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Highlights

- The intensity of product competition affects competing retailers' sampling strategies.
- Consumer switching behavior can soften price competition under asymmetric equilibria.
- Competing retailers may fall into prisoner's dilemma when they both provide samples.
- The retailers' decision sequence affects competing retailers' sampling strategies.
- Both retailers may be better off in a sequential game than in a simultaneous game.

Sampling and Pricing Strategy Under Competition

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Abstract

Consumers are often uncertain about how products fit their individual preferences. In this situation, free samples can be offered to allow consumers to resolve such uncertainty before purchase. Product samples thus can build up customer goodwill for the products by reducing consumers' risk of product fit uncertainty. However, product samples may also have negative effects, because consumers who realize poor fits after sampling trials may switch with a certain probability to competing products. With consideration of these tradeoffs, we study the sampling and pricing strategies for sellers of competing products in an oligopoly market. We formulate this problem as a Hotelling game and characterize the equilibrium solution. We first discuss the situation when competing retailers simultaneously make the decisions. We show that the intensity of product competition (i.e., the degree of product differentiation) and consumer switching behavior play important roles in determining equilibrium sampling strategy. When product competition is strong and no consumer switching behavior occurs, competing retailers always adopt symmetric sampling strategies. However, if consumer switching behavior exists and/or the product competition is relatively weak, retailers may begin to adopt asymmetric sampling strategies. Counter-intuitively, consumer switching behavior can soften price competition and thus benefit both retailers. This paper also sheds light on how the retailers' equilibrium sampling strategy is affected by the probability of realizing a good fit with a product and the magnitude of goodwill effect. We further extend the study to the case when retailers sequentially make the decisions. Different from the simultaneous game, we find that there exists second mover advantage in a sequential game. Thus, competing retailers may adopt asymmetric sampling strategies even if the intensity of competition is strong and consumers do not switch between retailers. In addition, both retailers may be better off in a sequential game than in a simultaneous game.

Keywords: Marketing; Consumer Fit Uncertainty; Fit-Revealing Strategy; Intensity of Product Competition; Decision Sequence.

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1. INTRODUCTION

For new products and experience goods such as cosmetics, clothing, drugs and foods, consumers are often uncertain about how these products fit their individual preferences before their purchases. For example, consumers may not be able to tell which flavor of ice cream (e.g., chocolate, vanilla or green tea) fits their tastes best before they have tried it. To resolve such uncertainty, many retailers may offer free product samples. According to the Promotion Marketing Association, product samples reach 70 million U.S. households each quarter. The market research firm Cegedim Strategic Data shows that $6.3 billion worth of free pharmaceutical samples are handed out to doctors in 2011. Howland (2017) reports that Walmart has expanded its e-commerce sampling program to 4 million sample packages each month. Based on the Procter & Gamble (P&G) 2016 Annual report, P&G has delivered samples of its best Pampers products to 70% of U.S. new moms, and has put Gillette Fusion ProGlide FlexBall razors in the hands of nearly 80% of young men (over two million in 2016) on their 18th birthday. As emphasized by Cindy Johnson, a corporate sampling program manager at P&G, product samples work well because many consumers do not want to invest dollars in new products and they rely on trial experience to tell whether they will like the product or not (Rhodes 2010).

When consumers have fit uncertainty for products, sampling can help increase consumers' faith in a product by reducing consumers' risk of loss (Roselius 1971; Anderson 2009; Rhodes 2010; Wong 2015). Heiman et al. (2001) show that sampling has a direct experiential effect to reduce consumers' risk of product uncertainty. They illustrate that sampling leads to an increase in the consumers' goodwill formation. Sprott and Shimp (2004) empirically show that sampling can enhance consumers' quality perceptions of a store brand. Hu et al. (2010) empirically find that sampling is a strong product quality signal to reduce product uncertainty and attract shoppers. These positive effects play an important role in attracting consumers to visit the retailer which provides product samples. We refer to this benefit as the *goodwill effect* of sampling in this paper.

Free samples, on the other hand, may have disadvantages. Consumers who realize a poor product fit after sampling trials can switch to competing products. As mentioned by Villas-Boas (2006), "If a consumer has a very poor experience with a product he chooses to try the other product." According to Daniela (2014), 62% of global consumers switch service providers due to poor customer service experience. In daily life, switching between retailers is common for consumers who try to find a product (e.g., clothes, cosmetics, and snacks) that suits their needs.

In markets with consumer fit uncertainty, competing retailers can adopt either the same or different sampling strategies. For example, Talk Fusion, a global provider in video marketing solutions, has launched its highly anticipated 30 day Free Trials to allow consumers to gain a full understanding of the proven effectiveness of video marketing. Its competitor, MyVideoTalk, however, does not provide such free trials. The significance of free trial program is illustrated by Founder & CEO of Talk Fusion— Bob Reina, "There is absolutely no comparison in the world to the value that we bring. We wanted to put Talk Fusion's products into as many hands across the world as fast as we could because we know that when people try our video marketing products, they want to buy them." (Talk Fusion 2016)

Competing firms in other industries may also use diversified sampling strategies. The restaurant P.F. Chang's provides free sushi samples (Harrison 2016) and the ice cream store Dairy Queen delivers free ice cream to consumers (Fisher 2016); their corresponding competitors, Peking Garden and Braum's Ice Cream & Dairy Stores, seldom provide free samples for consumer trials. Other competing retailers may adopt the same sampling strategy. Sephora and Aveda frequently provide a large volume of free perfume samples. Both Whole Foods and Trader Joe's offer fresh organic fruit samples on a regular basis (Fiegerman 2011).

These observations raise several questions. With the pros and cons of sampling[2], whether is it worthy of offering samples in an oligopoly market? Should competing retailers adopt the same or different sampling strategies? How are the retailers' sampling and pricing strategies affected by the intensity of product competition, consumer switching behavior and the goodwill effect of sampling? How is the equilibrium solution affected by the timing of retailers' decisions?

In this paper, we extend the Hotelling model to consider two products competing on two attributes, a certain attribute which is known to consumers and an uncertain attribute which represents consumers' fit uncertainty. Consumers are uncertain about how the two products' horizontal attributes (e.g., different flavors of ice cream) fit their individual preferences. Retailers decide whether or not to offer samples to resolve consumer fit uncertainty and set the corresponding equilibrium prices. We characterize competing retailers' equilibrium sampling and pricing strategies for the cases in which the retailers' products have different degrees of horizontal product differentiation. A low (high) degree of product differentiation corresponds to a strong (weak) intensity of competition (Li and Zhang, 2008; Liu and Nagurney, 2011).

We first discuss the situation when competing retailers simultaneously make the sampling decision. Our finding reveals that when the intensity of competition is strong (i.e., a low degree of horizontal product differentiation such as substitute products), and no consumer switching behavior occurs, competing retailers reach symmetric equilibria—either the Sample–Sample Nash equilibrium, in which both retailers offer samples, or the No Sample–No Sample Nash equilibrium, in which neither retailer offers samples. In this case, the Sample–Sample strategy is always dominated by the No Sample–No Sample strategy. The two retailers actually fall into the *prisoner's dilemma* when a Sample–Sample equilibrium is realized. Our finding further shows that, for the case with a relatively weak competition intensity (i.e., the degree of product differentiation is relatively high), retailers may not necessarily fall into the prisoner's dilemma when reaching the Sample–Sample equilibrium.

If consumer switching behavior exists, however, retailers begin to reach asymmetric equilibria, in which only one retailer offers samples. When the intensity of product competition becomes relatively weak, the retailers may also reach asymmetric equilibria even without consumer switching behavior. Particularly, with a larger consumer switching

[2] Sampling, of course, may have other features such as limited trial time or limited functionalities (Cheng and Tang 2010), and other functions such as demand cannibalization or market expansion (Bawa and Shoemaker 2004). This paper focuses on two of its key functions—revealing individual fit with products and raising consumer goodwill towards products, and tries to disclose the competing retailers' fit revelation strategies in oligopoly markets with different intensities of competition.

rate, retailers are more likely to reach the Sample–Sample Nash equilibrium when the intensity of competition is weak. Therefore, consumer switching behavior and the intensity of product competition play important roles in determining the equilibrium sampling strategy.

The retailers' equilibrium sampling strategy also critically depends on the values of goodwill effect and/or the probability for a consumer to realize a good fit with a product. In general, when the goodwill effect is strong (weak), the equilibrium is Sample–Sample (No Sample–No Sample). However, the impact of the probability for a consumer to realize a good fit on the choice of sampling strategy depends on the degree of competition. When competition is strong, only if the probability of realizing a good fit is in a middle interval, the equilibrium is asymmetric. When competition is weak, the equilibrium is asymmetric only if the probability of realizing a good fit is either high or low.

