IOSR Journal of Business and Management (IOSR-JBM)
e-ISSN: 2278-487X, p-ISSN: 2319-7668. Volume 22, Issue 5. Ser. III (May. 2020), PP 41-48
www.iosrjournals.org

Manage Product Fit Uncertainty in Online Retailing: The Value of Online Try Before You Buy Strategy

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Abstract: *It is not uncommon for consumers to suffer the problem of product fit uncertainty in online retailing. To mitigate this problem, this paperstudies how the online retailer should use theonline try before you buy strategy.Different from other marketing strategies, the online try before you buy strategy provides an opportunity for consumers to try the product at home before making the purchase decisions. Through the construction and analysis of a mathematical model,this paperderives the consumers' optimal purchase decisions and the online retailer's optimal pricingdecision when the online try before you buy strategy is adopted. In addition, we explore the optimality condition for the online retailer to carry out this strategy and its value to mitigate the problem of product fit uncertainty in online retailing.The results show thatwhen the matching probability between the product value and consumer preference and consumers' hassle cost to use the try before you buy service are low, the online retailer should adopt this strategy.With the decrease of consumers' hassle cost or the value loss caused by the mismatching, the adoption of the online try before you buy strategy can effectivelyimprovethe online retailer's profit more.*

Key words: *try before you buy; product fit uncertainty; heterogeneous consumer; hasslecost*

Date of Submission: 04-05-2020 Date of Acceptance: 18-05-2020

I. Introduction

With the rapid development of e-commerce, online shopping has become one of the important shopping methods in people's daily life. Compared with the traditional offline shopping, online shopping gets rid of the limitation of time and space to enable consumers to choose and purchaseproducts online at anytime and anywhere.However, in the online retailing environment, consumers cannot touch and feel the product, and usually can only rely on the product description and other consumers' comments to know about the product (Kwarket al., 2014).Therefore, it is difficult for consumers to accurately evaluate the product value before make the purchase decisionsin online channels, which leads to consumers' product fit uncertainty problem. This problem reduces consumers' confidence to purchase products online, which in turn negatively affects online retailers' product sales.

To solve this problem, online retailers have to introduce the return policy. However, when the mismatching between product value and consumer preference happens after consumers purchase the product, the online retailers suffer a large-scale of returns.In 2018, the cost of e-commerce returns in the United States reached $381 billion, which is expected to exceed $500 billion by 2020(Weathers et al., 2007; Mazareanu, 2019).Though online retailers promise to refund returns, considering the possible troubles caused by returns, consumersstill hesitate tomake the purchase decisions online due to the concerns of the possible mismatching problem.According to the survey of Narvar, 40% of consumers are dissatisfied with the return experience.Tedious return process and possible return friction are the important reasons that affect consumers' purchase again(Brightpearl, 2018).

Therefore, return policy is not an effectivemeasure for the product fit uncertainty problem in online retailing. The critical reason is that return policy does not directly solve the consumers' inability to touch and test products before making purchase decisions online.The emergence of the try before you buy strategy provides a new solution for online retailers to solve the problem of product fit uncertainty.Under the try before you buy strategy, consumers could try and test the product at home first andmake purchase decisions after that.Therefore, compared with the traditional online selling with return policy, the try before you buy strategy has a potential to better eliminate consumers' purchase anxiety in online retailing.

In June 2018, amazon launched its new service "Prime wardrobe", which is based on the concept of try before you buy, and aimed to eliminate the*ex ante*product fit uncertainty by offering a comprehensive pre-purchase experience.More specifically, under the try before you buy strategy, each consumercould selectsome products online first.Then, the online retailer will mail these products to the consumer. If a product is

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not matched with the consumer's preference, the consumer could return it, and if the product is satisfied, the consumer could keep it.As of 2018, the proportion of online retailers in the UK and the US who adopt the try before you buystrategy has reached 17.5% (Narvar, 2019).Some famous online retailers, such as Warby Parke, ASOS and Tmall, have all launched the try before you buy services.Take the "Credit purchase" launched by Tmall as an example, each consumercould choose a product online and try it within 7 days. The convenience of "try at home" has become an important reason to attract consumers to choose online shopping.

Therefore, the try before you buy strategy could directly solve the touchand test problem before consumers' purchase decisions.Although the try before you buy strategy has emerged in practice, the relevant theoretical research on how to take full advantage of this strategy to improve the operational potential of online retailers is still scare.There are some critical research question to study: When should the online retailer provide the try before you buy service? How do consumers' hassle costs in applying for the try before you buy service impact the efficiency of this strategy? What is the value of the try before you buy service in solving the product fit uncertainty problem in online retailing?To answer these questions, this paper constructs a mathematics model for an online retailer's try before you buy strategy and analyzes the game problem between consumers' purchase decisions and the online retailer's selling decision. More importantly, we study the optimality condition for the online retailer to adopt the try before you buy strategy and explore the value of this strategy.

