A Study of Cooperation Between Suppliers and E-Commerce Platforms Based on Biform Game

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ABSTRACT

This article considers e-commerce platforms with and without promotion, builds biform game models consisting of one and two supplier platforms, and calculates the profit distribution of the three parties using the Shapley value method. The optimal strategies of the three parties are discussed, including which platform the supplier will choose to cooperate with and which logistics service strategy to choose. In addition, how platforms make their commission rates to attract suppliers and which promotion strategy to choose are also studied. The results show that regardless of whether the platform promotes sales or not, in the case of charging consumers for the shipping fee when the standard shipping fee of unit product is low, the supplier will choose to cooperate with the platform without self-built logistics and use the third-party logistics to deliver products. When the standard shipping fee is high, the supplier will choose to cooperate with the platform with self-built logistics. But in the case of free shipping for consumers, the conclusion is just the opposite.

KEYWORDS
B2C E-Commerce, Biform Game, Logistics Service, Optimal Strategies, Sales Promotion, Shapley Value

INTRODUCTION

China has the largest group of internet users in the world, and the scale of e-commerce is also expanding. The B2C (business to consumer) e-commerce model is when companies sell products and provide services directly to consumers. In recent years, more and more companies have been involved in B2C e-commerce and regard it as a vital online sales channel (Xu et al., 2021). Many suppliers can sell products on the B2C e-commerce platform, which provides technical support and promotion services for suppliers who need to pay a commission to the platform for each unit of product sold there (Fu et al., 2021). TMALL.COM, the major B2C e-commerce platform in China,
is a service platform that provides services for suppliers to open flagship stores on it. However, it does not have its own logistics system and is supported by third-party logistics providers. Likewise, JD.COM uses a shopping mall format known as Plan of Open Platform (POP), where the suppliers selling products are identified as the third party. JD.COM has built its own logistics and warehouse capacity that offers an integrated solution to suppliers, including warehousing, transportation, delivery, and customer service (Wang et al., 2019).

With the rapid development of e-commerce, logistics service has become a bottleneck restricting the development of e-commerce (Tsang et al., 2021). On the one hand, the quality of logistics service affects the satisfaction and purchase decisions of consumers (Cotarelo et al., 2021). TMALL.COM has the advantages of complete categories and low rates, but its logistics and service are poor. In contrast, JD.COM has self-built logistics and good service, although it has incomplete categories and a high rate (Li & Zhong, 2021). On the other hand, the free shipping policy is a vital factor that affects the purchase decision of consumers. Generally, consumers are more willing to buy products with free shipping.

A biform game model is designed to formalize the notion of business strategy as making moves to try to shape the competitive environment in a favorable way. It is a two-stage game. The first stage is noncooperative and is designed to describe the strategic moves of the players. Analysis of the second stage then says how much value each player will capture (Wang et al., 2019). The biform game has been used to explain the competitive advantage of broker and investment incentives in supply chains (Feess & Thun, 2014). The biform game model established in this article is a two-stage, three-party game composed of one supplier and two e-commerce platforms. In the first stage, the supplier chooses which platform to cooperate with and the logistics service strategy. The strategy of the supplier does not directly generate revenue; rather, it forms the competitive environment in the second stage. In the second stage, the supplier sells the products on the platform. The platform collects commissions from the supplier at a certain rate and then completes the profit distribution for the two parties.

To sum up, the cooperation between suppliers and platforms and the choice of logistics services are hot issues in the field of B2C e-commerce, but the research on these problems is scarce. Moreover, the traditional game model often adopts a one-to-one hypothesis, but in reality, enterprises may face one-to-many choices. Therefore, the authors examine the cooperation problem between one supplier and two platforms and the choice of logistics service by using the biform game. Specifically, the supplier chooses which platform to cooperate with to sell its products and determines which logistics service strategy to choose to maximize its profit. At the same time, how the platforms make their commission rates attractive to suppliers and how they choose promotion strategies to maximize their profit are also studied. The results show that regardless of whether the platform promotes sales or not, in the case of charging consumers a shipping fee when the standard shipping fee of unit product is low, the supplier will choose to cooperate with the platform without self-built logistics and use the third-party logistics company to deliver products. When the standard shipping fee is high, the supplier will choose to cooperate with the platform with self-built logistics. In the case of free shipping for consumers, the conclusion is just the opposite. Finally, after conducting a numerical analysis, the authors study the influence of free shipping and promotion strategies on suppliers and platforms.

The rest of this article is organized as follows. After discussing the relevant literature, the following section outlines the main assumptions of the model. Then, the platform is considered with and without promotion to build three biform game models consisting of one supplier and two platforms and calculate the distribution of the profits of the three parties with the Shapley value method. After that, the authors discuss the optimal strategies of each of the three parties and conduct a numerical analysis to study the influence of free shipping and promotion strategies on suppliers and platforms.

**LITERATURE REVIEW**

By establishing a biform game model including one supplier, two heterogeneous e-commerce platforms, this article discusses the cooperation strategy between suppliers and platforms, competitive strategies
among heterogeneous platforms, the selection of logistics services, and the optimal promotion strategy of the platforms. Therefore, this section reviews the literature in the three research fields of logistics service selection, cooperation strategy, and sales promotion, respectively.

