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Pricing strategy for cross-market two-sided platforms based on joint membership system

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Abstract. Taking the joint membership system carried out by two cross-market bilateral platforms as the background, this paper studies how to achieve the optimal cooperation between two cross-market platforms, and analyzes the various influences brought by platform differences. Considering two cross-market two-sided platforms with differences basic services, we establish a horizontal cooperation model for cross-market bilateral platforms based on the joint membership system. Taking cross-network externalities as the starting point of the research, we compare and analyze the platform strategies under decentralized decision making and joint centralized decision making to obtain the benchmark for joint membership cooperation. Finally, we propose a two-part pricing mechanism that can make joint membership cooperation achieve the best, and analyze the impact of basic service differences on platform pricing, user participation, platform profits and coordination mechanism.

Keywords: Bilateral platform, Cross-market cooperation, Joint membership, Revenue sharing, Pricing strategy, Two-part pricing mechanism

1. Introduction

In recent years, with the rapid development of the internet and platform economy, a large number of consumers have been meeting their social, shopping, and entertainment needs through platforms. Intense competition has been launched among platforms, and as it has become common for customers to purchase memberships on different platforms due to diverse needs, there is overlap in the consumer groups among different platforms. Therefore, platforms have launched joint membership programs through cross-industry collaboration, such as joint membership of JD and iQiyi, and joint membership of Youku and Ele. Me. Joint membership enable consumers to meet various business needs with a single purchase, bringing more consumers to join the platform and playing an important role in increasing the profits of both sides of the platform.

The joint membership mode essentially belongs to the collaboration between platforms from different industries. Gassmann et al. found that cross-industry collaboration can effectively reduce research and development costs while mitigating the risk of independent research and development failures [1]. Bourreau et al. linked the social benefits of R&D cooperation in two-sided markets with the degree of externalities of both sides, and found that the social benefits of cross-industry R&D cooperation between two-sided platforms were highly correlated with the externalities released by both

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sides, and the high spillover effect benefited the platforms in cross-industry R&D cooperation [2]. Bader found that through inter-industry cooperation, heterogeneous strategic tools can be obtained to cope with competition, and inferior enterprises can even overturn the market position of traditional enterprises [3]. Additionally, there are a few studies on cross-industry collaboration in financial markets, such as the options market [4], stock and bond markets [5-7], and foreign exchange markets [8]. Furthermore, some studies have focused on cross-market commodity prices and business forecasts [9,10], as well as corporate mergers [11] and acquisitions [12]. For consumers, platform collaboration can not only improve consumer utility but also promote cooperative consumption. Benjaafar et al. proved that consumers can benefit from cooperative consumption, which can improve product utilization to a certain extent [13]. Takebayashi explored the conditions for cooperation between airlines and high-speed rail, and analyzed the outstanding performance of this collaboration in addressing excessive transportation demand [14].

The above facts indicate that cooperation between online platforms operating in different markets is an emerging issue that needs to be addressed. While it is common in practice for diverse online platforms to collaborate in promoting their services and products, platform operators and managers are not proficient in determining the optimal operational strategies under the joint pricing model. The specific cooperative strategies and mechanisms still require further in-depth research. In conclusion, this paper constructs a cross-industry platform collaboration model based on the joint membership. Considering the differences between the cooperating platforms, a joint membership pricing model for cross-industry platforms is established with the cooperating inviter as the Stackelberg game follower. By comparing decentralized decision-making with centralized decision-making, the optimal state of cooperation is determined. A two-part pricing coordination mechanism is then set based on the benchmark of user participation under the optimal cooperative state, achieving a win-win situation in cross-industry platform joint membership. This paper provides valuable insights into how bilateral platforms can engage in cross-industry cooperation and achieve mutual benefits through scientific pricing during the collaborative process.

2. Problem Descriptions And Assumptions

Assuming there are two bilateral platforms engaging in joint membership cooperation, namely Platform A and Platform B. Within the joint membership mechanism, each platform operates different types of businesses with their own strengths, and there is no competitive relationship between them. Platform A has excellent customer relationship management capabilities, with a registered base of high-quality consumers with diverse demands. However, Platform A has limited content production capabilities. On the other hand, Platform B possesses a high-quality group of content providers and a higher level of basic services. It can serve as a good complementary means to meet consumer needs, providing ample conditions for platform collaboration.

The specific operation mechanism of joint membership is shown in Figure 2.1 below: Consumers pay p to Platform A to obtain the joint membership qualification, and Platform A or B pays remuneration w_a or w_b to their respective affiliated group of content providers. The revenue sharing between the platforms for each individual order is represented by m. When m is greater than zero, Platform A pays Platform B; when m is less than zero, it indicates that Platform B pays Platform A the revenue share. Under the joint membership system, Platform A is the initiator of the cooperation. In order to provide more utility to consumers, Platform A shares profits with Platform B, thereby obtaining products or services that Platform B can offer. The decision of Platform B is crucial for determining whether the cooperation can proceed, thus resulting in a Stackelberg game between the two platforms, where Platform B acts as the leader and Platform A as the follower.

