A Big Data Discriminatory Pricing Strategy for Takeaway Platforms Considering Different Attributional Behaviors of Users

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Abstract. To address the big data discriminatory pricing problem of two takeout platforms with different attribution behaviors of platform users, the equilibrium pricing of the two platforms under different attribution behaviors is analyzed and compared based on the Hotelling model, and the effects of switching costs and network effects on pricing strategies are examined. The results show that: in the single-attribution-single-attribution model, the network effect affects the user scale of the platform, and then the pricing of the platform is affected by the switching costs and the network effect, and the pricing of the platform in the first stage affects the pricing decision in the second stage; in the single-attribution-partial-multi-attribution model, the pricing of the platform is affected not only by the switching cost and the network effect but also by the switching costs and the network effect of the user base. In the single-attribution-partial-multi-attribution model, platform pricing is not only affected by switching costs and network effects but also by users' base utility, and the platform's pricing in the first stage partially affects the pricing decision in the second stage.

Keywords: Takeaway platforms; pricing strategy; switching cost; network effects.

1. Introduction

In recent years, with the rapid development of the Internet, takeaway platforms represented by Meituan, Eleme, etc. surround everyone's life. Price discrimination based on purchasing behavior has gradually emerged with the enhancement of enterprises' information data collection and processing capabilities[1], For example, takeaway platforms have begun to use big data to locate and categorize platform users, and then implement different pricing strategies, a behavior that has been referred to by the media as “big data kills maturity”. After users who use these APPs leave traces of their use or purchase on the Internet, the platforms implement big data discriminatory pricing by relying on the huge scale of users and data to find differences in the huge amount of data and make more accurate pricing[2]. This discriminatory pricing behavior with respect to the frequency of users' usage may make users choose to shift their use of the platform, and the switching costs incurred in the process may affect users' willingness to shift their use of the platform. User-to-user network effects will make the platform's pricing strategy more complex and difficult to implement[3].

Currently, research on platform pricing has received extensive attention from scholars. Since switching cost is an important consideration for users in choosing whether to switch to a platform or not, switching cost has an important impact on users' decision to switch[4]. Some firms use switching costs as their competitive strategy, viewing them as a factor in targeting consumers[5], The magnitude of switching costs in a market also affects the entry strategy of late entrants [6]. A summary of the existing literature shows that price discrimination based on purchasing behavior is worthwhile in markets with switching costs, and that both consumers and firms can benefit from it[7]. The strategy of categorizing pricing between new and old users will not only lose its appeal to new users but also turn off old users and lose both new and old user group[8].

Existing literature examining firms' pricing strategies often assumes that the relationship between users and platforms is single-attribution, ignoring the impact of consumers or users with different attribution relationships on the platform's profitability. In general, attributional behavior affects firms' decision making[9], It also affects the pricing order of the firm [10], Different attribution behaviors can

also have an impact on service quality[11]. Under the influence of network effects, attributional behavior influences the utility of bilateral users[12], and their incentives to enter the market[13].Thus, In discriminatory big data pricing of platform users, takeaway platforms should consider both whether to impose switching costs and the attribution of users to ensure that they are able to make higher profits. Therefore, it is of great significance to study the pricing decisions of takeout platforms by considering the impact of switching cost and network effect strengths in the context of different attribution behaviors of users.

2. Model Description

Consider a market in which there are two takeout platforms with competitive behaviors, referred to as Platform A and Platform B. The sender (merchant) and the receiver (rider) are bilateral users of the two platforms. For the sender, it can directly join only one platform (single attribution) or both platforms (multiple attributions) for daily takeaway orders, while for the receiver (rider), it usually joins only one platform (single attribution) in order to make better use of the app for route planning and order coordination. In this paper, a two-stage dynamic game model is constructed on the basis of the hotelling model. In the first stage, the two platforms simultaneously provide uniform pricing to the users, and the users choose whether to continue to use the old platform or to transfer to the new platform according to their own interests in the second stage after the first stage of the experience is over. The superscripts n and o are used in the model to denote the difference between new and old customers.

3. Model Analysis and Calculation

3.1. Single Attribution-Single Attribution Big Data Discriminatory Pricing Models

In this part, we will analyze the equilibrium results of the two platforms adopting big data discriminatory pricing for regular customers at the same time in the second period. Assume that the subgame refined Nash equilibrium of the two-period dynamic game is $\{P_A^{1r}$、P_A^{1s}、P_B^{1r}、P_B^{1s}、$P_A^{or}(x)$、$P_A^{os}(y)$、$P_B^{or}(x)$、$P_B^{os}(y)$、P_A^{nr}、P_A^{ns}、P_B^{nr}、$P_B^{ns}\}$.As shown in Fig. 1,in the first period,the prices of the two platforms for receivers and senders are respectivelyP_A^{1r}、P_A^{1s}、P_B^{1r}、P_B^{1s},And there exist$x^*(0 \le x^* \le 1)$、$y^*(0 \le x^* \le 1)$,such that $x \in [0, x^*]$ riders choose to use platform A for order taking while other receivers choose platform B for order taking; $y \in [0, y^*]$ sender chooses to use platform A for its business activities, while other senders choose platform B for their business activities.

