Summer 6-30-2018

Seller Channel Choice and Optimal Pricing on Heterogeneous Platforms under Online Price Comparison System

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Abstract: This paper studies the channel choice and pricing strategy for sellers who are facing heterogeneous e-commerce platforms under the price comparison system. In such a system, consumers can see the sales information of the same product on different platforms, so they will compare and choose between different sellers and platforms. This paper portrays the behaviors of consumer's price comparing and builds a decision model of sellers in different channel selection modes which are based on the demand functions of consumer utility and Hotelling model. The optimal pricing and maximum profit of the sellers in different selection patterns will be obtained by solving the model and the final results can provide a decision-making reference for sellers who are in the face of similar situations.

Keywords: price comparison system, channel choice, online pricing, heterogeneous platforms

1. INTRODUCTION

With the rapid development of electronic commerce and Internet new technology, online shopping has become a trend and the various e-commerce platforms have also swarmed. These platforms provide a complete network infrastructure and online services to enable both parties to complete the entire transaction. In fact, different platforms also have different operating modes, they can be simply divided into two categories: one is the open platform, which does not charge the seller and the buyer's any fees, such as Taobao. The other is the for-profit platform, which will charge buyer and seller's a certain transaction costs in order to achieve better transaction protection and the perfect customer service, such us Tmall,Amazon[1]. In addition, consumers tend to have different degrees of acceptance of the platform, this can be comprehended from the following two aspects:(1)In terms of enterprise scale, reputation and sales, the entrance threshold of for-profit platform is higher than that of open e-commerce platform, so consumers tend to choose the for-profit platform that can provide higher quality goods.(2) The for-profit platform often provides a more perfect consumer protection mechanism than open e-commerce platform, which enables consumers to enjoy a more perfect shopping experience. At the same time, the changes in consumer shopping habits promote them to find products with good quality and low price, and there are a lot of online price comparison plug-ins now. These browser plug-ins can help consumers to observe the price of multiple online platforms with the same series of products, including the recent price movements, so consumers can select the most suitable items. For sellers, they are not independent of the sales process, the existence of these plug-ins makes the market competition more intense. The platform selection mode and pricing strategy of competitors will affect other sellers' decisions, so this paper focuses on the following questions:(1)How does the seller choose the channel when they are facing the heterogeneous e-commerce platform? (2)How does the competitors' decision affect other sellers' decisions? (3) How does the consumer's price comparison behavior affect the seller's decision? (4) How to determine the optimal pricing in the established selected pattern?

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The issue of channel choice and price strategy has always been the focus of academic research at home and abroad. In fact, some scholars focus on online channel, because the open platform and for-profit platform also have their own characteristics, we can see the heterogeneous platforms as two channels[2]-[3].With the popularity of online shopping, more and more sellers prefer to set up shop on the high-quality e-commerce platforms[1].Bilateral markets are also should be paid attention to it, Armstrong focuses on the competition in the bilateral market and discussed the equilibrium pricing under the different choice modes between the monopoly platform and the competitive platform[4]. In addition, many scholars also pay attention to the sellers' pricing strategy under the dual channel, Chiang,Dumrongsiri and Cai follows closely about the optimal pricing of the various stakeholders in the supply chain when both online and traditional physical stores exist[5]-[7]. In addition, some scholars also concern the pricing issues under the state of competition, Lin(2006)investigates the impact of value-added services on the sellers' optimal prices and their own needs, he also extends the model into many competitive sellers[8]. Under the background of stochastic demand, Cao considers the pricing and coordination problems of closed loop supply chain when two sellers are competing, and made specific analysis in two cases of centralized decision and decentralized decision respectively[9]. In the study process, the influence of the heterogeneity of consumers on sellers' decision also can't be ignored. Chen divides the consumers into strategic and short-sighted types, and analyzes the dynamic game pricing in the process of multiple sellers' price war[10].Wang also studies the impact of strategic consumers and short-sighted consumers on retailer pricing and inventory strategy[11]. Besides, Zhang shows the optimal strategy of digital product supply chain based on consumer preference[12]. Anyway, the research on network price comparison has received more attention in recent years. Bai analyzes the influence of the proportion of price comparison to consumers of manufacturers and retailers in a two-level supply chain system that composed by a manufacturer and a seller[13]. Shi considers the effect of retailer risk aversion on manufacturer channel selection under the network price comparison[14]. And Li discusses the pricing problem of online sellers under the price comparison behavior of strategic consumers and gave the optimal pricing of online sellers under dynamic pricing and price promises respectively[15]. Shen considers the pricing and coordination strategy of dual channel under the behavior of network price comparison, and use game theory to discuss the decision model of single channel and dual channel supply chain[16]. Deng explores the pricing strategy of sellers when adopting dual channel and showed that consumers' price comparison behavior can be reduced and the price perception can be improved in a specific way[17].