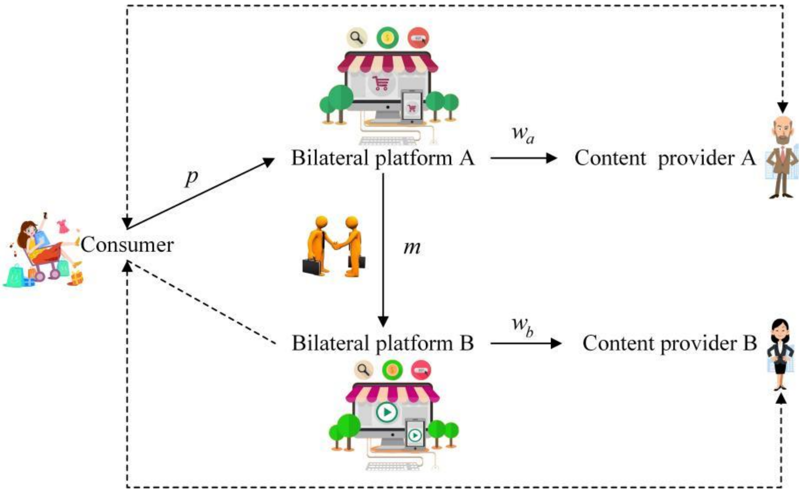

Figure 2. 1: Joint membership model for bilateral platforms

Platform cooperation inevitably involves issues of revenue distribution and mechanism coordination. The goal of this coordination is to optimize the joint membership system cooperation. To facilitate research, the following basic assumptions are made:

1.The user scale of content providers and consumers are both normalized to a unit scale of one. Each user group has heterogeneity. The heterogeneity of consumers is reflected in the basic service v provided by platform A, and the heterogeneity of content providers is reflected in the participation cost c_a or c_b . v , c_a and c_b are random variables that follow uniform distribution on the interval $[0,1]$.

2.The two platforms have overlapping basic services, but Platform B offers superior basic services compared to Platform A. The high-quality basic services provided by Platform B can bring an incremental increase in fundamental utility for consumers. The parameter Δ represents the degree of disparity in basic services between the two platforms, where Δ is greater than zero.

3.The utility created by each group is independent of the number of service occurrences with other groups, and only depends on the level of participation. It is determined by the product of the level of participation and the unit utility.

4.Within a single membership cycle, each consumer generates only one membership order.

3. Model Construction And Solution

Consumers' utility within the joint membership system is mainly influenced by three factors. First, the basic service utility v and the incremental basic service utility under the joint membership system Δ . Second, the positive utility αn_a and βn_b brought by the content provider group. Third, the pricing p set by Platform A. Referring to Armstrong's utility function setup, the comprehensive consideration of these three factors results in the total utility for consumers as follows.

$$u_c = v + \Delta + \alpha n_a + \beta n_b - p \tag{3.1}$$

Consumers choose to participate in the platform only when they obtain positive utility. When $u_c = 0$, the basic utility at this point is $v_0 = -(\Delta + \alpha n_a + \beta n_b - p)$, indicating the consumer's utility indifference point. The participation platform is chosen only when the base service is above the utility indifference point, then the number of consumer's participation n_c is

$$n_c = \int_{-(\Delta+\alpha n_a+\beta n_b-p)}^{1} dv = 1 + \Delta + \alpha n_a + \beta n_b - p \tag{3.2}$$

Similar to the utility obtained by consumers, the utility of a content provider under a joint membership is affected by three main factors: the pricing w_a or w_b of the corresponding platform, the positive utility an_c or bn_c due to the participation of consumers, and the cost of participation c_a or c_b on the corresponding platform. For content provider group A, the utility of the content provider by combining the three factors is

$$u_a = w_a + an_c - c_a \tag{3.3}$$

Content providers choose to participate in the platform only when they receive positive utility. For group A of content providers, when $u_a = 0$, the participation cost $c_{a0} = w_a + an_c$, which is the indifference point in the utility of group A of content providers. Only when $c_a \le c_{a0}$ can $u_a \ge 0$ be satisfied, so the number of participation n_a of content providers A is

$$n_a = \int_0^{w_a + an_c} dc_a = w_a + an_c \tag{3.4}$$

Similarly, the number of participants n_b for content provider group B is

$$n_b = \int_0^{w_b + bn_c} dc_b = w_b + bn_c \tag{3.5}$$

Ultimately, the profit functions of the two bilateral platforms participating in the joint membership system can be set up as follows.

$$\pi_A = (p - m)n_c - w_a n_a \tag{3.6}$$

$$\pi_B = mn_c - w_b n_b \tag{3.7}$$

Referring to Guijarro's solution, we adopt an indirect approach to solve the optimal pricing decision of the platform [15]. That is, first determine the optimal participation number that can make the platform gain the maximum profit, and then determine the optimal pricing required to support the optimal participation number. This can effectively avoid the omission of partial solutions caused by the presence of fractions and the strengthening of constraints during the process of solving price decisions. The participation numbers for each user group (equations 3.2, 3.4, and 3.5) are then converted into price expressed in terms of participation numbers as follows.

$$p = 1 + \Delta + \alpha n_a + \beta n_b - n_c \tag{3.8}$$

$$w_a = n_a - an_c \tag{3.9}$$

$$w_b = n_b - bn_c \tag{3.10}$$

By substituting equations (3.8), (3.9), and (3.10) into equations (3.6) and (3.7) respectively, we obtain the objective functions for each collaborative platform in terms of user participation numbers.

$$\pi_A = -n_c^2 - n_a^2 + (\alpha + a)n_c n_a + \beta n_c n_b + (1 + \Delta - m)n_c \tag{3.11}$$

$$\pi_B = -n_b^2 + bn_c n_b + mn_c \tag{3.12}$$

3.1. *Decentralized decision-making*

Platform B has the right to decide whether the joint membership can be implemented by its better basic services and the resources of the content providers. So it becomes the leader in the Stackelberg game. In the operation of the joint membership system, platform B first sets the revenue sharing price *m* and the pricing w_b for content providers of group B. Then, platform A sets the pricing p and w_a of consumers and content providers of group A according to the decision of platform B. In the process of calculating the optimal decision in this scenario, an inverse solution method needs to be adopted.

