A Study on Differentiated Pricing Strategies of Competitive Online Freight Platforms Considering Service Sensitivity

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Abstract. This paper introduces service sensitivity, constructs models for the two platforms charging transaction fee and membership fee respectively, and researches the differentiated pricing strategy between the platforms. It is found that the user pricing of the transaction fee platform and the owner H pricing of the membership fee platform are positively correlated with the owner H ratio, and the owner L pricing of the membership fee platform is negatively correlated with it. When the membership fee platform improves the service quality of different owners, the pricing strategy of different owners of the membership fee platform is different, and the pricing of cargo owners remains unchanged. The transaction fee platform decreases the pricing of cargo owners and the pricing of car owners remains unchanged. Therefore, the network freight platform should adjust the service quality according to the actual and develop reasonable pricing and service strategies.

Keywords: online freight transportation platform; competitive pricing strategy; service sensitivity

1 Introduction

The data show that in the first half of 2023 alone there were 436 new network freight transportation platforms, significantly higher than the 300 in the same period of 2022, but the platform's complaint incidents occur from time to time, network freight transportation platforms to stand out, must return to its essential business - service. In addition, the network freight platform as a bilateral platform pricing influencing factors and other platforms have significant differences, the differentiated pricing of network freight platforms in the competitive market deserves in-depth exploration and research. To this end, this paper provides scientific and effective guidance for the differentiated pricing of network freight forwarding platforms in competitive markets to help platforms improve their profits, based on the consideration of service sensitivity.

Yong Ku et al.[1] introduced three matching service quality parameters, namely transaction waiting time, user transaction cost, and user preference recognition, constructed a hotelling model to find out the optimal pricing decision, and put forward a reliable proposal to improve the competitiveness of the platform. Gui et al.[2] explored the impact of the fairness issue on pricing, matching and profitability of online freight transportation platforms in a competitive

MSEA 2024, May 24-26, Jinan, People's Republic of China

DOI 10.4108/eai.24-5-2024.2350070

bilateral market by constructing a platform pricing model based on hotelling pricing. fairness issues on pricing, matching and profits. Marc P. Saur et al.[3] analyze whether less perception is harmful to consumers when firms use consumer perception segmentation for price discrimination. Francesco et al.[4] investigated price discrimination by firms using consumer information in a two-dimensional duopoly model with horizontal product differentiation. Liang Jing[5] described in detail the path of pricing practice of global airlines in the pricing process, making full use of the dimensions of cost, time, place, price, and product to differentiate. Masashi et al.[6] analyzed behavior-based price discrimination in an asymmetric duopoly with switching costs, including vertical and horizontal differences. Kang Wenjuan et al.[7] showed that social e-commerce service quality has a significant positive impact on customer fit and repurchase intention.Yuki Inoue et al.[8] elucidated how face-to-face service quality in the last mile delivery affects consumers' use of e-commerce platforms. Zhu et al.[9] proposed to analyze the impact of service quality on customer loyalty in terms of five dimensions: tangibility, reliability, responsiveness, convenience and ease of use.

2 Model Construction

2.1 Basic assumptions

Suppose there are two competing online freight platforms in a linear market located at each end of the line segment [0,1]. Both bilateral users are partially multi-attributed. Assuming that the size of shippers (denoted by subscript a) and owners (denoted by subscript b) is 1 and uniformly distributed on the line segment, denote the number of bilateral users on the network freight platforms by n, the fee charged by the network freight platforms to the bilateral users by p, the quality of service provided by the owners on the platforms to the shippers by q_a , and the quality of service provided by the platforms to the owners by q_b . In order to satisfy the effectiveness of the service quality of the owner, the service sensitivity of the shipper must be larger than the service cost parameter of the owner, i.e., $\theta > \lambda$. r_a is the cross-network external utility of the owner to the shipper, r_b is the cross-network external utility of the shipper to the owner, r_a, $r_b \in (0,1)$. α denotes proportion of high service-sensitive vehicle owners. Considering that the unit transportation cost of shippers and vehicle owners to each platform is not the focus of consideration in the model of this paper, assuming that the unit transportation cost is 1, shippers and vehicle owners can express the cost in terms of their respective distances to the platform. The model is constructed based on the above assumptions and parameter settings.