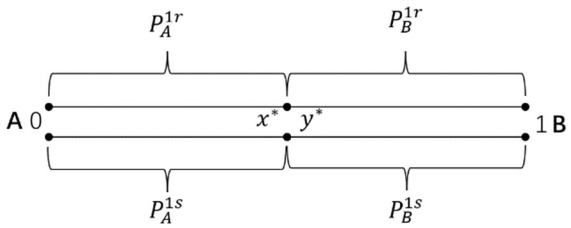


Figure 1. Single-attribution-single-attribution symmetric model Phase I diagrams

In the second period, as shown in Figures 2 and 3, platform A sets the price $P_A^{or}(x)$ for receivers with $x \in [0, x^*]$, while setting a uniform price P_A^{nr} for receivers with $x \in [x^*, 1]$; similarly, it sets the price $P_A^{os}(y)$ for senders with $y \in [0, y^*]$, while setting a uniform priceP_A^{ns} for senders with $y \in [y^*, 1]$.In the second period, as shown in Figures 2a and 2b, platform A sets the price $P_A^{or}(x)$ for receivers with $x \in [0, x^*]$, while setting a uniform price P_A^{nr} for receivers with $x \in [x^*, 1]$; similarly, it sets the price $P_A^{os}(y)$ for senders with $y \in [0, y^*]$, while setting a uniform price P_A^{ns} for senders with $y \in [y^*, 1]$.The new and old users owned by platform B and A are exactly

symmetrically distributed, and platform B will set a uniform price P_B^{nr} for receivers distributed in the range of $x \in [0, x^*]$ and $P_B^{or}(x)$ for receivers in the range of $x \in [x^*, 1]$, and a uniform price P_B^{ns} for senders in the range of $y \in [0, y^*]$, while setting a price $P_B^{os}(y)$ for receivers in the range of $y \in [y^*, 1]$. There exists $\hat{x}_1(\hat{x}_1 \in [0, x^*])$ such that the receiver with $x \in [0, \hat{x}_1]$ continues to choose platform A in the second period, while the receiver with $x \in [\hat{x}_1, x^*]$ moves to platform B. There exists $\hat{x}_2(\hat{x}_2 \in [x^*, 1])$ such that the receiver with $x \in [\hat{x}_2, 1]$ continues to choose platform B in the second period, while the receiver with $x \in [x^*, \hat{x}_2]$ receivers move to Platform A. Similarly, there exists $\hat{y}_1(\hat{y}_1 \in [0, y^*])$ such that senders with $y \in [0, \hat{y}_1]$ continue to choose Platform A in the second period, while senders with $y \in [\hat{y}_1, y^*]$ move to Platform B. There exists $\hat{y}_2(\hat{y}_2 \in [y^*, 1])$ such that senders with $x \in [\hat{y}_2, 1]$ continue to choose Platform B in the second period and senders with $y \in [y^*, \hat{y}_2]$ move to platform A.