Proposition 1 Under decentralized decision-making, Platform A and B conduct joint membership through cross-industry cooperation. When $H_1 = 4 - (\alpha + a)^2 > 0$ and $H_2 = 8 - 2(\alpha + a)^2 - (\beta + b)^2 > 0$, π_A^d is a concave function with respect to n_c and n_a, π_B^d is a concave function with respect to n_b and m, the optimal pricing for the joint membership and platform B's optimal revenue sharing pricing is determined as follows,

$$p^{d*} = \frac{(1+\Delta)(6 - (\alpha + a)(\alpha + 2a) - (\beta + b)b)}{8 - 2(\alpha + a)^2 - (\beta + b)^2}, \quad m_d^* = \frac{(1+\Delta)(4 - (\alpha + a)^2 - (\beta + b)b)}{8 - 2(\alpha + a)^2 - (\beta + b)^2},$$

Platform A's optimal pricing for content providers A and Platform B's optimal pricing for content providers B are determined as follows,

$$w_a^{d*} = \frac{(1+\Delta)(\alpha - a)}{8-2(\alpha+a)^2-(\beta+b)^2}, \quad w_b^{d*} = \frac{(1+\Delta)(\beta - b)}{8-2(\alpha+a)^2-(\beta+b)^2},$$

The optimal participation numbers for consumers, content providers A and content providers B are determined as follows,

$$n_c^{d*} = \frac{2(1+\Delta)}{8-2(\alpha+a)^2-(\beta+b)^2}, \quad n_a^{d*} = \frac{(1+\Delta)(\alpha + a)}{8-2(\alpha+a)^2-(\beta+b)^2}, \quad n_b^{d*} = \frac{(1+\Delta)(\beta + b)}{8-2(\alpha+a)^2-(\beta+b)^2},$$

The optimal profits for Platform A and Platform B are determined as follows,

$$\pi_A^{d*} = \frac{(1+\Delta)^2\left(4-(\alpha+a)^2\right)}{\left(8-2(\alpha+a)^2-(\beta+b)^2\right)^2}, \quad \pi_B^{d*} = \frac{(1+\Delta)^2}{8-2(\alpha+a)^2-(\beta+b)^2},$$

$$\Pi^{d*} = \pi_A^{d*} + \pi_B^{d*} = \frac{(1+\Delta)^2\left(12-3(\alpha+a)^2-(\beta+b)^2\right)}{\left(8-2(\alpha+a)^2-(\beta+b)^2\right)^2}.$$

3.2. Centralized decision-making

Centralized decision-making treats the two platforms within the joint membership mechanism as a unified whole, take the maximization of the profit sum of the two platforms as the decision-making objective, and solve the number of participants n_c^{j*}, n_a^{j*} and n_b^{j*} of each user group that can maximize the overall profit, as well as the pricing decision of maintaining the corresponding number of participants, p^{j*}, w_a^{j*} and w_b^{j*}. The objective function under centralized decision-making is obtained by summing equations (3.6) and (3.7).

$$\Pi^j = \pi_A + \pi_B = -n_c^2 - n_a^2 - n_b^2 + (\alpha+a)n_c n_a + (\beta+b)n_c n_b + (1+\Delta)n_c \tag{3.13}$$

Proposition 2 Under decentralized decision-making, Platform A and B conduct joint membership through cross-industry cooperation. when $H_3 = 4-(\alpha+a)^2-(\beta+b)^2 > 0$, Π^j is a concave function with respect to n_a, n_b and n_c, the optimal pricing for the joint membership is determined as follows,

$$p^{j*} = \frac{(1+\Delta)\left(2-(\alpha+a)a-(\beta+b)b\right)}{4-(\alpha+a)^2-(\beta+b)^2},$$

Platform A's optimal pricing for content providers A and Platform B's optimal pricing for content providers B are determined as follows,

$$w_a^{j*} = \frac{(1+\Delta)(\alpha - a)}{4-(\alpha+a)^2-(\beta+b)^2}, \quad w_b^{j*} = \frac{(1+\Delta)(\beta - b)}{4-(\alpha+a)^2-(\beta+b)^2},$$

The optimal participation numbers for consumers, content providers A and content providers B are determined as follows,

$$n_c^{j*} = \frac{2(1+\Delta)}{4-(\alpha+a)^2-(\beta+b)^2}, \quad n_a^{j*} = \frac{(1+\Delta)(\alpha + a)}{4-(\alpha+a)^2-(\beta+b)^2}, \quad n_b^{j*} = \frac{(1+\Delta)(\beta + b)}{4-(\alpha+a)^2-(\beta+b)^2},$$

Under centralized decision-making, The sum of optimal profits for Platform A and B are determined as follows,

$$\Pi^{j*} = \pi_A + \pi_B = \frac{(1+\Delta)^2}{4-(\alpha+a)^2-(\beta+b)^2}.$$

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3.3. Comparative analysis

Proposition 3 User participation and platform profit for decentralized and centralized decision-making scenarios.