Some existing literature suggests that consumer switching behavior intensifies price competition (Klemperer 1987a, 1987b and Farrell and Klemperer 2007). We show that counter-intuitively, consumer switching behavior can soften price competition and benefit both retailers when consumers hold fit uncertainty toward products. The reason is as follows. The information disclosure through sampling regarding the product fitness establishes the dispersion of consumers' posterior valuations across products, thus creating perceived differentiation between products. With consumer switching behavior, consumers who realize bad fits with the product at one retailer may switch to another retailer and find a product with a good fit. Consequently, consumer switching behavior can bring additional selling opportunities and retailers would increase their corresponding prices in response. The price competition is thus weakened. Consumer switching behavior along with sampling helps retailers capture the benefit of product differentiation and designates consumers with good fits to each store.

We then extend the discussion to the scenario when retailers sequentially choose the sampling strategy. Different from the game with simultaneous moves, we find that in a sequential game, competing retailers can adopt asymmetric sampling strategies even if the intensity of competition is strong and no consumer switching behavior exists. This difference is attributed to the existence of *second mover advantage* in a sequential game, specifically, the follower can undercut the price of the leader and earn higher profits. As a result, the leader has more incentive to make use of the goodwill effect of sampling to attract consumers to first visit his store. Competing retailers thus may reach a Sample–No Sample asymmetric equilibrium. In addition, when retailers make the sampling decision simultaneously and the intensity of competition is strong, the retailers' sampling game may act as a *chicken game*, in which both retailers are equally likely to provide sampling in the asymmetric equilibria. While in a sequential game, this situation will not happen. The leader is more likely to provide sampling while the follower tends to do no sampling in the asymmetric equilibria. Interestingly, in a sequential game, both retailers may achieve a larger profit than that in a simultaneous game. This is because retailers compete head-to-head in the simultaneous game that neither of them can charge a premium price. But in the sequential game, the follower can observe the leader's pricing decision and follow suit. Expecting this, the leader would charge a higher price and thus induce the follower to charge a higher price as well. Therefore, both retailers benefit from the sequential game.

To the best of our knowledge, this paper is the first to examine how competing retailers' sampling and pricing strategies are affected by consumer switching behavior, the goodwill effect of sampling, and the intensity of product competition. We extend the Hotelling model to study two products competing on a certain attribute and an uncertain attribute which represents consumers' fit uncertainty. In addition, we use a new method (i.e., Pearson correlation coefficient) to depict the intensity of product competition on the uncertain attribute. This paper also highlights the distinct fit revelation strategies when competing retailers simultaneously or sequentially make their decisions. All these insights can guide firms in choosing proper fit revelation and pricing strategies in oligopoly markets with different competition intensities.

This paper is structured as follows. Section 2 presents the literature review, and Section 3 describes the basic model. Section 4 provides the theoretical analysis of retailers' market payoffs and Nash equilibrium sampling strategy when competing retailers simultaneously make decisions. Section 5 extends to the case when competing retailers make their sampling decisions sequentially and play a Stackelberg game. Section 6 concludes the paper.

2. LITERATURE REVIEW

Our study is closely related to the research stream of whether sellers should provide information to resolve consumer valuation uncertainty. Lewis and Sappington (1994) show that a monopolist can reveal full information when consumers are heterogeneous and the production costs are high. Sun (2011) considers the product with horizontal and vertical attributes, and reveals conditions under which a monopolist should provide horizontal/vertical information. In addition, researchers have mentioned different types of marketing tools to reveal product information. Some have discussed whether a monopolist should resolve consumer valuation uncertainty through product sampling or trials. Chellappa and Shivendu (2005) discuss the sampling and pricing strategy when the market exists piracy, showing that sampling for digital goods is optimal only under limited situations. Wang and Zhang (2009) show that a monopolist can be better off when free samples are provided by third parties. Cheng and Tang (2010) conclude that offering free trials is highly profitable for a software monopoly with a strong network intensity. Cheng and Liu (2012) examine the trade-off between the sampling effects of reduced uncertainty and demand cannibalization. They conclude that the time-locked free trial becomes more profitable when the network effect is smaller than a threshold. Some researchers have considered to control buyer's knowledge of products through the timing of sale. Xie and Shugan (2001) point out that it can be more profitable to sell to consumers in advance when they only know the expected valuation of their future consumption. Bhargava and Chen (2012) argue that selling to privately informed consumers can be beneficial when heterogeneous consumers are divided into separate segments ex ante. Prasad et al. (2011) reveal that whether advance selling with consumer valuation uncertainty is beneficial depends on markets (e.g., market potential, uncertainty) and consumers (e.g., valuation, risk aversion and heterogeneity). Huang et al. (2017) consider the case when advance selling is conducted jointly with freebies. They conclude that a monopoly seller tends to adopt advance selling with consumer valuation uncertainty when the freebies bring much value and/or the capacity is limited. Some others consider to reveal information through informative advertising (see, e.g., Iyer et al. 2005; Anderson and Renault 2009; Anand and Shachar 2011; Anderson and Renault 2013) or through money back guarantee (see, e.g., Davis et al. 1995; Moorthy and Srinivasan 1995; Heiman et al. 2002; McWilliams 2012). In this paper, we consider the firms' sampling strategies in oligopoly markets with different competition intensities.

Our study contributes to the growing literature on the information-revealing strategy in competition. Kuksov and Lin (2010) investigate the information provision strategy when consumers face uncertainty for both product quality and their preferences for quality. They find that either the higher or lower quality firm may provide quality preference information, depending on the differences in products' marginal costs and quality levels. Gu and Xie (2013) explore how product quality levels affect competing firms' fit-revealing activities. They conclude the firm offering high-quality products implements fit-revealing activities in a greater intensity than the one offering low-quality products. Kuksov and Lin (2010) and Gu and Xie (2013) focus on how product quality levels affect firms' information-revealing strategies. By contrast, this paper illustrates how the competitive firms' fit-revealing strategy is affected by consumer switching behavior, goodwill effect of sampling and the intensity of product competition. Gu and Liu (2013) discuss how a retailer's shelf layout design is affected by the fit uncertain consumers. They show the retailer prefers to display the two manufacturers' competing products in the same place when the products are of the same fit probabilities and this probability is large; when fit probability difference between products is larger, the retailer prefers displaying competing products in distant locations. Gu and Liu (2013) assume that consumers can resolve their fit uncertainties upon arriving at the stores. Different from their study, this paper endogenizes a retailer's fit revelation decision and thus consumers can resolve fit uncertainty before purchasing only if the retailer provides the fit information. Boleslavsky et al. (2017) discuss an innovative firm's product demonstration strategies (i.e., the informativeness and the timing of the demonstration) with the existence of a competitor selling an established alternative. In our study, both firms are innovative, and they may either simultaneously or sequentially decide whether to reveal product fit information. In the field of economics, Ivanov (2013) discusses how sellers' information disclosure and pricing strategies are affected by the intensity of competition. In his study, the number of sellers is adopted as a measure of market competitiveness. He reveals that competing sellers reveal full information when the market becomes sufficiently competitive. By contrast, we capture the intensity of competition through the degree of horizontal product differentiation. In this setting, we obtain a result which is different from that of Ivanov (2013); specifically, sellers are more likely to reveal information when the intensity of competition is relatively weak (i.e., the degree of product differentiation is high). Besides, we demonstrate that sellers' fit-revealing strategies can be also affected by other factors, such as consumer switching behavior, the goodwill effect of sampling, and the competing retailers' decision sequence.

Table 1 below summarizes the main literature on information revelation strategy. The last seven columns of Table 1 list several important features of information-revealing problem, including revealing product vertical quality information, revealing product horizontal fit information, goodwill effect of sampling, consumer switching behavior, whether the sampling decision is endogenized, intensity of competition, and decision sequence. A check mark represents that the feature has been considered by the listed paper.

