Markdown and Bundling Pricing Decisions for Complementary Supply Chain with Strategic Consumers

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Abstract—In this paper, we investigate the selling strategy and price decisions for a seller who provides two complementary products to the strategic consumer over two periods under three selling strategies: markdown pricing (MD), second period bundling (SPB) and first period bundling (FPB). It is found that the seller’s optimal prices in the second period of SPB and FPB strategies are higher than that of MD strategy, the seller can obtain the maximum profit by FPB strategy, and obtain more profit in SPB strategy than that in MD strategy with some conditions. We also explore the effect of consumer strategic behavior and product complementarity on the seller’s selling strategy and profit. The effects of consumers’ strategic behavior and patience on seller’s profit and selling strategies are analyzed by the numeral examples.

Keywords—complementary products; markdown pricing; period bundling; strategic consumer

I. INTRODUCTION

Do you experience such bad things: The laptop computers for one of which you paid $3000 six weeks ago are on sell for $1500; the favorite coats of which you bought one last month are selling at a discount in the same shop? The prices of products are changed by the sellers at some time in the sale periods. Especially for electronic goods, fashion products or fresh products of which the value for most of the consumers will reduce in the late sales, many sellers choose to markdown pricing (MD) to maximize their profits during the sales cycle. The markdown pricing strategy used by sellers becomes more and more common with the shortening of product life cycle and the using of price management software. As a kind of dynamic pricing, the effect of markdown pricing strategy for revenue management has been proved by researches. Pashigian (1988) firstly studied the problem of MD and sales systematically. Recently, there are several reviews on the related problems, such as Elmaghraby and Keskinocak (2003), Bitran and Caldentey (2003), Shen and Su (2007), Aviv et al. (2009), Chen and Chen (2015).

Another result caused by markdown pricing strategy is consumer’s complaints and departure. What’s worse, the firms may suffer the loss of the loyal customers who tune to the substitute products and rival enterprises. A research report about some goods in USA market pointed out that: a regular customer can bring firms 20-85% more than a first-time buyer and the regular customers’ rose by 5% can cause the firms’ profit rose by 25%.

What we want to investigate in this paper is that whether the strategy of bundling complementary products is better than markdown pricing during the sales cycle. The affirmative answer will help the firms to improve their performance. Another problem we need to study is that when should the firms use bundling strategy: at the beginning of selling season or later in the season. In addition, the strategy customers who will decide the time of their purchase will be considered in our research. Then we will further study the effect of customers’ strategy behavior on the firms’ profit and selling strategy.

Our work is also related to the literatures on complementary products pricing and bundling, such as Gabszewicz et al. (2001), Yue et al. (2006), Wang (2006), Chris et al. (2013), etc. This research differs from the existing literature, we consider the markdown pricing and bundling strategy of complementary products in multiple periods, the consumer has the option to buy or not, and decide the time of buying with their strategic behavior. Besides, we also consider forward-looking strategic consumer who will make their buying decisions according to their prediction of firms’ future behavior. In the research, we focus on the firms’ price decisions and selling strategy considering the game process between the firm and the strategic consumer.

This paper is organized as follows. The next section presents the model description and results of MD strategy. Section 3 describes the period bundling strategies and compares the different strategies. The Effects of consumer’s strategic behavior are shown in Section 4. Section 5 concludes the paper.

II. PROBLEM DESCRIPTION AND MARKDOWN PRICING STRATEGY

In this section, we first describe the supply side and strategic consumer, and then discuss the equilibriums in the markdown pricing strategy.

A. Problem statement

We consider the firm selling two complementary products (A and C) in two periods. The major product A has independent value for the consumer, for example computers, mobile phones and so on, while the complementary product C doesn’t have value independently for the consumer but becomes valuable in the combination product AC. We assume that the value of product A in the first period is 1, then the
product AC has the value of $\delta$, i.e., $v_a = 1, v_{ac} = \delta$. The value of $\delta$ with $1<\delta<2$ indicates the complementary coefficient of products A and C. In the second period, the values of products A and AC decrease by $\alpha$ (i.e., the value discount coefficient, $0 < \alpha < 1$), and then $v_{2a} = \alpha, v_{2ac} = \alpha\delta$. In addition, the unit cost of products A and AC in two periods are $c$ and $\delta c$, respectively. To maximize her total profit over the selling period, the seller should determine the products prices in the first period and markdown pricing prices in the second period.

