BEHAVIOR-BASED PRICING IN SERVICE DIFFERENTIATED INDUSTRIES

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Abstract. Firms often upgrade service level to enhance their profitability, which leads to competing firms at service disadvantages using behavior-based pricing (BBP) strategy to fight back. The interaction between service differentiation and BBP affects the profits of both competitors. In order to explore the impact of BBP on the competition of firms with service differentiation, we use game theory method to construct a two-period dynamic pricing model. We explore the optimal BBP strategy by comparing and analyzing firms sub-game equilibrium profits. The main conclusions are as follows: (i) the degree of service differentiation and the relative service cost interact to influence firms optimal pricing strategy. Specifically, when the degree of service differentiation is low (high) and the relative service cost is small (large), both firms do not adopt (adopt) BBP. When the degree of service differentiation is low (high) but the relative service cost is large (small), competing firms have mixed strategic Nash equilibrium, and both firms have a certain probability to adopt BBP. (ii) BBP can help low-service firms to make up for the profits loss caused by the service disadvantage under certain conditions. However, it can lead to fierce price competition, which will damage the profits of both.

1. Introduction. The development of e-commerce strengthens firms ability to obtain customer information [1]. Firms can recognize customers and implement behavior-based pricing (BBP). Different from uniform pricing (UP), which means all customers get the same price, BBP can accurately provide specific discounts to new or old customers. Discounts for old customers, such as member discounts, are a defensive strategy to maximize profits by retaining as many old customers as possible. In the early stage of business practice, due to the limitation of information technology, firms can easily identify the old customers through traditional ways such as VIP card, therefore provide coupons or price discounts for them [13]. Nowadays,
with the development of mobile e-commerce and increasingly fierce market competition, firms are exploiting the opportunity of mobile e-commerce to develop the market as much as possible. Through the QR code, Wifi, APP and cookies, it is easy to track and record customer purchases to identify new customers [10]. Therefore, the aggressive strategy of preferential pricing for new customers has become more popular and has gradually become the focus of BBP theoretical research [15]. For example, China mobile business hall launches the discount packages for freshman during back-to-school season. Eleme takeaway platform offers 15 RMB discount for new users.

Compared with the non-discriminatory dynamic pricing method [3], [22], [17], BBP can make more profit by using “old customers-high prices” while making use of “new customers-low prices” to earn sales, so that firms can make up much loss of profits while using discounting promotion. However, BBP is also a “double-edged sword”. It may intensify the price competition among firms, and on the contrary, the profits of both competitors will be damaged [16]. Therefore, it is very important to grasp the timing of BBP.

With the improvement of living standards, the upgrading of product quality and service has become an inevitable trend to meet customer needs [11]. For example, some hotels invest heavily in decoration to improve the hotel’s service quality. Internet bars are upgraded to Internet cafes, so as to improve the computer configuration and improve the service environment. This kind of service upgrading has formed the situation of service differentiation among firms. For those high-service firms, how to attract new customers to experience the high service quality and consume is the key. However, for those low-service firms, they have to adopt BBP to compensate for the competitive disadvantage of service. Therefore, the interaction between BBP and service differentiation challenges firms to choose reasonable pricing and service strategies.

More specifically, we address the following research questions:

1. When competing firms with service differentiation adopt behavior-based pricing strategy (BBP) or uniform pricing strategy (UP), and how do they set two-period prices?
2. How do low-service firms and high-service firms choose the optimal pricing strategy?
3. What is the interaction between BBP and service differentiation?

The remainder of this paper is organized as follows. Section 2 reviews the relevant literature. Section 3 briefly introduces model assumptions, preprocessing and definition of key parameters. Section 4 provides the main models and solve the equilibrium results. By comparing and analyzing the equilibrium results, section 5 discusses competing firms optimal pricing strategy when they have service differentiation. After obtaining the specific conditions and timing for the competitors to adopt the BBP strategy, Section 6 introduces the impact of the interaction between BBP and service differentiation on the profits of both competitors. Section 7 concludes the paper and discusses possible extensions for future work.

2. Literature review. This paper is related to two research streams in the literature: BBP and service differentiation. The first is the literature on BBP. Villas-Boas [18], Fudenberg, and Tirole [5] found that BBP tends to intensify market price competition and decrease the profits of competing firms. However, if firms can make rational use of consumers psychological behavior, such as consumer fairness concerns
[12], preference for experience good [7] etc., it is possible to increase firms profits. This essentially eases the price conflict between competing firms at the expense of consumer surplus. Firms are even motivated to share consumer information with upstream manufacturers, and use BBP with manufacturers to further squeeze consumer surplus and increase their profits [10]. However, seeking short-term profits at the expense of consumers interests is bound to decrease customer loyalty [6]. To avoid this tragedy, Jing [8] proposed a better approach to competing firms to sell quality-differentiated products, thereby weakening the impact of price competition. Previous studies, however, have not considered the service factor and ignore the interaction between BBP and service differentiation. We focus on the selection of BBP strategies for competing firms with service differentiation, and we explore the impact of the dual role of service competition and price competition on firms.