II. Literature Review

Product fit uncertainty is defined by Hong and Pavlou(2014)as the degree to which consumers cannot assess whether the product attributes match their preferences. It is conceptualized as an information problem.Consumers usually suffers the problem of product fit uncertainty when shopping online(Mattand Hess, 2016). Previous literature researches mainly focus on two aspects to solve this problem. The first aspect considers how to designdifferent refund and return strategies to eliminate consumers' concerns about the product fit uncertainty.Davis et al.(1995)and Chu et al. (1998) studied the situations wherein the seller provides a full refund guarantee and a partial refund guarantee, respectively, and believed that providing a refund guarantee can alleviate the risk of consumers to deal with the uncertainty. Su(2009) and Yang et al.(2017) studied the impact of different refund policies on supply chain performance.Shang et al. (2017)effectively managed consumers' trial and speculation behavior by formulating optimal pricing and refund policies. The essence of the refund and return policy is an *ex post* compensation scheme, which cannot effectively solve the problem of product fit uncertainty. In addition, the complexprocess and strict conditions for the refund and return policy still cannot eliminate consumers' purchase concerns. Different from these literature, the try before you buy strategy studied in our paper is an *ex ante*measure to make consumers sufficiently grasp the product information before making purchase decisions.

The second aspect studies the influenceof information disclosure mechanism on consumers' product fit uncertainty.Shulman et al.(2009) considered the seller's return and information supply policy, and showed that the seller could take the advantage of consumers' product fit uncertainty to charge a high price to obtain more profits.Liu et al. (2017) considered the impact of online reviews on the uncertainty of the matching between consumer preference and product value. With the change of online shopping environment, the measures of information transmission is increasingly diversified. Augmented reality technologyallows people to conduct virtual trial before shopping. Among the many benefits that mobile augmented reality shopping application provides to users, the most prominent one is the level of product information completeness(Huang and Liao, 2015;Dacko, 2017). Although the new technology tries to make the online virtual experience of consumers close to the real experience, the development of sensory technology in the digital environment is still limited (Petit et al., 2019).The use of multi-channel retail and display is an important part of business strategy.Bell et al.(2018) found that after the introduction of offline showroom, the return rate of online retailers decreased and the overall demand increased.Gao and Su(2017) studied three information delivery mechanisms, namely online showroom, offline showroom and inventory information disclosure, and pointed out the optimal selection scheme forfirms under various scenarios.Dzyabura and Jagabathula(2018) studied the impact of product display strategy of offline stores on the total profit of online and offline channels. In these *ex ante* strategies, building offline showroom is the most similar to the try before you buy strategy. The main difference is that under the try before you buy strategy, consumers can try at home to avoid the visit in a physical store, which is incomparable to offline shopping. It is more effective and realistic for consumers to try and test products at home. In addition, the implementation of offline showroom depends on the geographical location of consumers, and it requires a lot of fixed costs for consumers. Therefore, the convenience of the offline showroomworse than the try before you buy strategy.

At present, there are few theoretical studies on the try before you buy strategy. The unique literature is fromLi et al. (2019), whostudied the try before buy strategy when consumers have self-mending behavior. Differently, our paper mainly studies how should the online retailer strategically adopt the joint strategy of try before you buy and traditional online selling to solve the problem of product fit uncertainty.

III. Model and preliminary analysis

3.1.Model setting

We consider an online retailer that sells a product at a unit price $p$through the online selling channel. All consumers in the market are heterogeneous, and the willingness to pay $v$follows the uniform distribution $U[0, a]$.Consumers are uncertain about the product's valuation before making the purchase decisions. Let βbe the matching probability of product value and consumer preference.$\theta_H$is the marginal value for each consumer when the product is a good fit,$\theta_L$is the marginal valuefor each consumer when the product is not a good fit, and $\theta_H > \theta_L$ holds.

When online retailers introduce a try before you buyservice, consumers can apply for this service to touch and try the product before make the purchase decisions. Under the try before you buy strategy,consumerscan fully obtain the product information before making purchase decisions. Therefore, this strategy can eliminate theproblem of product fit uncertainty for consumers.To apply for the try before you buy service, each customer should pay ahassle cost h for some online operations and logistics waiting.It has been observed that most online retailers offer free delivery and return service under the try before you buy strategy(Li et al., 2019).Let$L$ bethe unit cost for delivering or returninga unit product for the online retailer to adopt the try before you buy service.

The sequence of the eventsis as follows: First, the online retailerdetermines whether to offer the try before you buy service; Second, the online retailer announces the product retailing price p; Third, consumers observe the selling price, decide whether to buy the product, and choose between thetry before you buy policy and the traditionalpurchaseway.

3.2.Benchmark modelanalysis

Wefirst examine the traditional online selling strategy.It means that the online retailer does not offer the try before you buy service.We will discuss the value of the try before you buy strategy based on this benchmark casein the following.Under the traditional selling strategy, if a consumer withthe willingness to pay v purchases the product, the expected utility function can be expressed as

$$U_O = \beta v\theta_H + (1-\beta)v\theta_L - p. \tag{1}$$

The expected utility value is equal to zero if the customer does not purchase the product. Lemma 1 describes consumers' purchase decisions.

Lemma1. Under the traditional online selling strategy, there exists a thresholdvalue$v^d = \frac{p}{\beta(\theta_H-\theta_L)+\theta_L}$, such that consumers with$v \in [v^d, a]$ will purchase the product,and consumers with$v \in [0, v^d)$will not purchase.

