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Abstract: With the development of E-commerce and IT facilities, the online and offline channel are integrated in multiple forms. We study consumers' channel choice and retailer's operational decisions with or without the introduction of Buy-online-pick-up-in-store implementation. We find that under these conditions BOPS is more profitable: (1) the inventory cost is high and additional sales are moderate; (2) the consumer hassle cost in adopting BOPS is low and additional sales are large. Furthermore, we extend the model in a decentralized scenario. This research provides managerial insights to entrepreneurs in channel integration practices.

Keywords: Buy-Online-Pick-up-in-Store; consumer utility; inventory-dependent demand; revenue sharing; channel integration.

1. INTRODUCTION

Internet developments stimulate e-commerce and provide advantages for branding and marketing for e-tailers [1]. From the beginning of e-commerce era, online channel has been complementarities to the Brick-and-Mortar (B&M) channel, as a tool of advertising and promotion accounting for a small amount of overall sales[2, 3]. Nowadays, with the development of E-commerce and IT facilities, the online and offline channel are integrated in multiple forms, and a buy-online-and-pick-up-in-store (BOPS) function emerges as one of the most important implementation in omni-channel retailing [4]. The Japanese casual wear retailer Uniqlo, and sporting goods retailers Decathlon have the functionality in China that the consumer can buy products online, and pick them up in a nearby physical store as long as the products are in stock. Moreover, Uniqlo offers an electronic coupon exclusively to the consumers adopting BOPS service, to encourage the store traffic and possible additional sales in the physical stores [2]. BOPS provides a seamless shopping experience through online and offline channels [5], leading to changes in consumer segmentation and operation management in offline channels.

BOPS mode enables customers to gather product information and purchase the goods in the online shop, and obtain them in offline stores. Consumers consider the relative advantages and disadvantages of online channel, offline channel and BOPS in their decisions. For example, delivery leading time, product availability offline or other inconveniences to pick-up points are the main concerns for customers to determine their purchase process[6]. The first two factors mainly affect the consumers' perception of risks that they may not obtain the products immediately after they pay online[7]. What's more, consumers may suffer substantial loss both physically and mentally buying in online or offline channels [8]. Given that delivery lead time is exogenous because of the development of third-party logistics, the inventory level in offline stores becomes the key decision of the omni-channel retailer to segment consumers to different channels and to optimize the total profit.

Although BOPS provides better consumer experience and potential additional sales across channels, it's not always profitable with regards to all categories of products and consumers. Therefore, we intend to solve these problems in this article: (1) How does the introduction of BOPS affect the demand and profits, and how should the retailer make inventory decision to optimize the profit? (2) Under what conditions should the retailer

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introduce a BOPS setting? The rest of the paper is organized as follows. Section 2 reviews the related literature. Section 3 describes the overall model. Section 4 presents the analysis of consumers' channel choice and demand segmentation. Section 5 analyzes the inventory strategies and profits before and after BOPS. Section 6 concludes the paper and gives the future research directions.

2. LITERATURE REVIEW

Our work is related to several streams of literature. Channel integration in omni-channel retailing is a recent trend in practice and academic area. The retailing industry experiences the revolution that e-commerce brought from the early stage: online channel first acts as a complement [9], then operated separately and independently from the B&M stores (known as the dual channel structure) [10, 11], and finally is integrated with offline channel into an omni-channel structure. Dual channel studies mostly focus on the competition between online and offline retailers (or the manufacturer) in price and service. However, when channel integration eliminates the barriers between channels, the price transparency and service seamless connection brings challenges to the existing operation system. Bell et al. [5], Gallino and Moreno [2], Gallino [12] empirically studied how omni-channel retailing has changed the consumer segmentation, profits and operations with different channel integration implementations like inventory showrooms, BOPS or Ship-to-store(STS) service. Note that in these papers, sales and profits decrease in one channel is observed, but the overall profits increase if the integration programs are implemented properly. Gao and Su [4] studied the impact of BOPS on store operations through modeling the omni-channel retailer's decision making before and after BOPS, and found the product categories applied to BOPS.