Second, this paper is related to the literature on service differentiation. The concept of service differentiation mainly refers to service firms investing funds to improve the service environment (such as store decoration upgrade), upgrade the additional attributes of products (such as the establishment of after-sales service system), etc. Services become a special value-added product rather than service staff’s service attitude or product taste characteristics and other differences. With the rise of service economy and the enhancement of consumer service consciousness, service level has become an important factor for enterprises to enhance competitiveness and profits. [4] points out that the improvement of service level can not only increase the safety and convenience of products to attract more consumers to buy, but also enhance the loyalty of customers to enterprises and enhance the competitiveness of enterprises. [2] even thinks that for a given product, besides price, service has also become the decisive factor for consumers to buy. After that, scholars have done a lot of research on the impact of service level on enterprise decision-making in the supply chain. [20] studies the supply chain model that includes two manufacturers and one retailer from four aspects: no competition between two manufacturers, price competition only, service competition only and simultaneous service and price competition, and pointed out that service provision such as warranty and advertisement is always profitable for retailers. [9] points out that after-sales service level has a significant impact on enterprise performance and its relationship with customers. In addition, some scholars have also studied the impact of service level on enterprise decision-making in a dual-channel supply chain under the Internet environment. [19] studies a dual-channel supply chain consisting of one retailer and two manufacturers selling complementary products, and pointed out that blindly improving the service level of retailers will increase service costs and reduce demand, but will not necessarily increase the profits of retailers. [14] constructs a price-service contract between an online store and two TPRs according to consumers behavior factors in the online shopping service supply chain, and pointed out that the traditional price only contract can no longer coordinate the supply chain. [21] constructs a revenue sharing contract for a two-channel closed-loop supply chain composed of manufacturers and retailers, and pointed out that the increase of revenue sharing factor will encourage retailers to improve their service level and further increase offline sales.

3. Model description. Firm H which provides high service level ($s_H$) and Firm L which provides low service level ($s_L$) are located at 0 and 1 in the linear market. They respectively need to invest a fixed service cost $c_{H}$ and $c_{L}$ to build service systems. The customer obeys the uniform distribution in the linear market. The customer
located at $x$ consumes from firm H at the price of $p^H$ and obtains the utility of $U_H = v - tx - p^H + s_H$; and consumes from firm L at the price of $p^L$ and obtains the utility of $U_L = v - t(1 - x) - p^L + s_L$, where $v$ represents the basic value of the product and $t$ represents the travel cost of the customer. Sales are divided into two periods. Customers choose to consume in each period by comparing their utility. Each firm has two pricing strategies to choose: behavior-based pricing (BBP) and uniform pricing (UP). Accordingly, there are four possible competition scenarios \{UU, BB, BU, UB\}, to be specifically: both firm L and H adopt UP; both firm L and H adopt BBP; firm L adopt BBP while firm H adopt UP; firm L adopt UP while firm H adopt BBP. Firms H and L will aim at maximizing profit in two periods and decide the optimal pricing of products in each competitive situation.

In order to focus the analysis of the impact of the key variables, while simplifying modeling and solving complexity, the basic assumptions and models are processed as follows:

1. Following studies of Li (2018) and Jing (2017), the product value $v$ is large enough to meet the full coverage of the market demand, and the production cost is set to be 0.
2. Since the unit travel cost $t$ does not affect the main conclusions, we set $t = 1$.
3. $s = s_H - s_L$ means the services differences between firms with high and low service levels $c = c_H - c_L$ means the relative service cost. We assume that the relative service cost satisfies which could make sure income outweighs cost after firms upgrade their services. Lets make the low-service firm as the benchmark for comparison, and make its service level and service cost to be $s_L = 0, c_L = 0$.

4. **Main models.**

4.1. **Benchmark model: Case UU.** As a benchmark for comparison, a two-period unified pricing model without BBP is constructed. Since the two firms no longer adopt differential pricing in period 2, the game process and equilibrium of the two periods are the same. In period 1, make $x_1$ to be consumer utility indifference point, which means the utility is the same for consumer $x_1$ to go to firm H and firm L ($v - x_1 - p_1^H + s = v - (1 - x_1) - p_1^L$) thus we could get $x_1 = p_1^L - p_1^H + s + 1$. The demand for firm H is $x_1$ while the demand of firm L is $(1 - x_1)$. The profit functions of firms are $\pi_1^H = p_1^H x_1$ and $\pi_1^L = p_1^L (1 - x_1)$. Take the partial derivatives for $p_1^H$ and $p_1^L$, and make the first-order function formula to be zero, then we could get optimal price $p_1^H = \frac{3 + s}{3}, p_1^L = \frac{3 - s}{3}$. Bring the optimal prices into profit expression, we could obtain the profits for firm H and L in period 1 are $\pi_1^H = \frac{1}{18} (-18c + (3 + s)^2)$ and $\pi_1^L = \frac{1}{18} (-3 + s)^2$ respectively. The equilibrium price and profits in period 2 are the same as that in period 1. Thereby Lemma 4.1 is obtained as bellow.