All consumers are present at the beginning of selling period and leave the market when they purchase one unit of a product. They consider various alternatives including whether to buy a product, which kind of product to buy (major product A or combined product AC), when to buy a product (in the first period or latter in second period). In the first period, every strategic consumer decides whether to buy a product right away or wait for the markdown pricing in the second period with lower product value. The value of $\alpha$ indicates the degree of strategic customers’ patience, higher $\alpha$ means more patience. In period 2, the waiting consumer makes decisions of buy a product or leave the market without purchase. In the presence of strategic consumer, the seller needs to make price decisions taking account of consumer’s waiting behavior. We want to solve the equilibriums of waiting game between the seller and strategic consumer. The event timing of game is described in Figure 1.

The type $\hat{\theta}_i$ consumer obtains the same utility from buying product in period 1 and in period 2, and the type $\hat{\theta}$ ($\hat{\theta} > \hat{\theta}_i$) consumer will purchase products in period 1. In the first period, the threshold type $\hat{\theta}_{i\text{ac}}$ consumer gets the same utility from purchasing a major product A and combination product AC. Therefore, the type $\hat{\theta}$ consumer will buy combination product AC in period 1 if $\hat{\theta} > \hat{\theta}_{i\text{ac}}$, otherwise he will buy major product A if $\hat{\theta}_i < \hat{\theta} < \hat{\theta}_{i\text{ac}}$. We assume that $0 < \alpha\delta < 1$, which means that the consumer prefers buying product A to waiting for combination product AC in period 2 when these two products are priced equally. In period 2, there exists the threshold type $\hat{\theta}_{2\text{ac}}$ consumer who is indifferent of buying product AC or A. Finally, the waiting consumer gets lower utility from buying product A than no purchasing, if $\hat{\theta} < \hat{\theta}_{2\text{ac}}$, then he will leave the market without buying.

With the assumption of consumer utility from buying different products in different periods, we can get the threshold types: $\hat{\theta}_{i\text{ac}} = p_{i\text{a}} / (\delta - 1), \hat{\theta}_i$, determined by

$$\max(\hat{\theta}_i - p_{i\text{a}} - \hat{\theta}_i - p_{i\text{ac}}) = \alpha\hat{\theta}_i - p_{i\text{a}} - \alpha\hat{\theta}_i,$$

$$\hat{\theta}_{2\text{ac}} = p_{2\text{a}} / (\alpha(\delta - 1))$$

and $\hat{\theta}_{2c} = p_{2\text{c}} / \alpha$, in which $0 \leq \hat{\theta}_{2\text{c}} \leq \hat{\theta}_{2\text{ac}} \leq \hat{\theta} \leq \hat{\theta}_{i\text{ac}} \leq 1$. Then, the allocations of market demand are: $D_{i\text{ac}} = 1 - \hat{\theta}_{i\text{ac}}, D_{i\text{a}} = \hat{\theta}_i - \hat{\theta}_{i\text{ac}}, D_{2\text{ac}} = \hat{\theta}_i - \hat{\theta}_{2\text{ac}}$ and $D_{2\text{a}} = \hat{\theta}_{2\text{ac}} - \hat{\theta}_{2\text{c}}$.

B. Nash equilibrium of markdown pricing strategy

The business relationship between the seller and the strategic consumer is described by a non-cooperative game, and they are seeking a sub-game perfect Nash equilibrium (SPNE) to keep the long-term partnership. In the game, the seller optimizes the price in each period, and the strategic consumer makes their buying decisions optimally according to their rational expectation.

The seller decides his markdown prices based on the rational prices in period 1 to maximize his profit in period 2. The Nash equilibrium of period 2 is defined by

$$\max \Pi_2 = (\hat{\theta}_i - \hat{\theta}_{2\text{ac}})(p_{2\text{a}} + p_{2\text{c}} - \delta c) + (\hat{\theta}_{2\text{ac}} - \hat{\theta}_{2\text{c}})(p_{2\text{c}} - c),$$

where $0 \leq \hat{\theta}_{2\text{c}} \leq \hat{\theta}_{2\text{ac}} < \hat{\theta}_i$.