(i) $n_c^{j*} > n_c^{d*}, n_a^{j*} > n_a^{d*}, n_b^{j*} > n_b^{d*}, \Pi^{j*} > \Pi^{d*}$

(ii) $\frac{\partial n_c^{j*}}{\partial \Delta} > \frac{\partial n_c^{d*}}{\partial \Delta}, \frac{\partial n_a^{j*}}{\partial \Delta} > \frac{\partial n_a^{d*}}{\partial \Delta}, \frac{\partial n_b^{j*}}{\partial \Delta} > \frac{\partial n_b^{d*}}{\partial \Delta}, \frac{\partial \Pi^{j*}}{\partial \Delta} > \frac{\partial \Pi^{d*}}{\partial \Delta} > 0$

Proposition 3 illustrates the specific advantages of centralized decision-making over decentralized decision-making. It expands the scale of user participation and increases the total profit of the cooperative platforms within the joint membership mechanism. These specific impacts are achieved under the influence of pricing decisions. Additionally, the superiority of platform strategies in enhancing user participation and overall profit of cooperative platforms under joint centralized decision-making will expand as the incremental of basic services for consumers (referred to as " Δ ") increases.

Proposition 4 For platform pricing in decentralized versus centralized decision-making scenarios.

(i) $p^{d*} > p^{j*} > 0$, $\frac{\partial p^{d*}}{\partial \Delta} > \frac{\partial p^{j*}}{\partial \Delta} > 0$.

(ii) when $\alpha > a$, there exists $w_a^{j*} > w_a^{d*} > 0$, $\frac{\partial w_a^{j*}}{\partial \Delta} > \frac{\partial w_a^{d*}}{\partial \Delta} > 0$. when $\alpha = a$, there exists $w_a^{j*} = w_a^{d*} = 0$, $\frac{\partial w_a^{j*}}{\partial \Delta} = \frac{\partial w_a^{d*}}{\partial \Delta} = 0$. when $\alpha < a$, there exists $w_a^{j*} < w_a^{d*} < 0$, $\frac{\partial w_a^{j*}}{\partial \Delta} < \frac{\partial w_a^{d*}}{\partial \Delta} < 0$.

(iii) when $\beta > b$, there exists $w_a^{j*} > w_a^{d*} > 0$, $\frac{\partial w_a^{j*}}{\partial \Delta} > \frac{\partial w_a^{d*}}{\partial \Delta} > 0$.when $\beta = b$, there exists $w_a^{j*} = w_a^{d*} = 0$, $\frac{\partial w_a^{j*}}{\partial \Delta} = \frac{\partial w_a^{d*}}{\partial \Delta} = 0$. when $\beta < b$, there exists $w_a^{j*} < w_a^{d*} < 0$, $\frac{\partial w_a^{j*}}{\partial \Delta} < \frac{\partial w_a^{d*}}{\partial \Delta} < 0$.

Proposition 4 compares centralized decision-making with decentralized decision-making in terms of pricing, highlighting the superiority of platform strategies in pricing under centralized decision-making. For consumers, centralized decision-making reduces pricing for consumers, reducing their expenditure. For content providers, when platforms provide subsidies, centralized decision-making results in more subsidies compared to decentralized decision-making. When platforms charge fees, centralized decision-making results in lower fees than decentralized decision-making. Centralized decision-making increases the benefits or reduces the costs for content providers. From another perspective, the platform strategies under centralized decision-making effectively enhance the utility of each user group, and provides a strong explanation for the conclusion in Proposition 3.

However, in reality, both platforms typically have independent business and prioritize maximizing their own profits rather than the overall profit of the collaboration. Achieving true centralized decision-making becomes challenging in such circumstances, and centralized decision-making remains an idealized state. If the strategies developed under centralized decision-making can be applied to decentralized decision-making, this ideal state can become feasible and optimize the platform cooperation within the joint membership model.

4. Revenue Harmonization Under Two-Part Pricing

In order to achieve a win-win situation between participating platforms under the joint membership mechanism. The leading platform can adopt a two-part pricing mechanism during the price setting process. This mechanism involves revenue sharing and fixed fee F for each individual order. The fixed fee F is used to effectively allocate the optimal profit generated from the collaboration, creating a mutually beneficial cooperative scenario. Therefore, based on the profit functions of Platform A and Platform B under decentralized decision-making, the profit functions for both platforms under the two-part pricing strategy are set as follows.

$$\pi_A^t = (p - m) n_c - w_a n_a - F \tag{4.1}$$

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$$\pi_B^t = mn_c - w_b n_b + F \tag{4.2}$$

Under two-part pricing mechanism, platform decisions are still decentralized. The reaction process of platform A is essentially a response to platform B's order revenue sharing m and content providers B's participation n_b. This process is known by the game-leading platform B. The key difference from decentralized decision-making is that two-part pricing mechanism includes an additional step where both platforms engage in negotiations regarding fixed costs at the end.