**Logistics Service Selection**

With the increasingly close cooperation between platforms and e-retailers, the logistics services in many e-commerce platforms have changed from the original independent model to the logistics service cooperating model. For example, the platform shares its logistics service system with the seller (Ma et al., 2019). For this kind of research problem, many scholars explore logistics service selection. Qin et al. (2020) note that as the market potential increases, the equilibrium model evolves from no-sharing to sharing on logistics services. Further considering the impact of different cooperating modes, Qin et al. (2021) believe that the optimal choice of logistics modes by supplier and platform depends on the logistics service level. However, Cao et al. (2021) assume that the seller’s optimal logistics service selection strategies are comprehensively affected by the annual service fee and the logistics cost time-sensitivity coefficient, but they only consider the offline seller’s logistics choice between e-commerce platforms and third-party logistics providers.

Different from the above literature, this article explores the choice of different logistics service strategies for online suppliers who want to sell their products on an e-commerce platform. First, the authors consider the online supplier’s choice between the platform self-built logistics and third-party logistics and explore their decision on whether to charge a shipping fee. Second, this article considers the interaction between the logistics services selection and the sales strategies of competitive heterogeneous e-commerce platforms. In addition, the authors consider the impact of platform heterogeneity on the supplier’s decision about logistics services and find that the supplier’s optimal logistics decision is comprehensively affected by the postal policy, logistics cost, and platform promotion strategy.

**Cooperation Strategy**

Profit division of cooperative alliance is a significant issue in cooperative strategy research. For the profit distribution problem of fewer partners at a certain transaction stage, the revenue sharing or profit-sharing contract can solve it effectively (Gong et al., 2018; Shen, 2021; Xia et al., 2021). However, in the face of a more complex profit division problem in the alliance, which is when the game between competition and cooperation is on more than one stage, the Shapley value method is more applicable. Researchers have widely used the Shapley method in the cooperative game since its introduction in 1953 because it can ensure fairness, anonymity, effectiveness, additivity, and symmetry when allocating profit (Kemahloğlu-Ziya & Bartholdi, 2011). Liu et al. (2017) used the Shapley value method to provide a profit allocation mechanism for enterprises in a dynamic supply chain, but it requires related information from each firm at each time point. Gao et al. (2017) improved the Shapley value method to ensure fair profit distribution when two collaborators cooperate under uncertain profit. Considering the limitations of this method, Li et al. (2020) used the Shapley value method to distribute the profits from the combined operation of wind power pumped storage.

However, the above literature ignores the impact of platforms on cooperation strategy. Tian et al. (2018) explored the optimal cooperative strategy among the marketplace, reseller, or hybrid in platform, but they were only based on the perspective of the platform. Different from the above literature, the current article explores the optimal cooperating strategy decided by the online supplier. The authors divide the game process into two stages, the competition stage and the cooperation stage, to reflect the real situation. In addition, the authors further consider the impact of the heterogeneity of competing platforms and different promotion strategies on the supplier’s cooperating decision and profit distribution.

**Sales Promotion**

Sales promotion is a direct incentive to improve sales (Kaveh et al., 2020). Hu and Tadikamalla (2020) state that sales promotion increases sales of online fashion products. Further, considering the
interaction between website quality and sales promotion, Wiranata and Hananto (2020) indicate that sales promotion positively affects impulse buying. While Al (2021) indicates that sales promotion has a positive effect on impulsive buying, and promotions are the most influential in online purchasing decisions. However, this literature only explores the transactions in the social media platform, and most of the research is based on empirical and data analysis methods, which lacks universality. Considering the sales promotion in e-commerce platforms, Peng et al. (2019) investigate the impact of customer perceived value on purchase intention in online flash sales on social e-commerce platforms. But, they only focus on consumer surplus and purchase motivation; they ignore the game of cooperation and competition in the supply chain.

This article adds to the existing literature by exploring the promotion strategy of competitive heterogeneous e-commerce platforms. Considering the real market situation and consumer’s purchase motivation, the sales promotion effects of different types of platforms are distinguished to explore the impact of competitive factors and heterogeneity on platform sales promotion strategies. In addition to the competitive game between platforms, the authors also discuss the cooperative game between suppliers and platforms and study the interaction between supplier’s logistics service decision, cooperation selection, and platform promotion strategy to provide suggestions for the sales decision of e-commerce platforms facing different competition and cooperation situations.

To sum up, this article has the following innovations. First, a two-stage three-party game model consisting of one supplier and two e-commerce platforms is established, and there is a competitive relationship between the two e-commerce platforms, which is more suitable for the one-to-many cooperation in B2C e-commerce practice. Second, considering whether a free shipping strategy is adopted in logistics service, the authors study the cooperation decision-making between suppliers and e-commerce platforms to provide a reference for enterprises to improve customer satisfaction and loyalty and maximize profits. Third, considering e-commerce platforms with and without promotion, the authors build biform game models and give the optimal strategies for supplier and e-commerce platforms.

MODEL ASSUMPTIONS AND NOTATIONS

Suppose that there is one supplier (S) and two e-commerce platforms (P₁ and P₂) in the market. The supplier (S) plans to cooperate with an e-commerce platform (P₁ or P₂) to sell products online. P₁ does not have its own logistics system, so if S chooses to cooperate with P₁, it can only choose a third-party logistics company to provide logistics services. P₂ has a self-built logistics system. If S chooses to cooperate with P₂, it can use the self-built logistics system of P₂ for logistics services.

The assumptions of the model are listed below.

- The same product has the same price and quality on different e-commerce platforms.
- The standard shipping fee in the logistics market is uniform.
- After-sale service and other issues are not considered.
- Ignore the influence of consumer inertia on purchasing channels.

Set S + Pᵢ to indicate that the supplier S will cooperate with the e-commerce platform Pᵢ, where i = 1, 2. At this time, the purchase probability (also known as purchase intention) of consumers for this product is qᵢ. The total profit per unit product of S and Pᵢ is vᵢ. The standard shipping fee for a product in the logistics market is l, and the logistics service cost of a product of the platform’s self-built logistics is l₂. Assume that the platform’s self-built logistics can obtain logistics service profit, so l > l₂. Suppose the price of a product is p, and the production cost of a product is c₀.