2.2 Model description and solution

In this paper, we investigate the differentiated pricing strategies of online freight platforms in a competitive market by focusing on one platform charging a transaction fee (providing the same service and a uniform price to both types of owners) and the other platform charging a membership fee (charging a high price for providing high quality of service to Owner H, and charging a low price for providing low quality of service to Owner L). Considering that the two scenarios of platform 1 charging a membership fee and platform 2 charging a transaction fee and platform 1 charging a transaction fee and platform 2 charging a membership fee are similar, this paper sees them as one. Since the bilateral market users are all partially multi-attributed, the size of shippers and owners is shown in Figure 1.

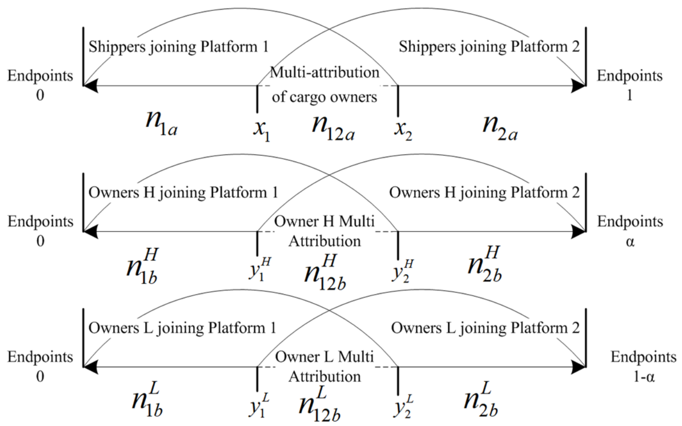

Fig. 1. Structure of a two-platform competitive market with both practicing discriminatory pricing.

As shown in equations (1) and (2), when platform 1 charges a membership fee and platform 2 charges a transaction fee, the utility that both platform 1 and platform 2 bring to the cargo owner and vehicle owner consists of the following components: the initial utility that the user obtains by joining the platform, the positive utility from the cross-network externality, the positive utility from the service provided by the vehicle owner/platform, the negative utility caused by the service cost of the owner, the negative utility caused by the payment of the service fee by the cargo owner and the transportation costs to the platform.

Shipper utility:

$$\begin{cases} u_{1a} = v_0 + (n_{1b}^H + n_{1b}^L + n_{12b}^H + n_{12b}^L)r_a + \theta q_{1a} - p_{1a} - x \\ u_{2a} = v_0 + (n_{2b} + n_{12b})r_a + \theta q_{2a} - p_{2a} - (1-x) \\ u_{12a} = v_0 + r_a + \theta(q_{1a} + q_{2a}) - p_{1a} - p_{2a} - 1 \end{cases} \tag{1}$$

Owner utility:

$$\begin{cases} u_{1b}^H = v_0 + (n_{1a} + n_{12a})r_b + q_{1b}^H - p_{1b}^H - \lambda q_{1a} - y^H \\ u_{1b}^L = v_0 + (n_{1a} + n_{12a})r_b + q_{1b}^L - p_{1b}^L - \lambda q_{1a} - y^L \\ u_{2b}^H = v_0 + (n_{2a} + n_{12a})r_b + q_{2b} - p_{2b} - \lambda q_{2a} - (1 - y^H) \\ u_{2b}^L = v_0 + (n_{2a} + n_{12a})r_b + q_{2b} - p_{2b} - \lambda q_{2a} - (1 - y^L) \\ u_{12b}^H = v_0 + r_b + q_{1b}^H + q_{2b} - p_{1b}^H - p_{2b} - \lambda(q_{1a} + q_{2a}) - 1 \\ u_{12b}^L = v_0 + r_b + q_{1b}^L + q_{2b} - p_{1b}^L - p_{2b} - \lambda(q_{1a} + q_{2a}) - 1 \end{cases} \tag{2}$$

