Coopetition between online and physical retailer under BOPS channel

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Abstract. Motivated by the flourishing environment of online shopping in Taiwan, we hope to study the commonly-seen practice here – buy online and pickup at convenience stores. Online retailer can benefit from the market expansion effect, while physical retailer is rewarded with transaction fee and cross-sale on the other goods in-store when they cooperate to open up BOPS channel. We formulate a Bertrand model to examine two retailers' pricing strategies and corresponding profits given existing sales channels. The numerical study reveals the way changes in exogenous parameters influence retailers' endogenous decisions and outcomes, and concludes that under certain conditions, BOPS channel will favor both online and physical retailer.

1 Introduction

Admittedly, with the pursuit of enhancing customer experience, there is a growing trend in the retailing industry that O2O (online to offline) mode is highly-valued. Buy-online-and-pickup-in-store (BOPS) is a vivid example and has been popular in recent years, for consumers are provided with a new option to make purchases.

BOPS is generally known as the combination of online shopping and immediate satisfaction from pick-ups at physical stores. Nowadays, a great number of retailers has already embraced this novel practice as their sales channel, to name but a few, UNIQLO, Crocs, PetSmart, GameStop, so as to reduce the hassle for their consumers. Yet, despite the fact that more and more firms are now adopting this measure, there is another channel much more popular in Taiwan —buy online, pickup at convenience stores.

With the traits of dense distribution, availability for 24/7, and daily necessities all in readiness, there is no denying that convenience stores are indispensable for people in Taiwan to maintain their daily lives. High dependency on convenience stores among the Taiwanese, or more generally speaking the Asian societies, is the very factor enabling pickup services through this channel to play a significant role in the last mile of online shopping.

According to Taipei International Logistics & IoT Exhibition, the number of parcels sent and picked up through convenience stores in 2017 amounted to 180 million, which indicates that this delivery option is highly preferred by e-commerce platforms. Moreover, another survey conducted by Institute for Information Industry (III) in 2020 has shown that convenience store pickup service ranked first, while home delivery was second to him when it comes to consumers' favorite shipping way. In contrast, emerging logistics methods such as ship-to-store, curbside pickup, and self-service collection are yet popular in Taiwan.

This paper aims to model the coopetition between an online retailer and a brick-to-mortar retailer (specifically refers to a convenience store here), to see how BOPS channel influences their pricing strategies as well as the demanded quantities, and whether they will be both better off after the adoption.

2 Literature Review

As more and more industries and brands adopt BOPS as their sales channel, scholars have addressed this issue in a great number of previous studies from various aspects.

Several researches delved into the dual channel supply chain where there are an upstream manufacturer and a downstream retailer. Dumrongsiri et al. (2008) showed that the difference in marginal costs turns out to determine whether the manufacturer should set up a direct channel to reach consumers or not. Chen et al. (2016) considered a newsvendor problem that the online retailer consigns a part of its products, complementary to the other goods in the physical store, to the offline retailer. Jiang et al. (2020) further researched the selection between a dual channel and an omni-channel, and how the retail service value influences manufacturer's and retailer's pricing strategies. Lin et al. (2020) as well explored the impact of introducing BOPS under scenarios either product is available both online and in-store or merely online.

In contrast, some researchers looked into the channel decision for a single retailer. Gao and Su (2017) developed an economic model to study the interaction between the retailer and consumers when BOPS channel provides the latter with information effect and convenience effect. Kong et al. (2020) proposed that consumers will incur different hassle costs in different channels and thus pricing strategies made by the retailer may differ before and after practicing BOPS. Yang and Zhang (2020) introduced hyperbolic discounting method to model consumers utility when they purchase online, and considered the conditions that products are not in stock.

Despite the differences in the way discussing an omni-channel environment or the heterogeneity in consumers' behaviors and characteristics, there is a universal concept proposed by previous researchers that the introduction of BOPS channel will stimulate cross-sale in the physical store. That is to say, every single consumer brought to the brick-to-mortar store through BOPS channel will contribute an additional amount of consumption when he picks up his parcel (Chen et al. 2016; Gao and Su 2017; Yang and Zhang 2020). On the other hand, the online retailer can harvest the market expansion effect (Jiang et al. 2020) since it offers its consumers a much more flexible option to make purchases, which may cater to those who consider home delivery to be less convenient or favorable to them.