Strategic consumers are widely studied in marketing and operational research and offers reference for firms to make pricing, promotion and channel structure decisions in an e-commerce environment [13, 14]. Delivery lead time is a major impact on consumer utility, creating the risk that he may not get the products in time. Hua et al [14] showed that the delivery lead time strongly influences the pricing strategies and profits in a two-echelon supply chain with a Stackelberg game. Lopez-Nicolas and Molina-Castillo[15] found lead time significantly contributes to the consumer perceived risks. Similarly, low level of product availability also contributes to this uncertainty[17]. In addition the consumers evaluate the risk and inconvenience in online and offline channels and finally make purchase decisions. We assume that the consumers differ in their distance to online and offline channels, and incorporate the disutility caused by delivery lead time and the risk of not finding the products in store, depicting the consumer strategic behavior in a new omni-channel retailing era.

Inventory-dependent demand is well studied in recent decades[18]. Baron [19] analyzed the joint shelf space allocation and inventory decisions for multiple items when demand depends on the inventory level. Li [20] proposed a multi-period stochastic dynamic programming model which shows that under mild conditions, the myopic inventory policy is optimal for the infinite horizon problem. It is generally believed that abundant inventories stimulate demand in that a large inventory signals a popular product, or provide consumers an assurance of high service levels and future availability [21]. Like Dana Jr [22], Dana Jr [23] and Chen et al.[6], we consider a model of consumer choice behavior with availability-based demand segmentation. In our setting, the retailer should decide the product availability level offline (i.e. the probability that an arriving consumer finds the product) to influence consumer utility, and in turn segment the demand. We study the optimal inventory strategy for the retailer in different settings, and examine if BOPS brings better performance, contributing to the literature in this area.

3. MODEL

First we consider a retailer sells a product through a direct channel online and an offline store. At the beginning of the sales season, the retailer sets the inventory level α ($\alpha \le 1$), the probability of not stocking out (Chen et al., 2008). Consumers evaluate the utilities in purchasing the products online and offline, with consideration of value v derived from the product, sales price p, delivery lead time l, the product availability level $\phi(\alpha)$, and hassle cost to each channel. Consumers differ in their position x in a unit-length line.

The market size denoted by Z is a uniformly distributed random variable between 0 and 1. The retailer obtains a net profit margin for each unit of online and BOPS demand, and in the offline store she has to make a single inventory service level decision α before random demand is realized, so there may not be unmet demand or leftovers at the end of sales season. The unit cost of inventory is c ($p-c>0$), and the salvage value of leftover units is normalized to zero. If the consumer visits store and finds the product unavailable, he would give up or switch to other alternatives.

4. CONSUMERS' CHANNEL CHOICE

According to Hotelling[24], with online and offline shops located at the ends of the line, the consumers suffer an online hassle cost tx, and an offline hassle cost $t(1-x)$, where t is the unit hassle cost parameter. Thus the consumers with index x derives $u_o = v - p - xt - l$ if he buy products online and receive the products with expedited shipping, and $u_s = \phi(\alpha)(v-p)-(1-x)t$ if he straightly visits the offline stores.

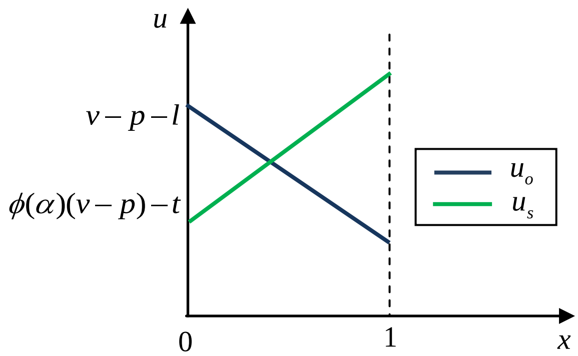

Figure 1. Consumer Utilities at Online and Offline Channels

We assume that the unit hassle cost parameter t satisfies $t \le v-p-l$, i.e. $v-p-l+t \ge 0$, to ensure every consumer derives a non-negative utility through online channel. The term $\phi(\alpha)$ is defined as the probability that a consumer finds the product in store inferred from the inventory level α. Figure 1 illustrates the consumer utilities at online and offline channel with regard to x, and the consumer at x_{os} find equal utilities buying online or offline. Thus consumers with a high value of index x should visit stores and the others go to the online channel in the situation showed in Figure 1.