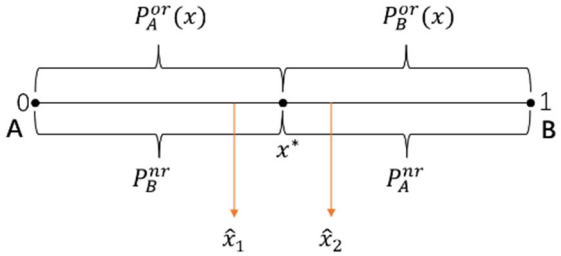


Figure 2. a Sender Single Attribution Symmetric Model Phase II Diagrams

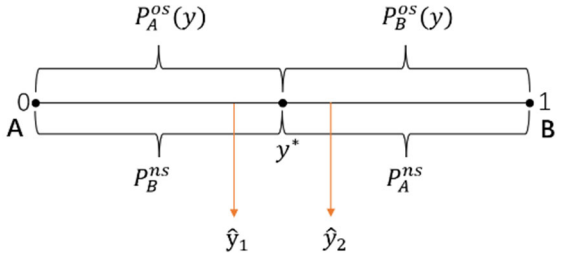


Figure 3. b Receiver Single Attribution Symmetric Model Phase II Diagrams

Draw on the logic of inverse induction to solve the above subgame-refined Nash equilibrium of this two-phase dynamic game: given$\{P_A^{1r}$、P_A^{1s}、P_B^{1r}、P_B^{1s} and x^*、$y^*\}$, consider the platform's choices in the second period. The range of Nash equilibria for the second period subgame is first determined analytically. First, when $x^* \in (0,1)$, $P_A^{or}(x) = \max\{c, P_B^{nr} + \alpha(n_A^s - n_B^s) + \beta(n_A^r - n_B^r) + t(1-2x) + s\}$for any $x \in [0, x^*]$.The platform will not reduce the price below the marginal cost c, so the platform's pricing minimum is c. Also, because according to the utility constancy equation yields $P_A^{or}(x) = P_B^{nr} + \alpha(n_A^s - n_B^s) + \beta(n_A^r - n_B^r) + t(1-2x) + s$. Secondly, when $0 < x^* \leq \frac{1}{2} + \frac{s+\alpha(n_A^s - n_B^s)+\beta(n_A^r - n_B^r)}{2t}$,if $P_B^{nr} > c$,according to the analysis above it is easy to get $P_A^{or}(x) = P_B^{nr} + \alpha(n_A^s - n_B^s) + \beta(n_A^r - n_B^r) + t(1-2x) + s > c$, Platform B cannot make a profit on the new user group unless it lowers its price to the same level as its marginal cost, otherwise, according to the optimal pricing of platform A, P_B^{nr} can always achieve an increase in its own profit by lowering its price. In this case, $P_B^{nr} = c$, $P_A^{or}(x) = c + \alpha(n_A^s - n_B^s) + \beta(n_A^r - n_B^r) + t(1-2x) + s$; Finally, when $x^* \geq \frac{1}{2} + \frac{s+\alpha(n_A^s - n_B^s)+\beta(n_A^r - n_B^r)}{2t}$, Platform B will not give up $\left[\frac{1}{2} + \frac{s+\alpha(n_A^s - n_B^s)+\beta(n_A^r - n_B^r)}{2t}, x^*\right]$ part of the market when it is profitable to do so. This suggests that there must exist $\hat{x}_1 \in \left[\frac{1}{2} + \frac{s+\alpha(n_A^s - n_B^s)+\beta(n_A^r - n_B^r)}{2t}, x^*\right]$ such that$P_B^{nr} = \alpha(n_A^s - n_B^s) + \beta(n_A^r - n_B^r) + t(1-2x) + s$, $P_A^{or}(\hat{x}_1) = c$. Similarly a range of values regarding the platform's pricing to senders can be obtained. First, when$y^* \in (0,1)$, $P_A^{os}(y) = \max\{c, P_B^{ns} + \alpha(n_A^r - n_B^r) + t(1-2y) + s\}$ for any

$y \in [0, y^*]$. Second, when $0 < y^* \leq \frac{1}{2} + \frac{s+\alpha(n_A^r - n_B^r)}{2t}$, $P_B^{ns} = c$ and, $P_A^{os}(y) = c + \alpha(n_A^s - n_B^s) + t(1-2y) + s$. Finally, when $y^* \geq \frac{1}{2} + \frac{s+\alpha(n_A^r - n_B^r)}{2t}$, there exists a $\hat{y}_1 \in \left[\frac{1}{2} + \frac{s+\alpha(n_A^r - n_B^r)}{2t}, y^*\right]$ such that $P_B^{ns} = c - [\alpha(n_A^r - n_B^r) + t(1-2y) + s]$, and $P_A^{os}(\hat{y}_1) = c$.

In the second period of the model, there is $v - t\hat{x}_1 - P_A^{or}(x) + \alpha n_A^s + \beta n_A^r = v - t(1-\hat{x}_1) - P_B^{nr} - s + \alpha n_B^s + \beta n_B^r, v - t\hat{y}_1 - P_A^{os}(y) + \alpha n_A^r = v - t(1-\hat{y}_1) - P_B^{ns} - s + \alpha n_B^r$, which follows: $\hat{x}_1 = \frac{-c+P_B^{nr}+t+\alpha(n_A^s - n_B^s)+\beta(n_A^r - n_B^r)+s}{2t}$; $\hat{y}_1 = \frac{-c+P_B^{ns}+\alpha(n_A^r - n_B^r)+t+s}{2t}$.

Suppose that in the second period the platform obtains a profit of π_i^j on class j users, then $\pi_i^j = \pi_i^{oj} + \pi_i^{nj}$, (i =A, B; j=r, s):

$$Max\pi_B^{nr} = (P_B^{nr} - c)(x^* - \hat{x}_1), Max\pi_B^{ns} = (P_B^{ns} - c)(y^* - \hat{y}_1)$$

Platform B derives its profit from the profit in the new and existing user base of the receivers and senders:

$$\pi_{B2}^r = \pi_B^{or} + \pi_B^{nr} = \int_{x^*}^1 [P_B^{or}(x) - c]dx + (P_B^{nr} - c)(x^* - \hat{x}_1)$$

$$\pi_{B2}^s = \pi_B^{os} + \pi_B^{ns} = \int_{y^*}^1 [P_B^{os}(y) - c]dy + (P_B^{ns} - c)(y^* - \hat{y}_1)$$

Platform A's profit in the second period is:

$$\pi_{A2}^r = \pi_A^{or} + \pi_A^{nr} = \int_0^{\hat{x}_1} [P_A^{or}(x) - c]dx$$

$$\pi_{A2}^s = \pi_A^{os} + \pi_A^{ns} = \int_0^{\hat{y}_1} [P_A^{os}(y) - c]dy$$

It is not difficult to find that platform A and platform B in the second period about the profits of both receivers and senders are a function of x^*、y^*, and the value of x^*、y^* to be determined by the price of the first period, The utility constant equation is obtained:

$$x^* = \frac{-P_A^{1r} + P_B^{1r} + (d_A^s - d_B^s)\alpha + (d_A^r - d_B^r)\beta + t}{2t}$$

$$y^* = \frac{-P_A^{1s} + P_B^{1s} + (d_A^r - d_B^r)\alpha + t}{2t}$$

Platforms A and B made profits in the first period, respectively:

$\pi_{A1}^r = (P_A^{1r} - c)x^*$、$\pi_{B1}^r = (P_B^{1r} - c)(1 - x^*)$

$\pi_{A1}^s = (P_A^{1s} - c)y^*$、$\pi_{B1}^s = (P_B^{1s} - c)(1 - y^*)$

$$Max\pi_A^r = \pi_{A1}^r + \pi_{A2}^r = (P_A^{1r} - c)x^* + \pi_{A2}^r$$

$$Max\pi_B^r = \pi_{B1}^r + \pi_{B2}^r = (P_B^{1r} - c)(1 - x^*) + \pi_{B2}^r$$

$x^* = -\frac{3s}{34t} + \frac{(5n_A^s - 5n_B^s + 4d_A^s - 4d_B^s)\alpha}{34t} + \frac{(5n_A^r - 5n_B^r + 4d_A^r - 4d_B^r)\beta}{34t} + \frac{19t}{34t}$, if and only if $s \leq \frac{(2d_A^s - 2d_B^s + 6n_B^s - 6n_A^s)\alpha}{10} + \frac{(2d_A^r - 2d_B^r + 6n_B^r - 6n_A^r)\beta}{10} + \frac{t}{10}$, and satisfy $x^* \geq \frac{s+\alpha(n_A^s - n_B^s)+\beta(n_A^r - n_B^r)}{2t} + \frac{1}{2}$,which means, The Nash equilibrium exists only if $s \leq \frac{(2d_A^s - 2d_B^s + 6n_B^s - 6n_A^s)\alpha}{10} + \frac{(2d_A^r - 2d_B^r + 6n_B^r - 6n_A^r)\beta}{10} + \frac{t}{10}$, at which point the subgame Nash equilibrium for the second period is:

$$\begin{cases} P_A^{nr} = c \\ P_A^{or}(x) = \frac{(2d_A^s - 2d_B^s + 11n_A^s - 11n_B^s)\alpha}{17} + \frac{(2d_A^r - 2d_B^r + 11n_A^r - 11n_B^r)\beta}{17} + \frac{(18-34x)t}{17} + \frac{7s}{17} + c \\ P_B^{nr} = \frac{(2d_B^s - 2d_A^s + 11n_B^s - 11n_A^s)\alpha}{17} + \frac{(2d_A^r - 2d_B^r + 11n_A^r - 11n_B^r)\beta}{17} - \frac{7s}{17} - \frac{t}{17} + c \\ P_B^{or}(x) = c + \alpha(n_B^s - n_A^s) + \beta(n_B^r - n_A^r) + t(2x-1) + s \end{cases}$$

Similarly:

$$y^* = \frac{(4d_A^r - 4d_B^r + 3n_A^r - 3n_B^r)\alpha - 5s + 15t}{26}$$

$$\hat{y}_1 = \frac{(d_A^r - d_B^r + 4n_A^r - 4n_B^r)\alpha + 2s + 7t}{13}$$

And when $s \le \frac{(2d_A^r - 2d_B^r + 8n_A^r - 8n_B^r + 13n_B^s - 13n_A^s)\alpha}{9} + \frac{t}{9}$, $y^* = \frac{(4d_A^r - 4d_B^r + 3n_A^r - 3n_B^r)\alpha}{26} + \frac{15t}{26} - \frac{5s}{26}$ and satisfy $y^* \ge \frac{1}{2} + \frac{s + \alpha(n_A^s - n_B^s)}{2t}$,at which point the subgame Nash equilibrium for the second period is:

$$\begin{cases} P_A^{ns} = c \\ P_A^{os}(y) = \frac{(2d_A^r - 2d_B^r + 21n_A^r - 21n_B^r)\alpha}{26} + \frac{(27 - 52y)t}{26} + \frac{17s}{26} + c \\ P_B^{ns} = \frac{(2d_A^r - 2d_B^r + 5n_B^r - 5n_A^r)\alpha}{26} + \frac{t}{26} - \frac{9s}{26} + c \\ P_B^{os}(y) = c + \alpha(n_B^r - n_A^r) + t(2y - 1) + s \end{cases}$$

Proposition 1: In the bilateral platform single-attributed users there is a transfer cost and consider the network effect between them, platforms A and B in the first period of uniform pricing, in the second period of the second period according to the first period of the user classification of the second period of the old users of the big data discriminatory pricing, for the new users are still uniformly priced, this two-period dynamic game there are three sets of subgame Nash equilibrium, respectively:

Group 1: $P_A^{1r} = \frac{(n_B^s - n_A^s + 6d_A^s - 6d_B^s)\alpha}{34} + \frac{(n_B^r - n_A^r + 6d_A^r - 6d_B^r)\beta}{34} - \frac{13s}{34} + \frac{10t}{17} + c, P_A^{nr} = c, P_A^{or}(x) = \frac{(2d_A^s - 2d_B^s + 11n_A^s - 11n_B^s)\alpha}{17} + \frac{(2d_A^r - 2d_B^r + 11n_A^r - 11n_B^r)\beta}{17} + \frac{(18 - 34x)t}{17} + \frac{7s}{17} + c$; $P_B^{1r} = -\frac{19s}{34} + \frac{12t}{17} + c + \frac{(9n_A^s - 9n_B^s - 20d_A^s + 20d_B^s)\alpha}{34} + \frac{(9n_A^r - 9n_B^r - 20d_A^r + 20d_B^r)\beta}{34}, P_B^{nr} = \frac{(2d_B^s - 2d_A^s + 11n_B^s - 11n_A^s)\alpha}{17} + \frac{(2d_A^r - 2d_B^r + 11n_A^r - 11n_B^r)\beta}{17} - \frac{7s}{17} - \frac{t}{17} + c, P_B^{or}(x) = c + \alpha(n_B^s - n_A^s) + \beta(n_B^r - n_A^r) + t(2x - 1) + s$; $P_A^{1s} = \frac{(n_B^r - n_A^r + 3d_A^r - 3d_B^r)\alpha}{13} - \frac{7s}{13} + \frac{8t}{13} + c, P_A^{ns} = c, P_A^{os}(y) = \frac{(2d_A^r - 2d_B^r + 21n_A^r - 21n_B^r)\alpha}{26} + \frac{(27 - 52y)t}{26} + \frac{17s}{26} + c$; $P_B^{1s} = \frac{(2n_A^r - 2n_B^r + 6d_B^r - 6d_A^r)\alpha}{13} - \frac{12s}{13} + \frac{10t}{13} + c, P_B^{ns} = \frac{(2d_A^r - 2d_B^r + 5n_B^r - 5n_A^r)\alpha}{26} + \frac{t}{26} - \frac{9s}{26} + c, P_B^{os}(y) = c + \alpha(n_B^r - n_A^r) + t(2y - 1) + s.$

Group 2: $P_A^{1r} = \frac{(9n_A^s - 9n_B^s - 20d_A^s + 20d_B^s)\alpha}{34} + \frac{(9n_A^r - 9n_B^r - 20d_A^r + 20d_B^r)\beta}{34} - \frac{19s}{34} + \frac{12t}{17} + c, P_A^{nr} = \frac{(2d_B^s - 2d_A^s + 11n_B^s - 11n_A^s)\alpha}{17} + \frac{(2d_A^r - 2d_B^r + 11n_A^r - 11n_B^r)\beta}{17} - \frac{7s}{17} - \frac{t}{17} + c, P_A^{or}(x) = c + \alpha(n_B^s - n_A^s) + \beta(n_B^r - n_A^r) + t(1 - 2x) + s$; $P_B^{1r} = \frac{(9n_A^s - 9n_B^s - 20d_A^s + 20d_B^s)\alpha}{34} + \frac{(9n_A^r - 9n_B^r - 20d_A^r + 20d_B^r)\beta}{34} - \frac{19s}{34} + \frac{12t}{17} + c, P_B^{nr} = c, P_B^{or}(x) = \frac{(2d_A^s - 2d_B^s + 11n_A^s - 11n_B^s)\alpha}{17} + \frac{(2d_A^r - 2d_B^r + 11n_A^r - 11n_B^r)\beta}{17} + \frac{(16 + 34x)t}{17} + \frac{7s}{17} + c$; $P_A^{1s} = \frac{(2n_A^r - 2n_B^r + 6d_B^r - 6d_A^r)\alpha}{13} - \frac{12s}{13} + \frac{10t}{13} + c, P_A^{ns} = \frac{(2d_A^r - 2d_B^r + 5n_B^r - 5n_A^r)\alpha}{26} + \frac{t}{26} - \frac{9s}{26} + c, P_A^{os}(y) = c + \alpha(n_B^r - n_A^r) + t(1 - 2y) + s, P_B^{1s} = \frac{(n_B^r - n_A^r + 3d_A^r - 3d_B^r)\alpha}{13} - \frac{7s}{13} + \frac{8t}{13} + c, P_B^{ns} = c, P_B^{os}(y) = \frac{(2d_A^r - 2d_B^r + 21n_A^r - 21n_B^r)\alpha}{26} + \frac{(25 + 52y)t}{26} + \frac{17s}{26} + c.$

Group 3: $P_A^{1r} = \frac{(n_B^s - n_A^s + 2d_A^s - 2d_B^s)\alpha}{5} + \frac{(n_B^r - n_A^r + 2d_A^r - 2d_B^r)\beta}{5} - s + t + c, P_A^{nr} = c, P_A^{or}(x) = c + \alpha(n_A^s - n_B^s) + \beta(n_A^r - n_B^r) + t(1 - 2x) + s, P_B^{1r} = \frac{(n_A^s - n_B^s + 2d_B^s - 2d_A^s)\alpha}{5} + \frac{(n_A^r - n_B^r + 2d_B^r - 2d_A^r)\beta}{5} - s + t + c, P_B^{nr} = c, P_B^{or}(x) = c + \alpha(n_B^s - n_A^s) + \beta(n_B^r - n_A^r) + t(2x - 1) + s$; $P_A^{1s} = \frac{(n_B^r - n_A^r + 2d_A^r - 2d_B^r)\alpha}{5} - s + t + c, P_A^{ns} = c, P_A^{os}(y) = c + \alpha(n_A^r - n_B^r) + t(1 - 2y) + s, P_B^{1s} = \frac{(n_A^r - n_B^r + 2d_B^r - 2d_A^r)\alpha}{5} - s + t + c, P_B^{ns} = c, P_B^{os}(y) = c + \alpha(n_B^r - n_A^r) + t(2y - 1) + s,$