Consumers may switch between competing firms when realizing poor product fits after sampling trials. One in-

Table 1: Research on Information Revelation Strategy

Study	Product Quality	Horizontal Fit	Goodwill Effect of Sampling	Consumer Switching Behavior	Endogenized Sampling Strategy	Intensity of Competition	Decision Sequence
This study		√	√	√	√	√	√
Heiman et al. (2001)			√		√		
Kuksov and Lin (2010)	√				√		√
Doganoglu (2010)		√		√			
Ivanov (2013)		√			√	√	
Gu and Xie (2013)	√	√			√		√
Gu and Liu (2013)		√		√			
Boleslavsky et al. (2017)		√			√		

triguing issue is whether consumer switching behavior can soften or intensity price competition. A common and intuitive message in the previous literature is that the existence of consumer switching behavior (i.e., low switching costs) can intensify price competition and lead competing firms to charge lower prices (von Weizs*ä*ker, 1984; Klemperer, 1987a, 1987b; Beggs & Klemperer, 1992; Farrell & Klemperer, 2007). Recently, many studies have demonstrated the opposite results. Dub*é*, Hitsch, and Rossi (2009) empirically present evidence of situations in which average prices in the market decrease with switching costs. The novel finding of Dub*é*, Hitsch, and Rossi (2009) is theoretically supported by Shin et al. (2009); they replicate the discussions within a two-period framework. Other researchers further offer their explanations for this novel finding. Arie and Grieco (2014) highlight the importance of a short term "compensating" effect on switching costs; that is, in order to compensate consumers who are switching from other goods, firms must decrease prices below the competitive level when switching costs exist. Rhodes (2014) demonstrates that switching costs may reduce prices in the long run but increase prices in the short run. In the present work, we show that consumer switching behavior can soften price competition. A major difference is that we consider consumers are uncertain about their preferences for experience goods before purchase, while the aforementioned studies do not discuss consumers' preference uncertainty for products. Our work shares the spirit of Doganoglu (2010) that considers consumers' uncertainty about their potential satisfaction from products. Doganoglu (2010) concludes that price competition can be fierce in the presence of switching costs. The underlying reason of this effect is that with consumer switching behavior, firms prefer to capture future marginal profits rather than current marginal profits and are thus compelled to charge a higher current price. By contrast, we provide an explanation for the tendency of consumer switching behavior to soften price competition through increasing firms' sales and capturing the value of product differentiation. Moreover, in the study of Doganoglu (2010), consumers' preference uncertainty for products is resolved over time and thus competing firms have no information-revealing decisions. In our case, firms should decide whether or not to reveal information to resolve preference uncertainty before consumers' purchases.

3. MODEL

We model the fit-revelation strategy in an oligopoly market as a Hotelling model (Hotelling 1929). Two competing retailers, A and B, sell experience goods of A and B to the same market at the prices p_A and p_B, respectively. The market size is fixed and normalized to 1. For ease of exposition, we assume the two products have the same marginal cost, c, which can be normalized to zero; and the same unit sampling cost, c_s. Product A and B both have two sets of attributes: a_1 and a_2. The attribute a_1 is known to consumers while a_2 is unknown to consumers. For example, consumers may know their preferences for the package of ice cream/chocolate, but are uncertain which flavor fits their appetites best. Product A and B are horizontally differentiated in attribute a_1 with locations at points 0 and 1, respectively, but may be the same or differentiated in attribute a_2. Suppose that the consumers' taste parameter for attribute a_1 is $x \in [0, 1]$, and x is uniformly distributed along a line of unit length $[0, 1]$. As shown in Figure 1, a consumer indexed by x incurs a mismatch cost of tx when purchasing from retailer A and a cost of $t(1 - x)$ when purchasing from retailer B, where t is the per unit disutility of mismatch parameter. As for product attribute a_2, consumers are uncertain about whether this product characteristic fits their individual preferences. We suppose before traveling to retailers, all consumers hold the same *ex ante valuation* $\bar{V}$ for a product without sampling and $\bar{V} + \Delta V$ for a product with sampling, where ΔV is the goodwill effect brought by sampling and $\Delta V \geq 0$. Thus, if retailer A provides sampling while retailer B does not provide sampling, before traveling to retailers, a consumer indexed by x expects to achieve a utility of $\bar{V} + \Delta V - tx - p_A$ from product A and a utility of $\bar{V} - t(1 - x) - p_B$ from product B, respectively. In this paper, we consider $\bar{V} - t \cdot 1 \geq c + c_s$, i.e., the consumers' expected utility less the mismatch cost should be no smaller than the total production and sampling costs. This condition ensures a full market coverage for both products, i.e., both products are in the consideration set of every consumer because they provide nonnegative values for consumers even at the far end of the line. A similar assumption is adopted by Villas-Boas (2006) and Doganoglu (2010).

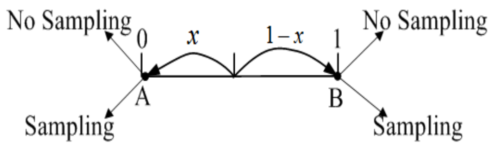


Figure 1: *A simple Hotelling model.*

The goodwill effect ΔV aligns with our own shopping experience that when we do not know how the products fit our preferences, we always prefer visiting the retailer with sampling over the one without sampling, given other parameters for the two retailers' products are the same. Existing literature has also confirmed that sampling may bring an increase in the consumer's goodwill formation by reducing their risk concern of product uncertainty (Roselius 1971; Heiman et al. 2001; Anderson 2009; Rhodes 2010). One point needs to be mentioned is that the value brought by the goodwill effect of sampling is not permanent and only exists when consumers hold fit uncertainties for products.

After consumers have resolved fit uncertainties, ΔV becomes zero. This assumption is supported by the studies of Wheatley, Chiu, and Goldman (1981) and Sprott and Shimp (2004), which show consumers who have actually tried a brand and experienced its intrinsic attributes rely less on extrinsic cues (e.g., product samples) when forming quality judgments compared to when judging quality without trial experience. However, our findings can be extended to the case when the goodwill effect of sampling still exists after consumers have resolved their fit uncertainties.

Retailers can either offer samples to make consumers totally informed of their horizontal fits with product attribute a_2 and incur a unit sampling cost c_s, or provide no samples to sell to consumers while they are uncertain of their fits. The retailers decide their sampling and pricing strategies and announce these strategies to the whole market (e.g., via advertising). Thus, all consumers are well aware of the retailers' strategies before traveling, but they do not know whether the products fit their individual preferences. Each consumer needs at most one unit of product, either product A or product B, or purchases nothing.

If product sampling is offered, consumers can know their preferences for product attribute a_2 before purchasing products. Denote consumers' *ex post* valuations for product A and product B as random variables, X and Y, respectively. Both X and Y follow a two-point distribution. For product A, each consumer has a probability of α_A to realize a good product fit with a high valuation H_A ($H_A \geq \bar{V}$) and $1-\alpha_A$ to realize a poor fit with a low valuation L_A ($L_A \leq \bar{V}$). For product B, each consumer has a probability of α_B to realize a good product fit with a high valuation H_B ($H_B \geq \bar{V}$) and $1-\alpha_B$ to realize a poor fit with a low valuation L_B ($L_B \leq \bar{V}$). We have $\bar{V} = \alpha_A H_A + (1-\alpha_A)L_A = \alpha_B H_B + (1-\alpha_B)L_B$. In addition, each consumer has a probability of ρ_{hh} to realize high valuations for both products (i.e., H_A and H_B), a probability of ρ_{ll} to realize low valuations for both products (i.e., L_A and L_B), a probability of ρ_{hl} to realize a high valuation for product A but a low valuation for product B (i.e., H_A and L_B), and a probability of ρ_{lh} to realize a low valuation for product A but a high valuation for product B (i.e., L_A and H_B). We have $\rho_{hh} + \rho_{hl} = \alpha_A$, $\rho_{lh} + \rho_{ll} = 1-\alpha_A$, $\rho_{hh} + \rho_{lh} = \alpha_B$ and $\rho_{hl} + \rho_{ll} = 1 - \alpha_B$. The Pearson correlation coefficient of X and Y is

$$r = \frac{E[XY] - E[X]E[Y]}{\sqrt{E[X^2] - E^2[X]}\sqrt{E[Y^2] - E^2[Y]}},$$

where $r \in [-1, 1]$.