At the critical point x_1 , the utility attributed to the owner of network freight platform 1 is the same as the utility obtained by joining platform 1 and platform 2 at the same time; at the critical point x_2 , the utility attributed to the owner of network freight platform 2 is the same as the utility obtained by joining platform 1 and platform 2 at the same time, so that u = u_{1a12a} and $u_{2a} = u_{12a}$. We obtain the size of the owner of the goods. Similarly, $u_{1b}^H = u_{12b}^H$, $u_{2b}^H = u_{12b}^H$, $u_{1b}^L = u_{12b}^L$, $u_{2b}^L = u_{12b}^L$. to get the owner size, and then get the profit function of the two platforms. Since the Hessian matrix $H(\pi_1)$, $H(\pi_2)$ matrix of the profit function is negative definite, it can be known that the objective function can obtain the unique optimal profit. The first-order partial derivatives of the shipper's price and the owner's price are obtained for the profit function, so that the first-order partial derivatives are both 0, and the optimal pricing of the shipper and the owner can be obtained, As shown in equation (3):

$$P_{1a}=\frac{B_1{}'}{A'},P_{2a}=\frac{B_2{}'}{A'},p_{1b}^{H}=\frac{C_1^{H\prime}}{A'},p_{1b}^{L}=\frac{C_1^{L\prime}}{A'},p_{2b}=\frac{C_2{}'}{A'} \tag{3}$$

Among them:

$$A'=2(2-r_ar_b)$$
$$B_1{}'=[3-\alpha-(2+2r_a+2\theta q_{1a})r_b-2q_{2b}+2\lambda q_{2a}]r_a+2\theta q_{1a}$$
$$B_2{}'=[2+\alpha-(2+2r_a+2\theta q_{2a})r_b-(q_{1b}^H+q_{1b}^L)+2\lambda q_{1a}]r_a+2\theta q_{2a}$$
$$C_1^{H\prime}=\left[2-\left(1-\frac{1}{2}\alpha+2r_b+\frac{3}{2}q_{1b}^H+\frac{1}{2}q_{1b}^L-2\lambda q_{1a}\right)r_a-\theta q_{2a}\right]r_b+2q_{1b}^H-2\lambda q_{1a}$$
$$C_1^{L\prime}=\left[2-\left(1-\frac{3}{2}\alpha+2r_b+\frac{1}{2}q_{1b}^H+\frac{3}{2}q_{1b}^L-2\lambda q_{1a}\right)r_a-\theta q_{2a}\right]r_b+2q_{1b}^L-2\lambda q_{1a}-2\alpha$$
$$C_2{}'=\alpha-1+[2-(\alpha+2r_b+2q_{2b}-2\lambda q_{2a})r_a-\theta q_{1a}]r_b+2q_{2b}-2\lambda q_{2a}$$

The optimal pricing can be obtained from the optimal size of the owner and the owner, and then the optimal size and optimal pricing into the platform's profit function to get the maximum profit, as shown in equation (4):

$$\pi_1^*=\frac{B_1'^2+C_1^{H\prime 2}+C_1^{L\prime 2}-(C_1^{H\prime}-C_1^{L\prime})^2r_ar_b}{A'^2(1-2r_ar_b)},\pi_2^*=\frac{B_2'^2+2C_2'^2}{A'^2(1-2r_ar_b)} \tag{4}$$

3 Analysis of impact factors

Owner H-ratio and membership fee platform service quality can have an impact on freight platform pricing, analyzing and comparing the pricing differences between online freight platforms that charge membership fees and transaction fees.