Proposition 1 shows that switching cost is an important internal cause of the big data killing of platform users by Internet platforms, and after adding the switching cost in the model, the user size of the platforms shifts, which makes the network effect among users start to play a role, and the network effect among the platform users pulls the users between the two platforms continuously. When the first set of equilibrium is established,$x^* = \hat{x}_2, y^* = \hat{y}_2$; when the second set of equilibrium

is established$x^* = \hat{x}_1, y^* = \hat{y}_2$,from the first and the second set of equilibrium price, platforms in the second period by the network effect is higher than the first period of the third set of equilibrium is established, the equilibrium point is located in the middle point of the model, the user size of the platforms A and B are equal, i.e.$x^* = \hat{x}_1 = \hat{x}_2 = \frac{1}{2}, y^* = \hat{y}_1 = \hat{y}_2 = \frac{1}{2}$, at this time the platform's pricing to users is not affected by the network effect.

3.2. Single Attribution-Partial Multi-Attribution Big Data Discriminatory Pricing Models

This section will consider the case where the receiver is single-attributed while the sender is multi-attributed. As shown in Figure 4, for senders, in the first period, there exist y_1^*、$y_2^* \in [0,1]$ such that $[0, y_1^*]$ senders choose to use platform A only, $[y_2^*, 1]$ senders choose to use platform B only, and $y_1^*, y_2^*]$ senders choose to use platforms A and B simultaneously.

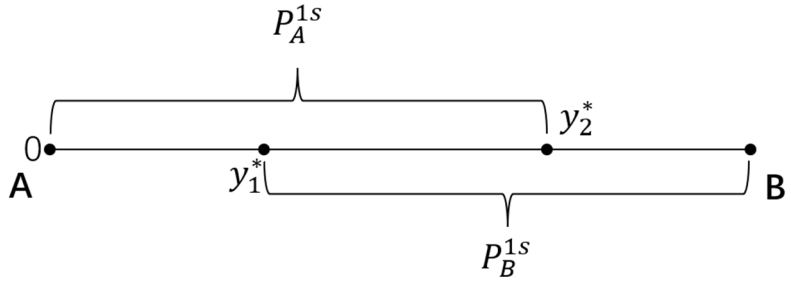


Figure 4. Sender partially multi-attributed symmetric model Phase I diagrams

In the second period, there exists $\hat{y}_1 \in [0, y_1^*]$ such that senders of $\hat{y}_1 \in [0, y_1^*]$ choose to continue to use Platform A, while senders of $[\hat{y}_1, y_1^*]$ choose to switch to using Platform B. There exists $\hat{y}_2, \hat{y}_3 \in [y_1^*, y_2^*]$such that senders of $[y_1^*, \hat{y}_2]$ choose to sender use of Platform B and change from multi-attribution to single attribution to Platform A, the sender of $[\hat{y}_3, y_2^*]$ chooses to give up the use of Platform A and change from multi-attribution to single attribution to Platform B, and the sender of $[\hat{y}_2, \hat{y}_3]$ continues to choose to multi-attribute with the two platforms; and there exists a $\hat{y}_4 \in [y_2^*, 1]$, such that the sender of $[\hat{y}_4, 1]$ chooses to continue to use Platform B, while the sender of $[y_2^*, \hat{y}_4]$ senders choose to switch to using Platform A

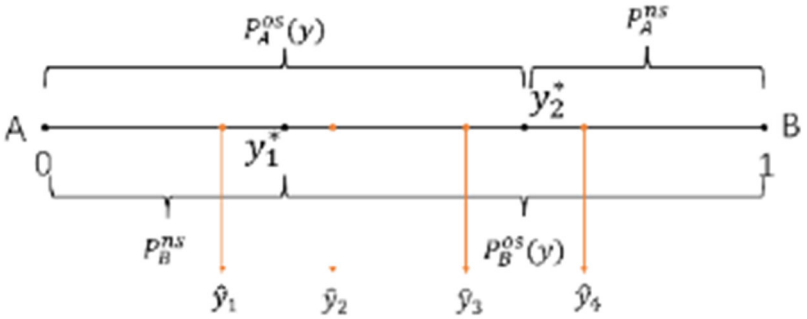


Figure 5. Sender partially multi-attributed symmetric model Phase II diagrams

given $\{P_A^{1r}, P_A^{1s}, P_B^{1r}, P_B^{1s}, y_1^*, y_2^*\}$, consider the platform's choices in the second period. The analysis of the range of values for each price in Model 1 still applies in this model.

$$P_A^{os}(y) = \begin{cases} c \ , y \in [\hat{y}_1, y_1^*) \\ P_B^{ns} + \alpha\left(\dot{n_A^r} - \dot{n_B^r}\right) + t(1-2y) + s, y \in [0, \hat{y}_1)] \cap [y_1^*, y_2^*] \end{cases}$$

$$P_A^{ns} = c$$

$$P_B^{os}(y) = c + \alpha\left(\dot{n_B^r} - \dot{n_A^r}\right) + t(2y-1) + s$$

$$P_B^{ns} = c - \left[\alpha\left(\dot{n_A^r} - \dot{n_B^r}\right) + t(1-2\hat{y}_1) + s\right]$$

Based on $v - t\hat{y}_1 - P_A^{os}(y) + \alpha n_A^{\dot{r}} = v - t(1-\hat{y}_1) - P_B^{ns} - s + \alpha n_B^{\dot{r}}$ 、 $v - t(1-\hat{y}_3) - P_B^{os}(y) + \alpha n_B^{\dot{r}} + s = 2v - t - P_B^{os}(y) - P_A^{os}(y) + \alpha$ which gives: $\hat{y}_1 = \frac{-c+P_B^{ns}+\alpha\left(n_A^{\dot{r}}-n_B^{\dot{r}}\right)+t+s}{2t}$ 、 $\hat{y}_3 = \frac{v-c+\alpha n_A^{\dot{r}}+s}{t}$.