**Lemma 4.1.** When low-service firm L and high-service firm H both adopt UP, the optimal price in two periods are $p_2^L = \frac{3 + s}{3}$ and $p_2^H = \frac{3 + s}{3}$. The total profits area $\pi_2^L = \frac{1}{5} (-3 + s)^2$ and $\pi_2^H = \frac{1}{5} (-18c + (3 + s)^2)$.

4.2. **BBP Models: Case BB, BU, UB.** Case BB:Firm L and firm H both adopt BBP

In the following, we construct a two-period dynamic pricing model when both firm H and firm L adopt BBP. In period 1, firm H and firm L decide the products
prices $p^H_1$ and $p^L_1$. After observing the price, $x_1$ customers will choose firm H for consumption while $1-x_1$ customers choose firm L ($x_1$ is the consumer utility indifference point in period 1).

At the beginning of period 2, firm H and firm L will identify customer types through their consumption in period 1 and make different price for new and old customers. The prices for old customers are $p^H_{old}$ and $p^L_{old}$. The preferential prices for new customers are $p^H_{new}$ and $p^L_{new}$. After observing the prices provided by the two firms, customers will decide whether to consume in one firm or turn to another firm. We get the consumer utility indifference point in period 2 by

$$v - x_H - p^H_{old} + s = v - (1 - x_H) - p^L_{new} \iff x_H = \frac{p^L_{new} - p^H_{old} + s + 1}{2}$$

$$v - (1 - x_L) - p^L_{old} = v - x_L - p^H_{new} + s \iff x_L = \frac{p^L_{old} - p^H_{new} + s + 1}{2}$$

As shown in Figure 1, customers locating at $[0, x_H]$ will continue to go to firm H for consumption in period 2; while customers locating at $[x_H, x_1]$ would switch to firm L attracted by the preferential prices. Similarly, customers locating $[x_1, x_L]$ buy firm L products in period 1 would switch to buy firm H in period 2. Customers locating at $[x_L, 1]$ repeat to buy firm L products in period 2.

**Figure 1. Products market share segmentation**

We use the inverse induction method to solve this model. First, we talk about the game in period 2. The profit functions of firm H and firm L are as below:

$$\pi^H_2 = p^H_{old} x_H + p^H_{new} (x_L - x_1)$$

$$\pi^L_2 = p^L_{old} (1 - x_L) + p^L_{new} (x_1 - x_H)$$

Since $\frac{\partial^2 \pi^H_2}{\partial p^H_{old}}, \frac{\partial^2 \pi^H_2}{\partial p^H_{new}}, \frac{\partial^2 \pi^L_2}{\partial p^L_{old}}, \frac{\partial^2 \pi^L_2}{\partial p^L_{new}} < 0$ are all satisfied, using the profits functions of $\pi^H_2$ and $\pi^L_2$ to take the partial derivatives for $p^H_{old}, p^H_{new}, p^L_{old}, p^L_{new}$ and make it zero. Jointly, we could get $p^H_{old} = \frac{1}{3} (s + 1 + 2x_1)$, $p^H_{new} = \frac{1}{3} (s + 3 - 4x_1)$, $p^L_{old} = \frac{1}{3} (3 - s - 2x_1)$, $p^L_{new} = \frac{1}{3} (4x_1 - 1)$.

$x_1$ is the consumer utility indifference point in period 1. Customer locating at $x_1$ will not only consider the consumer utility in period 1 but also consider the
equilibrium situation in period 2, therefore maximize expected utility in two periods. For customers locating at \( x_1 \), their expected utility in buying products H in period 1 and switch to buy products L in period 2 should equal to the expected utility in buying products L in period 1 and switch to buy products H in period 2, therefore we could get

\[
v - x_1 - p_1^H + s + v - (1 - x_1) - p_{\text{new}}^L = v - (1 - x_1) - p_1^L + v - x_1 - p_{\text{new}}^H + s
\]

\[\Rightarrow x_1 = \frac{2s + 4 - 3(p_1^H - p_1^L)}{8}\]

Return to the game in period 1, the profit functions of firm H and firm L are

\[
\pi_H^L = p_1^L x_1 + \pi_2^L
\]

\[
\pi_1^L = p_1^L (1 - x_1) + \pi_2^L
\]

