Pricing and Service Strategies Based on Buy-Online-and-Pick-up-in-Store

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Abstract: This paper studies whether the manufacturer with dual channels should carry out channel integration: BOPS (Buy-online-and-pick-up-in-store). Theoretical model is established to find out the optimal pricing and service strategies of the manufacturer before and after the implementation of BOPS. The influences of consumer's online shopping acceptance on pricing, service level are analyzed, and the comparison of manufacturer's price, online and offline service level, profits before and after the implementation of BOPS, and applicable conditions for the implementation of BOPS are given by numerical simulation.

1. Introduction

Increasingly, manufacturers are selling through their direct online channels, in addition to traditional (bricks-and-mortar) retail channels. It has been a global phenomenon that many customers choose to purchase products through online channel because of its great conveni-ence, large product variety, low price and search cost, etc [1, 2]. The Internet opens a new possibility for firms to increase their market coverage and profits by using their own direct online channel. Recently, various retail channels such as offline stores, Internet websites, and other various mobile devices are integrating into a single channel called an "omni-channel" and the borders between each of the channels are blurring [3]. Customers move freely between the offline and online store——PC or mobile, all within a single transaction process in the omni channel [4]. So, customers are able to access services such as "click and collect (BOPS, buy online and pick up in offline store)", "order in-store, deliver home", "order online, return to store", "showroom" and other combinations of online and traditional retail activities via the omni channel [5].

As an important mode of omni-channel, BOPS model not only provides consumers with faster service and better consumption experience, but also can bring additional consumption by draining consumers to offline stores [6].Tmall and Uniqlo have empolyed omni-channel. During the double 11 period in the year 2016, Uniqlo launched a "new retail experience economy", the use of online and offline synchronization promotion, buy-online-and-pick-up-in-store policy [7]. However, the implementation of BOPS has also increased the cost of services for offline stores, where offline stores may not have the incentive to offer BOPS pick-up services when the extra consumption is small [8-10]. At the same time, before the implementation of BOPS, manufacturer and retailer respectively control online and offline channels, the competition between them forms a price difference [11], the implementation of BOPS after the pricing strategy may reduce the fierce competition brought about by the ultra-low price, zero profit and other phenomena, but may also eliminate the benefits of appropriate competition. In addition, for different types of products, consumer channel preferences and channel transfer behavior will greatly affect pricing and service decisions, which challenges the implementation of BOPS and the design of profit distribution contracts between manufacturers and retailers [12, 13].

In the aspect of modeling research, Gao et al. have obtained the applicable conditions of BOPS from the point of view of inventory management, and think that BOPS has a positive effect on the expansion of consumer groups [14]. Chen et al. study the service competition and decision-making problem under the channel integration, takes the delivery time as the online channel service level, the product availability as the traditional retail channel service level, and tests the model through the experiment [15]. Chen et al. study the pricing and inventory decision of BOPS consignment model considering additional consumption under stochastic demand [16]. The above researches study the inventory problem, service decision or the joint decision of price and inventory in the case of BOPS. Our paper develops a tractable theoretical framework to study the problem of pricing and service joint decision-making before and after the implementation of BOPS.

The problem of pricing decision is widely studied in the research of dual channels [17], in which the joint decision of price and service has lots of research results [18]. Most of the research uses the method of manufacturer Stackelberg game and Bertrand game to depict the influence of price competition on dual-channel operation and management, and adopt pure price contract [19], income sharing contract, one-time transfer payment contract [20] and compensation contract and other contractual modalities for coordination. In addition, product type, shopping motivation and demographic factors all affect the cross-channel consumer group division, Bernstein et al. [21], Ding et al. [22] and others consider the channel selection and coordination strategy when consumer has the free-riding behavior. They found that the consumer's channel transferring behavior greatly affects channel selection, pricing and service decisions. All the above researches are about traditional dual channels, while this study introduces the BOPS one price system, compares the optimal decisions and profits before and after the implementation of BOPS.

The remainder of this paper is organized as follows: Section 2 specifies the model setup and its equilibrium analysis. Section 3 gives the numerical examples to analyze the effect of service allocation and consumer perception on the optimal solutions. We finally offer our conclusions and possibilities for future research in Section 4.