In this paper, we use the Pearson correlation coefficient r to depict the degree of product differentiation of two products, i.e., the correlation between consumers' valuations for two products. We borrow this model setting from the literature on recommender systems, in which the Pearson correlation coefficient describes the similarity of customers' preference on different products (Ekstrand et al. 2011, Lü et al. 2012 and Li et al. 2013). The less the product differentiation, the more similarity in customer valuations, the stronger the product competition (as mentioned by Li and Zhang 2008 and Liu and Nagurney 2011). If the two products are exactly the same, consumers who realize high (low) valuations for product A should also realize high (low) valuations for product B, and vice versa. Hence, $\rho_{hl} = \rho_{lh} = 0$, $\rho_{hh} = \alpha_A = \alpha_B$, and $r = 1$, the consumers' valuations for the two products are perfectly positively correlated, and the intensity of product competition is the strongest. If the two products are highly differentiated and targeted to different market segments, consumers who realize high (low) valuations for product A realize low (high) valuations for product B, and vice versa. For example, a customer who likes spicy food may dislike food of sweet flavor. Hence, $\rho_{hh} = \rho_{ll} = 0$, $\rho_{hl} = \alpha_A = 1 - \alpha_B$ and $r = -1$, the consumers' valuations for the two products are perfectly negatively correlated, and the intensity of product competition is the weakest. For any value of r ($r \in [-1, 1]$), it represents a degree of product competition in between. In this paper, we focus on three cases in which the competition between products are strong ($r = 1$), intermediate ($r = 0$), and weak ($r = -1$), respectively. We summarize the notations in Table 2 below.

Table 2: Notation

Notation	Description
p_i	Price charged by retailer i ($i = A, B$)
c_s	Unit sampling cost
a_1, a_2	Product attributes
x	Consumers' taste parameter for attribute a_1
t	Per unit disutility of mismatch
$\bar{V}$	Ex ante valuation for a product without sampling
ΔV	Goodwill effect of sampling
r	Pearson correlation coefficient
β	Proportion of low switching cost consumers
k_h/k_l	High/low switching cost
α_A/α_B	Probability of realizing good fits with attribute a_2 of product A/B
H_A/L_A	The ex post valuation for product A when realizing good/bad fits
H_B/L_B	The ex post valuation for product B when realizing good/bad fits

For a clear illustration of the model setting, consider that a consumer, Susan, decides to purchase some sauces for her meal. She searches and gets the selling information that there are two brands—Screamin' Mimi's and Louisiana, providing sauces. There are many features of the sauces Susan can know in advance, but she does not know the flavor of which sauce fits her appetite best before she tries them. Faced up with this fit uncertainty, Susan has more willingness to first visit the retailer providing free sauce samples given other settings the same. When free sauce samples are available, Susan may realize good fits with the sauce and make a purchase, or she may realize bad fits and switch to the other brand if her switching cost to the other store is low, and if the switching cost is high she will leave the market. Expecting the consumers' purchasing behavior, retailers decide whether to provide product sampling and what price to charge at the beginning of selling period.

The sequence of the consumers' decisions is depicted in Figure 2. In stage 1, each consumer chooses which retailer to visit. This decision depends on the two retailers' announced sampling and pricing strategies, the consumer's mismatch costs and her[3] *ex ante* valuations for the two products.

In stage 2, after traveling to retailers, each consumer may reevaluate the product. If sampling is available, the consumer resolves her fit uncertainty for product attribute a_2 and realizes an *ex post* valuation for the product; otherwise,

[3]Throughout the paper, consumer is referred to as "she", and retailer is referred to as "he".

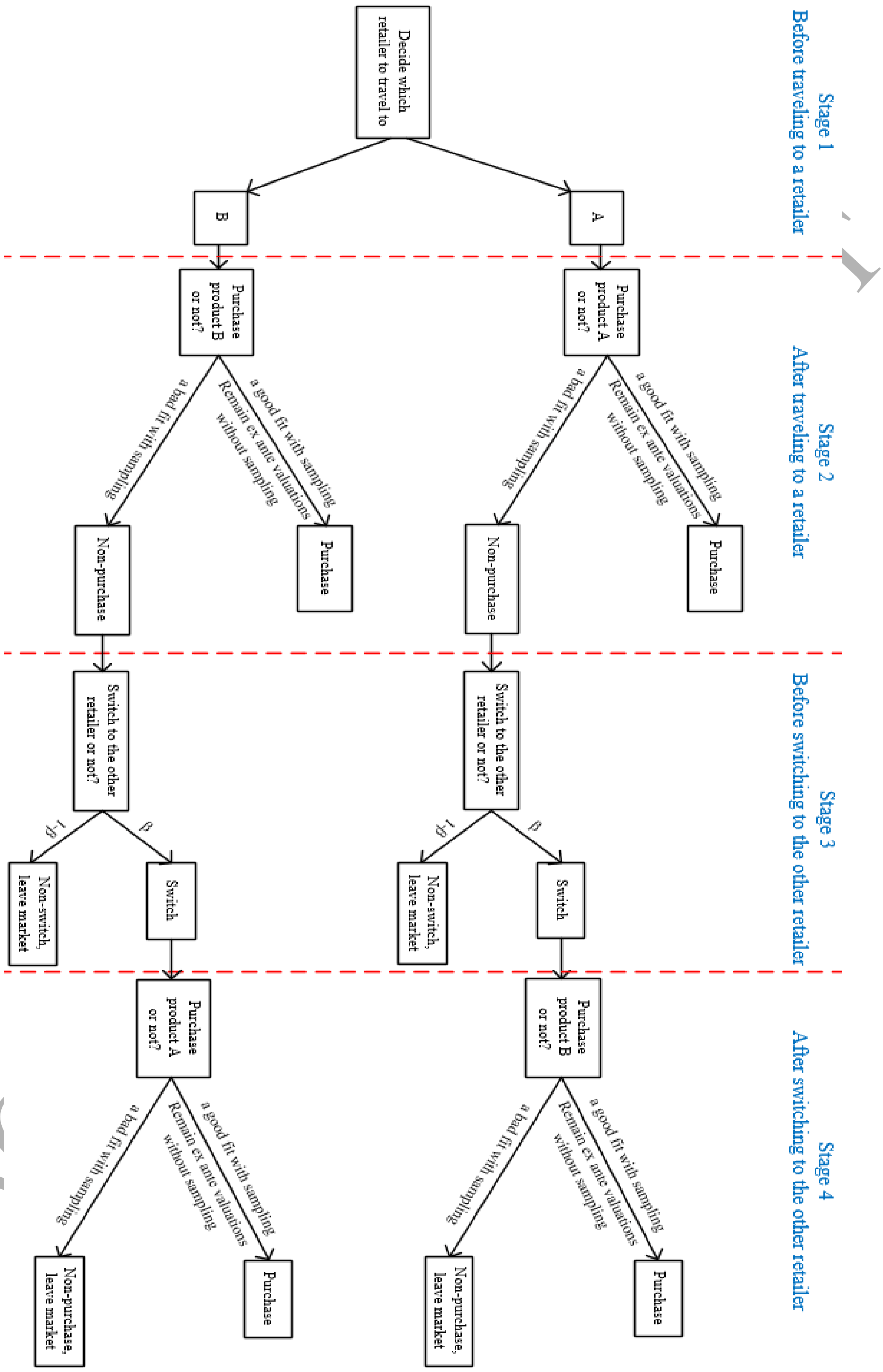


Figure 2: *Sequence of consumers' visiting and purchasing decisions.*

she remains her product valuation at the *ex ante* value. Then she decides whether or not to purchase this product. When her valuation for the product is greater than the price, the consumer purchases immediately from the focal retailer; otherwise, she does not purchase. Once the consumer does not purchase from this retailer, she needs to decide whether to switch to the other retailer for a further product trial, as shown in stage 3 of Figure 2. Note that before switching to the other retailer, a consumer remains her valuation uncertainty for the other retailer's product.[4] Thus, the consumers' switching decision depends on her *ex ante* valuation for the other product, the price of the other retailer's product, mismatch cost and her switching cost to travel to the other retailer. The switching cost exists because of the physical efforts and psychological costs such as those associated with time pressure. Suppose that consumers would incur a cost of $k \in \{k_l, k_h\}$ ($k_h > k_l$) to switch to the other retailer for a further trial. Consumers are endowed with heterogenous switching costs, specifically, for consumers with a busy work schedule, they may have a higher traveling cost k_h to visit the other retailer, and for consumers at leisure, they occur a much lower traveling cost k_l. Similar to the assumption of Gu and Liu (2013), we suppose that a proportion of β ($\beta \geq 0$) consumers have a low switching cost and a proportion of $1 - \beta$ consumers have a high one.[5] To simplify the analysis, we focus on the interesting case that the high switching cost k_h is too large to enable consumers to switch for a further trial, and only a proportion of β low switching cost consumers would switch to the other product upon bad fits with the initial one.

In stage 4 of Figure 2, after switching to the other product, consumers can reevaluate that product if sampling is available, then decide whether to purchase it. The decision process is almost the same as that in stage 2. Next, we find the equilibrium solution.