Since \( \frac{\partial^2 \pi_H^L}{\partial p_1^H} \cdot \frac{\partial^2 \pi_1^L}{\partial p_1^L} < 0 \) is satisfied, to take partial derivatives for \( p_1^H \) and \( p_1^L \) with profit functions \( \pi_H^L \) and \( \pi_1^L \), and set it to be zero. Jointly, we could get the optimal price and profits in period 1. See Lemma 4.2:

**Lemma 4.2.** When firm L and firm H both adopt BBP, the optimal prices in period 1 are \( p_1^L = \frac{16 - 3a}{12} \) and \( p_1^H = \frac{16 + 3a}{12} \). In the second period, firm L makes different prices for old and new customers which are \( p_{\text{new}}^L = \frac{4 - 3a}{12} \) and \( p_{\text{old}}^L = \frac{16 - 9a}{24} \), while firm H makes the prices for old and new customers are \( p_{\text{new}}^H = \frac{16 - 9a}{12} \) and \( p_{\text{old}}^H = \frac{16 + 9a}{24} \). The total profits for firm L and firm H are \( \pi_L^L = \frac{17}{18} + \frac{1}{384} q (-208 + 45q) \) and \( \pi_H^L = \frac{17}{18} - c + \frac{1}{384} q (208 + 45q) \).

Case BU: Firm L adopts BBP while Firm H adopts UP

In the following, we establish a two-period dynamic pricing model for firm L using BBP and firm H using UP. After identifying the consumers types in period 1, firm L will make different pricing for old and new customers in period 2 while firm H will set uniform prices for all customers. In this section, the process of market segmentation and game is similar to section 4.2.1. The duplicate processes are not detailed here. The difference is: in period 2, firm H set an uniform price \( p_{\text{new}}^H \) for all customers while firm L still makes different prices for old and new customers which are \( p_{\text{old}}^L \) and \( p_{\text{new}}^L \). Customers will decide whether to buy the previous products or switch to another firm by comparing the utility \( v - (1 - x_H) - p_{\text{old}}^L = v - x_H - p_{\text{new}}^L + s \), we could get the utility indifference point of consumers going to firm H is \( x_H = \frac{p_{\text{new}}^L - p_{\text{old}}^L + s}{2} \) in period 2. Similarly, though \( v - x_L - p_{\text{new}}^L = v - (1 - x_L) - p_{\text{new}}^L \), we could get the utility indifference point of consumers going to firm L for consumption \( x_L = \frac{p_{\text{old}}^L - p_{\text{new}}^L + s}{2} \).

The profit functions of firm H and firm L in period 2 are

\[
\pi_H^L = p_2^H (x_H + x_L - x_1)
\]

\[
\pi_2^L = p_{\text{old}}^L (1 - x_L) + p_{\text{new}}^L (x_1 - x_H)
\]

Since \( \frac{\partial^2 \pi_H^L}{\partial p_2^H} \cdot \frac{\partial^2 \pi_2^L}{\partial p_2^L} \cdot \frac{\partial^2 \pi_2^L}{\partial p_{\text{old}}^L} \cdot \frac{\partial^2 \pi_2^L}{\partial p_{\text{new}}^L} < 0 \) all are satisfied, we could get \( p_{\text{old}}^L = \frac{1}{6} (5 - x_1 - 2s) \), \( p_{\text{new}}^L = \frac{1}{6} (5x_1 - 2s - 1) \), and \( p_2^H = \frac{1}{3} (s + 2 - x_1) \). Then, we determine the consumer
utility indifference point $x_1$ in period 1. Since the customers expected utility in two periods are the same, which means

$$v - x_1 - p^H_1 + s + v - (1 - x_1) - p_{\text{new}}^L = v - (1 - x_1) - p^L_1 + v - x_1 - p^H_2 + s$$

$$\Rightarrow x_1 = \frac{4s + 5 - 6(p^H_1 - p^L_2)}{7}$$

Back to the game of period 1, profit functions are as formula (3) and (4). Then we could obtain the optimal prices and profits of the two periods.

**Lemma 4.3.** When firm $L$ adopts BBP and firm $H$ adopts UP, the optimal prices in the first period are $p^L_1 = \frac{46-18s}{69}$ and $p^H_1 = \frac{253+84s}{276}$. In the second period, firm $L$ sets the prices for old and new customers to be $p_{\text{new}}^L = \frac{23-24s}{92}$ and $p_{\text{Old}}^L = \frac{69-32s}{92}$ while firm $H$ sets the prices to be $p_{\text{new}}^H = \frac{23+14s}{46}$ and $p_{\text{Old}}^H = \frac{-21+14s}{46}$. The total profits of firm $L$ and firm $H$ are $\pi^L = \frac{31}{48} - 7\frac{1}{135} + 632\frac{7}{529}$ and $\pi^H = 17\frac{17}{24} - 52\frac{3}{138} + 632\frac{7}{529}$.