When the supplier sells products on the e-commerce platform, they can choose whether shipping is free for consumers. If the consumers are charged for shipping, when S + P₁, the consumers need
to pay the standard shipping fee of unit product $l$ to the third-party logistics company; when $S + P_2$, the consumers need to pay $l$ to the e-commerce platform $P_2$. If the shipping fee is free for the consumers, the shipping fee shall be borne by the supplier. When $S + P_1$, the supplier $S$ needs to pay the shipping fee of unit product to the third-party logistics company. In this case, the third-party logistics company will often give the supplier an agreement price ($l_1$) lower than the standard shipping fee, i.e. $l_1 < l$. When $S + P_2$, the supplier $S$ needs to pay a certain amount of shipping fee to the platform $P_2$. In this case, the platform can charge the supplier for shipping by adjusting the commission rate. Because consumers are more willing to buy free shipping products, the free shipping strategy of suppliers can increase the purchase probability of consumers by $\beta l_1^2$, in which $\beta$ is the sensitivity coefficient of consumers to a shipping fee.

**BIFORM GAME MODEL WITHOUT PROMOTION OF E-COMMERCE PLATFORM**

**Analysis of Supplier’s Strategies**

The game process is indicated below.

Step 1. The e-commerce platforms decide the commission rate charged to the supplier.
Step 2. The supplier decides whether to choose a free shipping policy for consumers.
Step 3. The supplier chooses which platform ($P_1$ or $P_2$) to cooperate with to sell products.
Step 4. The supplier and the selected e-commerce platform distribute the total profit.

The revenue matrix of the supplier’s strategies game model is shown in Table 1.

**Lemma 1.** For the alliance game $(N, \nu)$, the proportion of profit allocated to the player $i \in N$ by Shapley value method is:

$$\phi_i(\nu) = \frac{1}{|N|} \sum_{A \subseteq N \setminus \{i\}} \frac{1}{|A|} \left( \nu(A \cup \{i\}) - \nu(A) \right),$$

where $|A|$ and $|N|$, respectively, represent the number of elements in sets $A$ and $N$, $C_n^k = \frac{n!}{k!(n-k)!}$.

The profit distribution proportion shown in the above formula can be understood as the profit distributed to the players is directly proportional to their marginal contribution in the alliance.

**Table 1. The revenue matrix of the supplier’s strategies game model.**

| $\nu$             | $S + P_1$          | $S + P_2$          |
|-------------------|--------------------|--------------------|
| Charging Shipping | $(p - c_o)q_1$     | $(p - c_o + l - l_2)q_2$ |
| Free Shipping     | $(p - c_o - l_1)q_1 + \frac{1}{l^2}$ | $(p - c_o - l_2)q_2 + \frac{1}{l^2}$ |
The Shapley value method is used to obtain the equilibrium profit of each player in the supplier’s strategies game model, as shown in Table 2. See Proof 1 in the appendix for the proof process.

**Proposition 1.** In the biform game, the Shapley value method is used to distribute the total profit to get the supplier’s strategies by comparing and analyzing the profits $\pi_{S_i}^{\text{P}_i}$ distributed to $S$ in Table 2, as shown in Table 3.

### Analysis of e-commerce platform’s strategies

**Proposition 2.** According to the profit $\pi_{P_i}^{\text{P}_i}$ ($i = 1, 2$) distributed to the e-commerce platform in Table 2, we calculate the value range of commission rates $w_{P_i}^{\text{P}_i}$ charged by the e-commerce platforms to the supplier, as shown in Table 4. See Proof 2 in the appendix for the proof process.

## BIFORM GAME MODEL WITH PROMOTION OF E-COMMERCE PLATFORM

### Analysis of Supplier’s Strategies

To increase sales, e-commerce platforms always provide products promotions, such as TMALL’s “11.11” and JD’s “6.18” online shopping sprees in China. Therefore, on the basis of the previous section, we further consider the influence of e-commerce platform promotion on the decision-making of all parties in the game and total profit.

Suppose that the e-commerce platforms $P_1$ and $P_2$ both can decide their promotion input $c_i$ ($i = 1, 2$). Accordingly, promotion can increase the purchase probability of consumers by $\pm c_i^\frac{1}{2}$, where $\pm$ is the sensitive coefficient of consumers to promotion. As the promotion means of the major e-commerce platforms tend to be the same, it can be assumed that the sensitivity coefficients of consumers to the promotion of e-commerce platforms $P_1$ and $P_2$ are both $\pm$.

### Table 2. The equilibrium profit of each player in the supplier’s strategies game model.

| $\pi$       | $P_1$                                             | $P_2$                                             | $S$ |
|-------------|---------------------------------------------------|---------------------------------------------------|-----|
| Charging Shipping | $s + p_1, \frac{1}{2} (p - c_1)q_1 - \frac{1}{3} (p - c_1 + l - l_1)q_1$ | $s + p_2, \frac{1}{6} (p - c_0 + l - l_2)q_2$ | $s + p, \frac{1}{2} (p - c_1)q_1 + \frac{1}{6} (p - c_0 + l - l_1)q_1$ |
| Free Shipping | $s + p_1, \frac{1}{3} (p - c_0 - l_1)q_1 + \frac{1}{2} (p - c_0 - l)(q_1 + q_2)$ | $s + p_2, \frac{1}{6} (p - c_0 - l_2)q_2 + \frac{1}{2} (p - c_0 - l)(q_1 + q_2)$ | $s + p, \frac{1}{2} (p - c_0 - l_1)q_1 + \frac{1}{3} (p - c_0 - l)(q_1 + q_2) + \frac{1}{2} (p - c_0 - l)(q_1 + q_2)$ |
The game process is as follows:

Step 1. The e-commerce platforms decide the commission rate charged to the supplier.
Step 2. The supplier decides whether to choose a free shipping policy for consumers.
Step 3. The supplier chooses which platform ($P_1$ or $P_2$) to cooperate with to sell products.
Step 4. The e-commerce platform $P_i$ decides its promotion input $c_i$.
Step 5. The supplier and the selected e-commerce platform distribute the total profit.