4. Equilibrium Sampling Strategy under Simultaneous Decisions

In this section, we discuss the situation when competing retailers simultaneously make their sampling decisions. We later discuss the case that competing retailers sequentially choose their sampling strategies. We first find the equilibrium prices for a given sampling strategy and obtain the competing retailers' market payoffs under all possible sampling scenarios. We then examine retailers' Nash equilibrium sampling strategy.

4.1. Equilibrium Prices and Payoffs for Given Sampling Scenario

There are three possible sampling scenarios in the oligopoly market: (1) neither of retailers implements the sampling activity (No–No Strategy), (2) only one retailer implements the sampling activity (No Sample–Sample or Sample–No

[4] The two retailers' products are in the same product category, but each has its own private brand.

[5] The switching rate β here can also depict the consumers' intrinsic heterogeneity in their demands for products, i.e., rigid demands and elastic demands. For consumers with elastic demands, they are unwilling to pay more efforts to try other products upon dissatisfaction, while for the ones with strict demands, they would exert more efforts to switch to the other product for a further trial. For example, Mary and Emily both want to purchase fresh organic fruits. Emily does the shopping on a weekly basis, while Mary purchases fruits for a birthday party. After trying free samples of fruits in one store and realizing bad fits, Mary is more likely to switch to the other store for a further trial, while Emily may stop searching and go back home without purchasing any fruits.

Sample Strategy), and (3) both retailers implement the sampling activity (Sample–Sample Strategy). Next we present the retailers' prices and market payoffs under these three sampling scenarios.

4.1.1. No–No Strategy

When neither retailer A nor retailer B offers free samples (i.e., No–No strategy), all consumers hold the same ex ante valuation $\bar{V}$ for the two products. This situation is a traditional Hotelling game. Suppose the two retailers set the product prices at p_{nni} ($i = A, B$; nn represents the case in which neither of the retailers offers samples). The utility of a consumer located at x_{nn} ($x_{nn} \in [0, 1]$) is as follows:

$$U = \begin{cases} \bar{V} - p_{nnA} - tx_{nn}, & \text{if she purchases from retailer A,} \\ \bar{V} - p_{nnB} - t(1 - x_{nn}), & \text{if she purchases from retailer B.} \end{cases}$$

The point of division between the regions served by the two retailers is determined by the condition that it makes no difference for a consumer to purchase from retailer A or from retailer B. By equating the utility of purchasing from retailer A and retailer B, we have:

$$\bar{V} - p_{nnA} - tx_{nn} = \bar{V} - p_{nnB} - t(1 - x_{nn}).$$

Solving the equation, the point of division x_{nn} is $x_{nn} = \frac{p_{nnB} - p_{nnA}}{2t} + \frac{1}{2}$.

For the No–No strategy, sampling is not available and consumers thus cannot tell how the two products' horizontal attributes fit their preferences. In this situation, the extent of horizontal product differentiation (i.e., the intensity of competition) does not affect the two retailers' profits. Regardless of the degree of competition, the retailers' profit functions are the same, i.e., $\pi_{nnA} = p_{nnA} x_{nn}$ and $\pi_{nnB} = p_{nnB}(1 - x_{nn})$. Each retailer chooses his optimal price to maximize his profit. This is a symmetric game, the optimal prices and profits are:

$$p^*_{nnA} = p^*_{nnB} = t, \tag{1}$$

$$\pi^*_{nnA} = \pi^*_{nnB} = \frac{t}{2}. \tag{2}$$

4.1.2. No Sample–Sample Strategy

When retailer A does not provide samples, whereas retailer B provides samples (i.e., No Sample–Sample strategy), consumers hold an ex ante valuation $\bar{V}$ for product A and an ex ante valuation of $\bar{V} + \Delta V$ for product B. By equating the utility of visiting retailer A and retailer B, we have:

$$\bar{V} - p_{nsA} - tx_{ns} = \bar{V} + \Delta V - p_{nsB} - t(1 - x_{ns}), \tag{3}$$

where x_{ns} ($x_{ns} \in [0, 1]$) is the point of division at which it makes no difference for a consumer to travel to retailer A or to retailer B, and p_{nsi} is the product price of retailer i ($i = A, B$). ns represents the case in which retailer A does not offer samples and retailer B offers samples. By solving Equation (3), we obtain the point of division x_{ns} as $x_{ns} = \frac{p_{nsB} - p_{nsA} - \Delta V}{2t} + \frac{1}{2}$.

All consumers located at a distance no farther than x_{ns} visit and purchase from retailer A. The remaining $1 - x_{ns}$ consumers visit retailer B. Among the $1 - x_{ns}$ consumers, a proportion of α_B consumers who realize a good fit with a high valuation H_B purchase the product immediately ($H_A \geq \bar{V} > p_{nsB}$), while the other proportion of $1 - \alpha_B$ consumers who realize a low valuation L_B after sampling trials make a purchase if $L_B \geq p_{nsB}$, otherwise, these low valuation consumers give up purchasing this product and may switch to the other retailer if their switching cost is low. In the case with $L_B \geq p_{nsB}$, retailer B can serve all of these $1 - x_{ns}$ consumers who have tried product samples. Hence, in this situation, the main purpose of sampling is to make use of the goodwill effect to attract consumers. This provides an explanation for the marketing practice that firms may provide free samples even if consumers know the products well. In this paper, our discussion focuses on the case that only a proportion of α_B high valuation consumers purchase the product after sampling trials, i.e., $L_B < p_{nsB}$. In this way, sampling also achieves the function of consumer segmentation.

For the No Sample–Sample strategy, consumers can only resolve fit uncertainty for one product and thus they cannot tell the extent of differentiation between the two products. Therefore, the extent of horizontal product differentiation (i.e., the intensity of competition) does not affect the two retailers' profits. For different intensities of competition, the retailers' profit functions are the same, i.e., $\pi_{nsA} = p_{nsA}(x_{ns} + (1 - x_{ns})\beta(1 - \alpha_B))$ and $\pi_{nsB} = (p_{nsB} - c_s)(1 - x_{ns})\alpha_B$. The point of division x_{ns}, the two retailers' optimal prices p^*_{nsi} and profits π^*_{nsi} are:

$$x_{ns} = \frac{1}{2} - \frac{\Delta V - c_s}{6t} - \frac{\beta(1 - \alpha_B)}{3(1 - \beta(1 - \alpha_B))},$$

$$p^*_{nsA} = t + \frac{c_s - \Delta V}{3} + \frac{4\beta(1 - \alpha_B)t}{3(1 - \beta(1 - \alpha_B))}, \tag{4}$$

$$p^*_{nsB} = t + \frac{2c_s + \Delta V}{3} + \frac{2\beta(1 - \alpha_B)t}{3(1 - \beta(1 - \alpha_B))}, \tag{5}$$

$$\pi^*_{nsA} = \frac{1 - \beta(1 - \alpha_B)}{2t}\left(t + \frac{c_s - \Delta V}{3} + \frac{4\beta(1 - \alpha_B)t}{3(1 - \beta(1 - \alpha_B))}\right)^2, \tag{6}$$

$$\pi^*_{nsB} = \frac{\alpha_B}{2t}\left(t + \frac{\Delta V - c_s}{3} + \frac{2\beta(1 - \alpha_B)t}{3(1 - \beta(1 - \alpha_B))}\right)^2. \tag{7}$$

Note that the equilibrium prices for both product A and B are higher with a larger consumer switching rate β. This shows that, interestingly, consumer switching behavior can soften price competition when retailers adopt asymmetric sampling strategies. This is different from the result of Klemperer (1987a, 1987b) and Farrell and Klemperer (2007); they find that consumer switching behavior can intensify price competition. We conclude this counter-intuitive result as follows:

Proposition 1. *When competing retailers adopt asymmetric sampling strategies, consumer switching behavior can soften price competition and thus benefit both retailers.*

There are two reasons behind the price increases. First, when competing retailers adopt asymmetric sampling strategies, for example, the No Sample–Sample strategy, consumers retain their fit uncertainties for product A but resolve their fit uncertainties for product B. When consumers realize bad fits with product B and switch to product A, they gain a second chance to find products fitting their needs and may purchase from retailer A with some probability. Consequently, retailer A has additional selling opportunities and would raise his selling price. Given the increased price of retailer A, more consumers would initially choose to visit retailer B in the Hotelling model. Retailer B thus can also achieve more sales and would raise the corresponding price as well. Therefore, consumer switching behavior helps bring more selling opportunities to both retailers and thereby softens price competition.