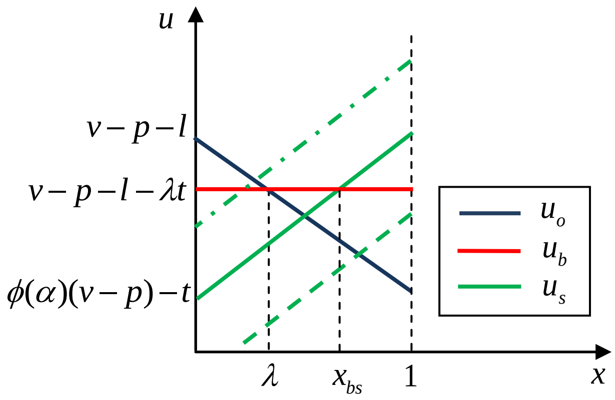

Figure 2. Consumer Utilities at Online, Offline channel and BOPS

We have Figure 2 to illustrate the demand segmentation after the retailer introduces BOPS. There are three conditions depending on the inventory level: when the inventory availability level is relatively low, only the online channel and the BOPS implementation are operational (as the green dash line shows), which is the same as that in 4.1; when it is high, the BOPS demand is eliminated (as the green dash-point line shows); when the inventory level is moderate, all three channels are operational. In this setting $x_{ob}=\lambda$ and $x_{bs}=1-\lambda+\frac{(1-\phi(\alpha))(v-p)-l}{t}$ divided the demand into three segmentation. To ensure every channel has demand, we let $x_{ob}\le x_{os}\le x_{bs}$ (i.e. $\phi(\alpha)\le\frac{v-p-l-(2\lambda-1)t}{v-p}$) and $x_{bs}\le 1$ (i.e. $\phi(\alpha)\ge\frac{v-p-l-\lambda t}{v-p}$). Similarly, we calculate the boundary value of α with $\hat{\alpha}_{\min}=\{\alpha\,|\,\phi(\alpha)=\frac{v-p-l-\lambda t}{v-p}\}$ and $\hat{\alpha}_{\max}=\min\{\{\alpha\,|\,\phi(\alpha)=\frac{v-p-l+(2\lambda-1)t}{v-p}\},1\}$ and the domain of α in BOPS setting is $[\hat{\alpha}_{\min},\hat{\alpha}_{\max}]$. Compare the α domain with 4.1 finding that with λ increases, the domain with BOPS narrows, down to $\alpha\equiv\phi^{-1}(\frac{v-p-l-\lambda t}{v-p})$ if λ reaches 1.

5. ANALYSIS

5.1 The operational decisions without BOPS

Before the retailer introduces BOPS, the online and offline consumers are segmented as in Section 3. Calculate the value of index x at which consumers derives an equal value through each channel, denoted as $x_{os}=\frac{1}{2}+\frac{(1-\phi(\alpha))(v-p)-l}{2t}$. According to Dana (2001), We have $x_{os}\in[0,1]$ to ensure that both channels are operational, which requires $\frac{v-p-l-t}{v-p}\le\phi(\alpha)\le\frac{v-p-l+t}{v-p}$. The demand functions of both channels are $D_o=x_{os}\cdot Z$ and $D_s=(1-x_{os})\cdot Z$ .The profit function of the retailer is

$$\Pi_0 = p \cdot E\min(D_s, q) - c \cdot q + r \cdot E(D_s) + w \cdot E(D_o) \tag{1}$$

The consumers visiting stores are inclined to make extra purchase, and bring an additional sales unit profit r in the third term. Besides, the retailer obtains w for one unit product sold online. According to Chen et al (2008) and Dana (2001), the stock quantity $q = \alpha(1 - x_{os})$ and consumes' product availability level $\phi(\alpha) = \alpha(1 - \ln(\alpha))$. Since $\frac{\partial \phi(\alpha)}{\partial \alpha} \geq 0$ and $t \leq v - p - l$, we calculate the boundary value of α with $\tilde{\alpha}_{\min} = \{\alpha \mid \phi(\alpha) = \frac{v-p-l-t}{v-p}\}$ and $\tilde{\alpha}_{\max} = \min\{\{\alpha \mid \phi(\alpha) = \frac{v-p-l+t}{v-p}\}, 1\}$, and the domain of α is $[\tilde{\alpha}_{\min}, \tilde{\alpha}_{\max}]$. We have