Actually, there are few studies based on consumer network price behavior, and current studies mainly focus on dual channels. The channel choice and pricing of sellers when are facing two heterogeneous platforms is rarely studied, this paper depicts the price behavior of consumers and shows the decision-making model of two competing sellers. The optimal pricing and profit of the sellers in different decision-making modes will be obtained after analysis, which will provide a reference for sellers.

2. BASIC MODEL

2.1 Model description

There are two heterogeneous e-commerce platforms: A, B, A is the for-profit platform and charges f_s, f_b to seller and consumer respectively, the fees are mainly used for the maintenance of the platform, the guarantee of the products and the protection of consumers' rights. B is the open platform and charges no fees. The various mechanisms are provided by the A platform, which make it easier and more secure for consumers to buy. Therefore, it is assumed that the basic purchasing utility is v in the A platform and θv in the B platform for consumers. v is the consumer valuation and is uniformly distributed within the consumer population from 0 to 1, with a density of 1,and θ is called the customer acceptance of the open platform. The model in this paper is developed for those products with $\theta \in [0,1]$.

Sellers can enter the open platform at any time because of the low entrance threshold and it's assumed that two sellers, s_1, s_2 already exist on the open platform before. But the for-profit platform A adopts the way of directional investment, only those who have successfully entered the platform brand pool can apply for entry. The aim of this measure is to cooperate with good brands, control product quality indirectly and provide good services for consumers. Assuming that platform A appears on the market now, s_1 has successfully entered the platform brand pool through the application, but s_2 has failed to enter the brand pool for its own reasons, so s_1, s_2 can choose the modes as:

(1) s_1, s_2 only settle on the B platform;

(2) s_1 settles on the A and B platform at the same time, and s_2 settles only on the B platform..

Besides, assuming that A and B platform have its loyal consumers respectively, and the proportion of loyal customers is N_A , N_B accordingly. Customers often search platform products through the keywords, and be ready to pay after comparison between different sellers. At this time, the price plug-ins will show the price information of the same good on the other website, then consumers will decide whether to jump to another website to purchase, so the decision order of sellers and customers is as follows:

(1) The seller sets the selling price under different choices;

(2) Consumers first choose between different products, then choose between different platforms after observing the price information.

Using the Hotelling model to describe the consumer's choice between sellers on the same platform, and the parameter t represents the costs of consumers searching online, so the market share when sellers are on the A platform is $q_{iA} = \frac{1}{2} + \frac{p_{jA} - p_{iA}}{2t}, i \in \{1,2\}$,the demand of sellers on the B platform at the same time is similar.

The parameters description are as follows:

Table 1. Parameters description

Parameter	Implication
$p_{iA}, p_{iB}, i \in \{1,2\}$	The pricing of s_1, s_2 on the A, B platform, respectively
θ	Customers' acceptance of the open platform
t	The search cost for consumers accessing the Internet
f_s, f_b	Fees charged to the sellers and the consumers by the for-profit platform, respectively
$Q_{iA}, Q_{iB}, q_{iA}, q_{iB}$ $i \in \{1,2\}$	The demand of s_1, s_2 on the A, B platform and the market share of s_1, s_2 on A or B
Π_{s1}, Π_{s2}	The total profit of s_1, s_2 respectively

