Advance Consumer Behavior Analysis Influenced by Technical Innovation and Promotion

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Abstract. This paper analysis the influence of technical innovation on advance and spot competition equilibrium. It finds out that the spot promotion has no influence on advance price, but it has a negative effect on both advance price and total revenues. And by providing newest technical innovation which costs little than before, it concludes that technical innovation enlarges consumer preference choice. It could improve firm’s advance price, but its optimal total revenue maybe decrease. And the advance price has a minimum value. So, technical innovation also can help firms to make their price strategy better.

Introduction
Today online advance selling strategy has become common in China, especially on Taobao, Jingdong, Biyao, and other online shopping platforms. At the same time, there come out many new marketing strategy that focus on close relationship with consumers. One is improving consumer’s shopping preferences by providing newest technical innovation, which provides new ideas, etc. and costs little than before, such as a label on bottled water that can help people recognize it more easily. Kinds of diversified marketing tools plus various of low-cost technical innovation at the same time make the competition more intense and complicated. In this paper, it focuses on some problems as follows:

When the advance and spot mix competition equilibrium happens, if consumer’s homogeneity is high, what will happen when consumer’s expected value vary much or little?
When the spot market is more popular for retailers? Why?
By providing newest technical innovation which costs little than before, how the optimal price and revenue of the retailers would change? What does that mean?

Gale and Holmes (1993) find that advance-purchase discounts allows a firm to price discriminate between homogeneous and heterogeneous consumers about their future utility for a product & service. Xie and Shugan (2001) extend the work of Shugan and Xie (2000) and show that selling in advance is good for a firm as long as the unit marginal cost is not too high. Cachon and Feldman (2017) show that with competition the firms may be better off if they sell only in the spot period, and advance selling is better described as a competitive necessity than as a advantageous tool to raise profits. LI Yi-peng and MA Shi-hua, etc. (2017) build an advance selling model and the result shows that advance selling can be harmful to retailer’s benefit if it can’t switch more consumers from competitors. In these papers, consumers never consider the influence of kinds of marketing tools, especially technical innovation to advance competition.
Basic Model

Model Description and Consumer Behavior Analysis

At advance period, the expected value of consumer’s preferred product is $\mathcal{E}[V]=\frac{1}{2}(v_L+v_H)$, where $V \in \{v_L,v_H\}$, $v_H \geq v_L > 0$, and the spot price is $v_H = \frac{2\mathcal{E}(V)}{\beta+1} \left( \beta = \frac{v_L}{v_H} \in \left(0, \frac{1}{2}\right) \right)$ which means that $v_H \geq 2v_L$ and $\beta$ is the value of $v_L$ relative to $v_H$. At the same time, it assume that $\alpha$ is the probability that one customer attaches for preferring firm 1 in the advance period, and $\alpha$ is a uniform random variable, $\alpha \sim U\left[\frac{1-\delta}{2}, \frac{1+\delta}{2}\right]$ where $\delta \in [0,1]$. As $\delta$ increases which might be caused by technical innovation, consumers become more heterogeneous about their eventual preference. It gives all consumer’s behavior in Figure 1 ($\delta > \frac{1}{3}$) as follows:

Firstly, consumer’s individual rationality constraint (IR) about preferring firm 1 is $p_i \leq \alpha \mathcal{E}[V]$; the curve $\Gamma_1$ means $p_i = \frac{1-\delta}{2} \mathcal{E}[V]$; the curve $\Gamma_2$ means $p_i = \frac{1+\delta}{2} \mathcal{E}[V]$. Similarly, $p_i \leq (1-\alpha)E[V]$ is consumer’s individual rationality constraint (IR) about preferring firm 2, and the curve $\Gamma_3$ means $p_i = \frac{1-\delta}{2} \mathcal{E}[V]$; the curve $\Gamma_4$ means $p_i = \frac{1+\delta}{2} \mathcal{E}[V]$.

Secondly, consumer’s incentive compatibility constraint (IC) about preferring firm 1 is $p_i \leq p_i - (1-\alpha) \mathcal{E}[V]$ $\left( (1-2\alpha) \sim U\left[-\delta, \delta\right] \right)$, the curve $\Gamma_5$ means $p_i = p_i + \alpha \mathcal{E}[V]$, the curve $\Gamma_6$ means $p_i = p_i - \alpha \mathcal{E}[V]$. And, $p_i \geq p_i - (1-2\alpha) \mathcal{E}[V]$ is consumer’s incentive compatibility constraint (IC) about preferring firm 2. If $p_i - \alpha \mathcal{E}[V] \leq p_i \leq p_i + \alpha \mathcal{E}[V]$, consumers can make an advance purchase decision from firm 1 or firm 2; if $p_i > p_i + \alpha \mathcal{E}[V]$, consumers would give up buying from firm 1 in advance period, and in the same way if $p_i \leq p_i - \alpha \mathcal{E}[V]$, there is no any consumers buying from firm 2 in advance period.