$$E\min(D_s, q) = \int_0^{\alpha(1-x_{os})} \gamma \frac{1}{1-x_{os}} d\gamma + \int_{\alpha(1-x_{os})}^{1-x_{os}} \alpha(1-x_{os}) \frac{1}{1-x_{os}} d\gamma$$
$$= (1 - x_{os})(\alpha - \frac{\alpha^2}{2})$$

Rewrite Equation (1) into

$$\Pi_0 = (p(\alpha - \frac{\alpha^2}{2}) - c\alpha + \frac{r}{2} - \frac{w}{2})(1 - x_{os}) + \frac{w}{2} \tag{2}$$

Because in Equation (2) $\frac{w}{2}$ is a constant, the retailer's decision making equals to

$$\text{Max } \mathrm{M}_0(\alpha) = (p(\alpha - \frac{\alpha^2}{2}) - c\alpha + \frac{r}{2} - \frac{w}{2})(\frac{1}{2} - \frac{(1-\phi(\alpha))(v-p)-l}{2t}) \tag{3}$$

subject to $\alpha \in [\tilde{\alpha}_{\min}, \tilde{\alpha}_{\max}]$.

Proposition 1 Without BOPS, the retailer has a unique local maximizer $\tilde{\alpha}$ in the domain $(0, \infty)$ satisfying

$$((3\tilde{\alpha}^2 - 4\tilde{\alpha})p + 4c_q\tilde{\alpha} - r + w) \cdot (v-p)\ln(\tilde{\alpha}) + 2((1-\tilde{\alpha})p - c) \cdot (l + t - (1-\tilde{\alpha})(v-p)) = 0, \tag{4}$$

and the optimal strategy is

$$\alpha_0^* = \begin{cases} \tilde{\alpha}_{\min}, if\, \tilde{\alpha} \leq \tilde{\alpha}_{\min}, \\ \tilde{\alpha}, if\, \tilde{\alpha}_{\min} < \tilde{\alpha} \leq \tilde{\alpha}_{\max}, \\ \tilde{\alpha}_{\max}, if\, \tilde{\alpha} > \tilde{\alpha}_{\max}. \end{cases}$$

if $M_0(\alpha_0^*) \geq 0$, otherwise $\alpha_0^* = \tilde{\alpha}_{\min}$.

If $\alpha_0^* = \tilde{\alpha}_{\min}$ we have $\Pi_0(\alpha_0^*) = \frac{1}{2}w$ and if $\alpha_0^* = \tilde{\alpha}_{\max}$, $\Pi_0(\alpha_0^*) = p(\tilde{\alpha}_{\max} - \frac{\tilde{\alpha}_{\max}{}^2}{2}) - c\tilde{\alpha}_{\max} + \frac{r}{2}$. In the former case, all consumers go to online channel and in the latter, all consumers visit store and contribute to an additional sales revenue of $\frac{r}{2}$.

5.2 The operational decisions with BOPS

The demand functions of three channels are $D_o = x_{ob} \cdot Z$, $D_b = (x_{bs} - x_{ob}) \cdot Z$ and $D_s = (1 - x_{bs}) \cdot Z$.

The profit function under BOPS is

$$\Pi_b = p \cdot E\min(D_s, q) - c \cdot q + r \cdot E(D_b + D_s) + w \cdot E(D_o + D_b) \tag{5}$$

Similarly, $E\min(D_s, q) = (1 - x_{bs})(\alpha - \frac{\alpha^2}{2})$. Rewrite the profit function into

$$\Pi_b = (p(\alpha - \frac{\alpha^2}{2}) - c\alpha - \frac{w}{2})(1 - x_{bs}) + \frac{r}{2}(1 - x_{ob}) + \frac{w}{2} \tag{6}$$

Because $\frac{r}{2}(1 - x_{ob}) + \frac{w}{2}$ in Equation (6) is constant, the retailer's problem equals to

$$\text{Max } \mathrm{M}_b(\alpha) = (p(\alpha - \frac{\alpha^2}{2}) - c\alpha - \frac{w}{2})(\lambda - \frac{(1 - \phi(\alpha))(v - p) - l}{t}) \tag{7}$$

subject to $\alpha \in [\hat{\alpha}_{\min}, \hat{\alpha}_{\max}]$.