Second, in the No Sample–Sample strategy, the information disclosure from the retailer with sampling establishes the dispersion of consumers' posterior valuations across products and thus creates perceived differentiation between the retailers' products. Specifically, in the No Sample–Sample strategy, consumers can realize their ex post valuations for the retailer with sampling, but remain their ex ante valuations for the one without sampling. As a result, the consumers' valuations for the two products are quite different. With perceived product differentiation and switching behavior, the retailer with sampling can serve high valuation consumers while the one without sampling can serve low valuation consumers who are switching from the retailer with sampling. When consumers do not switch between retailers, the retailer without sampling has no chance to serve consumers who realize low valuations for the retailer with sampling. Therefore, consumer switching behavior helps retailers capture the benefit of product differentiation and thus moderates price competition.

In Klemperer (1987a, 1987b) and Farrell and Klemperer (2007), there is no horizontal fitness uncertainty. Consumers know the products very well and switch between retailers only for getting a lower price. Thus, price competition intensifies with the existence of consumer switching behavior.

The goodwill effect of sampling affects retailers' optimal prices and profits as well.

Proposition 2. *When competing retailers adopt asymmetric sampling strategies, with a stronger goodwill effect of sampling, the price and profit of the retailer with sampling increase, but the price and profit of the one without sampling decrease.*

When competing retailers adopt asymmetric sampling strategies, for example, the No Sample–Sample strategy, with a stronger goodwill effect of sampling, more consumers prefer to visit the retailer with sampling (i.e., retailer B), and fewer consumers travel to the retailer without sampling (i.e., retailer A). Retailer A thus can only gets fewer sales while retailer B achieves more. In response to this tendency, retailer A would lower his price to prevent the erosion of his sales, while retailer B would raise price to maximize his profit. Therefore, the price and profit of retailer A decrease, whereas those of retailer B increase with the magnitude of goodwill effect.

In addition, the probability for a consumer to realize a good fit with a product also affects retailers' optimal prices and profits.

Proposition 3. *When competing retailers adopt asymmetric sampling strategies, the larger the probability of realizing a good fit with a product, the lower of both retailers' prices.*

This is intuitive. For the asymmetric sampling strategies, if the probability of realizing a good fit with a product is large, few consumers find the product unfit and switch to the other store. Thus, the retailer without sampling can get few sales from switching consumers and he prefers to charge a low price to attract more consumers to first visit his store. His competitor—the retailer with sampling, would also cut down the selling price in response.

4.1.3. Sample-Sample Strategy

When both retailers offer free samples (i.e., Sample–Sample strategy), consumers hold the same ex ante valuation $\bar{V} + \Delta V$ for the two products before traveling to retailers. We equate the utility of visiting retailer A and retailer B:

$$\bar{V} + \Delta V - tx_{ss} - p_{ssA} = \bar{V} + \Delta V - t(1 - x_{ss}) - p_{ssB}, \tag{8}$$

where x_{ss} ($x_{ss} \in [0, 1]$) is the point of division at which it makes no difference for a consumer to travel to retailer A or to retailer B, p_{ssi} is the product price of retailer i ($i = A, B$, ss represents the case in which both retailers offer samples). By solving Equation (8), we obtain the point of division x_{ss} as $x_{ss} = \frac{p_{ssB}-p_{ssA}}{2t} + \frac{1}{2}$.

Among the x_{ss} consumers who travel to retailer A, a proportion of $\rho_{hh} + \rho_{hl}$ (i.e., α_A) high valuation consumers purchase product A, a proportion of $\beta\rho_{lh}$ consumers switch to and purchase product B, and a proportion of $(1-\beta)\rho_{lh}+\rho_{ll}$ consumers leave the market without purchasing anything. Among the $1 - x_{ss}$ consumers who travel to retailer B, a proportion of $\rho_{hh} + \rho_{lh}$ (i.e., α_B) high valuation consumers purchase product B, a proportion of $\beta\rho_{hl}$ consumers switch to and purchase product A, and a proportion of $(1-\beta)\rho_{hl}+\rho_{ll}$ consumers leave the market without purchasing anything. The two retailers' profit functions $\pi_{ssi}(i = A, B)$ can be as follows:

$$\pi_{ssA} = (p_{ssA} - c_s)(x_{ss}(\rho_{hh} + \rho_{hl}) + (1 - x_{ss})\beta\rho_{hl}), \tag{9}$$

$$\pi_{ssB} = (p_{ssB} - c_s)((1 - x_{ss})(\rho_{hh} + \rho_{lh}) + x_{ss}\beta\rho_{lh}). \tag{10}$$

For the Sample–Sample strategy, consumers can resolve their fit uncertainties for both products and thus they can tell the extent of differentiation between the two products. The intensity of competition (i.e., the extent of horizontal product differentiation) begins to affect the two retailers' profits. Next, we discuss the two retailers' optimal profits in three scenarios in which the degree of competition is strong, intermediate, and weak, respectively.

Strong Intensity of Competition

When the intensity of competition is strong, the degree of horizontal product differentiation is low and consumers' ex post valuations for the two products are perfectly positively correlated. We have $r = 1$, $\rho_{hh} = \alpha_A = \alpha_B$ and $\rho_{ll} = 1 - \alpha_A = 1 - \alpha_B$. The two retailers' profit functions in Equations (9) and (10) become $\pi^{st}_{ssA} = (p_{ssA} - c_s)x_{ss}\alpha_B$ and $\pi^{st}_{ssB} = (p_{ssB} - c_s)(1 - x_{ss})\alpha_B$, respectively; here, the superscript *st* represents the case with a strong intensity of competition. The two retailers' optimal prices p^{st*}_{ssi} and profits π^{st*}_{ssi} are:

$$p^{st*}_{ssA} = p^{st*}_{ssB} = t + c_s, \tag{11}$$

$$\pi^{st*}_{ssA} = \pi^{st*}_{ssB} = \frac{\alpha_A t}{2} = \frac{\alpha_B t}{2}. \tag{12}$$

Interestingly, when both retailers offer samples and the intensity of competition is strong, consumer switching behavior does not affect the retailers' market payoffs. This phenomenon occurs because the two products are identical on attribute a_2. In this scenario, the switching consumers who find one product bad fits would also find the other product bad fits, and they thus leave the market without purchasing anything. Hence, the existence of consumer switching behavior has no impact on any retailer's profit. This finding is in contrast to that of Proposition 1, in which both retailers benefit from consumer switching behavior when only one retailer offers samples. The difference reveals that retailers' sampling strategies affect the impact of consumer switching behavior on their market payoffs.

Intermediate Intensity of Competition

When the intensity of competition is intermediate, the degree of horizontal product differentiation is moderate and consumers' ex post valuations for the two products are independent. We have $r = 0$, $\rho_{hh} = \alpha_A\alpha_B, \rho_{hl} = \alpha_A(1-\alpha_B), \rho_{lh} = (1-\alpha_A)\alpha_B, \rho_{ll} = (1-\alpha_A)(1-\alpha_B)$. Therefore, the two retailers' profit functions in Equations (9) and (10) become $\pi^{im}_{ssA} = (p_{ssA} - c_s)(x_{ss}\alpha_A + (1 - x_{ss})\beta(1-\alpha_B)\alpha_A)$ and $\pi^{im}_{ssB} = (p_{ssB} - c_s)((1 - x_{ss})\alpha_B + x_{ss}\beta(1-\alpha_A)\alpha_B)$, respectively; here, the superscript *im* represents the case with an intermediate intensity of competition. We derive the point of division x^{im}_{ss}, the two retailers' equilibrium prices p^{im*}_{ssi} and profits π^{im*}_{ssi} as below:

$$
\begin{aligned}
x^{im}_{ss} &= \frac{\beta(\alpha_B-\alpha_A)}{3(\beta(1-\alpha_A)-1)(\beta(1-\alpha_B)-1)} + \frac{1}{2}, \\
p^{im*}_{ssA} &= \frac{3t(1+\beta(1-\alpha_B)) + \frac{2\beta t(\alpha_B-\alpha_A)}{1-\beta(1-\alpha_A)}}{3(1-\beta(1-\alpha_B))} + c_s, \\
p^{im*}_{ssB} &= \frac{3t + 3\beta t(1-\alpha_A) - \frac{2\beta t(\alpha_B-\alpha_A)}{1-\beta(1-\alpha_B)}}{3(1-\beta(1-\alpha_A))} + c_s, \\
\pi^{im*}_{ssA} &= \frac{\alpha_A t}{18(1-\beta(1-\alpha_B))}\Big(3 + 3\beta(1-\alpha_B) + \frac{2\beta(\alpha_B-\alpha_A)}{1-\beta(1-\alpha_A)}\Big)^2, && (13) \\
\pi^{im*}_{ssB} &= \frac{\alpha_B t}{18(1-\beta(1-\alpha_A))}\Big(3 + 3\beta(1-\alpha_A) - \frac{2\beta(\alpha_B-\alpha_A)}{1-\beta(1-\alpha_B)}\Big)^2. && (14)
\end{aligned}
$$