It can be easily proved that $\Pi_2$ is concave, then the objective can be written as a Lagrange function:

$$L = \Pi_2(p_{2\text{a}}, p_{2\text{c}}) + \gamma_2(-\hat{\theta}_{2\text{c}}) + \gamma_2(\hat{\theta}_{2\text{ac}} - \hat{\theta}_{2\text{c}}) + \gamma_2(\hat{\theta}_{2\text{c}} - \hat{\theta}_i).$$

With the KKT conditions, we can get the equilibrium prices: $p^*_{2\text{a}} = (\alpha\hat{\theta}_i + c) / 2$, $p^*_{2\text{c}} = [\alpha(\delta - 1)\hat{\theta}_i + (\delta - 1)c] / 2$.

Then, $\hat{\theta}_{2\text{c}}^* = (\alpha\hat{\theta}_i + c) / 2\alpha$, which means that the
waiting consumer in period 2 will buy the combination product AC or leave the market.

With the equilibrium prices in period 2, the seller decides the price in period 1 to maximize the total profit in selling period. The game in period 1 are defined by

$$\max \Pi = (1 - \hat{\theta}_{ac})(p_{ia} + p_{ic} - \delta c) + (\hat{\theta}_{ac} - \hat{\theta})(p_{ia} - c) + \Pi'$$,

where $$\Pi' = (\hat{\theta} - \theta_{ac})(p_{ia}^* + p_{ic}^* - \delta c)$$, $$\hat{\theta}$$, determined by

$$\max(\delta \hat{\theta} - p_{ia} - p_{ic}, \hat{\theta} - p_{ia} - p_{ic}) = \max(\alpha \hat{\theta} - p_{ia} - p_{ic}, \alpha \hat{\theta} - p_{ia} - p_{ic})$$ .

$$p_{ia}^* = (\alpha \hat{\theta} + c)/2$$, and $$p_{ic}^* = [\alpha(\delta - 1)\hat{\theta}, + (\delta - 1)c]/2$$ .

The following Proposition 1 shows the seller’s optimal polices and the strategic consumer’s buying behavior.

**Proposition 1.** The SPNE in markdown pricing strategy.

1. When $$\frac{c}{2} + 1 < \theta < \frac{\alpha}{4 - 3\alpha}$$ ,

$$p_{ia}^* = \frac{(2 - \alpha \delta)^2 + (4 - 2\alpha \delta - \alpha^2)c}{8 - 6\alpha \delta}$$ ,

$$p_{ia}^* + p_{ic}^* = \frac{\delta c}{2} - \frac{\delta c}{2}$$ . The consumer with

$$\frac{2 - \alpha}{4 - 3\alpha} < \theta < \frac{2 - \alpha}{4 - 3\alpha}$$ buys product AC in period 1, and the consumer with

$$2 - \frac{\alpha}{4 - 3\alpha} < \theta < 2 - \frac{\alpha}{4 - 3\alpha}$$ buys product AC in period 2. From Proposition 1, by MD strategy, the seller will cut the price of complementary product in period 2 because of the reduction of product value. We also find that the prices of products A, C and AC decrease in $$\alpha$$, less reduction of product value cause lower decrease of prices. However, the price decreases of product AC increase with $$\delta$$, because higher $$\delta$$ means more value reduction of product AC.

III. PERIOD BUNDLING STRATEGIES AND COMPARISON

In this section, we investigate the period bundling strategy. The seller bundles complementary products in the first or second period to increase the products’ value, and he bundle products in one period but sell products separately in another period. The value of bundle product in the first period is $$v_{ij} = r$$, while $$r$$ means the bundling effect of complementary products A and C. We assume that $$1 < \delta < 2$$ and $$\alpha < 1$$. The value of bundled product is higher than that of combined products for consumer, and the consumer prefers to buy the major product A in the first period and buy the bundled products in second period with the same price. However, bundling will increase the production cost to $$c_{b} = r c$$.