The revenue matrix of the supplier’s strategy game model with the promotion of the platform is shown in Table 5.

| Conditions | Strategies |
|------------|------------|
| Charging Shipping | \( l < \frac{(p - c_0)q_1 - (p - c_0 - l_2)q_2}{q_2} \) | Choose $P_1$. |
| | \( l > \frac{(p - c_0)q_1 - (p - c_0 - l_2)q_2}{q_2} \) | Choose $P_2$. |
| Free Shipping | \( l < \frac{l_2q_2 - l_1q_1 - (p - c_0)(q_2 - q_1)^2}{(l_1 - l_2)^2\beta^2} \) | Choose $P_2$. |
| | \( l > \frac{l_2q_2 - l_1q_1 - (p - c_0)(q_2 - q_1)^2}{(l_1 - l_2)^2\beta^2} \) | Choose $P_1$. |

Table 3. Supplier’s strategies.

| Conditions | Strategies |
|------------|------------|
| $S + P_1$ | $w_{c_i}^{NP} \in \left[ \frac{1}{2p}(p - c_0)q_1 - \frac{1}{3p}(p - c_0 + l - l_2)q_2, \frac{5}{6p}(p - c_0)q_1 - \frac{2}{3p}(p - c_0 + l - l_2)q_2 \right]$ |
| $S + P_2$ | $w_{c_i}^{NP} \in \left[ \frac{1}{2p}(p - c_0 + l - l_2)q_2 - \frac{1}{3p}(p - c_0)q_1, \frac{5}{6p}(p - c_0 + l - l_2)q_2 - \frac{2}{3p}(p - c_0)q_1 \right]$ |

Table 4. The value range of commission rates of e-commerce platforms.

The game process is as follows:

Step 1. The e-commerce platforms decide the commission rate charged to the supplier.
Step 2. The supplier decides whether to choose a free shipping policy for consumers.
Step 3. The supplier chooses which platform ($P_1$ or $P_2$) to cooperate with to sell products.
Step 4. The e-commerce platform $P_i$ decides its promotion input $c_i$.
Step 5. The supplier and the selected e-commerce platform distribute the total profit.
Table 5. The revenue matrix of the supplier’s strategy game model with the promotion of the platform.

| v       | $S + P_1$                                                                 | $S + P_2$                                                                 |
|---------|----------------------------------------------------------------------------|----------------------------------------------------------------------------|
| Charging Shipping | $(p - c_0 - c_1)\left(q_1 + \pm c_{1}^{\frac{1}{2}}\right)$ | $(p - c_0 - c_2 + l - \ell)\left(q_2 + \pm c_{2}^{\frac{1}{2}}\right)$ |
| Free Shipping   | $(p - c_0 - c_1 - l)\left(q_1 + \pm c_{1}^{\frac{1}{2}} + 2 l^{\frac{1}{2}}\right)$ | $(p - c_0 - c_2 - l_2)\left(q_2 + \pm c_{2}^{\frac{1}{2}} + 2 l_2^{\frac{1}{2}}\right)$ |

The Shapley value method is used to calculate the equilibrium profit of each player in the supplier’s strategy game model with the promotion of the platform, as shown in Table 6.

**Proposition 3.** In the biform game, the Shapley value method is used to distribute the total profit to get the supplier’s strategy by comparing and analyzing the profits $\pi^{\Theta P}_{S}$ (where $c$ means considering the promotion of the platform) distributed to $S$ in Table 6, as shown in Table 7.

Table 6. The equilibrium profit of each player in the supplier’s strategy game model with the promotion of the platform.

| $\pi$ | $P_1$                                                                 | $P_2$                                                                 | $S$                                                                 |
|-------|----------------------------------------------------------------------------|----------------------------------------------------------------------------|----------------------------------------------------------------------------|
| Charging Shipping | $\frac{1}{2}\left[p - c_{0} - c_{1}\right]\left[q_{1} + \pm c_{1}^{\frac{1}{2}}\right]$ | $\frac{1}{6}\left[p - c_{0} - c_{1} + l - \ell\right]\left[q_{2} + \pm c_{2}^{\frac{1}{2}}\right]$ | $\frac{1}{2}\left[p - c_{0} - c_{1}\right]\left[q_{1} + \pm c_{1}^{\frac{1}{2}}\right]$ + $\frac{1}{6}\left[p - c_{0} - c_{2} + l - \ell\right]\left[q_{2} + \pm c_{2}^{\frac{1}{2}}\right]$ |
| Free Shipping | $\frac{1}{2}\left[p - c_{0} - c_{1} - l\right]\left[q_{1} + \pm c_{1}^{\frac{1}{2}} + 2 l^{\frac{1}{2}}\right]$ | $\frac{1}{6}\left[p - c_{0} - c_{1} - l - \ell\right]\left[q_{2} + \pm c_{2}^{\frac{1}{2}} + 2 l_2^{\frac{1}{2}}\right]$ | $\frac{1}{2}\left[p - c_{0} - c_{1} - l\right]\left[q_{1} + \pm c_{1}^{\frac{1}{2}} + 2 l^{\frac{1}{2}}\right]$ + $\frac{1}{6}\left[p - c_{0} - c_{2} - l_2\right]\left[q_{2} + \pm c_{2}^{\frac{1}{2}} + 2 l_2^{\frac{1}{2}}\right]$ |
ANALYSIS OF E-COMMERCE PLATFORM’S STRATEGIES

Proposition 4. In the biform game, the Shapley value method is used to distribute the total profit to get the promotion input strategies of e-commerce platforms, as shown in Table 8.