2. Basic Model

Firstly, we establish the model of BOPS mode. The manufacturer integrates its direct online channel and the retail channel, allowing consumers to order online and pick up the products in the retail stores. The manufacturer sets the online service level s_{ob}, the unit BOPS retail price p_b and offline service level s_{rb}. For buying one unit of product, the utility consumer gets from the direct online channel is $\mathrm{u_{ob}} = \theta \mathrm{v} - p_b + \beta\lambda s_{ob} + (1-\beta)s_{rb}$, where $\mathrm{v} \sim \mathrm{U}\,[0,1]$ denotes consumer's valuation of the product, θ represents customer's acceptance of online shopping, and λ is customer's perception of online service. With BOPS, the effect of service on the online customers stems from both the online and offline, where the ratios of the two channels are β, and $1-\beta$, respectively. Similarly, the utility consumer gets from the retailing channel is $\mathrm{u_{rb}} = \mathrm{v} - p_b + s_{rb}$. With $\mathrm{u_{ob}} = 0$, we have $\mathrm{v} = \mathrm{v_{ob}} = \frac{p_b - \beta\lambda s_{ob} - (1-\beta)s_{rb}}{\theta}$, indicating that the consumers with valuation $\mathrm{v_b}$ get zero utility from the direct channel. With $\mathrm{u_{rb}} = 0$, we have $\mathrm{v} = \mathrm{v_{rb}} = p_b - s_{rb}$, indicating the consumers with valuation $\mathrm{v_r}$ get zero utility from the retailing channel. With $\mathrm{u_{ob}} = \mathrm{u_{rb}}$, we have $\mathrm{v} = \mathrm{v_{eb}} = \frac{\beta\lambda s_{ob} - \beta s_{rb}}{1-\theta}$, indicating the consumers with valuation v_{eb} get the same utility from the two channels. Furthermore, when $\mathrm{v_{rb}} > \mathrm{v_{ob}}$, we have $\mathrm{v_{eb}} > \mathrm{v_{rb}} > \mathrm{v_{ob}}$; otherwise, $\mathrm{v_{eb}} < \mathrm{v_{rb}} < \mathrm{v_{ob}}$. Thus, when $\mathrm{v_{eb}} > \mathrm{v_{rb}} > \mathrm{v_{ob}}$, consumers with valuation $v \in [v_{ob}, v_{eb}]$ buy from the direct channel, and consumers with valuation $\mathrm{v} \in [\mathrm{v_{eb}}, 1]$ buy from the retailing channel (see Figure.1). We assume that the potential market scale is 1.

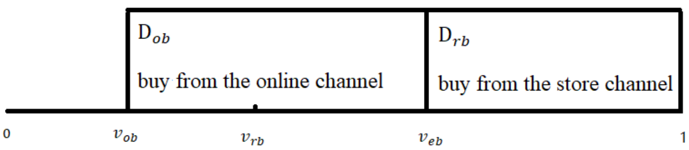

Figure 1. Demand when $\mathrm{v_{rb}} > \mathrm{v_{ob}}$

When $\mathrm{v_{eb}} < \mathrm{v_{rb}} < \mathrm{v_{ob}}$, the demand of direct channel is 0, consumers with valuation $\mathrm{v} \in$

$[v_{rb}, 1]$ buy from the retailing channel, the demand is shown in the following Figure.2.

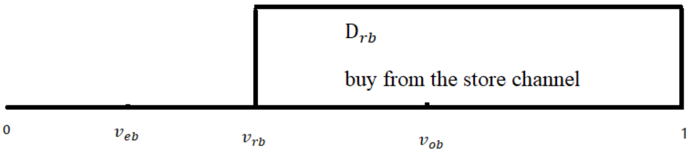

Figure 2. Demand when $v_{rb} < v_{ob}$

Thus, the demand of the direct channel and retailing channel is respectively:

$$D_{rb} = \begin{cases} 1 - \frac{\beta\lambda s_{ob} - \beta s_{rb}}{1-\theta}, & p_b \le \frac{(1-\theta-\beta)s_{rb} + \beta\lambda s_{ob}}{1-\theta} \\ 1 - p_b + s_{rb}, & p_b > \frac{(1-\theta-\beta)s_{rb} + \beta\lambda s_{ob}}{1-\theta}, \end{cases}$$

$$D_{ob} = \begin{cases} \frac{(1-\beta-\theta)s_{rb} + \beta\lambda s_{ob} - (1-\theta)p_b}{\theta(1-\theta)} & p_b \le \frac{(1-\theta-\beta)s_{rb} + \beta\lambda s_{ob}}{1-\theta} \\ 0, & p_b > \frac{(1-\theta-\beta)s_{rb} + \beta\lambda s_{ob}}{1-\theta} \end{cases}$$

According to the above assumptions, the problem of the manufacturer is:

$$\max_{\{p_b, s_{ob}, s_{rb}\}} \pi_m = p_b * (D_{ob} + D_{rb}) - \frac{\eta_o * s_{ob}^2}{2} - \frac{\eta_r * s_{rb}^2}{2} \quad (1)$$

s.t. $\frac{(1-\theta-\beta)s_{rb} + \beta\lambda s_{ob}}{1-\theta} - p_b \ge 0.$

The first and second term of (1) denote the manufacturer's profit from the direct channel and the retailing channel, and the last two terms of (1) denotes the manufacturer's online and offline service costs. We use subscript 'b' to represent the BOPS selling mode.