For the seller and the strategic consumer, there are two types of bundling strategies to achieve the optimal decisions, i.e., the Second Period Bundling (SPB) strategy and the First Period Bundling (FPB) strategy. In SPB strategy, the seller provides the complementary product C in period 1, but only provides the bundled product AC in period 2.

A. SPB strategy

In SPB strategy, the seller decides the prices of products A and C in period 1 ($$p_{ia}^{SPB}$$, $$p_{ic}^{SPB}$$) and the price of bundled product AC in period 2 ($$p_{ia}^{AC}$$). According to consumer types and rational expectations, the strategic consumer decides which kind of products to buy in period 1 and whether or not to wait for the bundled product in period 2. Then, the market allocations by the threshold consumer are shown in Figure 3.

![](image)

**Figure 3.** The allocation of market demand in SPB strategy

Given the consumer’s buying decisions, by solving the seller’s two-stage optimization problem, we get Proposition 2, which describes the optimal decisions for the supply chain members in SPB strategy.

**Proposition 2.** In SPB strategy,

1. When $$\frac{\alpha}{4 - 3\alpha} < \theta < \frac{\alpha(2 - \alpha)}{4 - 2\alpha - \alpha}$$ ,

$$p_{ia}^{SPB} = \frac{(2 - \alpha)^2 + (4 - 2\alpha - \alpha')c}{8 - 6\alpha}$$ ,

$$p_{ic}^{SPB} = \frac{(\delta - 1)(c + 1)}{2}$$ ,

$$p_{ia}^{AC} = \frac{\alpha(2 - \alpha)^2 + (4 - 2\alpha - \alpha')c}{2(4 - 3\alpha)(2 - \alpha)} - \frac{\delta c}{2} + \frac{\delta c}{2}$$ . The consumer with

$$\frac{2 - \alpha}{4 - 3\alpha} < \theta < 1$$ buys product AC in period 1, and the consumer with

$$\frac{2 - \alpha}{4 - 3\alpha} < \theta < \frac{2 - \alpha}{4 - 3\alpha}$$ buys product AC in period 2. From Proposition 1, by MD strategy, the seller will cut the price of complementary product in period 2 because of the reduction of product value. We also find that the prices of products A, C and AC decrease in $$\alpha$$, less reduction of product value cause lower decrease of prices. However, the price decreases of product AC increase with $$\delta$$, because higher $$\delta$$ means more value reduction of product AC.
When \( 0 < c < \frac{\alpha}{4-3\alpha} \),

\[
p_{i_1w} + p_{i_2w}^* = \frac{(\delta - ar)^2 + (4\delta^2 - 2\alpha dr - ar^2)c}{2(\delta - ar)(4\delta - 3ar)}
\]

and

\[
p_{i_2w} = \frac{ar}{2} \left( \frac{(\delta - ar)^2 + (4\delta^2 - 2\alpha dr - ar^2)c}{2(\delta - ar)(4\delta - 3ar)} - \frac{rc}{2\alpha} \right) + \frac{rc}{2}.
\]

The consumer with \( \frac{rc}{2\delta - ar} < \theta < 1 \) buys product AC in period 1, and the consumer with \( \frac{1}{2} \left( \frac{(\delta - ar)^2 + (4\delta^2 - 2\alpha dr - ar^2)c}{2(\delta - ar)(4\delta - 3ar)} - \frac{rc}{2\alpha} \right) + \frac{c}{2\alpha} < \theta < \frac{(\delta - ar)^2 + (4\delta^2 - 2\alpha dr - ar^2)c}{2(\delta - ar)(4\delta - 3ar)} - \frac{rc}{2\delta - ar} \) buys product AC in period 2.

**B. FPB strategy**

In FPB strategy, the seller provides the bundled product AC in period 1 and the complementary product C in period 2, separately. The market is allocated by four parts, which is shown in Figure 4.

![Figure 4. The allocation of market demand in FPB strategy](image)

Similarly, we have Proposition 3 about the optimal decisions in FPB strategy.