Case UB: Firm $L$ adopts UP and firm $H$ adopts BBP. The process of market segmentation and game is the same as that in section 4.2.2. A two-period dynamic pricing game model is constructed when firm $H$ adopts BBP. The difference in decision-making process is: in period 2, firm $L$ will make an uniform price $p^L_2$ for all customers while firm $H$ make different prices for old and new customers to be $p_{\text{Old}}^H$ and $p_{\text{New}}^H$. Through $v - (1 - x_H) - p^L_2 = v - x_H - p_{\text{New}}^H + s$ and $v - x_L - p_{\text{Old}}^H + s = v - (1 - x_L) - p^L_2$, we could get the consumers indifferent points to be $x_H = \frac{p^L_2 - p_{\text{Old}}^H + 1}{2}$ and $x_L = \frac{p^L_2 - p_{\text{New}}^H + 1}{2}$ respectively in period 2.

With the reverse induction method, the profit functions in period 2 are

$$\pi^H = p_{\text{Old}}^H x_H + p_{\text{New}}^L (x_L - x_1)$$

$$\pi^L = p^L_2 (1 - x_L + x_1 - x_H)$$

Similarly, satisfying the second-order condition, we could get $p_{\text{Old}}^H = \frac{1}{6}(2s + 4 + x_L)$, $p_{\text{New}}^L = \frac{1}{6}(2s + 4 - 5x_1)$, $p^L_2 = \frac{1}{6}(s + 1 + x_1)$. Through $v - x_1 - p^L_1 + s + v - (1 - x_1) - p^L_2 = v - (1 - x_1) - p^L_1 + v - x_1 - p_{\text{New}}^H + s$, the consumer utility indifference point $x_1 = \frac{4s + 2 - 6(p^H_1 - p^L_2)}{7}$. Then back to the game in period 1 and we get Lemma 4.4.

**Lemma 4.4.** When firm $L$ adopts UP and firm $H$ adopts BBP, the prices in period 1 are $p^L_1 = \frac{253-84s}{276}$ and $p^H_1 = \frac{18s+64}{69}$. In period 2, firm $L$ sets uniform price to be $p_{\text{New}}^L = \frac{23-24s}{92}$, while firm $H$ sets different prices for old and new customers to be $p_{\text{Old}}^H = \frac{23+24s}{92}$ and $p_{\text{New}}^H = \frac{-21+14s}{46}$. The total profits of firm $L$ and firm $H$ are $\pi^L = 17\frac{17}{24} - 52\frac{3}{138} + 632\frac{7}{529}$ and $\pi^H = 31\frac{17}{48} - 52\frac{3}{138} + 632\frac{7}{529}$.

5. **Firms optimal pricing strategy.** Lemma 4.1-4.4 answer the first research question in this paper, that is the optimal pricing and profits for two service-differentiated firms in the case of four different pricing strategies ($UU, BB, BU, BP$). Further, through the comparative analysis of the profits under these four pricing decisions, how should the service-differentiated firms choose their optimal pricing strategies (adopting BBP or UP)? In this section, we answer the second research question.
In reality, when two service-differentiated firms make pricing strategies, they form a non-cooperative complete information static game. The revenue matrix of firm H and firm L is shown in Table 1.

**Table 1. Revenue matrix for firms with service differentiation**

|       | Firm H |       |       |
|-------|--------|-------|-------|
| BBP   | $\frac{17}{18}$, $\frac{1}{384}$($-208 + 4s$), $\frac{31}{18}$, $\frac{1}{384}$($208 + 4s$) | $\frac{31}{18}$, $\frac{7}{138}$, $\frac{7}{12}$, $\frac{1}{138}$($208 + 4s$) |
| UP    | $\frac{17}{24}$, $\frac{37}{69}$, $\frac{31}{64}$, $\frac{1}{64}$($208 + 4s$) | $\frac{1}{9}$($3 + s$)², $\frac{1}{9}$($-18c + (3 + s)$²) |

In order to explore how service differentiation affects the choice of firms pricing strategy, we first analyze the basic situation. When there is no service differentiation, which means $s = c = 0$ in the profit function in table 1 and the Nash game benefit matrix is shown in Table 2.

