistics service level is much higher under centralized decision-making than under decentralized decision-making. Additionally, as the revenue sharing coefficient λ improves, the level of logistics service also improves accordingly. Logistics service providers gain more income from profit distribution and take relevant measures to improve their logistics service level, such as introducing advanced management, logistics technology, and logistics talent. Revenue sharing contracts can effectively improve the logistics efficiency of cross-border e-commerce. It has been found that the price of goods is lower under revenue sharing than under decentralized decision-making, while the level of logistics is higher. As a result, market demand is expected to be higher under revenue sharing than under decentralized decision-making. Revenue sharing contracts can effectively address the issues of low efficiency in cross-border e-commerce and the severity game between alliance members. This will strengthen the alliance relationship between cross-border e-commerce members and promote the development of cross-border e-commerce.

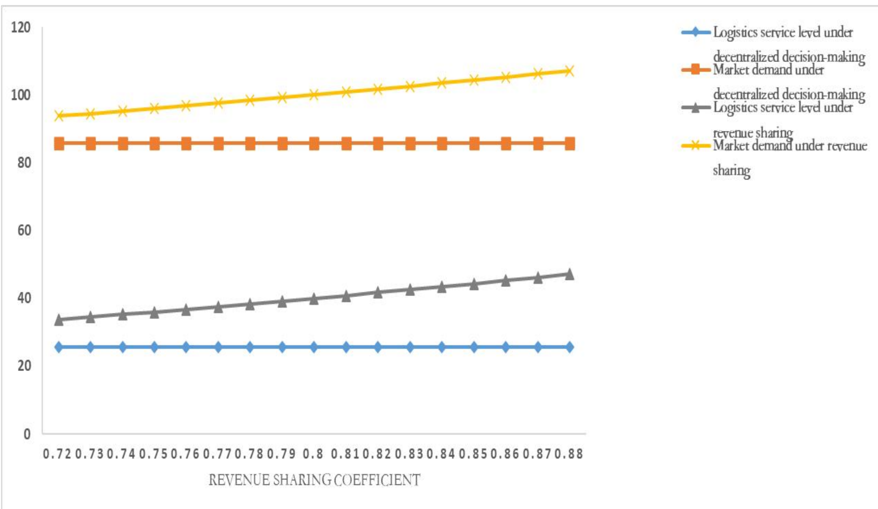

Fig. 4. Changes in logistics service level and market demand under different circumstances

6 Conclusion

This paper presents the design of a cross-border e-commerce alliance from the perspectives of organizational and interest distribution modes. The alliance is centered around a cross-border e-commerce platform and aims to address the issues of 'information islands' and conflicting interests among members of the cross-border e-commerce supply chain. To address the issue of 'information islands', the cross-border e-commerce alliance has developed a cloud platform that integrates logistics, information flow, capital flow, and business flow. Additionally, to tackle the issue of conflicting interests, the alliance has established Stackelberg game models, centralized decision models, and revenue sharing contract models for its horizontal members. The revised Raffia model is introduced to solve the benefit distribution problem of cross-border e-commerce vertical alliances. Numerical simulations are used to analyze the logistics service level, commodity price, market demand, and benefit distribution of alliance members under different decisions. The results demonstrate that: Under the revenue-sharing contract, the overall revenue of cross-border e-commerce and the benefit distribution of alliance members are higher than that of decentralized decision-making, which is in line with the Pareto improvement. Additionally, it is important to maintain the value range of the revenue sharing coefficient between 0.72 and 0.88 to ensure that all parties can reach an agreement. Thirdly, revenue sharing leads to lower prices for goods compared to decentralized decision-making, while also increasing the logistics level, thereby expanding market demand. In real life, there are numerous instances of cooperation breakdown between logistics service providers due to the unfair distribution of benefits. This paper's research holds significant reference value for addressing the issue of unfair benefit distribution.

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