Proposition 2 In the BOPS setting, the retailer's expected profit function has a unique local maximizer $\hat{\alpha}$ in the domain $(0, \infty)$ satisfying

$$((3\hat{\alpha}^2 - 4\hat{\alpha})p + 4c\hat{\alpha} + w) \cdot (v - p)\ln(\hat{\alpha}) + 2((1 - \hat{\alpha})p - c) \cdot (l + \lambda t - (1 - \hat{\alpha})(v - p)) = 0 \tag{8}$$

and the optimal strategy is

$$\alpha_b^* = \begin{cases} \hat{\alpha}_{\min}, if\, \hat{\alpha} \le \hat{\alpha}_{\min}, \\ \hat{\alpha}, if\, \hat{\alpha}_{\min} < \hat{\alpha} \le \hat{\alpha}_{\max}, \\ \hat{\alpha}_{\max}, if\, \hat{\alpha} > \hat{\alpha}_{\max}. \end{cases}$$

if $M_b(\alpha_b^*) > 0$, otherwise $\alpha_b^* = \hat{\alpha}_{\min}$.

With $\alpha_b^* = \hat{\alpha}_{\min}$ we have $\Pi_b(\alpha_b^*) = \frac{r}{2}(1 - \lambda) + \frac{w}{2}$, indicating that all consumers are fulfilled by the online inventory and $(1 - \lambda)$ of the total consumers are BOPS consumers who contributes to additional sales in store. With $\alpha_b^* = \hat{\alpha}_{\max}$, $\Pi_b(\alpha_b^*) = (p(\hat{\alpha}_{\max} - \frac{\hat{\alpha}_{\max}{}^2}{2}) - c\hat{\alpha}_{\max} + \frac{r}{2})(1 - \lambda) + \frac{w\lambda}{2}$, where no consumers adopt BOPS mode and the online and offline demand is divided by λ.

5.3 Discussions on introducing BOPS

As is shown in Equation (1) and (5), the operational decisions and outcomes are influenced by several parameters. We mainly focus on the impact of the variation of inventory cost c, the additional sales parameter

r and BOPS consumer hassle cost parameter λ on the profits before and after the implementation of BOPS. To specify the conditions, we use a numerical study to illustrate the situations before and after the introduction of BOPS. We adopt the parameter set of $\{v=1,\ p=0.5,\ l=0.1,\ t=0.35,\ w=0.2\}$ to obtain the domain of inventory level in different situations.

5.3.1 The impact of inventory cost and additional sales

We set $\lambda=0.5$ to represent that the consumers have middle-level hassle cost in adopting BOPS. Figure 3 shows the profit comparison with inventory level α when $c=0.1, 0.4$ and $r=0, 0.5, 1$.