Assume that the manufacturer is risk-neutral, and we derive the following proposition from (1).

Proposition 1. If $\eta_r > \frac{\eta_o(1-\beta)^2}{2\theta\eta_o - \beta^2\lambda^2}, \eta_o > \frac{\beta^2\lambda^2}{2\theta}$, the optimal retailing price, the online and offline service level of the manufacturer are as follows:

$$\boldsymbol{p_b}^* = -\frac{\theta^2\eta_o\eta_r}{\beta^2\lambda^2\eta_r + \eta_o\left((1-\beta)^2 - 2\theta\eta_r\right)},$$

$$\boldsymbol{s_{ob}}^* = -\frac{\beta\theta\lambda\eta_r}{\beta^2\lambda^2\eta_r + \eta_o\left((1-\beta)^2 - 2\theta\eta_r\right)},$$

$$\boldsymbol{s_{rb}}^* = -\frac{(1-\beta)\theta\eta_o}{\beta^2\lambda^2\eta_r + \eta_o\left((1-\beta)^2 - 2\theta\eta_r\right)}.$$

Proof. The Hessian matrix of (1) is: $H_1 = \begin{pmatrix} -\frac{2}{\theta} & \frac{\beta\lambda}{\theta} & \frac{1-\beta}{\theta} \\ \frac{\beta\lambda}{\theta} & -\eta_o & 0 \\ \frac{1-\beta}{\theta} & 0 & -\eta_r \end{pmatrix}$, H_1 is negatively definite if $\eta_r > \frac{\eta_o(1-\beta)^2}{2\theta\eta_o - \beta^2\lambda^2}$, $\eta_o > \frac{\beta^2\lambda^2}{2\theta}$. Therefore, it is a joint concave function of p_b, s_{ob}, s_{rb}, and there is a unique optimal solution. The Lagrangian function of problem (1) is:

$$L_1 = p_b * \frac{(1-\beta-\theta)s_{rb} + \beta\lambda s_{ob} - (1-\theta)p_b}{\theta(1-\theta)} + p_b * \left(1 - \frac{\beta\lambda s_{ob} - \beta s_{rb}}{1-\theta}\right) - \frac{\eta_o * s_{ob}^2}{2} - \frac{\eta_r * s_{rb}^2}{2} + \gamma_1 * \frac{(1-\theta-\beta)s_{rb} + \beta\lambda s_{ob} - (1-\theta)p_b}{1-\theta}.$$

KKT conditions:

$$\begin{cases} \frac{\partial L_1}{\partial p_b} = \frac{\theta - 2p_b + \beta\lambda s_{ob} + s_{rb} - \beta s_{rb} - \theta\gamma_1}{\theta} = 0 \\ \frac{\partial L_1}{\partial s_{ob}} = \frac{\beta\lambda p_b}{\theta} + \frac{\beta\lambda\gamma_1}{1-\theta} - s_{ob}\eta_o = 0 \\ \frac{\partial L_1}{\partial s_{rb}} = \frac{(-1+\beta+\theta-\beta\theta)p_b + \theta(-1+\beta+\theta)\gamma_1 - (-1+\theta)\theta s_{rb}\eta_r}{(-1+\theta)\theta} = 0 \\ \gamma_1 * \frac{(1-\theta-\beta)s_{rb} + \beta\lambda s_{ob} - (1-\theta)p_b}{1-\theta} = 0 \\ \gamma_1 \geq 0 \end{cases},$$

(1) $\gamma_1 = 0$,

$$p_b = -\frac{\theta^2\eta_o\eta_r}{\beta^2\lambda^2\eta_r + \eta_o\left((1-\beta)^2 - 2\theta\eta_r\right)}$$

$$s_{ob} = -\frac{\beta\theta\lambda\eta_r}{\beta^2\lambda^2\eta_r + \eta_o((1-\beta)^2 - 2\theta\eta_r)}$$

$$s_{rb} = -\frac{(1-\beta)\theta\eta_o}{\beta^2\lambda^2\eta_r + \eta_o((1-\beta)^2 - 2\theta\eta_r)}$$

p_b, s_{ob}, s_{rb} are all positive under the hessian matrix conditions, and there should be: $\frac{(1-\theta-\beta)s_{rb}+\beta\lambda s_{ob}-(1-\theta)p_b}{1-\theta} = \frac{\theta(\beta^2\lambda^2\eta_r+\eta_o((\beta-1)(\beta+\theta-1)+(\theta-1)\theta\eta_r))}{(\theta-1)(\beta^2\lambda^2\eta_r+\eta_o((1-\beta)^2-2\theta\eta_r))} > 0$.