(1) Impact of Owner H Ratio

Proposition 1: When two platforms charge a membership fee and a transaction fee respectively, as the proportion of owners H increases, the membership fee platform decreases the membership fee for shippers and owners L and increases the membership fee for owners H. The transaction fee platform increases the transaction fee for shippers and owners.

Proof: take the derivatives of p_{1a}, $p_{1b}{}^H$, $p_{1b}{}^L$, p_{2a}, and p_{2b} with respect to α, since $0 < r_a < r_b < 1$. , so $\frac{dp_{1a}}{d\alpha}<0, \frac{dp_{1b}^H}{d\alpha}>0,\ \frac{dp_{1b}^L}{d\alpha}<0,\ \frac{dp_{2a}}{d\alpha}>0,\ \frac{dp_{2b}}{d\alpha}>0.$

Taking r_a=0.3, r_b=0.8, λ=0.5, θ=0.6, $q_{1b}{}^H$=0.8, $q_{1b}{}^L$=0.2, q_{2b}=0.9, q_{1a}=0.8, q_{2a}=0.4, and $\alpha\epsilon(0,1)$, a curve of the relationship between optimal pricing and the proportion of owners' H is obtained by Matlab plotting, as shown in Figure 2.

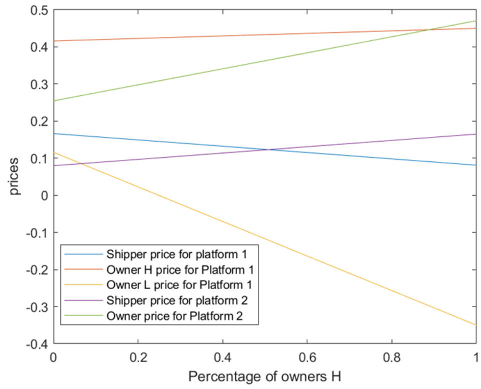

Fig. 2. The effect of the proportion of owners H on optimal pricing.

As shown in Figure 2, both platform pricing strategies are consistent with Proposition 1.

Proposition 1 suggests that if the sensitivity of car owners' services improves and car owners in the market are willing to raise their prices to enjoy better quality services, membership fee platforms will increase their investment in quality services and thus reduce their investment in low-quality services. Transaction fee platforms will also increase investment in quality services, and in turn, the platforms will increase pricing for car owners. In order to be profitable, transaction fee platforms will increase pricing for shippers. Membership fee platforms will decrease pricing for shippers to capture the market.

(2) Impact of the quality of service of membership fee platforms

Proposition 2: As the quality of service for different owners of the membership fee platform increases, the transaction fee platform decreases the transaction fee for shippers and the transaction fee for owners remains the same. The membership fee platform shippers' membership fees remain unchanged. As the high-quality service of the membership fee platform increases, the membership fee platform increases the membership fee for owner H and decreases the membership fee for owner L. As the low-quality service of the membership fee platform increases, the membership fee platform decreases the membership fee for owner H and increases the membership fee for owner L.

Proof: by taking the derivative of p_{1a}, p_{1b}^H, p_{1b}^L, p_{2a}, and p_{2b} with respect to q_{1b}^H, q_{1b}^L respectively, since $0 < r_a < r_b < 1$. , so $\frac{dp_{1a}}{dq_{1b}^H} = 0, \frac{dp_{1b}^H}{dq_{1b}^H} > 0, \frac{dp_{1b}^L}{dq_{1b}^H} < 0, \frac{dp_{2a}}{dq_{1b}^H} < 0, \frac{dp_{2b}}{dq_{1b}^H} = 0,$ $\frac{dp_{1a}}{dq_{1b}^L} = 0, \frac{dp_{1b}^H}{dq_{1b}^L} < 0, \frac{dp_{1b}^L}{dq_{1b}^L} > 0, \frac{dp_{2a}}{dq_{1b}^L} < 0, \frac{dp_{2b}}{dq_{1b}^L} = 0.$