Lemma 1 shows that when the online retailer adopts the traditional selling strategy, only a consumer with a high willingness to pay will purchase the product.A consumer with a low willingness to pay will leave the market.According to lemma 1, under the traditional selling strategy, the number of consumers who purchase the product is$D_d = a - \frac{p}{\beta(\theta_H-\theta_L)+\theta_L}$. Therefore, the expected profit function for the online retailer can be expressed as

$$\Pi_d(p) = p\left[a - \frac{p}{\beta(\theta_H-\theta_L)+\theta_L}\right]. \tag{2}$$

Proposition 1. When the online retailer adopts the traditional selling strategy, the optimal product retailing price is$p_d^* = \frac{a[\beta(\theta_H-\theta_L)+\theta_L]}{2}$.In equilibrium, the online retailer's optimal profit is $\Pi_d^*(p) = \frac{a^2[\beta(\theta_H-\theta_L)+\theta_L]}{4}$, consumers with$v \in [\frac{a}{2}, a]$ will purchase the product, and consumers with$v \in [0, \frac{a}{2})$ will not purchase.

Proposition 1 describes the consumers' optimal purchase decisions and the online retailer's optimal pricing decision when the traditional selling strategy is adopted. According to proposition 1, when the matching probability between the product value and consumer preferenceβ,or themarginal values$\theta_H$andθ_L increase, the online retailer could raise the retailing price to improve the product's profit. With the increase of the potential highest willingness to pay for consumers, the online retailer could provide services for more consumers with a higher product retailing price and achieve a higher profit.

IV. Analysis for the try before you buystrategy

Wenow study the equilibrium decisions for the online retailer and consumers whenthe try before you buy strategy is adopted.First of all, we analyze the two-stage purchase decisionproblemfor the consumers. In the first stage, consumers consider whether to pay a certain hassle cost $h$to apply for the try before you buy service. In the second stage, consumers decide whether to purchase the product after trying the product. Then, the expected utility function for consumers who choose the try before you buyservice can be expressed as

$$U_O^T = \max\{v\theta_H - p, 0\} - h, \tag{3}$$

the expected utility function for consumers who choose the traditional purchase way can be expressed as equation (1), and the utility value for consumers who leave the market is equal to zero. Note that only when

$v\theta_H - p - h > 0$, there exist consumers applying for the try before you buy service.Given the product's retailing price p,define $\bar{p} = \frac{h[\beta(\theta_H-\theta_L)+\theta_L]}{(1-\beta)(\theta_H-\theta_L)}$, $\bar{v} = \frac{h}{(1-\beta)(\theta_H-\theta_L)}$, and $v^r = \frac{p+h}{\theta_H}$, Lemma 2 characterizes the consumers'purchase decisions under the try before you buy strategy.

Lemma 2. When the online retailer providesthe try before youbuy option, given the product's retailing price p,the consumers' purchase decisions satisfy

(1) if$p < \bar{p}$,consumers with $v \in (\bar{v}, a]$ will choose the try before youbuy service to purchase the product, consumers with$v \in [v^d, \bar{v}]$ consumer will choose the traditionalway to purchase the product, and consumers with $v \in [0, v^d)$will not purchasethe product;

(2)if$p \geq \bar{p}$,for any $v \in [v^r, a]$consumerwill choose the try before youbuy,and dose not buy at all if $v \in [0, v^r)$.

Lemma 2 shows that the try before you buy service will be only considered by some consumers with high willingness to pay. In addition, only if the retailing price is sufficiently low, i.e., $p < \bar{p}$, the traditional selling way should be jointly used with the try before you buy strategy.According to Lemma 2, the number of consumers who choose the try before you buy service and the traditional purchaseway can be expressed as

$$D_O^T = \begin{cases} a - \frac{h}{(1-\beta)(\theta_H-\theta_L)} & p < \bar{p}, \\ a - \frac{p+h}{\theta_H} \, otherwise; & \end{cases}$$

$$D_O = \begin{cases} \frac{h}{(1-\beta)(\theta_H-\theta_L)} - \frac{p}{\beta(\theta_H-\theta_L)+\theta_L} & p < \bar{p}, \\ 0 & otherwise. \end{cases}$$

Then, the expected profit function for the online retailer to adopt the try before you buy strategy can beexpressed as $\Pi_1(p) = (p-L)(a-\bar{v}) + p(\bar{v} - v^d)$ when $p < \bar{p}$, and $\Pi_2(p) = (p-L)(a - v^r)$ when $p \geq \bar{p}$.Definea constant F that satisfies

$$F = -a^2\theta_H\theta_L + a^2\theta_H(\theta_H-\theta_L) + (a\theta_H + L - h)^2 + 4hL - \sqrt{\left[a^2{\theta_H}^2 + (a\theta_H + L - h)^2 + 4hL\right]^2 - 4a^2{\theta_H}^2(a\theta_H + L - h)^2}.$$

Then, the optimal pricing decisions for the online retailer to adopt the try before you buy strategy is characterized in Proposition 2.

Proposition 2. When the online retailer offers thetry before you buy service, the optimal pricing decision$p^*$is as follows.

(1) When$0 \leq h \leq \frac{(\theta_H-\theta_L)(a\theta_H+L)}{\theta_H+\theta_L}and\frac{F}{2\theta_H a^2(\theta_H-\theta_L)} < \beta \leq 1$, or$h > \frac{(\theta_H-\theta_L)(a\theta_H+L)}{\theta_H+\theta_L}and\beta \in [0,1]$, the optimal pricing decision is $p^* = p_1^* = \frac{a[\beta(\theta_H-\theta_L)+\theta_L]}{2}$.In equilibrium, the online retailer's optimal profit is $\Pi_1^*(p) = \frac{a^2[\beta(\theta_H-\theta_L)+\theta_L]}{4} - aL + \frac{hL}{(1-\beta)(\theta_H-\theta_L)}$, consumers with $v \in \left(\frac{h}{(1-\beta)(\theta_H-\theta_L)}, a\right]$ will choose the try before you buy service to purchase the product, consumers with$v \in [\frac{a}{2}, \frac{h}{(1-\beta)(\theta_H-\theta_L)}]$will choose the traditional way to purchase, and consumers with$v \in \left[0, \frac{a}{2}\right)$will not purchase.