2.2 Scenarios discussion

2.2.1 Scenario 1: s_1, s_2 sell product on the B platform only

When the loyal consumers on the B platform decide to buy product from $s_i, i \in \{1,2\}$,the basic utility needs to satisfy $\theta v - p_{iB} \geq 0, i \in \{1,2\}$, v is the consumption value. According to the consumer choice model, the number of consumers buying $s_i, i \in \{1,2\}$ product on the B platform is $N_B(1-\frac{p_{iB}}{\theta}), i \in \{1,2\}$,that is:

$$Q_{iB} = N_B(1-\frac{p_{iB}}{\theta})$$

Consumers will choose between the competing $s_i, i \in \{1,2\}$ on the B platform and the Hotelling model can be used to get the market share of the sellers, so the number of consumers from B platform is willing to choose $s_i, s_j, i, j \in \{1,2\}$ is:

$$q_{iB} = \frac{1}{2} + \frac{p_{jB} - p_{iB}}{2t}, i, j \in \{1,2\}, i \neq j$$

The profit of $s_i, i \in \{1,2\}$ selling goods on the B platform is:

$$\Pi_{iB} = Q_{iB}(p_{iB} - c_i)$$

$$= N_B(1 - \frac{p_{iB}}{\theta})(\frac{1}{2} + \frac{p_{jB} - p_{iB}}{2t})(p_{iB} - c_i)$$

Assuming that $c_i = 0$,after the partial derivative and analysis, the optimal pricing and profits are as follows,

$$p_{1B} = p_{2B} = t + \frac{\theta}{2} - \sqrt{t^2 + \frac{\theta^2}{4}}$$

$$\Pi_{iB} = \frac{N_B(1 - \frac{t + \frac{\theta}{2} - \sqrt{t^2 + \frac{\theta^2}{4}}}{\theta})(t + \frac{\theta}{2} - \sqrt{t^2 + \frac{\theta^2}{4}})}{2}, i = 1,2$$

Proposition 1 The optimal pricing and profit for sellers in scenario 1 is: $p_{1B} = p_{2B} = t + \frac{\theta}{2} - \sqrt{t^2 + \frac{\theta^2}{4}}$,

$$\Pi_{iB} = \frac{N_B(1 - \frac{t + \frac{\theta}{2} - \sqrt{t^2 + \frac{\theta^2}{4}}}{\theta})(t + \frac{\theta}{2} - \sqrt{t^2 + \frac{\theta^2}{4}})}{2}, i = 1,2.$$

Proposition 1 shows that when s_1, s_2 sell on the open platform only, the optimal pricing and profit of them is related to consumers' acceptance of the open platform and the online search costs and is positive correlated with both.

2.2.2 Scenario 2: S_1 sells product on the A and B platform, s_2 sells product on the B platform only

According to the idea of backward induction, the consumer's decision on the platform choice should be first expressed. Because s_1 sells product on the A and B platform, s_2 sells product on the B platform only, the loyal consumers of the A platform can only buy S_1 goods on the A platform, and there is no other brand choice. They just have to decide to buy on A or B platform, if they decide to buy on the A platform, the following conditions should be satisfied:

$$\begin{cases} v - p_{1A} \geq 0 \\ v - p_{1A} \geq \theta v - p_{1B} \end{cases} \tag{1}$$

If they decide to buy on the A platform, the following conditions should be satisfied:

$$\begin{cases} \theta v - p_{1B} \geq 0 \\ v - p_{1A} \leq \theta v - p_{1B} \end{cases} \tag{2}$$

After the analysis, the number of loyal customers from A platform decides to buy from S_1 on A is:

$$Q_{As1}^{A} = \begin{cases} 1 - \dfrac{p_{1A} - p_{1B}}{1-\theta}, & if\ \dfrac{p_{1B}}{\theta} \leq p_{1A} \\ 1 - p_{1A}, & else \end{cases} \tag{3}$$

The number of loyal customers from platform A decides to buy from S_1 on B is:

$$Q_{AS1}^{B} = \begin{cases} \dfrac{\theta p_{1A} - p_{1B}}{\theta(1-\theta)}, & if\ \dfrac{p_{1B}}{\theta} \leq p_{1A} \\ 0, & else \end{cases} \tag{4}$$

If consumers from B want to choose s_1 ,they will see the price information of s_1 product on the A, B platform through the price comparison system and then decide to buy from A or B .So if consumers are willing to buy the product of s_1 on A ,the condition should satisfy like(1),the demand Q_{BS1}^{A} is similar to(3),and if consumers are willing to buy the product of s_1 on B ,the condition should satisfy like(2),the demand Q_{BS1}^{B} is similar to(4). Besides,since s_2 sells product on the platform B only, consumers who want to buy from s_2 can conclude s_2 on the platform B through the price comparison system and will go to the platform B totally.