At this point, Platform A owns senders with a market share of $[0,\hat{y}_1] \cap [y_1^*,\hat{y}_3]$ for old users, and a market share of $[\hat{y}_1, y_1^*]$for new customers of Platform B's users Platform B will choose P_B^{ns} to maximize its profit in the new user market:

$$Max\pi_B^{\dot{n}s} = (P_B^{ns} - c)(y_1^* - \hat{y}_1)$$

The profit of platform B comes from the profits of new and old user groups of receivers and senders:

$$\pi_{B2}^{\dot{s}} = \pi_B^{\dot{o}s} + \pi_B^{\dot{n}s} = \int_{y_1^*}^{1}[P_B^{os}(y) - c]dy + (P_B^{ns} - c)(y_1^* - \hat{y}_1)$$

Platform A's profit in the second period is:

$$\pi_{A2}^{\dot{s}} = \pi_A^{\dot{o}s} + \pi_A^{\dot{n}s} = \int_0^{\hat{y}_1}[P_A^{os}(y) - c]dy + \int_{y_1^*}^{y_2^*}[P_A^{os}(y) - c]dy$$

At this point platform A, B in the second period about the sender's profit is a function of about y_1^*,y_2^*, and y_1^*,y_2^* by the price of the first period. In the first period, The utility constant equation is obtained: $y_1^* = \frac{P_B^{1s}-\alpha d_B^{\dot{r}}-v+t}{t}, y_2^* = \frac{v-P_A^{1s}-\alpha d_A^{\dot{r}}}{t}$

Platforms A and B receive a profit on the sender side for the first period:

$\pi_{A1}^{\dot{s}} = (P_A^{1s} - c)y_2^*$、$\pi_{B1}^{\dot{s}} = (P_B^{1s} - c)(1 - y_1^*)$

Platform A chooses price P_A^{1s} to maximize the sum of its profits:

$Max\pi_A^{\dot{s}} = \pi_{A1}^{\dot{s}} + \pi_{A2}^{\dot{s}} = (P_A^{1s} - c)y_2^* + \pi_{A2}^{s}$

Platform B chooses price P_B^{1s} to maximize the sum of its profits:

$Max\pi_B^{\dot{s}} = \pi_{B1}^{\dot{s}} + \pi_{B2}^{\dot{s}} = (P_B^{1s} - c)(1 - y_1^*) + \pi_{B2}^{s}$

At this point, the equilibrium prices are:

$$P_A^{os}(y) = \frac{(-d_A^{\dot{r}} + n_A^{\dot{r}} - n_B^{\dot{r}})\alpha}{2} + \frac{(3-4y)t}{2} + \frac{c}{2} + \frac{s}{2} - \frac{v}{2}$$

$$P_A^{ns} = c$$

$$P_B^{os}(y) = c + \alpha\left(n_B^{\dot{r}} - n_A^{\dot{r}}\right) + t(2y-1) + s$$

$$P_B^{ns} = \frac{(-d_A^{\dot{r}} - n_A^{\dot{r}} + n_B^{\dot{r}})\alpha}{2} + \frac{3t}{2} + \frac{3c}{2} - \frac{s}{2} - \frac{v}{2}$$

When $y_1^* = \hat{y}_1 = \hat{y}_2 = \frac{1}{3}$, $y_2^* = \hat{y}_3 = \hat{y}_4 = \frac{2}{3}$, according to the value range, we can obtain: $P_A^{ns} = P_B^{ns} = c$, $P_A^{os}(y) = c + s + \alpha(n_A^r - n_B^r) + t(1-2y)$, $P_B^{os}(y) = c + \alpha(n_B^r - n_A^r) + t(2y-1) + s$. At this time, platforms A and B cannot obtain any benefits in the new user market, only in the old user market. The profit obtained from platform A and B in the second period is: $\pi_{A2}^{s} = \pi_A^{os} = \int_0^{\hat{y}_1}[P_A^{os}(y) - c]dy + \int_{y_1^*}^{y_2^*}[P_A^{os}(y) - c]dy$

$$\pi_{B2}^{s} = \pi_B^{os} = \int_{y_1^*}^{1}[P_B^{os}(y) - c]dy$$

Demand is y_2^*, $1 - y_1^*$, determined by the prices of platforms A and B in the first period. Platforms A and B choose P_A^{1s}、P_B^{1s} to maximize their profits in the two periods:

$$Max\pi_A^{s} = \pi_{A1}^{s} + \pi_{A2}^{s} = (P_A^{1s} - c)y_2^* + \pi_{A2}^{s}$$

$$Max\pi_B^{s} = \pi_{B1}^{s} + \pi_{B2}^{s} = (P_B^{1s} - c)(1 - y_1^*) + \pi_{B2}^{s}$$