The curve of optimal pricing versus the platform's service quality to owner H is obtained by taking r_a=0.3, r_b=0.8, λ=0.5, θ=0.6, α=0.7, q_{1b}^L=0.4, q_{2b}=0.5, q_{1a}=0.8, q_{2a}=0.4, $q_{1b}^H \epsilon (0.4,1)$, and is shown in Fig. 3. The relationship curve between optimal pricing and the platform's service quality to owner L is obtained by taking r_a=0.3, r_b=0.8, λ=0.5, θ=0.6, α=0.7, q_{1b}^H=0.9, q_{2b}=0.5, q_{1a}=0.8, q_{2a}=0.4, $q_{1b}^L \epsilon (0,0.9)$, as shown in Fig. 4.

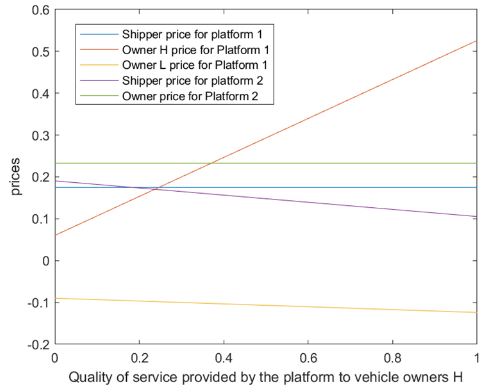

Fig. 3. Impact of $q_{1b}{}^{H}$ on pricing impact on pricing.

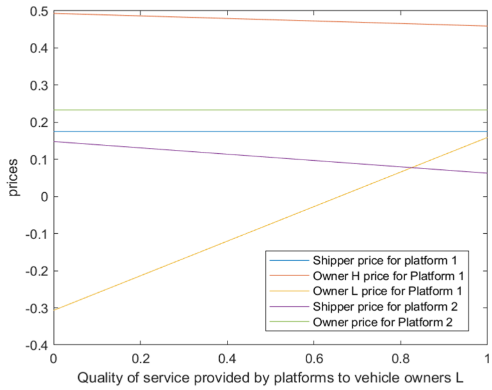

Fig. 4. Impact of $q_{1b}{}^{L}$ on pricing impact on pricing.

From Figures 3 and 4, the platform pricing strategy is consistent with Proposition 2.

Proposition 2 shows that when a membership fee platform increases the service quality of owner H, the platform passes on the increased service cost to owner H by increasing its pricing and decreasing owner L's pricing to reduce owner churn. The same is true for the owner pricing strategy when the membership fee platform increases owner L's service quality. The transaction fee platform reduces the owner's pricing to attract owners to join the platform, and the owner's service fee remains unchanged in order to avoid owner churn.

4 Conclusions

This paper develops a differentiated pricing model for competitive online freight platforms and analyzes the impact of owner H ratio and differentiated services. The study finds:

(1) User pricing on transaction fee platforms is positively correlated with the proportion of owners with high service sensitivity, owner H pricing on membership fee platforms is positively correlated, and cargo owner pricing and owner L pricing are negatively correlated. Therefore,

the platform should pay attention to the market dynamics in real time, grasp the owner's requirements for services, and adjust the pricing strategy in time according to the nature of the owner.

(2) When the membership fee platform improves the quality of service to owner H, the membership fee platform should increase the pricing of owner H to pass on the cost of the service, decrease the pricing of owner L to reduce owner churn, and leave the pricing of shippers unchanged. The transaction fee platform should reduce the pricing of the owner, attract owners to join the platform by increasing the number of owners, and leave the owner's pricing unchanged in order to avoid owner churn. The same applies to membership fee platforms that increase the service quality of owners. The platform should not blindly increase the service quality, but should choose the appropriate service quality for owners with different service sensitivities according to the actual situation of users' demand and service quality of competing platforms in order to obtain greater profits.

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