**Table 2. Revenue matrix for firms without service differentiation**

|       | Firm H |       |
|-------|--------|-------|
| BBP   | $\frac{17}{18}$, $\frac{17}{18}$ | $\frac{31}{18}$, $\frac{17}{48}$, $\frac{17}{48}$ |
| UP    | $\frac{17}{24}$, $\frac{31}{48}$, $\frac{31}{48}$ | (L,D) |

There are two pure strategy equilibrium solutions for Nash Game: (BBPBBP) and (UPUP). Since both (UP, UP) counterparts have higher returns than (BBP, BBP), when there is no difference in service levels, the optimal choice for both firms is to adopt the UP strategy. BBP is a kind of pricing method that damages people and disadvantages themselves. It causes both firms to lose profits in the process of competing for customers. Therefore, we could obtain the corollary as below:

**Corollary 1.** When competing firms have no service differentiation, their optimal pricing strategy is (UP, UP).

However, when there are service differentiation, if both firms still choose UP strategy, profits of Firm L will be decreased by $(1 - \frac{c}{18}(-3 + s)^2)$ while the profits of Firm H could increase by $(1 - \frac{1}{9}(-18c + (3 + s)^2))$ under some appropriate circumstances $(c \leq c_1(s) = \frac{s^2 + 6s}{15})$. This will motivate firm L who is at a disadvantage in the service competition to adopt BBP, attempting to enhance its competitiveness through price means, while firm H has to use BBP for price confrontation. Therefore, in the case of service differentiation, how would competing firms make pricing strategy and what is the condition? Let $c_1(s) = \frac{s^2 + 6s}{15}$, $c_2(s) = \frac{64 + 144s - 7s^2}{1152}$, $s_1^* = 0.25$, $s_2^* = \ldots$
choose UP. Thus we could get that (BBP, BBP) and (UP, UP) are two purely strategy solutions, according to oddness theorem, in this case, both firm H and firm L adopt uniform pricing strategy. Similarly, when $c_2(s) < c < c_1(s), s_1^* < s < s_2^*$ and $0 < c < c_2(s), s_2^* < s < 1$, firm L has a probability of $p_a$ to use BBP, and a probability of $(1-p_a)$ to use UP while firm H has a probability of $p_b$ to use BBP and a probability of $(1-p_b)$ to use UP.

**Proof.** Comparing the equilibrium profit in Table 1 we can get: if firm L chooses BBP, since $c \leq c_1(s) = \frac{s^2}{18} + \frac{2}{3}$, then $\pi_H^{BB} > \pi_H^{BU}$, Firm H will also tend to choose BBP; Similarly, if the firms L chooses UP, since $\pi_L^{UB} < \pi_L^{UU}$, firm L also tends to choose UP. On the contrary, if firm H chooses BBP, since $\pi_H^{BB} > \pi_H^{UB}$, firm L will tend to choose BBP; if firm H choose UP, since $\pi_L^{BU} < \pi_L^{UU}$, firm L will also tend to choose UP. Thus we could get that (BBP, BBP) and (UP, UP) are two purely strategic Nash equilibrium solutions. When $0 < c < \min(c_1(s) = \frac{s^2}{18}, c_2(s) = \frac{64 + 144x - 7x^2}{1162})$, $0 < s < s_1^* = 0.25$, since $\pi_L^{UU} > \pi_L^{BB}$ and $\pi_H^{BU} > \pi_H^{BB}$, therefore, (UP, UP) is always better than (BBP, BBP), and there is a dominant equilibrium : (UP, UP), that is, both firm H and firm L adopt uniform pricing strategy. Similarly, when $c_2(s) < c < c_1(s), 0.79 = s_2^* < s < 1$, since $\pi_L^{UU} < \pi_L^{BB}$ and $\pi_H^{UU} < \pi_H^{BB}$, therefore, (BBP, BBP) is always better than (UP, UP), and there is a dominant equilibrium: (BBP, BBP), that is, both firm H and firm L adopt BBP strategy. When $c_2(s) < c < c_1(s), s_1^* < s < s_2^*$ or $0 < c < c_2(s), s_2^* < s < 1$, and where $\pi_L^{UU} > \pi_L^{BB} > \pi_L^{UB}$ or $\pi_L^{UU} < \pi_L^{BB} < \pi_L^{UB}$, there is no dominant situation for two pure strategy solutions, according to oddness theorem, in this case, there is a mixed strategy Nash equilibrium (MNE), and lets assume that firm L has a probability to choose BBP and $1-p_a$ probability to choose UP; firm H has $p_a$ probability to choose BBP and $1-p_a$ probability to choose UP. The expected profits of Firm L and Firm H are as shown in Equations (9) and (10).

\[
\pi_L^* = a[\pi_L^{BB} + (1-b)\pi_L^{BU}] + (1-a)[\pi_L^{BB} + (1-b)\pi_L^{UU}] \quad (9)
\]

\[
\pi_H^* = b[a\pi_H^{BB} + (1-a)\pi_H^{BU}] + (1-b)[a\pi_H^{BB} + (1-a)\pi_H^{UU}] \quad (10)
\]

By using equations (9) and (10) to take the partial derivative for $a$ and $b$ and make the first derivative to be 0, we could obtain: $p_a = \frac{8(26979-76176c+11592q-464q^2)}{359720-60948q+96048q-4873q^2}$ and $p_b = \frac{8(26979-76176c+11592q-464q^2)}{359720-60948q+96048q-4873q^2}$.