Proposition 2: In the case of multiple sender attribution, platforms A and B still have three sets of equilibrium prices, respectively:

Group 1: $P_A^{1s} = -\frac{\alpha \dot{d_A^r}}{2} + \frac{c}{2} + \frac{v}{2}$, $P_A^{ns} = c$, $P_A^{os}(y) = \frac{(-\dot{d_A^r} + \dot{n_A^r} - \dot{n_B^r})\alpha}{2} + \frac{(3-4y)t}{2} + \frac{c}{2} + \frac{s}{2} - \frac{v}{2}$, $P_B^{1s} = \frac{\alpha \dot{d_B^r}}{2} + \frac{c}{2} + \frac{v}{2}$, $P_B^{ns} = \frac{(-\dot{d_A^r} - \dot{n_A^r} + \dot{n_B^r})\alpha}{2} + \frac{3t}{2} + \frac{3c}{2} - \frac{s}{2} - \frac{v}{2}$, $P_B^{os}(y) = c + \alpha\left(\dot{n_B^r} - \dot{n_A^r}\right) + t(2y - 1) + s$。

Group 2: $P_A^{1s} = \frac{\alpha \dot{d_B^r}}{2} + \frac{c}{2} + \frac{v}{2}$, $P_A^{ns} = \frac{(-\dot{d_A^r} - \dot{n_A^r} + \dot{n_B^r})\alpha}{2} + \frac{3t}{2} + \frac{3c}{2} - \frac{s}{2} - \frac{v}{2}$, $P_A^{os}(y) = c + \alpha\left(\dot{n_B^r} - \dot{n_A^r}\right) + t(1 - 2y) + s$, $P_B^{1s} = -\frac{\alpha \dot{d_A^r}}{2} + \frac{c}{2} + \frac{v}{2}$, $P_B^{ns} = c$, $P_B^{os}(y) = \frac{(-\dot{d_A^r} + \dot{n_A^r} - \dot{n_B^r})\alpha}{2} + \frac{(4y-1)t}{2} + \frac{c}{2} + \frac{s}{2} - \frac{v}{2}$。

Group 3: $P_A^{1s} = \frac{(-3\dot{d_A^r} - \dot{n_A^r} + \dot{n_B^r})\alpha}{4} + \frac{c}{4} - \frac{s}{4} - \frac{t}{4} + \frac{3v}{4}$, $P_A^{ns} = c$, $P_A^{os}(y) = c + s + \alpha(n_A^r - n_B^r) + t(1 - 2y)$, $P_B^{1s} = \frac{\alpha \dot{d_B^r}}{2} + \frac{c}{2} + \frac{v}{2}$, $P_B^{ns} = c$, $P_B^{os}(y) = c + \alpha(n_B^r - n_A^r) + t(2y - 1) + s$。

Proposition 2 shows that three sets of Nash equilibria still exist in the case where the platform allows users to be multi-attributed. Unlike Model 1, in Model 2, platforms A and B change their pricing strategies for single-attributed receivers only due to changes in the receiver's user size, while the platforms' pricing for partially multi-attributed senders will be completely different. This implies that partial multi-attribution behavior can bring additional benefits to senders while also reducing some of their expenses there.

In addition, in Model 2, the size of users affecting each price is no longer the same as in Model 1, and the platform's pricing to sender in the first period is no longer affected by platform B when the sender is multi-attributed, nor is it related to the size of users in the second period. The extent to which transfer costs affect platform pricing increases under the assumption that users incur transfer costs when switching from multi-attribution to single-attribution.

4. Conclusion

This paper investigates the optimal pricing decision of the platform considering the user transfer cost under the single-attribution-single-attribution and single-attribution-partial-multi-attribution scenarios by establishing a hotelling model, and compares the differences in the user size and the changes in the influence of the network effect in the two scenarios. The main findings are as follows:

(1) In the single-attribution-single-attribution case, the model has two symmetric equilibrium prices and one equilibrium price at a special point. At the non-special point, the different pricing of the platform for new and old users makes the users transfer their willingness to use the platform, and the existence of the transfer cost will change the original transfer willingness of the users, so that the change in user scale occurs, and then the network effect between the users occurs, which has an impact on the optimal pricing of the platform. Therefore, when pricing users, platforms should not only consider how to adjust the transfer cost of users, but also consider how the user scale will change under the influence of the network effect after adjusting the transfer cost, in order to obtain better profits.

(2) In the single-attribution-partial-multi-attribution case, the optimal pricing is not only affected by the transfer cost and network effect, but also by the user's base utility. When a user chooses to belong to two platforms, he will get the basic utility of the two platforms at the same time, which makes the user not only consider the transfer cost, but also consider whether to give up the part of the basic utility when giving up the use of the platform, and at this time, the transfer cost will jointly influence the transfer willingness of the platform users in terms of the basic utility provided by the platform to the users. Therefore, when pricing for users with different attribution behaviors, platforms should fully consider the base utility obtained by users, and this part of the base utility provided to users also affects the platform's own profit.

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