Then, we have $\eta_o < \frac{\beta^2\lambda^2}{\theta(1-\theta)}$, $\eta_r > \frac{\eta_o(1-\beta)(\beta+\theta-1)}{\beta^2\lambda^2-\theta\eta_o(1-\theta)}$ and $\eta_o > \frac{\beta^2\lambda^2}{\theta(1-\theta)}$, $\eta_r < \frac{\eta_o(1-\beta)(\beta+\theta-1)}{\beta^2\lambda^2-\theta\eta_o(1-\theta)}$.

(2) $\gamma_1 > 0$,

$$p_b = \frac{(\beta+\theta-1)^2\eta_o + \beta^2\lambda^2\eta_r}{\beta^2\lambda^2(2\eta_r - 1) + \eta_o(2\beta(\beta+\theta-1) + (1-\theta)^2\eta_r)}$$

$$s_{ob} = \frac{\beta\lambda(\beta+\theta-1+(1-\theta)\eta_r)}{\beta^2\lambda^2(2\eta_r - 1) + \eta_o(2\beta(\beta+\theta-1) + (1-\theta)^2\eta_r)}$$

$$s_{rb} = \frac{\beta^2\lambda^2 + (\theta-1)(\beta+\theta-1)\eta_o}{\beta^2\lambda^2(2\eta_r - 1) + \eta_o(2\beta(\beta+\theta-1) + (1-\theta)^2\eta_r)}$$

$$\gamma_1 = \frac{(\theta-1)\left(\beta^2\lambda^2\eta_r + \eta_o\left((\beta-1)(\beta+\theta-1) + (\theta-1)\theta\eta_r\right)\right)}{\theta(\beta^2\lambda^2(2\eta_r - 1) + \eta_o(2\beta(\beta+\theta-1) + (1-\theta)^2\eta_r))}$$

In this case, there is no demand in the online channel, so there is no need to carry out BOPS. We don't consider this case.

From proposition 1, we can get the following corollaries.

Corollary 1. $s_{ob}{}^*$ and $s_{rb}{}^*$ decrease with θ.

Proof. Differentiating $s_{ob}{}^*$ with respect to θ, we have: $\frac{\partial s_{ob}{}^*}{\partial\theta} = \frac{(-1+\beta)\eta_o((-1+\beta)^2\eta_o+\beta^2\lambda^2\eta_r)}{(\beta^2\lambda^2\eta_r+\eta_o((-1+\beta)^2-2\theta\eta_r))^2}$. Absolutely, it is negative. Similarly, differentiating $s_{rb}{}^*$ with respect to θ, we have: $\frac{\partial s_{rb}{}^*}{\partial\theta} = -\frac{\beta\lambda\eta_r((-1+\beta)^2\eta_o+\beta^2\lambda^2\eta_r)}{(\beta^2\lambda^2\eta_r+\eta_o((-1+\beta)^2-2\theta\eta_r))^2}$, which is also negative.

This corollary shows that if consumers like shopping online (larger θ), the manufacturer would lower its online and offline service level. The manufacturer can lower its online service level because consumers like online shopping, the manufacturer don't need to offer very high level of online service to attract consumers. The manufacturer can lower its offline service level because consumers like online shopping. For example, the manufacture can employ fewer people in the store.

Corollary 2. When θ is not too large, $p_b{}^*$ decrease with θ; when θ increases to a certain number, $p_b{}^*$reaches the minimal value, and then $p_b{}^*$ increases with θ.

Proof. Differentiating $p_b{}^*$ with respect to θ, we have $\frac{\partial p_b{}^*}{\partial\theta} = -\frac{2\theta\eta_o\eta_r(\beta^2\lambda^2\eta_r+\eta_o((-1+\beta)^2-\theta\eta_r))}{(\beta^2\lambda^2\eta_r+\eta_o((-1+\beta)^2-2\theta\eta_r))^2}$. Make $\beta^2\lambda^2\eta_r + \eta_o((-1+\beta)^2 - \theta\eta_r) = 0$, we can see that $\theta = \frac{\beta^2\lambda^2\eta_r+\eta_o(-1+\beta)^2}{\eta_o\eta_r}$. So, $\theta <$

$\frac{\beta^2\lambda^2\eta_r+\eta_o(-1+\beta)^2}{\eta_o\eta_r}$, $p_b{}^*$ decrease with θ; $\theta = \frac{\beta^2\lambda^2\eta_r+\eta_o(-1+\beta)^2}{\eta_o\eta_r}$, $p_b{}^*$ reaches the minimal value; $\theta > \frac{\beta^2\lambda^2\eta_r+\eta_o(-1+\beta)^2}{\eta_o\eta_r}$, $p_b{}^*$ increases with θ.