Nonetheless, whether it is profitable or not to adopt this integrating channel heavily depends on the relative magnitude of the pros and cons. Setting up an omni-channel is sure to incur additional operating costs (Kong et al. 2020) and may split some market share from the physical store (Yang and Zhang 2020). While cross-sale effect may offset the negative influences that BOPS channel has on the brick-to-mortar store.

In this paper, we mostly refer to the Bertrand model applied in Jiang et al. (2020), which mainly focused on the interaction between retailers and simplified the model with linear demand of consumers.

Table 1: List of parameters and decision variables.

	Parameters
a	basic market demand
λ	(0, 1), market share that the online retailer initially owns
θ	[0, 1], competitive level between two retailers
c	unit cross-sale for physical retailer providing BOPS service
k	unit cost for physical retailer providing BOPS service
v	(0, 1), extra value when consumers pay a visit to physical store
δ	(0, 1), effect of market expansion under BOPS channel
	Decision Variables
p_p	selling price of the physical retailer
p_o	selling price of the online retailer
q_p	market demand of the physical retailer
q_o	market demand of the online retailer in original channel
q_b	market demand of the online retailer in BOPS channel
f	transaction fee charged by physical retailer through BOPS

3 Model

We consider two scenarios, one with BOPS channel and the other without BOPS channel. To simplify the problem, we assume that the competition only occurs between one online retailer and one physical retailer, and the production cost will be normalized to 0.

3.1 Without BOPS Channel

Under this situation, consumers can either make purchases in the physical store or shop online, so the two retailers will split the whole market into two segments as follows:

$$\begin{cases} q_p = (1-\lambda)a - p_p + \theta p_o + v \\ q_o = \lambda a - p_o + \theta p_p - v \end{cases}. \tag{1}$$

The market share online retailer initially owns, λ, describes the fraction that potential consumers will choose online channel. θ depicts the competitive level or homogeneity between two retailers. When θ approaches 1, it represents that there is extremely high level of competition or the fact that physical and online retailer become more similar. The extra value v can be interpreted as added value or additional utility, such as kind greetings from the clerks, consumers acquire when they make purchases or pick up their parcels at physical store. Aligns with the intuition, higher extra value provided in-store will lead to a larger physical demand.

Given the demand functions, two retailers engage in an one-stage game, that is, both of them determine their selling prices to maximize individual profits simultaneously.

3.2 With BOPS Channel

Nonetheless, if the physical retailer decides to provide pickup service for the online retailer, the online market demand will become

$$\begin{cases} q_o = (1-v)(\lambda+\delta)a - p_o + \theta p_p \\ q_b = v(\lambda+\delta)a - p_o + \theta p_p \end{cases}, \tag{2}$$

while the physical demand remains the same as stated previously.

Adopting BOPS channel will have a direct effect on the online demand through market expansion, which enables online retailer to reach more potential consumers, especially those who have longer working hours or value their privacy to a higher extent.

Under this scenario, physical and online retailer will participate in a sequential two-stage game. Physical retailer will first determine the transaction fee he is going to charge from online retailer. Afterwards, they simultaneously establish their pricing strategies given the transaction fee set in the first stage.

The transaction fee f is determined solely by physical retailer, and can be used to alter the selling prices in different channels later in the second stage; thereby affecting the demand quantities and expected profits.

4 Analysis

In this section, we solve the optimization problems in a backward fashion. We first derive the two retailers' optimal prices respectively. Then, we add the BOPS channel and derive the optimal transaction fee for physical retailer and optimal prices for two retailers.

4.1 Without BOPS Channel

With no BOPS channel, the game remains only one stage, that is, the two players determine their selling prices simultaneously.

Since we use Bertrand model to describe the relationship between online and physical retailer, we state their profit maximization problems as

$$\begin{cases} \hat{\pi}_p = \max\limits_{p_p \geq 0} \ p_p((1-\lambda)a - p_p + \theta p_o + v) - \dfrac{v^2}{2} \\ \hat{\pi}_o = \max\limits_{p_o \geq 0} \ p_o(\lambda a - p_o + \theta p_p - v) \end{cases}. \tag{3}$$

We can therefore solve the selling prices and quantities of two retailers

$$\begin{cases} \hat{p}_p = \hat{q}_p = \dfrac{2a\lambda + \theta a(1-\lambda) + (\theta - 2)v}{4 - \theta^2} \\ \hat{p}_o = \hat{q}_o = \dfrac{2a(1-\lambda) + \theta a\lambda - (\theta - 2)v}{4 - \theta^2} \end{cases}. \tag{4}$$