**Proposition 3.** When \( 0 < c < \frac{\alpha(2r - \alpha\delta)}{4r - 2ar - \alpha\delta} \),

\[
p_{i_1w}^{FPB} = \frac{(2r - \alpha\delta)^2 + (4r^2 - 2\alpha dr - \alpha\delta^2)c}{8r - 6\alpha\delta}
\]

and

\[
p_{i_2w}^{FPB} + p_{i_2w}^{FPB} = \frac{\alpha}{2} \left( \frac{2r - \alpha\delta + 2(r - \delta)c}{4r - 3\alpha\delta} \right) + \frac{\delta c}{2}. \]

The consumer with \( \frac{2r - \alpha\delta + 2(r - \delta)c}{4r - 3\alpha\delta} < \theta < 1 \) buys the bundled product AC in period 1, and the consumer with \( \frac{2r - \alpha\delta + 2(r - \delta)c}{4r - 3\alpha\delta} < \theta < \frac{2r - \alpha\delta + 2(r - \delta)c}{4r - 3\alpha\delta} \) buys the products A and C in period 2.

In the period bundling strategy, the bundling increases the added value of products in the bundling period and the seller will increase the price of bundled product to capture benefit from the bundling effect of complementary products. From the propositions 2 and 3, it is found that the optimal price of bundled product in period 2 of SPB and that in period 1 of FPB increase in the bundling effect, and the price of major product A in period 1 of SPB decreases in bundling effect and the total price of product A and C in period 2 of FPB increases in bundling effect.

**C. Comparisons**

Because \( 1 < \delta < 2 \) and \( 0 < a < 1 \), it can be proved that

\[
\frac{\alpha(2r - \alpha\delta)}{4r - 2ar - \alpha\delta} < \frac{\alpha(2 - ar)}{4 - 2a - \alpha - \delta} < \frac{\alpha(2r - \alpha\delta)}{4r - 2ar - \alpha\delta}. \]

To compare the different strategies, we assume \( 0 < c < \frac{\alpha(2r - \alpha\delta)}{4r - 2ar - \alpha\delta} \), which is the existence condition of SPNE. Comparing Propositions 2 and 3 with Proposition 1, we can get the following conclusion about the seller’s price decisions in different strategies.

**Proposition 4.**

\[
p_{i_1}^{SPB} < p_{i_1}^{SPB} < p_{i_1}^{SPB}, \quad p_{i_2}^{SPB} + p_{i_2}^{SPB} > p_{i_2}^{SPB} + p_{i_2}^{SPB}, \quad p_{i_2}^{SPB} > p_{i_2}^{SPB} + p_{i_2}^{SPB} > p_{i_2}^{SPB} + p_{i_2}^{SPB}.
\]

Proposition 4 shows that the seller’s optimal price of bundle product in period 2 of SPB and period 1 of FPB are higher than the prices of combined products in MD strategy.

Also, the effects of strategies on the seller’s profit in entire selling period are shown in Proposition 5.

**Proposition 5.** When \( \frac{\alpha}{4 - 3\alpha} < c < \frac{\alpha(2 - ar)}{4 - 2ar - \alpha\delta} \),

\[
\Pi^{SPB} < \Pi^{FPB}, \quad \text{when } 0 < c < \frac{\alpha}{4 - 3\alpha} \quad \Pi^{SPB} < \Pi^{FPB} \text{ if } \frac{2}{3} < \alpha / \delta < 1, \text{ otherwise } \Pi^{SPB} < \Pi^{FPB}.
\]

In the presence of strategic consumer, the profit of seller with complementary products is highest in FPB strategy where he bundles the products in period 1 and sells products separately in period 2, when \( 0 < c < \frac{\alpha(2 - ar)}{4 - 2ar - \alpha\delta} \). However, the SPB strategy is not also better than MD strategy. When \( 0 < c < \frac{\alpha}{4 - 3\alpha} \), SPB strategy is better if \( \frac{2}{3} < \alpha / \delta < 1 \), otherwise SPB strategy is worse than MD strategy. When \( \frac{\alpha}{4 - 3\alpha} < c < \frac{\alpha(2 - ar)}{4 - 2ar - \alpha\delta} \), the seller gets less profit in SPB strategy than that in MD strategy.