**FIGURE 2** is to visualize optimal pricing strategies choices of the two firms in Proposition 1. The area of $c > c_1(s)$ indicate the profit of firm H decreases after increasing its service due to the high cost of service upgrade and therefore it has no willingness to differentiate services. The above analysis shows that when competitive firms have no service differentiation in, the optimal choice of both sides is UP strategy.

When the degree of service differentiation and the relative service cost are small, for firm L, the profit loss caused by price competition will be higher than that caused by service differentiation, therefore firm L is not willing to adopt BBP. However, for firm H, it has already got profits from service differentiation, so it would like to adopt UP to avoid the unnecessary price war. When the degree of service differentiation and relative service cost of the two firms are relatively large, for firm L, the loss...
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Figure 2. Firms optimal pricing strategy with service differentiation

of profits caused by service differentiation occupies a dominant position, therefore it would make up of profit loss through price competition. For firm H, it has to adopt BBP to confront and prevent loss of profits caused by customer loss. When the degree of service differentiation is small and the relative service cost is large, one of them will occupy an absolutely advantageous position, and there will be no pure strategy Nash equilibrium and the pricing strategy of one party will inevitably hurt the profit of the other party. In this case, there is only mixed strategy Nash equilibrium, and the competitors will have a certain probability to choose a pricing strategy according to the reaction of their competitors.

6. Interaction between service differentiation and BBP. In the previous section, we discussed how competing firms with service differentiation make price strategies. Service differentiation affects firms pricing strategy, which makes the competing firms change from “adopting UP strategy in the case of no differentiation” to the more complex strategy combination shown in Proposition 1. The change of pricing strategy will affect the optimal profit in the case of service differentiation. Therefore, this section will analyze the impact of service differentiation and BBP interaction on the profits of both competitors.

First, we analyze the impact of service differentiation on the profits. When one firm improves its service level and differentiates its services from competitors, this firm can profit from the improvement of services, which leads to a decrease in the profits of competitors at service disadvantage. Therefore, service differentiation is conducive to the promotion of high-service firm and damage the profits of low-service firm. This kind of game results conform to the current social development trend, which leads more and more firms to gradually improve the service level within the scope of their capabilities, in line with the current policy orientation and the needs of the masses.

However, for the firms which lack the ability to upgrade their services (such as geographical location, limited capital, firm scale and capacity, etc.), in order to make up for the loss of profits caused by service disadvantages, BBP will be used to
enhance their profitability. BBP is a double-edged sword, which not only expands demands, but also causes firms to compete for customers and thus intensifies the price competition. The introduction of BBP has led to the strategic choice of Proposition 1 for high-service firms and low-service firms. In this case, can low-service firms adopt BBP to make up for service disadvantages? May high-service firms decrease profits due to BBP? To this end, this paper gives Proposition 2 and Proposition 3 are as follows:

**Proposition 2.** For the low-service firm, when \( c_2(s) < c < c_1(s), s_2^* < s < 1 \), BBP can make up for part of the loss of profit brought by the service differentiation; but when \( c_2(s) < c < c_1(s), s_1^* < s < s_2^* \) and \( 0 < c < c_2(s), s_2^* < s < 1 \), BBP would cause fierce price competition and further decrease its profits.

**Proof.** If firm L does not use BBP, from Proposition 1 we could know that that firm H does not use BBP, too, at this time, the profit obtained by firm L is \( \pi_L^{U} \). When firm L adopt BBP, firm H will also adopt BBP and at this time, the profit obtained by firm L is \( \pi_L^{BB} \). when \( c_2(s) < c < c_1(s), s_2^* < s < 1 \) are satisfied, we could get \( \pi_L^{BB} - \pi_L^{U} > 0 \). Therefore, the profit obtained by adopting BBP for firm L is greater than that obtained by not adopting BBP. when \( c_2(s) < c < c_1(s), s_1^* < s < s_2^* \) or \( 0 < c < c_2(s), s_2^* < s < 1 \) are satisfied, Nash equilibrium of mixed strategy is formed between the two sides. Bringing \( p_0 = \frac{8(26979-11599y+464qy)}{359720-609408q+56904q^4-4873q^6} \), in to the equation (9), we could get the expected profit of firm L under the mixed strategic Nashi equilibrium is \( \pi_L^{*} = \frac{-1412017269(s(-1336228609+569044q-4873q^6)+4761(-359720+359720+96048+4873q^6))}{4761(-359720+359720+96048+4873q^6)} \), since \( \pi_L^{*} - \pi_L^{UU} < 0 \). The adoption of BBP by firm L results in the decrease of profit under the mixed strategic equilibrium.