To assure $\hat{p}_p,\ \hat{p}_o,\ \hat{q}_p,\ \hat{q}_o$ are all greater than or equal to 0, the following condition should be satisfied:

$$-2a \leq (2-\theta)(v - \lambda a) \leq \theta a. \tag{5}$$

4.2 With BOPS Channel

If the physical retailer wants to build a BOPS channel, the game will become two-stage. In the first stage, physical retailer offers a contract with transaction fee f to online retailer. After that, physical retailer and online retailer determine their selling prices simultaneously. Since the moment physical retailer decides to adopt BOPS, the transaction fee will be set to induce online retailer to accept the contract, so there is no need to further consider whether online retailer will agree with this practice or not.

We first state two players' profit maximization problems as

$$\begin{cases} \pi_p^* = \max_{p_p \geq 0} p_p((1-\lambda)a - p_p + \theta p_o + v) \\ \qquad\qquad + (f+c-k)((\lambda+\delta)va - p_o + \theta p_p) - \dfrac{v^2}{2} \\ \pi_o^* = \max_{p_o \geq 0} p_o((\lambda+\delta)a - 2p_o + 2\theta p_p) - f((\lambda+\delta)va - p_o + \theta p_p) \end{cases}. \tag{6}$$

We therefore solve the optimal selling prices of these two retailers

$$\begin{cases} p_p^* = \dfrac{4a(1-\lambda) + (\lambda+\delta)\theta a + \theta f + 4v + 4\theta(f+c-k)}{2(4-\theta^2)} \\ p_o^* = \dfrac{(\lambda+\delta)a + (1-\lambda)\theta a + \theta v + (f+c-k)\theta^2 + f}{4-\theta^2} \end{cases}. \tag{7}$$

We can also get the optimal quantities of three channels

$$\begin{cases} q_p^* = \dfrac{4a(1-\lambda) + (\lambda+\delta)\theta a + \theta f + 4v - 2\theta(f+c-k)(2-\theta^2)}{2(4-\theta^2)} \\ q_o^* = \dfrac{2a(1-v)(\lambda+\delta)(4-\theta^2) + 2\theta a(1-\lambda) + 2\theta v}{2(4-\theta^2)} \\ \qquad + \dfrac{2\theta^2(f+c-k) - ((\lambda+\delta)a + f)(2-\theta^2)}{2(4-\theta^2)} \\ q_b^* = \dfrac{2va(\lambda+\delta)(4-\theta^2) + 2\theta a(1-\lambda) + 2\theta v + 2\theta^2(f+c-k)}{2(4-\theta^2)} \\ \qquad - \dfrac{((\lambda+\delta)a + f)(2-\theta^2)}{2(4-\theta^2)} \end{cases}. \tag{8}$$

Given online and physical retailers' optimal choices, physical retailer's optimization problem of setting transaction fee in the first stage will be

$$\begin{aligned} \pi_p^* = \max_{f \geq 0} p_p^* q_p^* + (f+c-k)q_b^* - \frac{v^2}{2} \\ \text{s.t. } p_o^*(q_o^* + q_b^*) - f q_b^* \geq \hat{p}_o \hat{q}_o. \end{aligned} \tag{9}$$

To simplify, we assume $a = 1,\ v = 0.5,\ k = 0$, then we can solve the optimal transaction fee in the contract

$$
\begin{aligned}
f^* =& \frac{(2\theta^4 - 4\theta^3 - 2\theta^2 - 24\theta + 16)\lambda + (2\theta^4 - 2\theta^2 + 16)\delta}{32 - 8\theta^4 - 26\theta^2} \\
&+ \frac{(8\theta^4 + 12\theta^2 - 16)c + (6\theta^3 + 36\theta)}{32 - 8\theta^4 - 26\theta^2},
\end{aligned}
\tag{10}
$$

and it will satisfy the constraint that the online retailer's expected profit with BOPS channel must be greater than or at least equal to that without BOPS channel.