In FPB, the seller will benefit from the bundling effect and high added value bundle products in period 1 attract more consumers make their buying in full value period. On the contrary, in SPB, the bundling in period 2 will make the consumer waiting and cause the profit reduction of seller in period 1. For improving his selling period profit, the seller would rather choose to bundle complementary product in period 1 to increase the added value for the consumer expectation than sell products separately.

Moreover, in the presence of strategic consumer, the period bundling of complementary product as an important mean to extend the firms’ product life cycle and improve enterprise brand could also increase the firms’ profit. But the seller needs to consider the time when he can use the strategy.
Most of the time, he would bundle the complementary products in the first period of selling time, and sell the products separately late in the selling time. Only when the unit cost of major product A satisfies $0 < c \leq \frac{\alpha}{4 - 3\alpha}$ and $\frac{2}{3} < \frac{\alpha r}{\delta} < 1$, the bundling strategy in period 2 is benefit.

IV. ANALYSIS OF CONSUMER’S STRATEGIC BEHAVIOR

Different with the strategic consumer, the myopic consumer in the market makes his buying decision according to the prices of products in the present period, that’s to say, the consumer does not have the strategic waiting behavior. For the myopic consumer, we can describe the market allocations with the threshold consumer as $\hat{\theta}_{1ac} = p_{1c}^e / (\delta - 1)$, $\hat{\theta}_{2c} = p_{2c}^e$, $\hat{\theta}_{3c} = p_{3c}^e / (\alpha(\delta - 1))$ and $\hat{\theta}_{ac} = p_{ac}^e / \alpha$, see in Figure 5.

With the assumption that $0 < c < \alpha / (2 - \alpha)$, we get the equilibrium solutions in MD strategy with the myopic consumer: the seller decides his prices as $p_{1u}^* + p_{1c}^* = \frac{2\delta + \delta c}{4 - \alpha}$, $p_{1u}^* + p_{2c}^* = \frac{\alpha \delta + 2\delta c}{4 - \alpha}$, and the consumer with $\frac{2 + c}{4 - \alpha} < \theta < 1$ buys product AC in period 1 and the consumer with $\frac{\alpha + 2c}{(4 - \alpha)\alpha} < \theta < \frac{2 + c}{4 - \alpha}$ buys product AC in period 2. When $c > \frac{\alpha}{2 - \alpha}$, there is no selling in period 2.

<table>
<thead>
<tr>
<th>Product A in period 2</th>
<th>Product AC in period 2</th>
<th>Product A in period 1</th>
<th>Product AC in period 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\hat{\theta}_{1c}$</td>
<td>$\hat{\theta}_{2c}$</td>
<td>$\hat{\theta}_{1a}$</td>
<td>$\hat{\theta}_{2a}$</td>
</tr>
</tbody>
</table>

Figure 5. The allocation of market demand in MD with myopic consumer

Similarly, we get the equilibrium solutions in SPB and FPB strategy with the myopic consumer.

In SPB strategy, $p_{1u}^{SPB} + p_{1c}^{SPB} = \frac{2\delta + (2\delta^2 - r\delta)c}{4\delta - r\alpha}$, $p_{2u}^{SPB} = \frac{\alpha r}{2\delta} \left( \frac{2\delta^2 + (2\delta^2 - r\delta)c}{4\delta - r\alpha} \right) + \frac{r c}{2}$, the consumer with $\frac{2\delta + (2\delta^2 - r\delta)c}{4\delta - r\alpha} < \theta < 1$ buys products A and C in period 1, and the consumer with $\frac{1}{2\delta} \left( \frac{2\delta + (2\delta^2 - r\delta)c}{4\delta - r\alpha} \right) + \frac{c}{2\alpha} < \theta < \frac{2\delta + (2\delta^2 - r\delta)c}{4\delta - r\alpha}$ buys product AC in period 2.