(2) When$0 \leq h \leq \frac{(\theta_H-\theta_L)(a\theta_H+L)}{\theta_H+\theta_L}and0 \leq \beta \leq \frac{F}{2\theta_H a^2(\theta_H-\theta_L)}$,the optimal pricing decision is$p^* = p_2^* = \frac{a\theta_H+L-h}{2}$. In equilibrium, the online retailer's optimal profit is$\Pi_2^*(p) = \frac{(a\theta_H+L-h)2}{4\theta_H} - a\mathrm{L} + \frac{hL}{\theta_H}$,consumers with$v \in [\frac{a\theta_H+L+h}{2\theta_H}, a]$will choose the try before you buyservice to purchase the product, and consumers with$v \in [0, \frac{a\theta_H+L+h}{2\theta_H})$will not purchase.

Proposition 2 shows that when the matching probability between the product value and consumer preference$\beta$and the hassle cost $h$are sufficiently low, consumers will choose the try before you buy service if they are willing to purchase the product.Thus, in this case, the online retailer could only offer the try before you buyservice, and adopt a relatively high pricing strategy.When the matching probability$\beta$is sufficiently highor the hassle cost h is sufficiently high, consumers with a high willingness to pay will choose the try before you buy service to purchase the product, while consumers with an intermediatewillingness to pay will choose traditional way to purchase. Thus, in these cases, the online retailer should jointly provide the traditional purchase way and the try before you buy option, and adopt a low pricing strategy.

Under the traditional online selling strategy, consumers can only try the product after they purchase, and it is difficult to avoid the returns caused by the mismatching between product value and consumer preference.However, according to Proposition 2, it is found that the try before you buy strategy can reduce returns through the adjustment of the retailing price. Then, the consumers who sufficiently hope to purchase the product can be encouragedto try the product. Even if there are a small number of returns, the cost of returns can

be easily borne by the online retailer. Therefore, the try before you buy strategy can mitigate the mismatching problem, eliminate the purchase concerns for consumers, and furthermore to achieve the sales growth.
We next comparethe try before you buystrategy to the traditional selling way in the benchmark caseto obtain the optimal conditions touse the try before you buy strategy and the value of this strategy. The results can be seen in Proposition 3.

Proposition3. If and only if $L > \frac{2a\theta_H\theta_L - a\sqrt{\theta_H\theta_L}(\theta_H-\theta_L)}{2\theta_H}$, $h < a\theta_H - L - a\sqrt{\theta_H\theta_L}$, and $\beta < 1 - \frac{2a\theta_H(L+h)-(L+h)^2}{a^2\theta_H(\theta_H-\theta_L)}$, the online retailer should adopt the try before you buy strategy with the optimal retailing price $p^* = \frac{a\theta_H+L-h}{2}$.Then, the online retailer's optimal profit is $\Pi_c^*(p) = \frac{(a\theta_H+L-h)2}{4\theta_H} - aL + \frac{hL}{\theta_H}$, consumers with$v \in [\frac{a\theta_H+L+h}{2\theta_H}, a]$ will choose the try before you buy service to purchase the product, and consumers with$v \in [0, \frac{a\theta_H+L+h}{2\theta_H})$will not purchase the product.

Figure 1 illustrates a representative numerical example for Proposition 3 under the basic parameter setting:a=1,θ_H=1,θ_L=0.5, and$L$=0.1.The results show thatif and only ifthe return cost $L$is sufficiently high, the matching probability between the product value and consumer preference $\beta$is sufficiently low, and the hassle cost h paid by consumers is sufficiently low, the online retailer should adopt thetry before you buystrategy; otherwise,theonline retailer should only adopt the traditional purchase way.It means that the try before you buy strategy can effectively solve the low-probability matching problem under the traditional online selling way.Under the same basic parameter setting, Figure 2 illustrates that the use of the try before you buy strategy can improve the online retailer's profit.

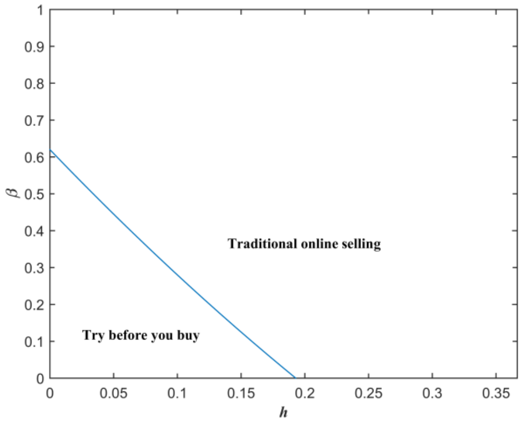

Figure 1 The illustration of the optimality conditions for the online retailer to adopt the try before you buy strategy and the traditional online selling way.

On the other hand, the large hassle cost will discourage the consumers to use the try before you buy service. As Figure 2 indicates, the benefit caused by the use of the try before you buy service decreases with the increase of the hassle cost. Therefore,to take the full advantage of the try before you buy strategy,the online retailer should take measures to reduce the consumers'hassle cost to use the try before you buy service.