Table 8. The promotion input strategies of e-commerce platforms.

| Conditions | \( S + P_1 \) | \( S + P_2 \) | \( S + P_1 \) | \( S + P_2 \) |
|-----------|-------------|-------------|-------------|-------------|
| **Charging Shipping** | \( 3q_1^2 (p - c_0) + 2q_1 \left(q_1 - \sqrt{q_1^2 + 3q_1^2(p - c_0)} \right) \) \( 9\alpha^2 \) | \( 2q_1 \left(q_1 - \sqrt{q_1^2 + 3q_1^2(p - c_0 + l_1 - l_2)} \right) + 3\alpha^2 \left(p - c_0 + l_1 - l_2 \right) \) \( 9\alpha^2 \) | \( 3q_1^2 (p - c_0) + 2q_1 \left(q_1 - \sqrt{q_1^2 + 3q_1^2(p - c_0)} \right) \) \( 9\alpha^2 \) | \( 2q_1 \left(q_1 - \sqrt{q_1^2 + 3q_1^2(p - c_0 + l_1 - l_2)} \right) + 3\alpha^2 \left(p - c_0 + l_1 - l_2 \right) \) \( 9\alpha^2 \) |
| **Free Shipping** | \( 3q_1^2 (p - c_0) + 2q_1 \left(q_1 - \sqrt{q_1^2 + 3q_1^2(p - c_0)} \right) \) \( 9\alpha^2 \) | \( 2q_1 \left(q_1 - \sqrt{q_1^2 + 3q_1^2(p - c_0 + l_1 - l_2)} \right) + 3\alpha^2 \left(p - c_0 + l_1 - l_2 \right) \) \( 9\alpha^2 \) | \( 3q_1^2 (p - c_0) + 2q_1 \left(q_1 - \sqrt{q_1^2 + 3q_1^2(p - c_0)} \right) \) \( 9\alpha^2 \) | \( 2q_1 \left(q_1 - \sqrt{q_1^2 + 3q_1^2(p - c_0 + l_1 - l_2)} \right) + 3\alpha^2 \left(p - c_0 + l_1 - l_2 \right) \) \( 9\alpha^2 \) |
**Proposition 5.** According to the profit $\pi_{cP}^i$ ($i = 1, 2$) distributed to the platform in Table 6, the value range for commission rates $w_{cP}^i$ is calculated by the platforms to the supplier, as shown in Table 9.

| S + P₁ | S + P₂ |
|--------|--------|
| Charging Shipping | $\nu_{nP}^i = \frac{1}{2p}(p - c_i - c_p)\left[q_i + \alpha_i^2\right] - \frac{1}{3p}(p - c_i - c_p + l_i)\left[q_i + \alpha_i^2\right] + \frac{1}{3p}(p - c_i - c_p)\left[q_i + \alpha_i^2\right]$ | $\nu_{nP}^i = \frac{1}{2p}(p - c_i - c_p + l_i)\left[q_i + \alpha_i^2\right] - \frac{1}{3p}(p - c_i - c_p)\left[q_i + \alpha_i^2\right]$ |
| Free Shipping | $\nu_{nP}^i = \frac{1}{2p}(p - c_i - c_p - \ell_i)\left[q_i + \alpha_i^2 + \ell_i^2\right] - \frac{1}{3p}(p - c_i - c_p - \ell_i)\left[q_i + \alpha_i^2 + \ell_i^2\right] + \frac{1}{3p}(p - c_i - c_p - \ell_i)\left[q_i + \alpha_i^2 + \ell_i^2\right]$ | $\nu_{nP}^i = \frac{1}{2p}(p - c_i - c_p - \ell_i)\left[q_i + \alpha_i^2 + \ell_i^2\right] - 2\frac{1}{3p}(p - c_i - c_p)\left[q_i + \alpha_i^2 + \ell_i^2\right]$ |

**NUMERICAL ANALYSIS**

Wolfram Mathematica software is used to conduct the numerical analysis. The parameter values assigned in the numerical analysis are outlined here:

$p = 3; c_0 = 0.5; q_1 = 0.68; q_2 = 0.74; l_1 = 1; l_2 = 0.5; \alpha = 0.4; \pm = 0.8$

Figure 1a shows the influence of free shipping strategy on the profit of $S$ without promotion, where $\Delta\pi_{cP}^i = \pi_{cP}^{nBP} - \pi_{cP}^{nNP} (i = 1, 2)$. Figure 1b shows the influence of the free shipping strategy on the profits of $P_1$ and $P_2$ without promotion, where $\Delta\pi_{cP}^i = \pi_{cP}^{nP} - \pi_{cP}^{nNP} (i = 1, 2)$.