This corollary indicates that when θ is not too large, the retailer would set a low price to attract consumers. When θ is large enough, the manufacturer would increase its price to make more profits.

Then, we form the model of traditional dual channel retailing. The manufacturer sells products both through its direct online channel and retail channel respectively. The manufacturer simultaneously sets the unit direct price p_o and online service level s_o, and the retailer sets the unit retail price p_r and store service level s_r. For buying one unit of product, the utility consumer gets from the direct online channel is $u_o = \theta v - p_o + \lambda s_o$. Similarly, the utility consumer gets from the retailing channel is $u_r = v - p_r + s_r$.

With $u_o = 0$, we have $v = v_o = \frac{p_o-\lambda s_o}{\theta}$, the consumers with valuation v_o get zero utility from the direct channel; With $u_r = 0$, we have $v = v_r = p_r - s_r$, the consumers with valuation v_r get zero utility from the retailing channel. With $u_o = u_r$, we have $v = v_e = \frac{p_r-p_o+\lambda s_o-s_r}{1-\theta}$, the consumers with valuation v_e get same utility from the two channels. Furthermore, when $v_r > v_o$, we have $v_e > v_r > v_o$, or else, $v_e < v_r < v_o$. So, when $v_e > v_r > v_o$, consumers with valuation $v \in [v_o, v_e]$ buy from the direct channel, consumers with valuation $v \in [v_e, 1]$ buy from the retailing channel. When $v_e < v_r < v_o$, the demand of direct is 0, consumers with valuation $v \in [v_r, 1]$ buy from the retailing channel. Thus, the demand of the direct channel and retailing channel is respectively:

$$D_r = \begin{cases} 1 - \dfrac{p_r - p_o + \lambda s_o - s_r}{1-\theta}, & p_r \geq \dfrac{p_o - \lambda s_o + \theta s_r}{\theta} \\ 1 - p_r + s_r, & p_r < \dfrac{p_o - \lambda s_o + \theta s_r}{\theta} \end{cases}$$

$$D_o = \begin{cases} \dfrac{\theta(p_r - s_r) - p_o + \lambda s_o}{\theta(1-\theta)}, & p_r \geq \dfrac{p_o - \lambda s_o + \theta s_r}{\theta} \\ 0, & p_r < \dfrac{p_o - \lambda s_o + \theta s_r}{\theta} \end{cases}$$

According to the above assumptions, the problem of the manufacturer is:

$$\max_{\{p_o, p_r, s_o, s_r\}} \pi_m = p_o * D_o + p_r * D_r - \frac{\eta_o * s_o{}^2}{2} - \frac{\eta_r * s_r{}^2}{2} \qquad (2)$$

s.t. $p_r - \frac{p_o-\lambda s_o+\theta s_r}{\theta} \geq 0$.

The first and second term of (2) denote the manufacturer's profit from the direct channel, the retailing channel, and the last two terms of (2) denote manufacturer's online and offline service costs.

Assume that the manufacturer is risk-neutral, and we derive the following proposition from (2).

Proposition 2. If $\eta_o > \frac{\lambda^2}{2\theta(1-\theta)}$, $\eta_r > \max\left\{\frac{2\theta\eta_o-\lambda^2}{4\theta\eta_o(1-\theta)-2\lambda^2}, 1\right\}$, the optimal online price and service level, and the optimal retailing price and store service level of the manufacturer are as follows:

$s_o{}^* = 0$,

$s_r{}^* = \frac{1}{2\eta_r-1}$,

$p_o{}^* = \frac{(\eta_r-1)\theta}{2\eta_r-1}$,

$p_r{}^* = \frac{\eta_r}{2\eta_r-1}$.