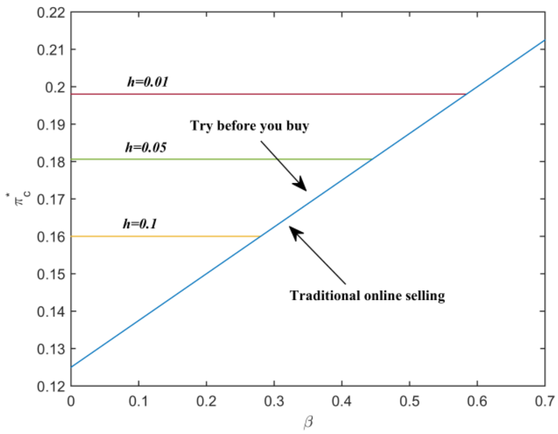

Figure 2 The illustration of the benefit from the try before you buy strategy under the varying of the hassle cost.

The matching probability between the product value and consumer preference β is critical to determine the optimality condition for the online retailer to adoptthe try before you buy strategy. According to Proposition 3, the try before you buy strategy should be used only if β is smaller than a threshold $1-\frac{2a\theta_H(L+h)-(L+h)^2}{a^2\theta_H(\theta_H-\theta_L)}$.Define $\bar{\beta}=1-\frac{2a\theta_H(L+h)-(L+h)^2}{a^2\theta_H(\theta_H-\theta_L)}$. Then, we discuss how thisimplemented condition range forthe try before you buystrategy changes under the varying of the relevant parameters. The results are listed in the following corollary.

Corollary: The threshold $\bar{\beta}$satisfies the following properties: (1)The threshold $\bar{\beta}$ decreases with the increase of h and L; (2)The threshold $\bar{\beta}$ decreases with the increase of θ_L, andwhen$\theta_H>\frac{2\theta_L+2(L+h)+\sqrt{[2\theta_L+2(L+h)]^2-4(L+h)^2}}{2a}$,the threshold $\bar{\beta}$increases with the increase ofθ_H; (3)When $a>\frac{\theta_H(L+h)+\sqrt{\theta_H{}^2(L+h)^2-\theta_H(\theta_H-\theta_L)(L+h)^2}}{\theta_H(\theta_H-\theta_L)}$, the threshold $\bar{\beta}$increases with the increase of a.

Corollary (1) shows that with the increase of the return cost and the hassle cost, the advantage of the try before you buy strategy reduces. Thus, the implemented range for the try before you buy strategy decreases. Only when the matching probability between the product value and consumer preference is sufficiently low, the online retailer can benefit from the try before you buy strategy.Corollary (2) indicates that when the value loss caused by the mismatching increases,the implemented range for the try before you buy strategy decreases. It means that it is more difficult to attract consumers to choose the try before you buy service in this case.Corollary (3) characterizes the impacts of the varying of the potential highest willingness to pay on the threshold value. It indicates that with the increase of consumers' highest willingness to pay, it is more beneficial for the online retailer to implement the try before you buy strategy.

V. Conclusion

In this paper, westudy the value of the try before you buy strategy on solving the problem of product fit uncertainty in online shopping. We build a model for the try before you buy strategy, and derive theconsumers'optimal purchase decisions and the online retailer's optimal pricing strategy under this strategy.Then, we compare the performance between the try before you buy strategy and the traditional selling way to explore the optimality condition for the online retailer to use the try before you buy strategy. The results show thatthe try before you buy strategy can effectively solve the deficiency of the traditional online selling strategy in dealing with theconsumers'product fituncertainty problem. The online retailer should usethe try before you buystrategywhen the matching probability between the product value and consumer preferenceis sufficiently low and the hassle cost for consumers to use the try before you buy service is sufficiently small. The benefit from the try before you buy strategy of online retailers increases with the decrease of the hassle cost paid by consumers. Thus, the online retailer should provide a more convenient service for this strategy to take the full advantage.With the decrease of the loss fromthe mismatching problemor the increase of consumers' highest willingness to pay, the online retailer could adopt the try before you buy strategy in a wider parameter range.

Appendix

Proofof Lemma1. The condition for consumers to purchase the productis $U_O\geq 0$. We can obtain the results in Lemma 1 by simplify this condition. □

Proof of Proposition 1. It can be examined that the profit function in equation (2) is concave. The optimal pricing decision can be obtainedaccording to the first-order condition. Then,thecorresponding optimalprofit for the online retailer and the corresponding optimal purchase decisions for the consumers can be obtained based on Lemma 1.□

Proofof Lemma 2. The condition for consumers to choose the try before you buy service is$U_O^T\geq 0$. Simplifying this condition, we have only when $v\geq v^r$, consumers will consider whether to choose the try before you buy service. According to Lemma 1, when$v\geq v^d$, consumers will consider whether to choose the traditional purchase way. Thus, we then study how the consumers should choose between the try before you buy service and the traditional selling way.Let$U_O^T=U_O$, we can find the willingness to pay $\bar{v}$ for the consumer who is indifferent between choosing the traditional purchase way and the try before you buy service. Then, consumers with$v\geq\bar{v}$ will choose the try before you buy service,and consumers with $v<\bar{v}$will choose the traditional way.Furthermore, if$p<\bar{p}$,$\bar{v}>v^r>v^d$ holds;therefore, consumers with$v>\bar{v}$ will choose the try before you buy service, consumers with$v^d\leq v\leq\bar{v}$ will choose the traditional purchase way, and consumers with $v<v^d$ with not purchase.If$p\geq\bar{p}$, $v^d>v^r>\bar{v}$ holds;therefore, consumers with$v\geq v^r$will choose the try before you buy service and consumers with $v<v^r$ will not purchase.□