In order to align consumers and the participation of content providers A attracted by platform A with centralized decision-making, platform B will first establish its pricing decision to align the participation of content providers B with centralized decision-making.

$$n_b^{t*} = n_b^{j*} = \frac{(1+\Delta)(\beta+b)}{4-(\alpha+a)^2-(\beta+b)^2} \tag{4.3}$$

Substituting equation (4.3) into the impact on Platform A's reaction process to consumer decisions yields

$$n_c^t = \frac{2-\left(\beta\dfrac{(1+\Delta)(\beta+b)}{4-(\alpha+a)^2-(\beta+b)^2} - m + \Delta + 1\right)}{4-(\alpha+a)^2} \tag{4.4}$$

Let equation (4.4) be equal to the number of consumer participation n_c^{j*} under centralized decision making, and obtain platform B's revenue sharing price m^{t*} as follows

$$m^{t*} = -\frac{b(1+\Delta)(\beta+b)}{4-(\alpha+a)^2-(\beta+b)^2} \tag{4.5}$$

Then, the optimal profit for platform A and B is respectively

$$\pi_A^{t*} = \frac{(1+\Delta)^2\left(4-(\alpha+a)^2\right)}{\left(4-(\alpha+a)^2-(\beta+b)^2\right)^2} - F,\ \pi_B^{t*} = \frac{(1+\Delta)^2(\beta+b)^2}{\left(4-(\alpha+a)^2-(\beta+b)^2\right)^2} + F \tag{4.6}$$

$$\Pi^{t*} = \pi_A^{t*} + \pi_B^{t*} = \frac{(1+\Delta)^2}{4-(\alpha+a)^2-(\beta+b)^2} \tag{4.7}$$

The sum of platform profits Π^{t*} after the coordination of two-part pricing is consistent with the sum of platform profits under centralized decision-making, so the two-part pricing mechanism can achieve the overall optimality.

In order to ensure the effective coordination function of the two-part pricing scheme on the coalition membership mechanism. It is necessary to constrain the negotiation scope of fixed costs. It must be ensured that the profit of the platform under two-part pricing mechanism is not lower than the profit under decentralized decision-making, thereby obtaining the fixed cost F's negotiable space $\Omega \in [F_{\min}, F_{\max}]$, where

$$F_{\min} = (1+\Delta)^2\left(\frac{1}{H_2} + \frac{(\beta+b)^2}{(H_3)^2}\right),\ F_{\max} = (1+\Delta)^2 H_1\left(\frac{1}{(H_3)^2} - \frac{1}{(H_2)^2}\right) \tag{4.8}$$

To support the optimal number of user participation required under two-part pricing mechanism, the platform's pricing should be respectively

$$p^{t*} = \frac{(1+\Delta)\left(2-(\alpha+a)a-(\beta+b)b\right)}{4-(\alpha+a)^2-(\beta+b)^2} \tag{4.9}$$

$$w_a^{t*} = \frac{(1+\Delta)(\alpha-a)}{4-(\alpha+a)^2-(\beta+b)^2},\ w_b^{t*} = \frac{(1+\Delta)(\beta-b)}{4-(\alpha+a)^2-(\beta+b)^2} \tag{4.10}$$

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Obviously, the sum of profits and platform pricing of cooperative platforms under the two-part pricing mechanism are consistent with those under the joint centralized decision, provided that the optimal number of participants under the joint centralized decision is taken as the benchmark. Combined with the conclusions of Proposition 3 and 4, it can be inferred that after the coordination of the two-part pricing mechanism, the platform strategy will reduce user costs or increase subsidies, improving user utility compared to decentralized decision-making, boosting user participation, and ultimately increasing total platform profits in participating in the joint membership system, achieving a win-win situation among platforms. Moreover, the positive effects brought by platform differences can be more effectively utilized, and as platform differences expand, the advantages of coordinated dual pricing become more apparent.

Proposition 5 In order to ensure the range of consumer participation number n_c^{t*} within $\left(0,1\right]$, the incremental of basic services Δ must be controlled within $\left(0,\frac{H_3}{2}-1\right]$

Proposition 5 illustrates the reasonable range of differences between platforms participating in the joint membership system. The most obvious consequence of significant platform differences is the inability to engage in joint membership cooperation, rendering the coordinating role of two-part pricing ineffective. This is because platform differences represent the relative contribution of platforms in providing basic services to consumers and form the basis for negotiating revenue sharing and fixed fees in member order arrangements. When platform differences are substantial, follower platforms may be suppressed by leader platforms, contributing their profits to the leaders and becoming their "vassals." Additionally, if the leader platform has a significant advantage, it must offer a larger share of member order revenue to the followers to sustain cooperation, resulting in a relatively low attractiveness of the benefits brought by follower platforms. In short, when there are significant disparities in basic services between platforms, both leaders and followers are unwilling to choose cooperation.

Proposition 6 Specific setup for the harmonization of the pricing benefits of two-part pricing mechanism

(i) $F>0$, $\frac{\partial F_{\min}}{\partial\Delta}>0$, $\frac{\partial F_{\max}}{\partial\Delta}>0$, $\frac{\partial\left(F_{\max}-F_{\min}\right)}{\partial\Delta}>0$.