Thirdly, the curve $\Gamma_7$ is $p_i + p_i = \mathcal{E}[V]$, which indicates that if $p_i + p_i < \mathcal{E}[V]$, all consumers would like to buy from firm 1 or firm 2 in advance period.

Finally, Figure 3 is divided into 7 parts in summary. The point $A\left(\frac{1-\delta}{2} \mathcal{E}[V], \frac{1+\delta}{2} \mathcal{E}[V]\right)$ is the intersection of four curves; the point $B\left(\frac{1+\delta}{2} \mathcal{E}[V], \frac{1+\delta}{2} \mathcal{E}[V]\right)$ is the intersection of two curves; the point $C\left(\frac{1-\delta}{2} \mathcal{E}[V], \frac{1-\delta}{2} \mathcal{E}[V]\right)$ is the intersection of two curves; the point $D(0, \alpha \mathcal{E}[V])$, the point $E(\alpha \mathcal{E}[V], 0)$ are another two points in Figure 3. All of these seven areas represent the purchasing demand trends of consumers in different regions respectively. For example, the area $(\alpha_2)$ indicates that within the $(p_1; p_2)$ price space, consumers will only choose to buy in advance from firm 2; the area $(\alpha_1, \alpha_3)$ means that consumers will buy from the spot market or buy in advance from firm 1, but not from firm 2; the area $(\alpha_1, \alpha_3, \alpha_3)$ means that consumers in the $ABC$ triangle area may buy from the spot market, or buy in advance from firm 1 or firm 2, all of which may occur. And so on.
Besides, if $0 < \delta \leq \frac{1}{3}$, there is $\mathbb{E}[V] \leq \frac{1-\delta}{2} \mathbb{E}[V]$, and Figure 1 will change, as shown in Figure 2. The only difference is that the area of the $ABC$ triangle becomes smaller.

**Advance Competition Equilibrium**

Firstly, in the range of $(\alpha, \alpha_2)$, firm 1 and firm 2 join in advance competition together, and firm 1’s profit function is

$$
\prod_{11} = \frac{p_1}{2\delta} \left( \delta - \frac{p_2 - p_1}{\mathbb{E}[V]} \right),
$$

firm 2’s profit function is

$$
\prod_{21} = \frac{p_2}{2\delta} \left( \delta - \frac{p_2 - p_1}{\mathbb{E}[V]} \right).\
$$

when $p_{11}^* = p_{21}^* = \mathbb{E}[V]$, the two firms realize maximal revenues.

Secondly, in the range of $(\alpha, \alpha_2, \alpha_3)$, firm 1 and firm 2 join in both advance competition and spot market, and firm 1’s profit function is

$$
\prod_{1i}(p_1; p_2) = p_1 \times \frac{1}{\delta} \times \left( 1 + \frac{\delta}{2} - \frac{p_1}{\mathbb{E}[V]} \right) \frac{2\mathbb{E}[V]}{\beta + 1} \int_{1-\alpha/\mathbb{E}[V]}^{1-\alpha/\mathbb{E}[V]} \frac{dF}{\alpha}.\
$$

Here, spot market demand from firm 1 is $D^i = \frac{\mathbb{E}[V]}{2} dF$, and the spot market demand from firm 2 is $D^i = \frac{\mathbb{E}[V]}{2} dF$. consumer’s advance demand is $F(\alpha(p_1, p_2))$ from firm 2 and consumer’s advance demand is $\mathbb{E}[V] - F(\alpha(p_1, p_2))$ from firm 1. where $F(\alpha)$ is the cdf of $\alpha$, and $\hat{\alpha} = \frac{1}{2} \left( 1 + \frac{p_1 - p_2}{\mathbb{E}[V]} \right)$. By derivation it finds that $p_{12}^* = p_{22}^* = \frac{(1 + \delta)(\beta + 1)\mathbb{E}[V]}{2(2\beta + 1)}$. In Cachon, G. P. & Feldman, P(2017) it has given the detailed analysis, and the conclusion is as follows in Theorem 1.
Theorem 1 In the range of \(0 < \delta \leq \frac{5 + 10\beta + \beta^2 - 2\sqrt{1 + \beta - 3\beta^2 - \beta^3 + 2\beta^4}}{7 + 18\beta + 7\beta^2} \), the advance competition equilibrium realizes at the point of \(p_{11}^* = p_{21}^* = \delta E[V] \); in the range of \(\frac{5 + 10\beta + \beta^2 - 2\sqrt{1 + \beta - 3\beta^2 - \beta^3 + 2\beta^4}}{7 + 18\beta + 7\beta^2} < \delta \leq \frac{1}{2}\), firms would compete in both advance competition and spot market, and the competition equilibrium realizes at the point of \(p_{12}^* = p_{22}^* = \frac{(1 + \delta)(\beta + 1)E(V)}{2(2\beta + 1)}\).

Further, in the range of \(\left[\delta_1(\beta), \frac{5 + 10\beta + \beta^2 - 2\sqrt{1 + \beta - 3\beta^2 - \beta^3 + 2\beta^4}}{7 + 18\beta + 7\beta^2}\right]\), both of the two competition equilibrium exist. Besides, in the range of \(\delta < \frac{1 + 2\beta - \beta^2}{(1 + \beta)^2}\) both of the firms will compete only on spot market.