According to the idea of backward induction, now it is necessary to determine the consumers' choice from platform A and B on the product brands s_1 and s_2 . As s_1, s_2 sell on the platform B in scenario1, the ratio of consumers willing to choose $S_i, S_j, i, j \in \{1,2\}, i \neq j$ is $q_{iB} = \frac{1}{2} + \frac{p_{jB} - p_{iB}}{2t}$, and because there is only s_1 on the platform A , customers on platform A will buy from s_1 totally, so they just need to make a decision on which platform to buy the product.

In brief, the profits brought to S_1 by consumers buying goods through A and B platforms are as follows:

$$\Pi_{s1} = \begin{cases} [(1 - \dfrac{p_{1A} - p_{1B}}{1-\theta})(p_{1A} - f_s) + \dfrac{\theta p_{1A} - p_{1B}}{\theta(1-\theta)} p_{1B}][N_A + (\dfrac{1}{2} + \dfrac{p_{2B} - p_{1B}}{2t})N_B], & if\ \dfrac{p_{1B}}{\theta} \leq p_{1A} \\ (p_{1A} - f_s)(1 - p_{1A})[N_A + (\dfrac{1}{2} + \dfrac{p_{2B} - p_{1B}}{2t})N_B], & else \end{cases}$$

The profits brought to s_2 by consumers buying goods through the B platform are as follows:

$$\pi_{S2} = p_{2B} N_B \left(\frac{1}{2} + \frac{p_{1B} - p_{2B}}{2t} \right)$$

When $\frac{p_{1B}}{\theta} > p_{1A}$, the final profit of S_1 can be solved as $\Pi_{S1} = 0$,this is the case that s_1 does not want to see, so we don't discuss this condition. And when $\frac{p_{1B}}{\theta} \le p_{1A}$, the final pricing can be obtained after solving:

$$\begin{cases} \partial\pi_{S1}/\partial p_{1A} = 0 \\ \partial\pi_{S1}/\partial p_{1B} = 0, \\ \partial\pi_{S2}/\partial p_{2B} = 0 \end{cases}$$

And the results are as follows:

$$p_{2B} = \frac{p_{1B}+t}{2}$$

$$p_{2A} = p_{2B} + \frac{f_s - \theta + 1}{2}$$

$$p_{1B} = \frac{(4N_A/N_B+3)t}{4} + \frac{3\theta - M}{8}$$

And $M = \sqrt{4t(3+\frac{4N_A}{N_B})[t(3+\frac{4N_A}{N_B}) - q] + \frac{q[8(1-f_s)^2 + q(16f_s - q - 7)]}{1-q}}$ (M is meaningful)

The equilibrium solutions under this model need to satisfy the following conditions:

$$\frac{p_{1B}}{\theta} \le p_{1A}, 0 \le p_{1A} \le 1, 0 \le p_{iB} \le \theta, i \in \{1,2\}$$

So the parameters need to satisfy the following conditions in order to make the solutions exist:

$$0 \le f_s \le 1+\theta,\ \ 0 \le t \le 2\theta,\ 0 \le p_{1B} \le \min\{\frac{\theta(f_s-\theta+1)}{2(1-\theta)}, \theta, 2\theta - t, \frac{1-f_s+\theta}{2}\}$$

In order to simplify the calculation, we select a part of the scope to discuss: When $0 \le t \le \theta$, $0 \le f_S \le 1-\theta$,

$\theta \le t(w+3) \le \frac{5}{2}\theta, w = \frac{4N_A}{N_B}$, p_{1B} should satisfy: $0 \le p_{1B} \le \frac{\theta(1-\theta+f_S)}{2(1-\theta)}$