(ii) $m^{t*}<0$, $\frac{\partial m^{t*}}{\partial\Delta}<0$.

Proposition 6 illustrates the range of negotiable fixed fees required for the effective coordination function of two-part pricing in the joint membership system, while Proposition 5 addresses the specific setting of two-part pricing. The concrete form of dual pricing for coordinating the joint membership system is that platform B should first charge a certain fixed fee to platform A, and then adopt a rebate-based profit sharing model for each individual order. Furthermore, as the participation of platform B in the joint membership system brings an increase in basic services, both the upper and lower limits of the fixed fee will increase. However, the increase in the upper limit will be greater than that in the lower limit, expanding the negotiable space. At the same time, since the proportion of basic services provided by platform B increases, platform A's relative contribution decreases while platform B's relative contribution rises. This leads to a decrease in the rebates offered by platform B to platform A and a decrease in the revenue sharing of individual orders being received by platform A.

5. Calculation Analysis

In order to better observe the joint membership system under two-part pricing coordination, and analyze the impact of the incremental basic services on the coordination mechanism, pricing, user participation, and platform profits, the following numerical examples will be tested and analyzed. There are three sets of values for the four unit utilities α, a, β and b under the condition that H_1, H_2 and H_3 are all greater than zero, in order to simulate as much as possible the unit utility situations among different user groups in reality. Denoted by A, B and C, these three sets of taken values are (0.1, 0.15, 0.3, 0.15), (0.3, 0.5, 0.2,

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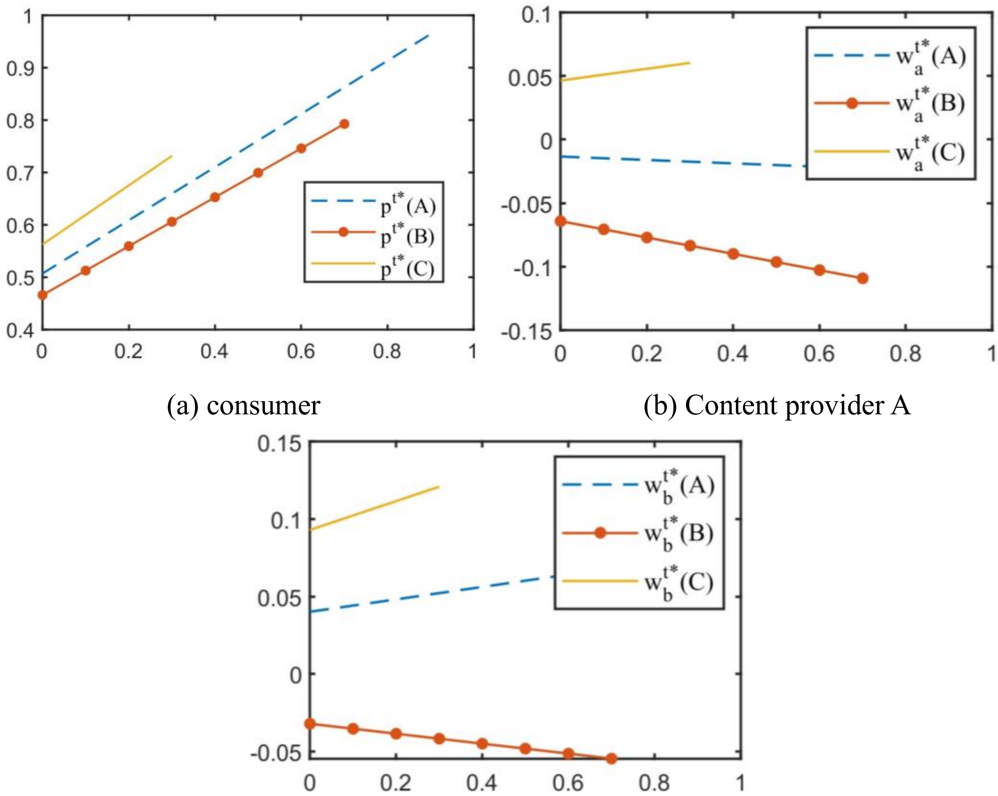
0.3) and (0.6, 0.5, 0.5, 0.3), and the corresponding upper limits of the incremental basic service Δ are 0.9725, 0.72 and 0.3, over the corresponding intervals. Δ as the horizontal axis to plot each image associated with Δ .

The first is the relationship between the pricing decisions made by the platform under the two-part pricing coordination (Figure 5.1) and the number of participation of each user group under the pricing decisions (Figure 5.2) and the incremental volume of the underlying service.



(a) consumer (b) Content provider A

(c) Content provider B

Figure 5.1. Optimal pricing of the platform for each user group

According to Figure 5.1, the pricing decisions made by platforms are positively correlated with the increase in basic services if a charging strategy is adopted. On the other hand, if a subsidy model is implemented, the pricing amount is negatively correlated with the incremental volume of basic services, which actually means that the amount of subsidy $|w_a|$ or $|w_b|$ is positively correlated with the incremental volume of basic services. This is to ensure that content providers can maintain their participation in the joint membership system even if their benefits are insufficient. By providing subsidies, the platform can meet the service demands of consumers more effectively.