We further check the natural conditions, that is, prices and demands should be greater than or equal to zero, of those optimal choices with and without BOPS channel. We find that before adding BOPS channel, $\hat{p_o}^*$, $\hat{p_p}^*$, $\hat{q_o}^*$, $\hat{q_p}^*$ are all bigger than zero when $\theta \in [0, 1]$. Also, after substituting the optimal transaction fee into two players' optimal choices with BOPS channel, p_p^*, p_o^*, q_o^*, q_b^* will always be bigger than zero when $\theta \in [0, 1]$, but when the competitive level is high, physical retailer's market demand will fall below zero. Therefore, we regard the physical quantity as zero at that time in the later discussion.

5 Discussion

In this section, we will compare the decision variables under BOPS channel to those without BOPS channel. To evaluate the impacts of adding the channel, we do some numerical studies by setting $\lambda = 0.7,\ \delta = 0.4,\ c = 2$.

5.1 Profit

We first discuss the profits of two players. By the constraint we set in the aforementioned optimization problem, we know that the online retailer's expected profit with BOPS channel must be at least the same as that without BOPS channel. On the other hand, for the physical retailer, we discuss its profits in Figure 1. When $\theta \in [0, 1]$, physical retailer's profit with BOPS channel is always bigger than that without BOPS channel. Therefore, we can conclude that both the online and the physical retailer will benefit from BOPS channel.

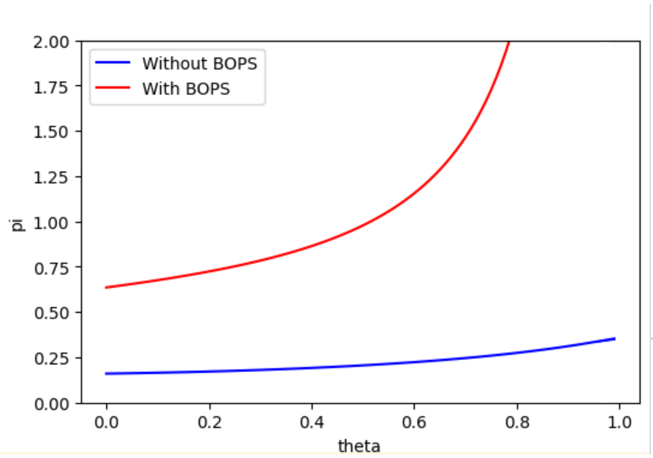

Figure 1: The impact of θ on π_p.

5.2 Price

Figure 2 and Figure 3 depict the relationship between prices of two retailers and the competitive level. In both figures, prices after adding BOPS channel are greater than or equal to prices without BOPS channel in all level of competition between two retailers.

With BOPS channel, online retailer will set higher price since the transaction fee raises his costs, which also gives physical retailer some spaces to raise the price. Furthermore, when the competition between two players become fiercer and fiercer, physical retailer may become less competitive due to the small market share. Therefore, he will raise his selling price further to increase the BOPS demand, through which to earn transaction fees and cross-sale profits. At that time, online retailer can also make its price much higher.

5.3 Demand

Figure 4 and Figure 5 describe the relationship between market demand of two retailers and the competitive level. The market demand of online retailer is bigger with BOPS channel, but for physical retailer, demand will decrease after adding the BOPS channel.

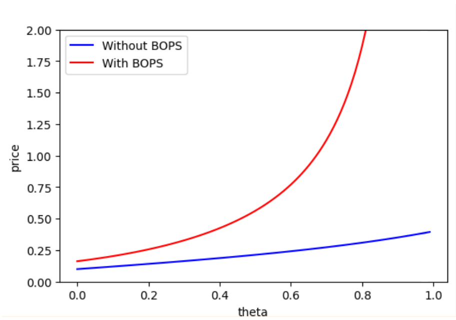

Figure 2: The impact of θ on p_o.

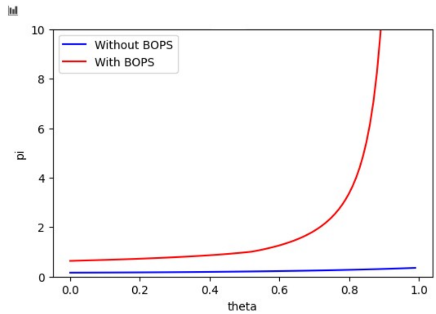

Figure 3: The impact of θ on p_p.

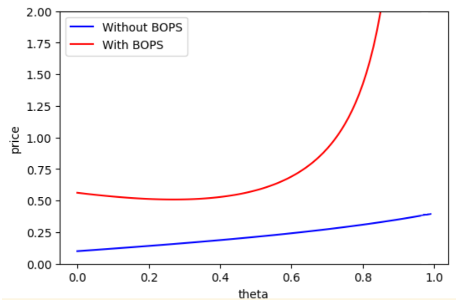

Figure 4: The impact of θ on q_o.