Weak Intensity of Competition

When the intensity of competition is weak, the degree of horizontal product differentiation is high and consumers' ex post valuations for the two products are perfectly negatively correlated. We have $r = -1$, $\rho_{hh} = \rho_{ll} = 0$, $\rho_{hl} = \alpha_A = 1-\alpha_B$ and $\rho_{lh} = \alpha_B = 1-\alpha_A$. The two retailers' profit functions in Equations (9) and (10) become $\pi^{wk}_{ssA} = (p_{ssA} - c_s)(x_{ss}\alpha_A + (1 - x_{ss})\beta\alpha_A)$ and $\pi^{wk}_{ssB} = (p_{ssB} - c_s)((1 - x_{ss})\alpha_B + x_{ss}\beta\alpha_B)$, respectively; here, the superscript *wk* represents the case with a weak intensity of competition. We derive the two retailers' optimal prices p^{wk*}_{ssi} and profits π^{wk*}_{ssi} as below:

$$
p^{wk*}_{ssA} = p^{wk*}_{ssB} = c_s + \frac{(1+\beta)t}{1-\beta}, \tag{15}
$$

$$
\pi^{wk*}_{ssA} = \frac{\alpha_A t(\beta+1)^2}{2(1-\beta)}, \tag{16}
$$

$$
\pi^{wk*}_{ssB} = \frac{\alpha_B t(\beta+1)^2}{2(1-\beta)}. \tag{17}
$$

Especially, when $\beta = 1$, all consumers will switch upon dissatisfaction. Both retailers thus can achieve patronage of all consumers. The two retailers' profit functions become $\pi^{wk*}_{ssA} = \alpha_A(p^{wk*}_{ssA} - c_s)$ and $\pi^{wk*}_{ssB} = \alpha_B(p^{wk*}_{ssB} - c_s)$, respectively.

Note that before traveling to retailers, each consumer anticipates to achieve a nonnegative utility from purchasing products, i.e., $\bar{V} + \Delta V - t - p_{ssi}^{wk} \geq 0$. Thus, the retailers' maximum prices are $p_{ssA}^{wk*} = p_{ssB}^{wk*} = \bar{V} + \Delta V - t$. Therefore, in the case with $\beta = 1$, the retailers' optimal profits are $\pi_{ssA}^{wk*} = \alpha_A(\bar{V} + \Delta V - t - c_s)$ and $\pi_{ssB}^{wk*} = \alpha_B(\bar{V} + \Delta V - t - c_s)$, respectively.

In this case, with a larger consumer switching rate, both retailers set higher prices and achieve more profits. We conclude this result as follows.

Proposition 4. *When the intensity of competition is weak, that is, the degree of product differentiation is high, competing retailers' prices and profits are nondecreasing with the consumer switching rate if both retailers offer sampling.*

When the degree of horizontal product differentiation is high and both retailers offer sampling, if a consumer realizes a bad fit with the initial product after sampling trials, she can find the other product fit once switching to the other retailer. With a larger switching rate, more consumers can find products matching with their individual preferences. Consequently, both retailers prefer to charge a premium price to only serve consumers who realize good fits with their own products and leave consumers realizing bad fits to the competitor.

The result revealed in Proposition 4 is quite different from that in the case when both retailers offer sampling but with a strong intensity of competition, where both retailers cannot benefit from consumer switching behavior. This phenomenon indicates that the intensity of competition affects the impact of consumer switching behavior on the retailers' market payoffs.

We have solved the equilibrium solution for any given sampling strategy. Next, we discuss the retailers' choice of sampling strategy in Nash equilibrium.

4.2. Equilibrium Sampling Strategy

In this section, we examine the competing retailers' Nash equilibrium sampling strategies for three scenarios with different intensities of competition: (1) strong intensity of competition, (2) intermediate intensity of competition, and (3) weak intensity of competition.

4.2.1. Strong Intensity of Competition

When the intensity of competition is strong, i.e., the degree of horizontal product differentiation is low and the Pearson correlation coefficient is $r = 1$, we can derive the retailers' Nash equilibrium by comparing the retailers' profits under the No Sample–Sample strategy with those under the No–No strategy and Sample–Sample strategy (Eq. (12) versus Eq. (6) and Eq. (2) versus Eq. (7)). The equilibrium outcome is presented in Proposition 5.

Proposition 5. *In a simultaneous move game, when the intensity of product competition is strong, the equilibrium sampling strategy is as follows,*

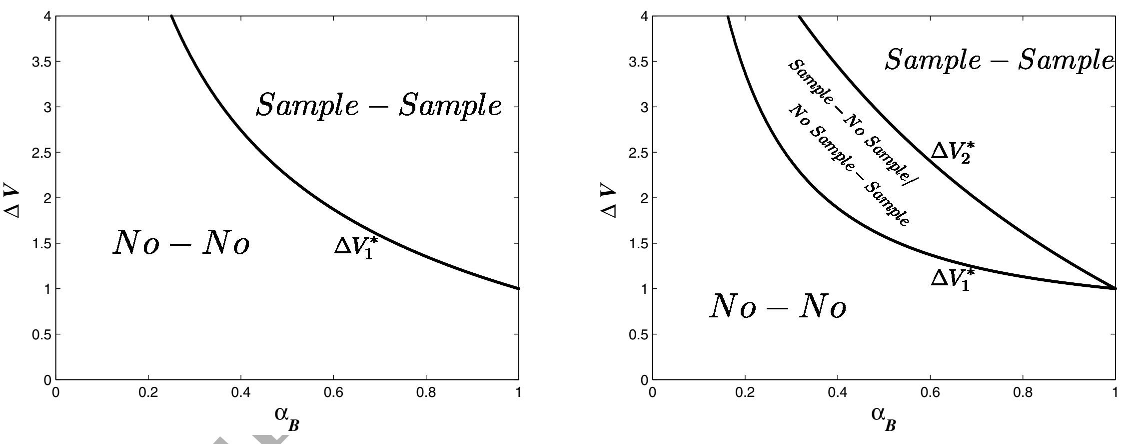
(1) In the case when all consumers occur high switching costs (i.e., $\beta = 0$), the Nash equilibrium is a No–No equilibrium if $\Delta V < \Delta V_1^*$, where $\Delta V_1^* = c_s - \frac{2\beta(1-\alpha_B)t}{1-\beta(1-\alpha_B)} + 3t(\frac{1}{\sqrt{\alpha_B}} - 1)$; otherwise it's a Sample-Sample equilibrium.

(2) In the case when some parts of consumers occur high switching costs (i.e., $\beta > 0$), the Nash equilibrium is a No–No equilibrium if $\Delta V < \Delta V_1^*$; the Nash equilibrium is a No Sample–Sample or Sample–No Sample equilibrium if $\Delta V \in [\Delta V_1^*, \Delta V_2^*]$, where $\Delta V_2^* = c_s + \frac{4\beta(1-\alpha_B)t}{1-\beta(1-\alpha_B)} + 3t(1 - \sqrt{\frac{\alpha_B}{1-\beta(1-\alpha_B)}})$; otherwise it's a Sample-Sample equilibrium.

Especially, ΔV_1^* is the threshold at which it makes no difference for a retailer to adopt sampling or no sampling given his competitor adopting no sampling, ΔV_2^* is the threshold at which it makes no difference for a retailer to adopt sampling or no sampling given his competitor providing sampling.

Proposition 5 reveals that competing retailers prefer sampling only if the goodwill effect of sampling is strong. This finding keeps in consistency with the practice that companies such as Procter & Gamble and Unilever, are willing to invest a lot on providing free product samples, because free samples are powerful to reach consumers (Tuttle 2011).

Proposition 5 can be also stated in terms of the probability α_B that a consumer realizes a good fit with the product, that is, in the case without consumer switching, there exists α_B^* such that if $\alpha_B < \alpha_B^*$, the Nash equilibrium is a No–No equilibrium; otherwise the Nash equilibrium is a Sample-Sample equilibrium. In the case with consumer switching behavior, the equilibrium is asymmetric if the probability of realizing a good fit is in a middle interval.