In FPB strategy, $p_{1u}^{FPB} = \frac{2r^2 + (2r - \delta)c}{4r - \alpha \delta}$ and $p_{2u}^{FPB} + p_{2c}^{FPB} = \frac{\alpha \delta}{2} \left( \frac{2r + (2r - \delta)c}{4r - \alpha \delta} \right) + \frac{\delta c}{2}$, the consumer with $\frac{2r + (2r - \delta)c}{4r - \alpha \delta} < \theta < 1$ buys product AC in period 1, and the consumer with $\frac{1}{2} \left( \frac{2r + (2r - \delta)c}{4r - \alpha \delta} \right) + \frac{c}{2\alpha} < \theta < \frac{2r + (2r - \delta)c}{4r - \alpha \delta}$ buys products A and C in period 2.

With the myopic consumer, $\Pi^{FPB} > \Pi^{SPB} > \Pi^M$, which means that the seller will have more profit by the period bundling of complementary, especially bundling in period 1. This result is different from Proposition 4 in which the seller games with strategic consumer, the consumer’s strategic behavior will affect seller’s choice of selling strategy.

Furthermore, in any selling strategy, the consumer’s strategic behavior impact on seller’s pricing decisions. In the presence of strategic consumer, it can be derived that $p_{1u}^* + p_{1c}^* < p_{1u}^* + p_{2c}^*$, $p_{2u}^{SPB} + p_{2c}^{SPB} < p_{2u}^{FPB} + p_{2c}^{FPB}$ and $p_{1u}^{FPB} < p_{1u}^{SPB}$, which mean that the seller will cut his prices in the market with strategic consumer.

By the numerical experiments, we get the Figure 6 and Insight 1, which show the effects of consumer strategic behavior on seller’s profits in three selling strategies (MD, SPB and FPB).

Insight 1. In three selling strategies, the seller will suffer a loss of profit in the presence of strategic consumer, and the loss will increase with the consumer’s patience. However, the profit reduction in FPB strategy is highest of all and that in SPD and MD strategy are similar.

As proved that the seller’s profit is reduced with the consumer’s strategic behavior in every selling strategy, and more patience of consumer cause more reduction. But in SPB strategy, bundling increases the consumer’s patience to $\alpha \delta$ in period 2, so the loss in SPB is higher than that in MD. When seller bundles products in period 1, the added value of products in period 1 attracts the consumer to make purchase in period 1 and decrease the consumer’s patience. At the same time, the prices reduction of bundled product in period 1 caused by consumer’s strategic behavior is higher than that of product AC. When consumer’s patience is low, the loss in FPB is less than that in MD. But when $\alpha$ is high, the loss in FPB is higher than that in MD.

Next, we investigate the effects of consumer’s patience on seller’s profits, which are shown in Figure 7.
From Figure 7, we have the Insight 2.

**Insight 2.** In the presence of strategic consumer, the seller’s profit in MD and FPB strategies decreases in the consumer’s patience, while the profit in SPB first decreases and increases later in the consumer’s patience.

When the consumer is more patient, the seller will utilize MD and FPB strategies to make more reduction of prices in period 1, and he gets less profit in all selling period. However, in SPB strategy, with the increase of \( \alpha \), the seller gets more benefit from the bundled product but lost more profit for consumer’s patience. When the value \( \alpha \) is high enough, the benefit is higher than loss and seller’s profit increase in \( \alpha \).

From Figure 7, we also can find that the profit in FPB strategy is higher than that in other two strategies. For SPB and MD strategies, in a small area when \( \alpha \) is quite high, SPB strategy is better than MD strategy, otherwise SPB is worse for seller.

**V. CONCLUSION**

We analyze the selling strategy and price decision for the seller providing two complementary products in two periods in the presence of strategic consumer.

We first establish three pricing - purchase game models under selling strategies of markdown pricing, second period bundling and first period bundling, and obtain the closed-form solutions to the optimal prices in each period and consumer’s buying behavior.

Secondly, we provide some comparisons of the equilibrium solutions and profits under three different selling strategies. Our results show that the product prices in second period under period bundling strategy are higher than that under markdown pricing strategy, and the seller will get the most profit using first period bundling strategy, while the profit under second period bundling strategy is not always better than that under markdown pricing strategy.

Thirdly, we explore the effect of consumer’s strategic behavior and patience on the seller’s selling strategy and profit, and provide some interesting managerial insights.

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**REFERENCES**