**Observation 1.** As shown in Figure 1a, considering e-commerce platform without promotion, when $S$ cooperates with $P_1$, if $l < 1.4$, the supplier $S$ can get less profit by choosing a free shipping strategy compared to choosing to charge for shipping (i.e., $\Delta\pi_{cP}^i < 0$); if $l > 1.4$, the supplier $S$ can get more profit by choosing a free shipping strategy than by choosing to charge for shipping (i.e., $\Delta\pi_{cP}^i > 0$); and $\Delta\pi_{cP}^i$ increases with the increase of $l$. When $S$ cooperates with $P_2$, if $l < 1.13$, the supplier $S$ can get more profit by choosing a free shipping strategy than by choosing to charge for shipping (i.e., $\Delta\pi_{cP}^i < 0$); and $\Delta\pi_{cP}^i$ decreases with the increase of $l$.

**Observation 2.** As shown in Figure 1b, considering e-commerce platform without promotion, when $S$ cooperates with $P_1$, if $l < 1.23$, the profit of $P_1$ under the free shipping strategy is less than charging for shipping (i.e., $\Delta\pi_{cP}^i < 0$); if $l > 1.23$, the profit of $P_1$ under the free shipping strategy is higher than charging for shipping (i.e., $\Delta\pi_{cP}^i > 0$); and $\Delta\pi_{cP}^i$ increases with the increase of $l$. When $S$ cooperates with $P_2$, if $l < 1.21$, the profit of $P_2$ under the free shipping strategy is higher than charging for shipping (i.e., $\Delta\pi_{cP}^i > 0$); if $l > 1.21$, the profit of $P_2$ under the free shipping strategy is less than charging for shipping (i.e., $\Delta\pi_{cP}^i < 0$); and $\Delta\pi_{cP}^i$ decreases with the increase of $l$. 

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The reasons for observation 1 and 2 is as follows. If \( S \) cooperates with \( P_1 \), the supplier will use a third-party logistics company to deliver products. When the standard shipping fee is low, the sales volume brought by the free shipping strategy is also low, and it is not enough to make up for the cost paid by the supplier for free shipping. Therefore, both the supplier and the platform gain less profit from free shipping than from charging for shipping. When the standard shipping fee is large, the sales volume from the free shipping strategy is large enough to make up for the cost paid by the supplier for free shipping, so both the supplier and the platform gain more profit from free shipping than from charging for shipping. If \( S \) cooperates with \( P_2 \), the supplier will use the self-built logistics of the platform to deliver products, and the platform can profit from the logistics service. When the standard
shipping fee is low, the free shipping strategy makes the logistics service profit lost by the platform small and increases the sales volume, so both the supplier and the platform gain more profit from the free shipping than from charging for shipping. When the standard shipping fee is high, the free shipping strategy can increase the sales volume, but it is not enough to make up for the lost logistics service profit by the platform, so both the supplier and the platform gain less profit from free shipping than from charging for shipping.

According to observations 1 and 2, considering an e-commerce platform without promotion, the following conclusion can be drawn. If the standard shipping fee is low when \( S \) cooperates with \( P_1 \), both of them are more willing to choose to charge for shipping. However, when \( S \) cooperates with \( P_2 \), both of them are more willing to choose the free shipping strategy. If the standard shipping fee is high, the result turns out contrary.

Figure 2a shows the influence of the free shipping strategy on the profit of \( S \) with promotion, where \( \Delta \pi_s^{cp_i} = \pi_s^{np_i} - \pi_s^{np_i} \ (i = 1, 2) \). Figure 2b shows the influence of the free shipping strategy on the profits of \( P_1 \) and \( P_2 \) with promotion, where \( \Delta \pi_{P_i}^{cp_i} = \pi_{P_i}^{np_i} - \pi_{P_i}^{np_i} \ (i = 1, 2) \).

**Observation 3.** As shown in Figure 2a, considering e-commerce platform with promotion, regardless of whether \( S \) cooperates with \( P_1 \) or \( P_2 \), the supplier can get less profit by choosing a free shipping strategy than by choosing to charge for shipping (i.e. \( \Delta \pi_s^{cp_i} < 0 \), \( i = 1, 2 \)), and \( \Delta \pi_s^{cp_i} \) decreases with the increase of \( l \).

**Observation 4.** As shown in Figure 2b, considering an e-commerce platform with promotion, regardless of whether \( S \) cooperates with \( P_1 \) or \( P_2 \), the profits of both \( P_1 \) and \( P_2 \) under the free shipping strategy are larger than when charging for shipping (i.e. \( \Delta \pi_{P_i}^{cp_i} > 0 \), \( i = 1, 2 \)), and \( \Delta \pi_{P_i}^{cp_i} \) increases with the increase of \( l \), \( \Delta \pi_{P_2}^{cp_i} \) decreases with the increase of \( l \).

According to observations 3 and 4, considering an e-commerce platform with promotion, the following conclusion can be drawn. Regardless of whether \( S \) cooperates with \( P_1 \) or \( P_2 \), the supplier is more willing to choose to charge for shipping, while the platform is more willing to let the supplier

![Figure 2. (a) The influence of free shipping strategy on the profit of S with promotion](image-url)
choose the free shipping strategy. However, if the supplier chooses the charging shipping strategy, the platform will charge a certain compensation to the supplier by increasing the commission rate.