Proof. The Hessian matrix of (2) is: $H_2 = \begin{pmatrix} \frac{2}{(\theta-1)\theta} & \frac{2}{1-\theta} & \frac{\lambda}{\theta(1-\theta)} & \frac{1}{\theta-1} \\ \frac{2}{1-\theta} & \frac{2}{\theta-1} & \frac{\lambda}{\theta-1} & \frac{1}{1-\theta} \\ \frac{\lambda}{\theta(1-\theta)} & \frac{\lambda}{\theta-1} & -\eta_o & 0 \\ \frac{1}{\theta-1} & \frac{1}{1-\theta} & 0 & -\eta_r \end{pmatrix}$, H_2 is negatively definite if $\eta_o > \frac{\lambda^2}{2\theta(1-\theta)}$, $\eta_r > \frac{2\theta\eta_o-\lambda^2}{4\theta\eta_o(1-\theta)-2\lambda^2}$. Therefore, it is a joint concave function of p_o, p_r, s_o, s_r, and there is a unique optimal solution. The Lagrangian function of problem (2) is:

$$L_2 = p_o * \frac{\theta(p_r-s_r)-p_o+\lambda s_o}{\theta(1-\theta)} + p_r - p_r * \frac{p_r-p_o+\lambda s_o-s_r}{1-\theta} - \frac{\eta_o * {s_o}^2}{2} - \frac{\eta_r * {s_r}^2}{2} + \gamma_2 * \frac{\theta p_r-p_o+\lambda s_o-\theta s_r}{\theta}.$$

KKT conditions:

$$\begin{cases} \frac{\partial L_2}{\partial p_o} = \frac{\lambda s_o-2p_o-\theta(-2p_r+s_r-\gamma_2)-\gamma_2}{(1-\theta)\theta} = 0 \\ \frac{\partial L_2}{\partial p_r} = \frac{1-\theta+2p_o-2p_r-\lambda s_o+s_r}{1-\theta} + \gamma_2 = 0 \\ \frac{\partial L_2}{\partial s_o} = \frac{\lambda(p_o+\gamma_2-\theta(p_r+\gamma_2))}{(1-\theta)\theta} - s_o\eta_o = 0 \\ \frac{\partial L_2}{\partial s_r} = \frac{p_r-p_o-(1-\theta)(\gamma_2+s_r\eta_r)}{1-\theta} = 0 \\ \gamma_2 * \frac{\theta p_r-p_o+\lambda s_o-\theta s_r}{\theta} = 0 \\ \gamma_2 \geq 0 \end{cases},$$

(1) $\gamma_2 = 0$,

$$p_o = \frac{\theta\left(\lambda^2\eta_r + \theta\eta_o(1+2(-1+\theta)\eta_r)\right)}{\lambda^2(2\eta_r-1) + 2\theta\eta_o(1-2(1-\theta)\eta_r)}$$

$$p_r = \frac{\lambda^2\eta_r + \theta\eta_o(\theta+2(-1+\theta)\eta_r)}{\lambda^2(2\eta_r-1) + 2\theta\eta_o(1-2(1-\theta)\eta_r)}$$

$$s_o = \frac{\theta\lambda}{\lambda^2(2\eta_r-1) + 2\theta\eta_o(1-2(1-\theta)\eta_r)}$$

$$s_r = \frac{\lambda^2 + 2(-1+\theta)\theta\eta_o}{\lambda^2(2\eta_r-1) + 2\theta\eta_o(1-2(1-\theta)\eta_r)}$$

This solution should be given up, because s_o is always negative under the condition that $\eta_o > \frac{\lambda^2}{2\theta(1-\theta)}$, $\eta_r > \frac{2\theta\eta_o-\lambda^2}{4\theta\eta_o(1-\theta)-2\lambda^2}$.

(2) $\gamma_2 > 0$,

$$\gamma_2 = \frac{\theta}{(2\eta_r-1)(1-\theta)}$$

$$p_o = \frac{(\eta_r-1)\theta}{2\eta_r-1}$$

$$s_o = 0$$

$$p_r = \frac{\eta_r}{2\eta_r-1}$$

$$s_r = \frac{1}{2\eta_r-1}$$

To make sure that $p_o,\ p_r,\ s_r > 0$, we have $\eta_r > 1$.

3. Numerical Study

We compare the manufacturer's price, online and offline service level, profits before and after the implementation of BOPS as shown in Figure. (3), (4), (5). The superscript B stands for the manufacturer's decisions before BOPS, and superscript A stands for the manufacturer's decisions after BOPS. The default parameter is set as $\beta = 0.8$; $\lambda = 0.6$; $\eta_o = 1$; $\eta_r = 11$.