Proof of Proposition 2. When $p<\bar{p}$, the online retailer's profit function is$\Pi_1(p)=(p-L)(a-\bar{v})+p(\bar{v}-v^d)=a(p-L)+\frac{hL}{(1-\beta)(\theta_H-\theta_L)}-\frac{p^2}{\beta(\theta_H-\theta_L)+\theta_L}$,which is concave on p.Then, according to the first-order condition, the optimal product price is $p_1^*=\frac{a[\beta(\theta_H-\theta_L)+\theta_L]}{2}$.To satisfy the condition $p_1^*<\bar{p}$, we have:(1)When $h \le \frac{a(\theta_H-\theta_L)}{2}$ and $1-\frac{2h}{a(\theta_H-\theta_L)} < \beta \le 1$, $p_1^* = \frac{a[\beta(\theta_H-\theta_L)+\theta_L]}{2}$ and $\Pi_1^*(p) = \frac{a^2[\beta(\theta_H-\theta_L)+\theta_L]}{4} - aL + \frac{hL}{(1-\beta)(\theta_H-\theta_L)}$;(2)When $h \le \frac{a(\theta_H-\theta_L)}{2}$ and $0 \le \beta \le 1-\frac{2h}{a(\theta_H-\theta_L)}$, $p_1^* = \bar{p} = \frac{h[\beta(\theta_H-\theta_L)+\theta_L]}{(1-\beta)(\theta_H-\theta_L)}$ and $\Pi_1^*(\bar{p}) = \frac{ah[\beta(\theta_H-\theta_L)+\theta_L]+Lh}{(1-\beta)(\theta_H-\theta_L)} + \frac{h^2[\beta(\theta_H-\theta_L)+\theta_L]}{[(1-\beta)(\theta_H-\theta_L)]^2} - aL$;(3)When $h > \frac{a(\theta_H-\theta_L)}{2}$ and $1-\frac{2h}{a(\theta_H-\theta_L)} < 0$, $p_1^* = \frac{a[\beta(\theta_H-\theta_L)+\theta_L]}{2}$ and$\Pi_1^*(p) = \frac{a^2[\beta(\theta_H-\theta_L)+\theta_L]}{4} - aL + \frac{hL}{(1-\beta)(\theta_H-\theta_L)}$.

When $p \ge \bar{p}$, the online retailer's profit function is$\Pi_2(p) = (p-L)(a-v^r) = (p-L)\left(a-\frac{p+h}{\theta_H}\right)$,which is concave on p. and$\frac{\partial \Pi_2(p)}{\partial p} = a - \frac{2p+h-L}{\theta_H}$.Then, according to the first-order condition, the optimal product price is $p_2^* = \frac{a\theta_H+L-h}{2}$.To satisfy the condition $p_2^* \ge \bar{p}$ we have:(1)When $h \le \frac{(\theta_H-\theta_L)(a\theta_H+L)}{\theta_H+\theta_L}$ and $0 \le \beta \le 1-\frac{2h\theta_H}{(\theta_H-\theta_L)(a\theta_H+L+h)}$, $p_2^* = \frac{a\theta_H+L-h}{2}$ and $\Pi_2^*(p) = \frac{(a\theta_H+L-h)2}{4\theta_H} - a\mathrm{L} + \frac{hL}{\theta_H}$;(2)When $h \le \frac{(\theta_H-\theta_L)(a\theta_H+L)}{\theta_H+\theta_L}$ and $1-\frac{2h\theta_H}{(\theta_H-\theta_L)(a\theta_H+L+h)} < \beta \le 1$, $p_2^* = \bar{p} = \frac{h[\beta(\theta_H-\theta_L)+\theta_L]}{(1-\beta)(\theta_H-\theta_L)}$ and $\Pi_2^*(\bar{p}) = \frac{ah[\beta(\theta_H-\theta_L)+\theta_L]+Lh}{(1-\beta)(\theta_H-\theta_L)} + \frac{h^2[\beta(\theta_H-\theta_L)+\theta_L]}{[(1-\beta)(\theta_H-\theta_L)]^2} - aL$;(3)When$h > \frac{(\theta_H-\theta_L)(a\theta_H+L)}{\theta_H+\theta_L}and1-\frac{2h\theta_H}{(\theta_H-\theta_L)(a\theta_H+L+h)} < 0$,$p_2^* = \frac{a\theta_H+L-h}{2}$ and$\Pi_2^*(p) = \frac{(a\theta_H+L-h)2}{4\theta_H} - aL + \frac{hL}{\theta_H}$.