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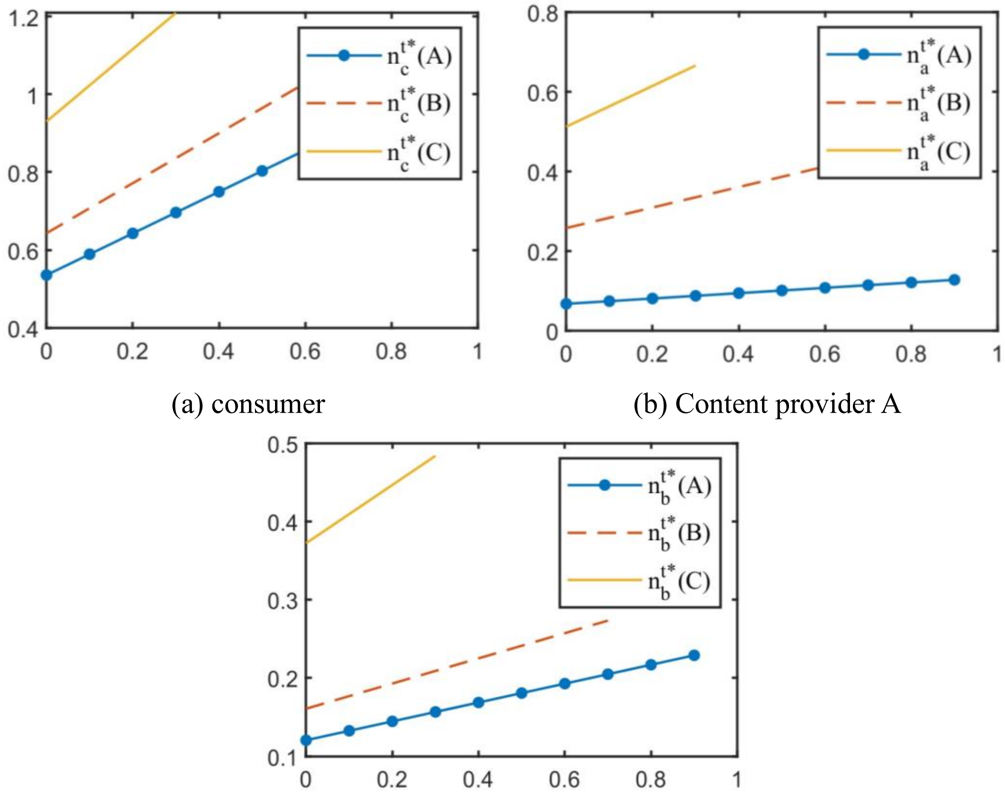

(a) consumer (b) Content provider A

(c) Content provider B

Figure 5.2. Optimal participation number of each user group

According to Figure 5.2, the optimal number of participation of user groups are positively correlated with the incremental increase in basic services. This correlation is particularly evident for consumers, as they are the primary users of the platform's basic services. The increased engagement of content providers is indirectly influenced by the positive cross-network externality between them and consumers in terms of unit utility. Additionally, the existence of positive cross-network externality ensures the maintenance of active user participation on the platform. This is demonstrated by the fact that even when the platform introduces charges for consumers or content providers due to the improvement of basic services, it does not lead to a decrease in the participation levels of these respective groups.

Thirdly, a simulation on how to set two-part pricing based on the increase in basic services to achieve coordination in the joint membership system is shown in Figure 5.3. The dashed line in the figure represents the relationship between the minimum fixed fee and the increase in basic services.

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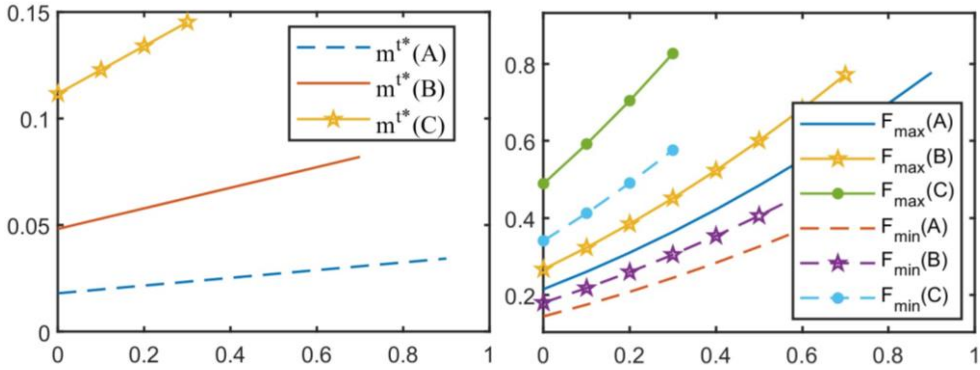
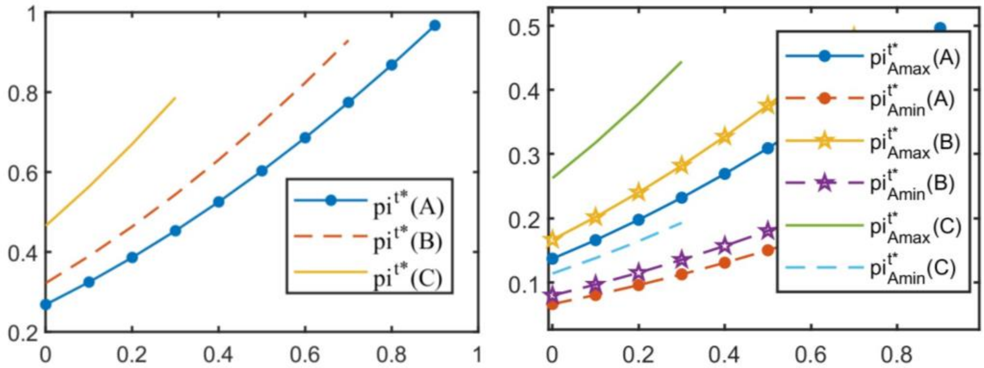