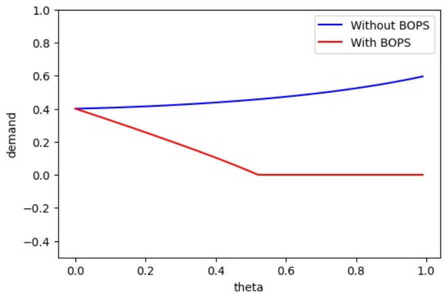

Figure 5: The impact of θ on q_p.

By the assumption of our model, online retailer's market demand will increase after adding BOPS channel. Also, when the competition between two retailers become fiercer, the physical retailer will further raise his selling price, which makes the market demand of online retailer much higher. Although under BOPS channel, online retailer's selling price becomes higher, the former effect dominates the latter. On the other hand, physical retailer will increase the selling price after adding the BOPS channel, which may lower its market demand. Furthermore, when the competitive level becomes higher, physical retailer will set the price even higher, so its market demand may have a rapid decrease until it reaches 0.

6 Extensions

In this section, we will discuss some restrictions in our model and do some extensions. First, we'll look back our model and conclude some restrictions within it. Second, we'll generalize our results. Finally, we'll present an alternative idea towards the optimization problem under BOPS channel.

6.1 Restrictions of Bertrand Model

The model has already been discussed thoroughly with the variation of parameters in the appendix, yet the original deficiency in Bertrand structure will make the pricing strategies somehow counter-intuitive, that is, when the retailers become more homogeneous, they tend to mark up selling prices rather than step into price cutting competition.

Also, Bertrand model cannot capture consumers' heterogeneity in their types, such as impatience for waiting an online parcel or convenience level to receive home delivery, that it is unable to reflect the true market condition shaped by consumers with unique characteristics.

6.2 Generalization

In the discussion above, we use numerical study to evaluate the influence of parameters on decision variables. However, in practice, those parameters have more possibilities. Therefore, we may examine the effects under all conditions.

6.3 Alternative

In this part, we propose a possible variation of our model where f is set as a given parameter. We will discuss the impact of BOPS on the service quality v physical retailer provides.

The game will be one-stage. Given the exogenous transaction fee, the physical retailer will determine his own selling price and service quality, and the online retailer will also set his selling price. In following part, we will derive the optimal service quality for physical retailer without and with the BOPS channel.

Table 2: List of parameters and decision variables.

	Parameters
a	basic market demand
λ	(0, 1), market share that the online retailer initially owns
θ	[0, 1], competitive level between the retailers
c	unit cross-sale for physical retailer providing BOPS service
k	unit cost for physical retailer providing BOPS service
δ	(0, 1), effect of market expansion under BOPS channel
f	transaction fee charged by physical retailer through BOPS
β	Scalar for cost of providing service quality v
	Decision Variables
p_o	selling price of the online retailer
p_p	selling price of the physical retailer
q_p	market demand of the physical retailer
q_o	market demand of the online retailer in original channel
q_b	market demand of the online retailer in BOPS channel
v	(0, 1), extra value when consumers pay a visit to physical store

6.3.1 Without BOPS Channel

We first discuss the original scenario, that is, the two retailers haven't built the BOPS channel. In this scenario, the profit functions of two players are

$$\begin{cases} \pi_p = p_p((1-\lambda)a - p_p + \theta p_o + v) - \dfrac{\beta v^2}{2} \\ \pi_o = p_o(\lambda a - p_o + \theta p_p - v)) \end{cases}. \tag{11}$$

6.3.2 With BOPS Channel

After adding the BOPS channel, the two retailers' profit functions become

$$\begin{cases} \pi_p = & p_p((1-\lambda)a - p_p + \theta p_o + v) \\ & + (f + c - k)(va(\lambda+\delta) - p_o + \theta p_p) - \dfrac{\beta v^2}{2} \\ \pi_o = & p_o((\lambda+\delta)a - 2p_o + 2\theta p_p) - f(va(\lambda+\delta) - p_o + \theta p_p) \end{cases}. \tag{12}$$

6.3.3 Results

Without BOPS channel, physical retailer will set his service quality as

$$\hat{v} = \frac{2(1-\lambda)a + \theta\lambda a - \theta v}{4\beta - 2 - \beta\theta^2}.$$

With BOPS, physical retailer will set his service quality as

$$v^* = \frac{(1-\lambda)a + \theta p_o + (f + c - k)[2(\lambda + \delta)a + \theta]}{2\beta - 1}.$$

7 Conclusions

In this research, we present a Bertrand game to investigate two retailers' pricing strategies with and without BOPS channel, and under what conditions will the BOPS channel be built. We solve all decision variables in those two scenarios and find some main contributions.