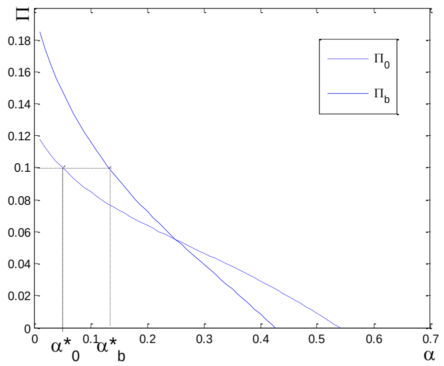

Figure 3(a) $c=0.4,\ r=0$

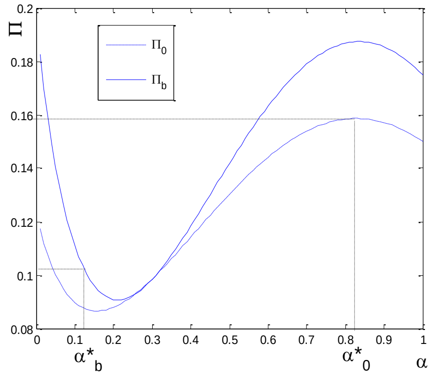

Figure 3(b) $c=0.1,\ r=0$

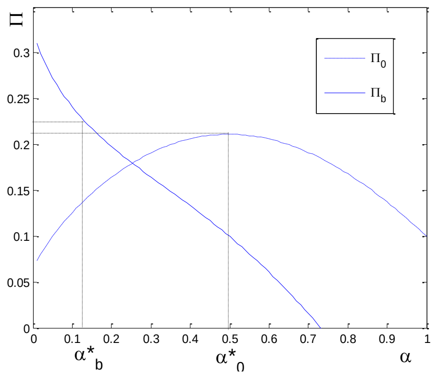

Figure 3(c) $c=0.4,\ r=0.5$

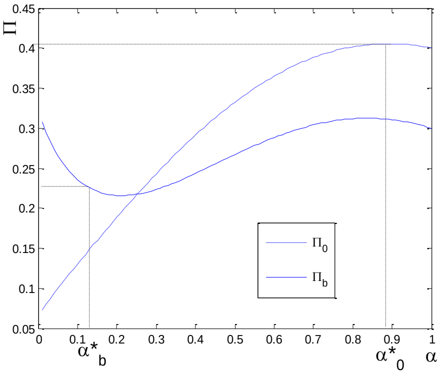

Figure 3(d) $c=0.1,\ r=0.5$

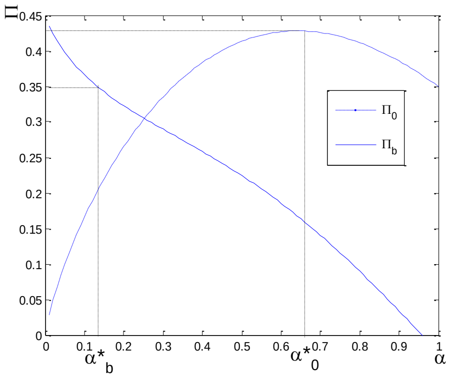

Figure 3(e) $c=0.4,\ r=1$

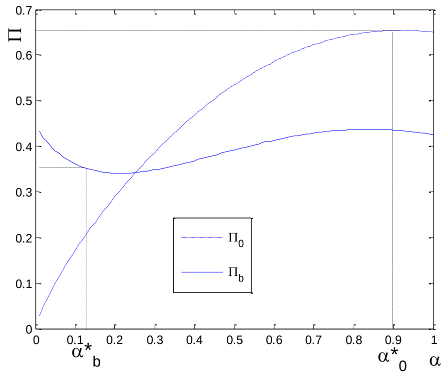

Figure 3(f) $c=0.1,\ r=1$

Figure 3. The impact of inventory cost and additional sales on profits

Figure 3(a) shows the situation that before and after the introduction of BOPS, the retailer set the inventory to the lowest level of $\tilde{\alpha}_{\min}$ and $\hat{\alpha}_{\min}$. From Appendix A we know that the parameter set satisfies $(p-c)^2 + p(r-w) < 0$ (or $(p-c)^2 - pw < 0$), and increasing the inventory level brings a negative effect on the profit. Thus the retailer in both settings does not stock in store, and fulfill all consumers with the headquarters inventory. With or without BOPS, provided no additional sales occur in store, the retailer obtains the same profit in both settings.

Figure 3(a)(c)(e) show the profit comparison with the presence of a high inventory cost. With a moderate level of r (as is in Figure 3(c)), the retailer set a higher inventory level than that in Figure 3(a)'s conditions, but the profit is lower compared to the BOPS profit. This is because the additional sales in store cannot counteract the negative effect brought by a high inventory cost. However, when the additional sales in store reaches a high level, the benefit of stocking exceeds the harm to the profit, and BOPS is less profitable.

Figure 3(b)(d)(f) show the profit comparison with a relatively low inventory cost. BOPS is not advantageous in these conditions. Although in Figure 3(b) $\Pi_b(\hat{\alpha}) > \Pi_0(\tilde{\alpha})$, while $\alpha_b^* > \hat{\alpha}_{\max}$ and $M_b < 0$ on $[\hat{\alpha}_{\min}, \hat{\alpha}_{\max}]$, the retailer remains to the strategy in Figure 3(a).