Corollary 1 the spot market promotion improves online market total demand and decreases spot price. The spot market promotion has an positive effect on total revenues, however, it has no influence on advance price \(p_1\) or \(p_2\). On the other hand, The spot market promotion has an negative effect on both advance price and total revenues.

Corollary 2 By providing newest technical innovation which costs little than before for firm 1, technical innovation enlarges consumer preference choice, that is, the firm’s parameter \(\delta\) becoming bigger.

**Technical Innovation Numerical Analysis**

**General Numerical Analysis**

In figure 3, curve① refers to \(\delta = \frac{2\beta + 1}{\beta + 1}\) which comes from \(p_1 + p_2 \geq E[V]\); curve② refers to \(\delta = \delta_2(\beta)\) which comes from Cachon, G. P. & Feldman, P(2017)’s conclusion; curve③ refers to \(\delta = \frac{5 + 10\beta + \beta^2 - 2\sqrt{1 + \beta - 3\beta^2 - \beta^3 + 2\beta^4}}{7 + 18\beta + 7\beta^2}\); and curve④ refers to \(\delta < \frac{1 + 2\beta - \beta^2}{(1 + \beta)^2}\). The general numerical analysis comes out in Figure 3 and Table 1:

![Figure 3. Areas in the (δ, β) parameter space for which kind of competition is better for two firms.](image-url)
### Table 1. Figure 1’s Numerical Analysis.

<table>
<thead>
<tr>
<th>Parameter value</th>
<th>Conclusions</th>
</tr>
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<tbody>
<tr>
<td>( \delta = 0.8 ) &amp; ( \beta = 0.8 )</td>
<td>If consumer’s expected value ( V_L ) is close to ( V_H ) which means the product or service usually is necessities, advance purchase is better choice when consumer preference difference is too low or too high. So firms have to investigate consumer markets clearly. On the contrary, spot purchase or spot &amp; advance purchase is better choice for firms.</td>
</tr>
<tr>
<td>( \delta = 0.2 ) &amp; ( \beta = 0.8 )</td>
<td></td>
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By providing newest technical innovation which costs little than before for firm 1, such as creatively signable labels on mineral water bottles, foldable boiling water cup for travel, etc, what will happen about the optimal price and revenue of the retailers would change? All of these kinds of technical innovation make the difference in advance consumer’s preferences become larger. Based on Figure 3, it focused on curve② and curve③ to analyse the advance price’s rules as parameter \( \beta \) becoming bigger in Figure 4, Figure 5, Figure 6, and Figure 7. Here, the bigger parameter \( \delta \) is, the better the influence of technical innovation is; the bigger parameter \( \beta \) is, the closer the different value between expected value of \( V_L \) and \( V_H \). Besides, it assumes that \( E[V]=500 \).

![Firm1’s advance price’s curve as parameter \( \delta \) becoming bigger.](image1)

**Figure 4.** Firm1’s advance price’s curve as parameter \( \delta \) becoming bigger.

![Firm 1’s optimal revenues curve.](image2)

**Figure 5.** Firm 1’s optimal revenues curve.

In Figure 4, as the parameter \( \delta \) becoming bigger, the advance price \( p_1 \) ’s rule is different. When the influence of innovation technique is low, as the parameter \( \beta \) improving, the advance price \( p_1 \) ’s curve is concave, which is shown more clearly in Figure 6 and Figure 7. The advance price \( p_1 \) has a minimum value which increases as the parameter \( \delta \) becoming bigger. Further, if it improves the parameter \( \beta \) the minimum value of advance price \( p_1 \) curve moves towards that
upper right corner. So, technical innovation could improve firm’s advance price, and it also can help firms to make their price strategy better.

On the other hand, when the influence of innovation technique is high, the advance price \( p_i \) curve becomes almost a straight line rising to the right and up, which shows that if both the expected value of \( v_L \) and \( v_H \) is very near, advance price will be high; however, if the expected value of \( v_L \) is far below \( v_H \), the advance price may be low too, which is consistent with our life experience.

![Figure 6. Firm1’s advance price’s curve as parameter \( \delta = 0.45 \).](image)

![Figure 7. Firm1’s advance price’s curve as parameter \( \delta = 0.5 \).](image)

Finally, firm 1’s optimal advance price decreases slowly with the increasing parameter \( \beta \). However, it increases significantly with the improving parameter \( \delta \). Further, firm 1’s optimal total revenue decreases as the parameter \( \beta \) increasing, and the same rule happens as the parameter \( \delta \) increases.

Above all, if consumer’s advance demand utility and spot demand utility vary widely (\( \beta \) is small), both firm 1’s optimal advance price and optimal total revenue are high. If technical innovation has an positive effect (\( \delta \) is getting bigger), firm 1’s optimal advance price increases (Figure 4) but its optimal total revenue decrease, which means that neither consumers nor firms would like to this situation. The future research direction will be advance competition in different positions of enterprises, etc.

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**References**