For the first place, we find that physical retailer can always benefit from BOPS channel in spite of the lower demand in his original gateway, and also, online retailer makes higher profits due to the increase in both price and demand. Thus, both players benefit from the new channel. On the other hand, we conclude that physical retailer can either adjust transaction fee or his selling price to manipulate consumers to purchase through BOPS channel, and therefore reap larger amount of profits. Last but not least, the physical and online retailer are more willing to cooperate with each other and build the BOPS channel when they have high homogeneity.

8 Appendix

In the appendix, we narrowly collate varying directions of those decision variables when taking derivatives respectively to λ, θ, δ and c.

To be noticed, all our discussions will focus on $\theta \in [0, 1]$, which is the assumption of Bertrand model. Furthermore, $q_p^* = 0$ when $\theta \notin [0, 0.5205)$, so when it is out of the interval, its derivative will become 0.

8.1 Variation in Initial Online Market Share

1. $\frac{\partial f^*}{\partial \lambda} > 0 \iff \theta < 0.609$
   When the competition between retailers is relatively small, there exists certain level of heterogeneity in two channels, which encourages

physical retailer to earn profits from his original demand on one hand, and raise the transaction fee to generate higher revenues from every unit demand brought by BOPS.

2. $\frac{\partial p_o^*}{\partial \lambda} > 0 \iff \theta < 0.7152$
   Intuitively, the online selling price increases in its initial market share in most of the case. Nevertheless, when the competitive level is rather fierce, physical retailer will lower his transaction fee to amplify online retailer's incentive to cooperate, hence cutting online selling costs and thereby the price.

3. $\frac{\partial q_o^*}{\partial \lambda} > 0 \iff \theta < 0.8685$
   It is fairly obvious that online demand increases in its initial market share for most of the time.

4. $\frac{\partial p_p^*}{\partial \lambda} < 0$
   In line with the intuition, physical selling price decreases in online market share, for the physical retailer will lower its price to maintain his competitiveness when the market becomes gradually eaten up by online retailer.

5. $\frac{\partial q_p^*}{\partial \lambda} < 0 \iff \theta < 0.5205$
   Certainly, physical demand decreases in online market share for most of the time. Nonetheless, when the competitive level becomes bigger than 0.5205, market demand of physical retailer drops to 0, so its derivative also becomes 0.

To sum up, when the initial online market share increases, the online demand will augment while physical demand will decrease through the direct effect on the demand functions. Physical retailer will lower his selling price to maintain certain competitiveness, while an exogenous higher market share empowers online retailer to mark up his price. With a larger fraction of consumers choosing online channel and higher online price being set as a result, physical retailer will have an incentive to raise the transaction fee, since online retailer can now tolerate higher costs, and for every unit of demand from BOPS channel, physical retailer can thereby generate more profits.

8.2 Variation in Competitive Level between Two Retailers

1. $\frac{\partial f^*}{\partial \theta} > 0$
   Higher competitive level represents the fact that two retailers become more homogeneous. Therefore, instead of cutting his own selling price to boost demand, physical retailer will rather choose to earn more profits from transaction fee. Physical retailer will not only benefit from the BOPS demand, but also steer online retailer to raise selling price due to higher costs under BOPS, and accordingly create a higher demand for himself.

2. $\frac{\partial p_o^*}{\partial \theta} > 0$
   When the competitive level becomes higher, online selling price will augment as a result. Since this finding is quite counter-intuitive, we may recall the initial shortcoming of a Bertrand model that prices will somehow increase in competitiveness between two players. A reasonable interpretation is that two retailers can collude to drive up their prices as if they are integrated rather than decentralized.

3. $\frac{\partial q_o^*}{\partial \theta} > 0$
   When the competitive level increases, it will become more difficult for physical retailer to compete in his initial channel, he will thereby put much emphasis on earning profits through BOPS that he raises the selling price to ensure sufficiently large online demand.