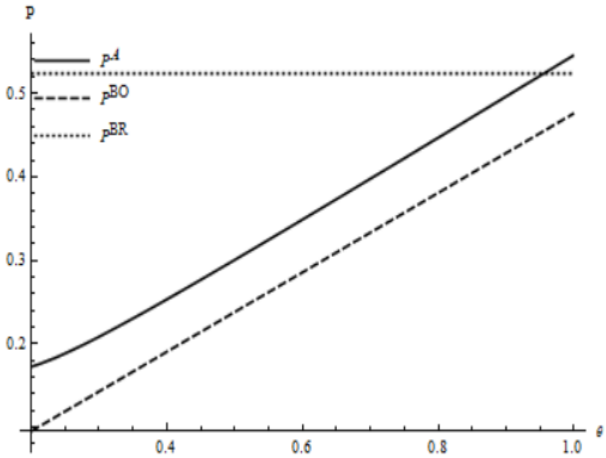

Figure 3. Comparison of price

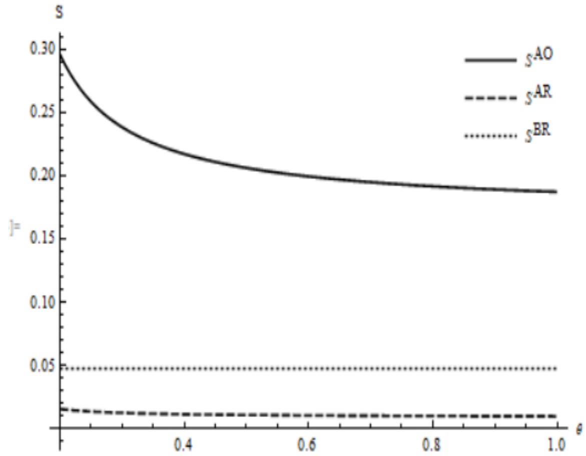

Figure 4. Comparison of service level

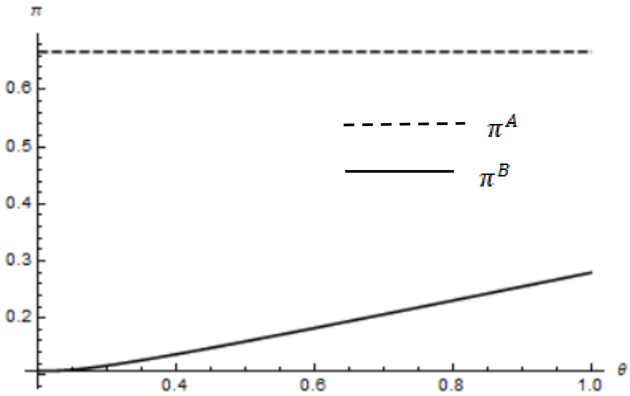

Figure 5. Comparison of profit

From Figure. (3), we can see that after the implementation of BOPS, the manufacturer's BOPS selling price is lower than its offline store selling price when θ is not too large; when θ is large enough, the manufacturer's BOPS selling price is bigger than its offline store selling price. The manufacturer's BOPS selling price is always bigger than its online store selling price.

From Figure. (4), we can see that the manufacturer's online service level rises from 0 to a rather high level. While, manufacturer's offline service level decreases a little bit.

From Figure. (5), we can see that after the implementation of BOPS, the manufacturer's profit is bigger than the traditional case. The manufacturer sells products with a lower price and provides higher service level after the implementation of BOPS. This is beneficial to the consumers, and therefore this strategy helps the manufacturer build a good reputation among the consumers which is very helpful for the manufacturer to expand its market.

4. Conclusion

Based on the consumer utility model and optimization theory method, this paper studies the optimal pricing and service decisions of the manufacturer before and after the implementation of BOPS, analyzes the correlation between consumer's online shopping acceptance and the optimal decisions, and probes into the influence of offline service cost factor on the optimal decisions and profits of the manufacturer. The numerical simulation shows that in the existence of BOPS, under certain conditions, the manufacturer will improve the online service level and lower the price even though the profits will go down. If a company seeks to expand its market and build a good reputation among the consumers, it can take the BOPS strategy.

BOPS has achieved the integration of online and offline channels, so that consumers can enjoy a seamless shopping experience. Whether or not to carry out BOPS practice depends on the original competitive conditions, consumer group division and product attributes and other factors. This article provides reference for the company' decision to carry on the BOPS practices, and gives the management enlightenment to the omni-channel mode implementation. However, this paper still has limitations in research method and category. Firstly, the analytic solution of the optimal strategy is complicated, the method of numerical analysis is emphatically used in the comparison of optimal decisions and profits, and the conclusion obtained has certain parameter dependence. Secondly, the comparison before and after the implementation of BOPS was investigated only in terms of price and service, but not by other related factors such as inventory. Based on this, the next step will be to add other relevant factors in BOPS operations to the study, to obtain more scientific and instructive conclusions.