We then compare these two cases. We have

$$\Pi_1^*(p) - \Pi_2^*(p) = a(p-L) + \frac{hL}{(1-\beta)(\theta_H-\theta_L)} - \frac{p^2}{\beta(\theta_H-\theta_L)+\theta_L} - (p-L)\left(a-\frac{p+h}{\theta_H}\right)$$

$=$

$-a^2\theta_H(\theta_H-\theta_L)^2\beta^2 + [a^2\theta_H(\theta_H-\theta_L)^2 - a^2\theta_H\theta_L(\theta_H-\theta_L) + (a\theta_H +$ $L-h)^2(\theta_H -$
$\theta L+4\theta H-\theta LhL\beta+a2\theta H\theta L\theta H-\theta L+4\theta HhL-a\theta H+L-h2\theta H-\theta L-4\theta H-\theta LhL$.

Then, according to the definition of F,if$\frac{F}{2\theta_H a^2(\theta_H-\theta_L)} < \beta$, we have$\Pi_1^*(p) > \Pi_2^*(p)$ holds. Because $\frac{a(\theta_H-\theta_L)}{2} < \frac{(\theta_H-\theta_L)(a\theta_H+L)}{\theta_H+\theta_L}$, $1-\frac{2h}{a(\theta_H-\theta_L)} < 1-\frac{2h\theta_H}{(\theta_H-\theta_L)(a\theta_H+L+h)}$, and $\beta \in [0,1]$, we then have:(1)When $0 \le h \le \frac{(\theta_H-\theta_L)(a\theta_H+L)}{\theta_H+\theta_L}$ and $\frac{F}{2\theta_H a^2(\theta_H-\theta_L)} < \beta \le 1$, $\Pi_1^*(p) > \Pi_2^*(p)$ holds andwe thus have $p^* = \frac{a[\beta(\theta_H-\theta_L)+\theta_L]}{2}$ and $\Pi_1^*(p) = \frac{a^2[\beta(\theta_H-\theta_L)+\theta_L]}{4} - aL + \frac{hL}{(1-\beta)(\theta_H-\theta_L)}$;(2)When $0 \le h \le \frac{(\theta_H-\theta_L)(a\theta_H+L)}{\theta_H+\theta_L}$ and $0 \le \beta \le \frac{F}{2\theta_H a^2(\theta_H-\theta_L)}$,$\Pi_1^*(p) < \Pi_2^*(p)$ holds and wethus have$p^* = \frac{a\theta_H+L-h}{2}$ and$\Pi_2^*(p) = \frac{(a\theta_H+L-h)2}{4\theta_H} - aL + \frac{hL}{\theta_H}$;(3)When $h > \frac{(\theta_H-\theta_L)(a\theta_H+L)}{\theta_H+\theta_L}and\beta \in [0,1]$, $\Pi_1^*(p) > \Pi_2^*(p)$ holds and wethus have$p^* = \frac{a[\beta(\theta_H-\theta_L)+\theta_L]}{2}$ and$\Pi_1^*(p) = \frac{a^2[\beta(\theta_H-\theta_L)+\theta_L]}{4} - aL + \frac{hL}{(1-\beta)(\theta_H-\theta_L)}$.□

Proof of Proposition 3. According to Proposition 2,when$p < \bar{p}$,if $\beta > 1-\frac{h}{a(\theta_H-\theta_L)}$, consumers with$v \in [\frac{a}{2}, a]$will choose the traditional purchase way.In this case,the online retailer's optimal profit is$\Pi_1^*(p) = \Pi_d^*(p) = \frac{a^2[\beta(\theta_H-\theta_L)+\theta_L]}{4}$.

When $0 \le h \le \frac{(\theta_H-\theta_L)(a\theta_H+L)}{\theta_H+\theta_L}$ and $\frac{F}{2\theta_H a^2(\theta_H-\theta_L)} < \beta \le 1$,or when $h > \frac{(\theta_H-\theta_L)(a\theta_H+L)}{\theta_H+\theta_L}$ and $\beta \in [0, 1]$, $\Pi_1^*(p) - \Pi_d^*(p) = \frac{a^2[\beta(\theta_H-\theta_L)+\theta_L]}{4} - aL + \frac{hL}{(1-\beta)(\theta_H-\theta_L)} - \frac{a^2[\beta(\theta_H-\theta_L)+\theta_L]}{4} = -aL + \frac{hL}{(1-\beta)(\theta_H-\theta_L)}$.Then, if $\beta > 1-\frac{h}{a(\theta_H-\theta_L)}$,$\Pi_1^*(p) > \Pi_d^*(p)$ holds. Because $1-\frac{h}{a(\theta_H-\theta_L)} > \frac{F}{2\theta_H a^2(\theta_H-\theta_L)}$, we have: ① when $h \le a(\theta_H-\theta_L)$ and $\beta > 1-\frac{h}{a(\theta_H-\theta_L)}$, $\Pi_1^*(p) = \Pi_d^*(p)$ holds and wethushave $\Pi_c^*(p) = \frac{a^2[\beta(\theta_H-\theta_L)+\theta_L]}{4}$;② when $h \le a(\theta_H-\theta_L)$ and $\frac{F}{2\theta_H a^2(\theta_H-\theta_L)} < \beta \le 1-\frac{h}{a(\theta_H-\theta_L)}$,$\Pi_1^*(p) < \Pi_d^*(p)$ holds and wethus have $\Pi_c^*(p) = \frac{a^2[\beta(\theta_H-\theta_L)+\theta_L]}{4}$;③ when $h > a(\theta_H-\theta_L)$ and $1-\frac{h}{a(\theta_H-\theta_L)} < \beta$, $\Pi_1^*(p) = \Pi_d^*(p)$ holds and wethus have$\Pi_c^*(p) = \frac{a^2[\beta(\theta_H-\theta_L)+\theta_L]}{4}$. Therefore, when $\frac{F}{2\theta_H a^2(\theta_H-\theta_L)} < \beta$, the online retailer only provides the traditional purchase way.