(a) Single order sharing (b) Upper and lower limits of fixed costs F

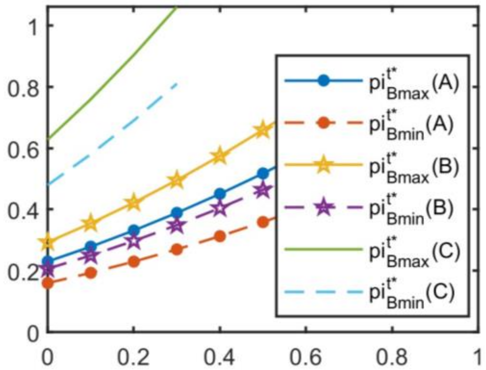
Figure 5.3. Pricing coordination mechanism setup in Department II

From Figure 5.3, it can be seen that the amount of member order share $\left|m^{t^*}\right|$ paid by the game leader Platform B to Platform A is positively correlated with the incremental volume of basic services. Platform B offers higher membership order sharing to provide platform A with greater profitability, ultimately facilitating effective collaboration in the joint membership system. Regarding the fixed fees charged by platform B, whether it is the maximum value, the minimum value, or the difference between the maximum and minimum values, all exhibit a positive correlation with the increase in basic service increment. This implies that as the basic service increment becomes larger, platform B has a greater range in setting fixed fees and the negotiation regarding fixed fees becomes more flexible. In conclusion, through the coordination of a dual pricing mechanism, reasonable differentiation provide the leading platform with more advantages. Furthermore, this advantage becomes more prominent when there are significant disparities between platforms.

Finally, it is the relationship between the total platform profits and the individual profits of the cooperative platforms under the two-part pricing system, as shown in Figure 5.4.



(a)Total platform profit (b)Profitability of bilateral platform A



(c)Profitability of bilateral platform B

Figure 5.4. Platform profits under two-part pricing coordination

According to Figure 5.4, the minimum profit represents the optimal profit of each platform within the range of platform differentiation under decentralized decision-making. It is significantly lower than the platform profit under two-part pricing coordination, clearly demonstrating the superiority of two-part pricing coordination. Additionally, the figure shows that after the two-part pricing coordinates the pricing of the cooperative members, both the total profit of the platform and the maximum and minimum profits of individual platforms are strictly positively correlated with the increase in basic services. Particularly, the difference between the growth rate and the maximum and minimum profits is also positively correlated with the increase in basic services. This indicates that as the basic services increase, there is a larger negotiation space for fixed costs. Firstly, when selecting the cooperative platforms for implementing the cooperative membership system, besides controlling the differences within a reasonable range, the differences between the selected platforms should preferably be close to the upper limit of the allowed difference. Then, during the negotiation process for fixed costs, platforms should strive to control the range of fixed costs to maintain their profit levels under the cooperative membership system.

6. Conclusions

Starting from the perspective of joint membership implemented by two-sided platform, this paper conducts research on how to achieve optimal platform cooperation and analyzes various impacts brought about by platform differentiation. Under the centralized decision-making where the cooperative platforms are treated as a whole, the influence of cross-network externality on user participation and total platform profit, reflected through pricing, is higher than that of decentralized decision-making. Setting the number of user participation under centralized decision-making as the benchmark, the two-part pricing coordination mechanism effectively addresses the issue of profit distribution that cannot be achieved through centralized decision-making. The pricing strategies of two-sided platforms after two-part pricing coordination, as well as the sum of platform profits, are consistent with those under centralized decision-making. Users willingly bind themselves to the cooperative membership system, obtaining negotiation space for fixed costs under the constraint of higher profits for each platform after coordination. Ultimately, a two-part pricing system is established where the leading platform charges fixed fees and pays rebates to follower platforms. The two-part pricing system enables the superiority of platform strategies under centralized decision-making to be realized, transforming the pure economic cooperative relationship in the cooperative membership system into a mutually beneficial relationship, truly achieving value co-creation and value sharing.

Platforms with high-quality basic services become leaders in joint membership cooperation and bring incremental improvements to consumers, which reflect the differences between cooperative platforms. To ensure the effective coordination of two-part pricing and the smooth operation of cooperative membership systems, it is necessary to control the platform differences within a certain

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range. Within the allowable range of platform differentiation, user participation, the profit space of each platform, and the sum of profits of cooperative platforms are strictly positively correlated with platform differentiation. The rebate and fixed fee space of the two-part pricing coordination mechanism are also strictly positively correlated with platform differentiation. Therefore, when selecting cooperative partners, platform differentiation should be kept within the permissible upper limit, transforming the differentiation into higher platform profits through cross-network externality in the bilateral market. Negotiations on fixed fees can then be conducted without affecting cooperation.

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