5.3.2 The impact of BOPS consumer hassle cost and additional sales

We set $c = 0.1$ to analyze the situation where the offline store is ready to stock products. Figure 3(b)(d)(f) to illustrates the profit comparison when λ=0.5. If λ is very high, the BOPS functionality is not operational, we have Figure 4 to illustrate the profit comparison with inventory level α when $\lambda = 0.05$ and $r = 0, 0.5, 1$.

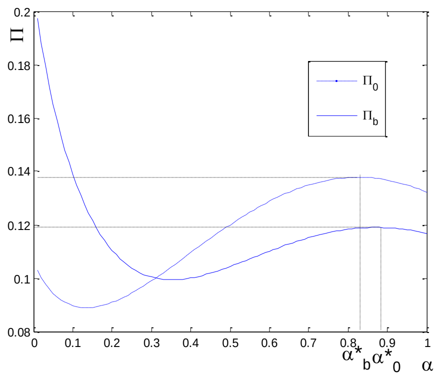

Figure 4(a) $r = 0$

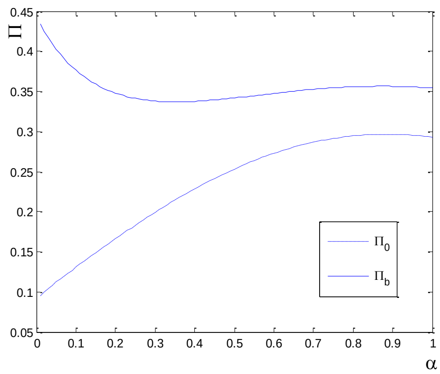

Figure 4(b) $r = 0.5$

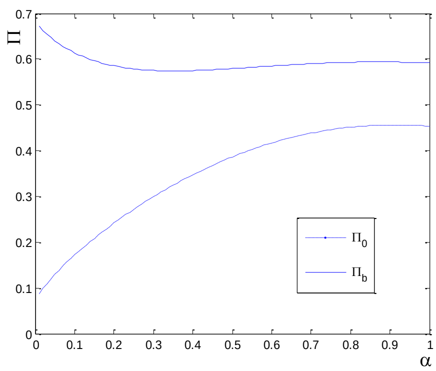

Figure 4(a) $r = 1$

Figure 4. The impact of BOPS consumer hassle cost and additional sales on profits

Figure 4 shows that if a consumer finds it easy to make a BOPS purchase, it's profitable for a retailer to integrate the online and offline channels even when inventory cost is low and additional sales are large. With a lower consumer hassle cost in BOPS, the retailer can adjust the inventory level in store with a bigger range. Introducing BOPS leads to a fixed segmentation of consumers visiting store relating to the BOPS hassle cost parameter. This brings different effects depending on the store operations. If the in-store inventory cost is high and the product availability level is not attractive to consumers, BOPS drives online consumers to visit store, contributing to a certain amount of additional sales. While the in-store operation is cost effective, the fixed segmentation hinders stocking offline, and lowers the profit especially when the additional sales are large. The retailer should offer seamless service to consumers to increase their utilities derived from BOPS, or attract consumers to adopt BOPS with discount or coupon like Uniqlo, generating a bigger BOPS consumer base.

6 CONCLUSIONS

We build a consumer choice model with the advent of BOPS, and compare the operational decisions and profit with or without the introduction of BOPS. A model extension in decentralized system is analyzed. We have several findings.

After introducing of BOPS, the retailer makes inventory decisions without consideration of additional sales because the consumer segmentation of store patronage is fixed through BOPS. Thus, we find the conditions where BOPS is more profitable: (1) the inventory cost is high and additional sales parameter is moderate; (2) the consumer hassle cost in adopting BOPS is low and additional sales parameter is high. We attribute these to the product features and consumer characteristics, and offer managerial insights in BOPS implementation.

To strengthen the explanation to reality, this paper can be extended in several directions. For instance, consumer returns in store, online and offline inventory integration may be introduced into the model. Furthermore, a "free-riding" behavior may occur in multiple sales channel patterns, which calls for more research in the future.

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