When $0 \le h \le \frac{(\theta_H-\theta_L)(a\theta_H+L)}{\theta_H+\theta_L}$ and $0 \le \beta \le \frac{F}{2\theta_H a^2(\theta_H-\theta_L)}$, $\Pi_2^*(p) - \Pi_d^*(p) = \frac{(a\theta_H+L-h)^2}{4\theta_H} - aL + \frac{hL}{\theta_H} - \frac{a^2[\beta(\theta_H-\theta_L)+\theta_L]}{4} = \frac{a^2\theta_H(\theta_H-\theta_L)(1-\beta)+(L+h)^2-2a\theta_H(L+h)}{4\theta_H}$.Then, if$\beta < 1-\frac{2a\theta_H(L+h)-(L+h)^2}{a^2\theta_H(\theta_H-\theta_L)}$, $\Pi_2^*(p) > \Pi_d^*(p)$ holds. It can be examined that $1-\frac{2a\theta_H(L+h)-(L+h)^2}{a^2\theta_H(\theta_H-\theta_L)} < \frac{F}{2\theta_H a^2(\theta_H-\theta_L)}$ holds.Because $\beta \in [0,1]$, if $h < a\theta_H - L - a\sqrt{\theta_H\theta_L}$, we have $1-\frac{2a\theta_H(L+h)-(L+h)^2}{a^2\theta_H(\theta_H-\theta_L)} > 0$ holds. Furthermore, when $L > \frac{2a\theta_H\theta_L - a\sqrt{\theta_H\theta_L}(\theta_H-\theta_L)}{2\theta_H}$,

$\frac{(\theta_H-\theta_L)(a\theta_H+L)}{\theta_H+\theta_L} > a\theta_H - L - a\sqrt{\theta_H\theta_L}$holds,we thus have:①when$L > \frac{2a\theta_H\theta_L - a\sqrt{\theta_H\theta_L}(\theta_H-\theta_L)}{2\theta_H}$, $h \le a\theta_H - L - a\sqrt{\theta_H\theta_L}$ and $1 - \frac{2a\theta_H(L+h)-(L+h)^2}{a^2\theta_H(\theta_H-\theta_L)} < \beta$, $\Pi_2^*(p) > \Pi_d^*(p)$ holds and we thus have $\Pi_c^*(p) = \frac{(a\theta_H+L-h)2}{4\theta_H} - a\mathrm{L} + \frac{hL}{\theta_H}$,andin this case, the online retailer onlyprovides the try beforeyou buy option; ② when $L > \frac{2a\theta_H\theta_L - a\sqrt{\theta_H\theta_L}(\theta_H-\theta_L)}{2\theta_H}$, $h \le a\theta_H - L - a\sqrt{\theta_H\theta_L}$ and $\beta \le 1 - \frac{2a\theta_H(L+h)-(L+h)^2}{a^2\theta_H(\theta_H-\theta_L)}$, $\Pi_2^*(p) \le \Pi_d^*(p)$holds,and we thus have$\Pi_c^*(p) = \frac{a^2[\beta(\theta_H-\theta_L)+\theta_L]}{4}$,and in this case, the online retailer onlyprovides the traditional purchase way.□

Proof of Corollary.(1) Taking the first derivative of the threshold $\bar{\beta}$with respect to h and L, we have $\frac{\partial\bar{\beta}}{\partial h} = -\frac{2a\theta_H-2h-2L}{a^2\theta_H(\theta_H-\theta_L)} < 0$ and$\frac{\partial\bar{\beta}}{\partial L} = -\frac{2a\theta_H-2L-2h}{a^2\theta_H(\theta_H-\theta_L)} < 0$.Thus, we know that $\bar{\beta}$is decreasing in h and L.

(2)Taking the first derivative of the threshold $\bar{\beta}$with respect toθ_L, we have $\frac{\partial\bar{\beta}}{\partial\theta_L} = \frac{-2a^3{\theta_H}^2(L+h)+a^2\theta_H(L+h)^2}{[a^2\theta_H(\theta_H-\theta_L)]^2} < 0$ .Thus, $\bar{\beta}$ is decreasingin θ_L . Taking the first derivative of $\bar{\beta}$ with respect to θ_H , we have $\frac{\partial\bar{\beta}}{\partial\theta_H} = \frac{2a\theta_H(L+h)-2(L+h)^2}{a^2{\theta_H}^2(\theta_H-\theta_L)^3}$.Thus, when$\theta_H > \frac{2\theta_L+2(L+h)+\sqrt{[2\theta_L+2(L+h)]^2-4(L+h)^2}}{2a}$,$\bar{\beta}$is increasing in θ_H.

(3)Taking the first derivative of the threshold $\bar{\beta}$with respect to$a$, we have$\frac{\partial\bar{\beta}}{\partial a} = \frac{2a\theta_H(L+h)-2(L+h)^2}{a^3\theta_H(\theta_H-\theta_L)^3}$. Thus, when $a > \frac{\theta_H(L+h)+\sqrt{{\theta_H}^2(L+h)^2-\theta_H(\theta_H-\theta_L)(L+h)^2}}{\theta_H(\theta_H-\theta_L)}$,$\bar{\beta}$is increasingin$a$.□

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