Figure 3a shows the influence of promotion strategy on the profit of \( S \), where \( \Delta \pi_{SP}^{NP} = \pi_{S}^{cNP} - \pi_{S}^{nNP} \), \( \Delta \pi_{SP}^{BP} = \pi_{S}^{cBP} - \pi_{S}^{nBP} \) \((i = 1, 2)\). Figure 3b shows the influence of promotion strategy on the profit of \( P_1 \), where \( \Delta \pi_{P1}^{BP} = \pi_{P1}^{cBP} - \pi_{P1}^{nBP} \), \((y \in \{N, B\})\). Figure 3c shows the influence of promotion strategy on the profit of \( P_2 \), where \( \Delta \pi_{P2}^{BP} = \pi_{P2}^{cBP} - \pi_{P2}^{nBP} \), \((y \in \{N, B\})\).
Observation 5. As shown in Figure 3a, when the supplier charges for shipping, regardless of whether S cooperates with P₁ or P₂, the supplier’s profit under the promotion strategy is greater than that under the non-promotion strategy (i.e., $\Delta\pi^{{NP_i}}_S > 0$), $i = 1, 2$, and $\Delta\pi^{{NP_i}}_S$ increases with the increase of $l$. When the supplier chooses the free shipping strategy, no matter $S$ cooperates with $P_1$ or $P_2$, the profit of the supplier under the promotion strategy is smaller than that under the non-promotion strategy (i.e., $\Delta\pi^{{BP_i}}_S < 0$), $i = 1, 2$, and $\Delta\pi^{{BP_i}}_S$ decreases with the increase of $l$.

Observation 6. As shown in Figure 3b, if $S$ cooperates with $P_1$, regardless of whether the supplier chooses free shipping or not, the platform’s profit in promotion is greater than that in non-
Observation 7. As shown in Figure 3c, if \( S \) cooperates with \( P_2 \), regardless of whether the supplier chooses free shipping or not, the platform's profit in promotion is greater than that in non-promotion (i.e., \( \Delta \pi_{P_1}^{vP_2} > 0 \), \( y \in \{N, B\} \) ), and \( \Delta \pi_{P_1}^{NP_2} \) decreases with the increase of \( l \), \( \Delta \pi_{P_1}^{BP_2} \) increases with the increase of \( l \).

According to observations 5, 6, and 7, considering e-commerce platforms with promotion, the following conclusion can be drawn. E-commerce platforms are always more willing to choose the promotion strategy, and the supplier will choose to charge for shipping to maximize profit.

**CONCLUSION AND DISCUSSION**

Considering e-commerce platforms with and without promotions, three biform game models consisting of one supplier and two platforms can be built, and the profit distribution of the three parties can be calculated with the Shapley value method. Based on this, the optimal strategies of each of the three parties are discussed. Based on the results, the authors draw the following five main conclusions.

First, regardless of whether the platforms promote sales or not, in the case of charging consumers a shipping fee when the standard shipping fee is low, the supplier will choose to cooperate with the platform without self-built logistics and use third-party logistics to deliver products; when the standard shipping fee is large, the supplier will choose to cooperate with the platform with self-built logistics. But in the case of free shipping for consumers, the conclusion is just the opposite. These results agree with Qin et al. (2021) that different cooperating modes affect suppliers' logistics decisions, but the conclusion from this study is different. Qin et al. (2021) assume that the optimal choice of logistics models by a supplier depends on the cost performance of the logistics service; when it is low, the optimal logistics strategy is that the platforms offer self-built logistics to the supplier. While the present study finds that the optimal logistics service selection is comprehensively affected by the postal policy and standard shipping fee of the product. The main reason for the differing conclusions is because the present study considers the heterogeneity and competition of platforms.

Second, the authors calculated the range of commission rates charged by platforms to suppliers, under promotion and non-promotion conditions, according to whether the suppliers choose free shipping. In addition, the authors calculated the promotion input strategies of platforms. These conclusions are somehow similar to those of Hu and Tadikamalla (2020). They indicate that sales promotion will increase sales of online fashion products. On this basis, the authors also found that the sales promotion strategy is affected by the logistics service selection of suppliers. In addition, the equilibrium state that all platforms promote sales is caused by the occupation strategy between competing platforms.

Third, considering an e-commerce platform without promotion, if the standard shipping fee is low when the supplier cooperates with the platform \( P_1 \), both of them are more willing to pay for shipping. However, when the supplier cooperates with the platform \( P_2 \), both of them are more willing to choose the free shipping strategy. If the standard shipping fee is high, the conclusion is just the opposite. These results agree with Cao et al. (2021) that a supplier's logistics decision depends on the annual logistics service fee, but the conclusion here is also different. The present study found that a supplier’s optimal logistics decision is comprehensively affected by the postal policy, logistics cost, and platform promotion strategy because the authors further consider the impact of platform heterogeneity and the sales promotion. Different sales promotion strategies of heterogeneous platforms affect the decision-making of consumers and the supplier’s final profits.

Fourth, on the one hand, considering an e-commerce platform with promotion, regardless of whether the supplier cooperates with the platform \( P_1 \) or \( P_2 \), the supplier is more willing to choose the charging for shipping strategy, while the platform is more willing to let the supplier choose the
free shipping strategy. This is similar to Qin et al.’s (2020) conclusion that the optimal cooperating strategy of the seller is to deliver the products by the logistics service offered from the platform when the market potential is large. On this basis, the authors further show that in the equilibrium state, the heterogeneity of the platform has no impact on this decision, but their different sales promotion strategies will lead to the opposite decision between the supplier and the platform. On the other hand, if the supplier chooses to charge for shipping, the platform will charge a certain compensation to the supplier by increasing the commission rate, which is consistent with the operational strategy of the e-commerce platform in reality.

Finally, considering e-commerce platforms with promotions, e-commerce platforms are always more willing to choose the promotion strategy, and the supplier will choose to charge for shipping to maximize profit. The present findings and Huang et al.’s (2018) findings illuminate that competitive factors affect the decision-making of each member in the cooperative alliance. But, Huang et al. (2018) attribute the different decisions of competing retailers to different myopic and far-sighted strategies in the supply chain. In comparison, the present study demonstrates that the heterogeneity and different promotion strategies of competing platforms also affect the cooperation strategies and supplier decisions.