4. $\frac{\partial p_p^*}{\partial \theta} > 0$
   As stated previously, when the competitive level increases, there will be a higher incentive for two retailers to collude and mark up prices, since they become even more closer to perfect substitute for each other.

5. $\frac{\partial q_p^*}{\partial \theta} < 0 \iff \theta < 0.5205$
   Within the interval which makes market demand greater than or equal to zero, physical retailer's demand decreases when the competitive level increases.

In brief, when the competitive level becomes higher, physical and online retailer will increase their selling prices accordingly, which is somehow counter-intuitive due to the defect of Bertrand model. A possible explanation is that two retailers may collude and act as if they are integrated and thereby set the prices higher. Moreover, it will become more difficult for physical retailer to compete in his initial sales channel when there exists a fiercer competition, and he will turn to depend more heavily on BOPS as a consequence. In this way, online demand will advance, whereas physical demand will drop, which further propels physical retailer to charge higher transaction fee.

8.3 Variation in Market Expansion Rate for Online Retailer

1. $\frac{\partial f^*}{\partial \delta} > 0$
   The transaction fee increases in the market expansion effect since higher demand on online market leads to larger online profits, hence allowing physical retailer to raise transaction fee and earn more expected profits.

2. $\frac{\partial p_o^*}{\partial \delta} > 0$
   Larger market expansion effect empowers online retailer to set the selling price higher, for there is a growing online demand.

3. $\frac{\partial q_o^*}{\partial \delta} > 0$
   Intuitively, larger market expansion effect brings more consumers to make purchase, hence contributing to higher demand.

4. $\frac{\partial p_p^*}{\partial \delta} > 0$
   As the market expansion effect becomes larger, physical retailer will be enabled to charge higher transaction fee, since BOPS now brings more good points to the online retailer that he will be more willing to afford higher costs. Online selling price will advance due to the increase in costs, which thereby ensures physical retailer a room to augment his price.

5. $\frac{\partial q_p^*}{\partial \delta} < 0 \iff \theta < 0.5205$
   When the market expansion effect becomes larger, online demand will increase more significantly through direct influence. At this moment, physical retailer will raise the transaction fee to make more profits on one hand, and set his own selling price higher to ensure that there is sufficiently large demand for online retailer.

All in all, when the market expansion effect increases, online demand will be directly enlarged, thus driving the online selling price up. Also, higher online demand will push physical retailer into being more reliant on BOPS channel that he will on one hand raise his own price to ensure sufficiently large online demand, and on the other hand charge a higher transaction fee to harvest greater amount of profits.

8.4 Variation in Cross-sale Effect

1. $\frac{\partial f^*}{\partial c} > 0$
   Aligns with the intuition, larger cross-sale effect will induce physical retailer to further rely on BOPS channel, and at this moment, raising transaction fee can enable himself to earn more profits from every single unit of BOPS demand.

2. $\frac{\partial p_o^*}{\partial c} > 0 \iff \theta > 0.8165$
   Certainly, when cross-sale effect becomes larger, physical retailer will become more dependent on BOPS, and he can ensure a higher online demand through raising his own selling price if two retailers are quite homogeneous, thus giving online retailer more room to mark up selling price.

3. $\frac{\partial q_o^*}{\partial c} > 0$
   An increase in cross-sale effect will make physical retailer tend to earn more profits through BOPS channel, and he can raise his own selling price so as to enlarge online demand.

4. $\frac{\partial p_p^*}{\partial c} > 0$
   As the reasons stated previously, physical selling price will increase in cross-sale effect.

5. $\frac{\partial q_p^*}{\partial c} < 0 \iff \theta < 0.5205$
   In line with the previous logic, larger cross-sale effect will make physical retailer tend more to manipulate consumers to make purchases through BOPS, which certainly lower his own demand.

In short, the larger cross-sale effect will make physical retailer more dependent on the BOPS channel, and thus set his selling price higher to ensure sufficiently large online demand. Then, to generate more profits for every single unit of BOPS demand, physical retailer will charge a higher transaction fee, which accompanied by the markup of his own selling price, compels online retailer to raise the price.

Here, we summarize another key finding in this study: as the transaction fee or cross-sale raise, physical retailer will be more dependent on BOPS, for every consumer brought in-store to pick up his parcel brings about marginal increase in physical revenues.

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