After calculation, the final results are as follows:

(1) $if\ 0 \le \theta \le \frac{1}{6}, 0 \le t \le \theta, \theta \le t(w+3) \le \frac{5}{2}\theta,$

$$\begin{cases} if\ \ 0 \le f_s \le 1-\theta-\sqrt{2t(w+3)(1-\theta)},\ p_{1B} = 0; \\ 1-\theta-\sqrt{2t(w+3)(1-\theta)} \le f_s \le 1-\theta,\ p_{1B} = \frac{(w+3)t}{4} + \frac{3\theta - M}{8} \end{cases}$$

(2) $if\ \frac{1}{6} < \theta < \frac{1}{3}, 0 \le t \le \theta$

$$\begin{cases} if\ \ \theta \le t(w+3) \le \frac{1-\theta}{2}, \begin{cases} if\ \ 0 \le f_s \le 1-\theta-\sqrt{2t(w+3)(1-\theta)},\ p_{1B} = 0; \\ 1-\theta-\sqrt{2t(w+3)(1-\theta)} \le f_s \le 1-\theta,\ p_{1B} = \frac{(w+3)t}{4} + \frac{3\theta - M}{8} \end{cases} \\ \frac{1-\theta}{2} \le t(w+3) \le \frac{5}{2}\theta,\ p_{1B} = \frac{(w+3)t}{4} + \frac{3\theta - M}{8} \end{cases}$$

(3) $if\ \frac{1}{3} < \theta < 1, 0 \le t \le \theta, 0 \le f_s \le 1-\theta, \theta \le t(w+3) \le \frac{5}{2}\theta$

$$p_{1B} = \frac{(w+3)t}{4} + \frac{3\theta - M}{8}$$

So the final optimal price and profit of s_1, s_2 are:

$if\ \ p_{1B}=0$

$$p_{1A}=\frac{f_s-\theta+1}{2},\ p_{2B}=\frac{t}{2},$$

$$and\ \begin{cases}\Pi_{s1}=N_B\dfrac{(w+3)(f_s+\theta-1)^2}{16(1-\theta)}\\ \Pi_{s1}=N_B\dfrac{t}{8}\end{cases}$$

$if\ \ \ p_{1B}=\dfrac{(w+3)t}{4}+\dfrac{3\theta-M}{8}$

$$p_{1A}=\frac{4f_s+4-\theta-M}{8},\ p_{2B}=\frac{3\theta-M}{16}+\frac{(w+7)t}{8},$$

$$and\ \begin{cases}\Pi_{s1}=N_B[\dfrac{w+3}{4}+\dfrac{u}{2t}][\dfrac{(4u+f_s+\theta-1)}{4(1-\theta)}+\dfrac{4u^2(\theta-1)-u\theta(f_s-\theta+1)}{\theta(1-\theta)}]\\ \Pi_{s1}=N_B\dfrac{(t-2u)^2}{8t}\end{cases}$$

And $w=\dfrac{4N_A}{N_B},u=\dfrac{M}{16}-\dfrac{3\theta}{16}-\dfrac{t(w+3)}{8}$

Proposition 2 The optimal price and profit of sellers in scenario 2 is influenced by various parameters, different range of parameters will determine the final pricing and profit.

3. CONCLUSIONS

This paper studies the channel choice and pricing strategy of sellers facing heterogeneous platforms under the price comparison system. We show the optimal pricing strategy and the maximum profit of s_1 and s_2 when they sell goods on the B platform as well as s_1 on the A, B platform and s_2 on B platform. The research shows that when s_1 and s_2 only sell goods on the B platform, the optimal pricing strategy and profit of s_1, s_2 are affected by two factors, that is the acceptance of consumers to B platform and the online search cost of consumers. And when s_1 is on the A, B platform at the same time and s_2 is on the B platform, the optimal pricing decision of the sellers is different under different parameters range. The future research needs to compare the profits of the two sellers in two scenarios and get the optimal decision combination of them through numerical analysis.

ACKNOWLEDGMENT

Thanks the support from the research foundation of Zhongnan University of Economics and Law Under Grant 2016GS03.

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