MANAGERIAL IMPLICATIONS AND LIMITATIONS

The results provide valuable managerial implications for business managers, including which e-commerce platform the supplier will choose to cooperate with to sell products and which logistics service strategy to choose to maximize profit. The findings also shed light on how e-commerce platforms can set commission rates to attract suppliers and how to choose promotion strategies to maximize profits.

This article contains several limitations; yet the model can be extended in several ways for future study. First, this study examines the problem that the supplier can only choose one e-commerce platform for cooperation. In the future, researchers may consider the situation that the supplier cooperates with multiple e-commerce platforms at the same time. Second, for the cooperation between one supplier and multiple e-commerce platforms, the authors built a biform game model and used the Shapley value method to calculate the profit distribution of all parties. This problem can also be studied by building Stackelberg game and Nash game models. In the future, researchers may compare the results of different methods. Finally, this model can be extended to investigate optimal strategies for multiple suppliers in a competitive environment.

FUNDING AGENCY

The publisher has waived the Open Access Processing fee for this article.
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APPENDIX A – ADDITIONAL PROOFS

**Proof 1.** The authors consider the case that $S$ chooses $P_1$ to cooperate with and choose to charge consumers for shipping as an example to prove other cases are similar. When $S$ chooses $P_1$ to cooperate with and chooses to charge consumers for shipping, $v\left(\{S, P_1, P_2\}\right) = v\left(\{S, P_1\}\right)$.

\[
\pi^{\text{nP}}_{P_1} = \frac{1}{C_2^1} \left( v\left(\{P_1, S\}\right) - v\left(\{S\}\right) \right) + \frac{1}{C_2^0} \left( v\left(\{P_1\}\right) - v(\varnothing) \right) \\
= \frac{1}{3} \left[ \left( p - c_0 \right) q_1 - \left( p - c_0 + l - l_2 \right) q_2 \right] + \frac{1}{2} \left( p - c_0 \right) q_1 - 0 + 0 + 0 \\
= \frac{1}{2} \left( p - c_0 \right) q_1 - \frac{1}{3} \left( p - c_0 + l - l_2 \right) q_2.
\]

\[
\pi^{\text{nP}}_{P_2} = \frac{1}{3} \left[ \frac{1}{C_2^2} \left( v\left(\{P_2, S, P_1\}\right) - v\left(\{P_2, P_1\}\right) - v(\{S, P\}) \right) + \frac{1}{C_2^1} \left( v\left(\{P_2\}\right) - v(\varnothing) \right) \right] \\
= \frac{1}{3} \left[ \left( p - c_0 \right) q_1 - \left( p - c_0 \right) q_1 \right] + \frac{1}{2} \left( p - c_0 - l - l_2 \right) q_2 - 0 + 0 + 0 \\
= \frac{1}{6} \left( p - c_0 + l - l_2 \right) q_2.
\]

\[
\pi^{\text{nP}}_{S} = \frac{1}{3} \left[ \frac{1}{C_2^2} \left( v\left(\{S, P_1, P_2\}\right) - v\left(\{P_1, P_2\}\right) \right) + \frac{1}{C_2^1} \right] \\
= \frac{1}{3} \left[ \frac{1}{C_2^2} \right] + \frac{1}{C_2^0} \left( v\left(\{S\}\right) - v(\varnothing) \right) \\
= \frac{1}{3} \left[ \left( p - c_0 \right) q_1 - 0 \right] + \frac{1}{2} \left( p - c_0 - l - l_2 \right) q_2 - 0 + 0 + 0 \\
= \frac{1}{2} \left( p - c_0 \right) q_1 + \frac{1}{6} \left( p - c_0 + l - l_2 \right) q_2.
\]
In the above formulas, $\pi^{nNP}_x$ represents the profit distributed to the player $x$ ($x \in \{S, P_1, P_2\}$) when the supplier cooperates with the e-commerce platform $P_i$ ($i = 1, 2$) and chooses $y$ strategy ($y \in \{N, B\}$, where $N$ means charging shipping, $B$ means free shipping) without promotion of e-commerce platform (expressed in $n$).

Proof 2. Considering e-commerce platform without promotion, when the supplier cooperates with the e-commerce platform $P_i$ and chooses to charge for shipping, the profit of the e-commerce platform can be obtained $P_1$ as $\frac{1}{2}(p - c_0)q_1 - \frac{1}{3}(p - c_0 + l - l_2)q_2$ (see Table 2) using the Shapley value method. According to the formula $w^{nNP}_{P_i} = \frac{\pi^{nNP}_i}{p}$, the lower limit of commission rate of e-commerce platform can be achieved $P_i$ as $\frac{1}{2p}(p - c_0 - l_1)\left(q_1 + \beta^2\right) - \frac{1}{3p}(p - c_0 - l_2)\left(q_2 + \beta^2\right)$. In addition, $S$ chose to cooperate with $P_i$ because $\pi^{nNP}_S > \pi^{nNP}_S$, i.e. $\pi^{nNP}_S = \pi^{nNP}_S - \pi^{nNP}_S > 0$. The e-commerce platform $P_i$, which pursues profit maximization, can get more profit by charging a higher commission rate to $S$, so the upper limit of commission rate of e-commerce platform $P_i$ is $w^{nNP}_{P_i} = w^{nNP}_{P_i} + \frac{\Delta \pi^{nNP}_i}{p} = \frac{5}{6p}(p - c_0)q_1 - \frac{2}{3p}(p - c_0 + l - l_2)q_2$. Similarly, the range of commission rates in other cases is in Table 4.
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