**Proposition 3.** For the high-service firm, when \( \max(c_2(s), c_3(s)) < c < c_1(s), s_1^* < s < s_2^* \) and \( c_2(s) < c < c_1(s), s_2^* < s < 1 \), BBP can further increase its profits; however, when \( c_2(s) < c < c_3(s), s_3^* < s < s_2^* \) and \( 0 < c < c_2(s), s_2^* < s < 1 \), BBP decreases its profits.

**Proof.** when \( c_2(s) < c < c_1(s), s_2^* < s < 1 \) are satisfied, firm H and L both adopt BBP, at this time \( \pi_L^{BB} - \pi_L^{U} > 0 \), therefore , the adoption of BBP can increase the profit of firm H in the case of service differentiation; when \( \max(c_2(s), c_3(s)) < c < c_1(s), s_1^* < s < s_2^* \) are satisfied, through equation (10), the expected profit of firm H under mixed strategic Nashi equilibrium can be obtained as

\[
\pi_H^* = -\frac{2518569(561+8c(-221+14c))+1168032(-1141+1747c)+3703(-115505+65554c)c^2}{4761(-359720+609408c+(-96048+4873c)x+4761(-359720+609408c+(-96048+4873c)x))}
\]

At this time, \( \pi_H^{*} - \pi_H^{UU} > 0 \), it can be seen that BBP makes profit increase of firm H under mixed strategic equilibrium. However, when \( c_2(s) < c < c_3(s), s_3^* < s < s_2^* \) or \( 0 < c < c_2(s), s_2^* < s < 1 \), since \( \pi_H^{*} - \pi_H^{UU} < 0 \), at this time, BBP decreases the profit of firm H.

In order to visually show how the BBP affects firms profits described in Proposition 2 and 3, we use ↑ and ↓ to indicate in FIGURE 3. For example, ↓↑ indicates that BBP in the decision area decreases the profits of firm L and increase the profits of firm H. It is easy to see from FiGURE 3 that when the relative service cost and the degree of service differentiation are small \( 0 < c < \min(c_1(s), c_2(s)), 0 < s < s_1^* \), the best choice for firms is to not use BBP. At this time, only the service differentiation factor affects the profits of both firms. But when the relative service cost is
large and the degree of service differentiation is large ($c_2(s) < c < c_1(s), s_2^* < s < 1$) BBP can help firm L improve their profits and make up for some of the loss of profits caused by service differentiation (the total profits are still decreased). At the same time, the profits of firm H are increase under the dual effects of BBP and service differentiation. Therefore, under this condition, BBP achieved a Pareto improvement of the profits for both firms, achieving a win-win situation. In other areas, the competition form a mixed strategic Nash equilibrium. The interaction between BBP and service difference makes the profits of both sides fluctuate, resulting in an irreconcilable competitive situation. At this time, BBP will decrease the profits of both sides. However, it should be noted that when the relative service cost is large ($\max(c_2(s), c_3(s)) < c < c_1(s), s_1^* < s < s_2^*)$, the service differentiation no longer increase the profits of firm H, but BBP becomes an effective means to increase profits.

In summary, the interaction between BBP and service differentiation affects firms pricing decisions and profits. Under certain conditions, BBP can improve the contradiction caused by the uneven division of interests in service competition of firms, but sometimes it is easy to make both sides of the competition fall into the double quagmire of service competition and price competition. This warns managers that the best way to create profit margins is through upgrading services, rather than chasing profits through short-term price means. The strategic focus should be shifted from price competition to service competition.

7. Conclusions. Behavior-based pricing (BBP), as an effective means of market expansion and price competition, has gradually been widely used in commercial practice. The subjective initiative of strategic customers makes the competition among firms more intense. BBP becomes a double-edged sword, sometimes intensifying the price war. This paper focuses on how to choose BBP strategy for competitive firms with service differentiation, and analyzes the interaction between

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**Figure 3.** Impact of BBP on firms’ profits with service differentiation

*Note: “-”,”↑”, and “↓” indicate that the profit is unchanged, rising, and falling.*
BBP and service differentiation on the impact of corporate profits. The research results not only provide decision-making basis and insight for the firm managers that the strategic focus should be shifted from short-term price competition to long-term service competition. The problems worthy of further study are as follows: (1) BBP may increase the unfairness psychology of consumers. Considering the impact of consumer fairness on the choice of BBP strategy is meaningful expansion; (2) consumers may not be able to know the price discounts information in time, therefore it is also meaningful to study how advertising investment affects BBP strategy selection.

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