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References

[1] E. Brynjolfsson, Y. Hu, and M. D. Smith. Consumer Surplus in the Digital Economy: Estimating the value of increased product variety at online booksellers. Management Science, 2003, 49 (11): 1580-1596.

[2] A Dukes, L. Liu. Online Shopping Intermediaries: The Strategic Design of Search Environments. Management Science, 2015, 62 (4): 1064-1077.

[3] Jae-Cheol Kim, Se-Hak Chun. Cannibalization and Competition Effects on a Manufacturer's Retail Channel Strategies: Implications on an Omni-channel Business Model. Decision Support Systems, 2018, 109: 5-14.

[4] E Juaneda-Ayensa, A Mosquera and M Y Sierra. Omnichannel Customer Behavior: Key Drivers of Technology Acceptance and Use and Their Effects on Purchase. Frontiers in Psychology, 2016, 7(125).

[5] W. Piotrowicz, R. Cuthbertson. Introduction to the Special Issue Information Technology in Retail: Toward Omnichannel Retailing. International Journal of Electronic Commerce, 2014, 18 (4): 5–16.

[6] S Gallino, A Moreno. Integration of online and offline channels in retail: The impact of sharing reliable inventory availability information. Management Science, 2014, 60(6): 1434–1451.

[7] C Fan, Y M Liu, X H Chen. Pricing and Service Cooperation in BOPS Implementation:

Considering Channel Competition and Consumer Behavior. Journal of Systems Engineering, 2018, 33 (3): 387-396.

[8] J Shin. How Does Free Riding on Customer Service Affect Competition? Marketing Science, 2007, 26 (4): 488–503.

[9] L Tian, Y F Xu. Dynamic Channel Selection and Pricing Based on Customer Behavior. Journal of Management Sciences in China, 2015, 18 (8): 39–51.

[10] D Xing, T Liu. Sales Effort Free Riding and Coordination with Price Match and Channel Rebate. European Journal of Operational Research, 2012, 219 (2): 264–271.

[11] W Chiang, D Chhajed, Hess J. Direct Marketing, Indirect Profits: A Strategic Analysis of Dual-Channel Supply Chain Design. Management Science, 2003, 49 (1): 1–20.

[12] S Heitz-Spahn. Cross-channel Free-riding Consumer Behavior in a Multichannel Environment: An Investigation of Shopping Motives, Sociodemographic and Product Categories. Journal of Retailing and Consumer Services, 2013, 20 (6): 570–578.

[13] J G Liu, D Zhou, Y M Liu, J L Zhao. Research on Manufacturer's Channel Selection Based on Free-riding. Journal of Systems Engineering, 2014, 29 (6): 813–823.

[14] F Gao, X Su. Omnichannel Retail Operations with Buy-online-and-pick-up-in-store. Management Science, 2017, 63 (8): 2478–2492.

[15] Kay-Yut Chen, Murat Kaya, Özalp Özer. Dual Sales Channel Management with Service Competition. Manufacturing & Service Operations Management, 2008, 10 (4): 654–675.

[16] X Chen, Y Liu, Z Wan. Optimal Decision Making for Online and Offline Retailers under BOPS Mode. The Australian and New Zealand Industrial and Applied Mathematics Journal, 2016, 58 (2): 1–22.

[17] Z H Cao, J Zhao, C T Zhang, J Min and Y W Zhou. Pricing and Channel Structure Selecting under Brand Competition and Channel Competition. Journal of Systems Engineering, 2015, 30 (1): 104–114.

[18] A Dumrongsiri, M Fan, A Jain, and K Moinzadeh. A Supply Chain Model with Direct and Retail channels. European Journal of Operational Research, 2008, 187 (3): 691–718.

[19] J Chen, H Zhang, Y Sun. Implementing Coordination Contracts in a Manufacturer Stackelberg Dual-channel Supply Chain. Omega: International Journal of Management Science, 2012, 40 (5): 571–583.

[20] G Y Xu, B Dan, X M Zhang, and C Liu. Coordinating a Dual-channel Supply Chain with Risk-averse under a Two-way Revenue Sharing Contract. International Journal of Production Economics, 2014, 147 (1): 171–179.

[21] F Bernstein, J Song, X Zheng. Free Riding in a Multi-channel Supply Chain. Naval Research Logistics, 2009, 56 (8): 745–765.

[22] Z P Ding, Y Z Liu. Revenue Sharing Contract in Dual Channel Supply Chain in Case of Free Riding. Journal of Systems Engineering, 2013, 28 (3): 370–376.