(a) $\beta = 0$ (b) $\beta = 0.5$

Figure 3: *Nash equilibrium in $(\alpha_B, \Delta V)$ parameter space with $r = 1$, $\alpha_A = \alpha_B$.*

Figures 3a and 3b illustrate the competing retailers' Nash equilibrium sampling strategy in different $(\alpha_B, \Delta V)$ parameter regions for $\beta = 0$ and $\beta = 0.5$, respectively, when $t = 1, c_s = 1, \alpha_A = \alpha_B, r = 1$. If the probability α_B that a consumer realizes a good fit with the product becomes large, retailers begin to prefer sampling for getting more high valuation consumers. If the goodwill effect of sampling ΔV becomes strong, retailers prefer sampling because it attracts more consumers' visits. These mechanisms explain why the Nash equilibrium is a Sample–Sample equilibrium when the probability of realizing a good fit is large and the goodwill effect of sampling is strong, as shown in Figures 3a and 3b. Moreover, with the increasing of α_B or ΔV, the Nash equilibrium shifts from No–No to Sample–

Sample equilibrium in Figure 3a, and in Figure 3b, it shifts from No–No to No Sample–Sample/Sample–No Sample equilibrium, and from No Sample–Sample/Sample–No Sample to Sample–Sample equilibrium.

In Figure 3b with consumer switching behavior, the No Sample–Sample/Sample–No Sample Nash equilibrium exists in the area of $\Delta V \in [\Delta V_1^*, \Delta V_2^*]$. In this region, the retailers' game is equivalent to a *chicken game*, in which each retailer's sampling strategy depends on his competitor's sampling decision. Moreover, retailer A and B are equally likely to provide sampling in the asymmetric equilibria. However, this asymmetric equilibrium never exists in Figure 3a where no consumer switching behavior occurs. The difference reveals to us the following insight:

Corollary 1. *In a simultaneous game, when the intensity of product competition is strong, competing retailers can reach asymmetric equilibria only if consumer switching behavior exists.*

When the intensity of competition is strong, $r = 1$ and $\alpha_A = \alpha_B$, the retailers' game is symmetric. Without consumer switching behavior, retailers always adopt symmetric sampling strategies. When consumer switching behavior exists, both retailers benefit from this switching behavior if they adopt asymmetric sampling strategies (see Proposition 1). Hence, with a large switching rate, both retailers have additional incentive to adopt asymmetric sampling strategies, especially in the region of $\Delta V \in [\Delta V_1^*, \Delta V_2^*]$, where the goodwill effect of sampling is neither strong enough to induce both retailers to adopt sampling nor weak enough for both retailers to abandon sampling.

Furthermore, as illustrated in Figure 3, ΔV_1^* and ΔV_2^* decrease as α_B increases in $[0, 1]$ (i.e., the Sample–Sample Nash equilibrium tends to exist with a large α_B). This phenomenon occurs because when the probability of realizing a good fit with the product is large, sampling becomes so appealing that even a weaker goodwill effect of sampling is enough for both retailers to choose sampling.

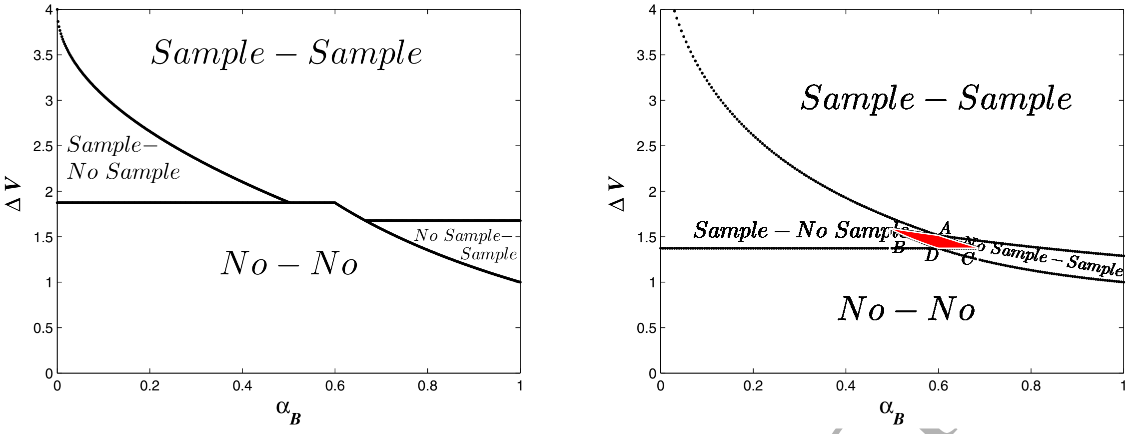
Interestingly, when the intensity of product competition is strong, both retailers can achieve higher profits under the No–No strategy than that under the Sample–Sample strategy. Competing retailers indeed fall into the *prisoner's dilemma* when reaching the Sample–Sample equilibrium. We conclude this result as follows.

Proposition 6. *When the intensity of competition is strong, that is, the degree of product differentiation is low, competing retailers fall into the prisoner's dilemma when reaching the Sample–Sample Nash equilibrium.*

Proposition 6 shows that competing retailers can actually be worse off when both of them provide samples than when neither of them offers sampling. That's because retailers in the No–No equilibrium can capture all of the consumers. However, in the Sample–Sample equilibrium, retailers will lose consumers who dislike their products. In addition, the benefit from the goodwill effect of sampling is canceled when both retailers provide free samples, and both retailers cannot benefit from consumer switching behavior.

4.2.2. Intermediate Intensity of Competition

When the intensity of competition is intermediate, i.e., the degree of product differentiation is moderate and the Pearson correlation coefficient is $r = 0$, we follow a similar logic to the case of strong competition to derive the retailers' Nash equilibrium sampling strategy, as shown in Figure 4.



(a) $\beta = 0$ (b) $\beta = 0.5$

Figure 4: *Nash equilibrium in* $[\alpha_B, \Delta V]$ *parameter space with* $r = 0$, $\alpha_A = 0.6$.

Figures 4a and 4b illustrate the competing retailers' Nash equilibrium sampling strategy in different $(\alpha_B, \Delta V)$ regions for $\beta = 0$ and $\beta = 0.5$, respectively, where $t = 1, c_s = 1, \alpha_A = 0.6, r = 0$. Similarly, the large value of ΔV makes sampling appealing to both retailers. Thus, when ΔV becomes large, the Nash equilibrium shifts from No–No to Sample–No Sample/No Sample–Sample and from Sample–No Sample/No Sample–Sample to Sample–Sample. As for the impact of the product fit probability on the sampling strategy, we show that when the two products are of different fit probabilities, i.e., α_B is quite different from $\alpha_A = 0.6$ here, retailers are more likely to reach asymmetric equilibria. This is because the probabilities of realizing good fits with the two products are independent. When the probability of realizing a good fit with one retailer's product is low while that of the other retailer's product is high, the retailer with a high fit probability suffers a little from losing consumers for their dislike of the product, so that he is more likely to provide sampling; while the one with a low fit probability suffers a lot and prefers no sampling. This result is quite different from that in the case with a strong competition, where asymmetric equilibria exist when the probability of realizing a good fit is in a middle interval.

Interestingly, when the intensity of competition is intermediate, competing retailers may reach asymmetric equilibria even without consumer switching behavior (i.e., $\beta = 0$), as shown in the left and right regions of Figure 4a. We conclude this point as follows.

Proposition 7. *With a relatively weak intensity of product competition, competing retailers can reach asymmetric equilibria even if consumers do not switch between retailers.*

The result revealed in Proposition 7 is in contrast to that in Corollary 1, where competing retailers can reach asymmetric equilibria only if consumers switch between retailers when the intensity of product competition is strong. The difference reveals that weakened intensity of product competition can impel retailers to adopt asymmetric fit-revealing strategies. This is because when the intensity of product competition is relatively weak, i.e., the degree of product horizontal differentiation is relatively high, competing retailers have more incentive to adopt different sampling strategies to induce consumer differentiation and serve appropriate customer segments. Furthermore, the two results in Proposition 7 and Corollary 1 show that the existence of asymmetric equilibria depends on both the consumer switching behavior and the intensity of product competition.

In the region ABCD of Figure 4b, there are multiple Nash equilibria. Retailers can either reach a Sample–No Sample equilibrium or a No Sample–Sample equilibrium. Under this situation, the retailers' game can be also regarded as a chicken game, in which both retailers' sampling strategies depend on his competitor's sampling decision. In other regions of Figure 4b, the equilibrium solution is unique and at least one retailer's sampling choice does not depend on his competitor's sampling decision.

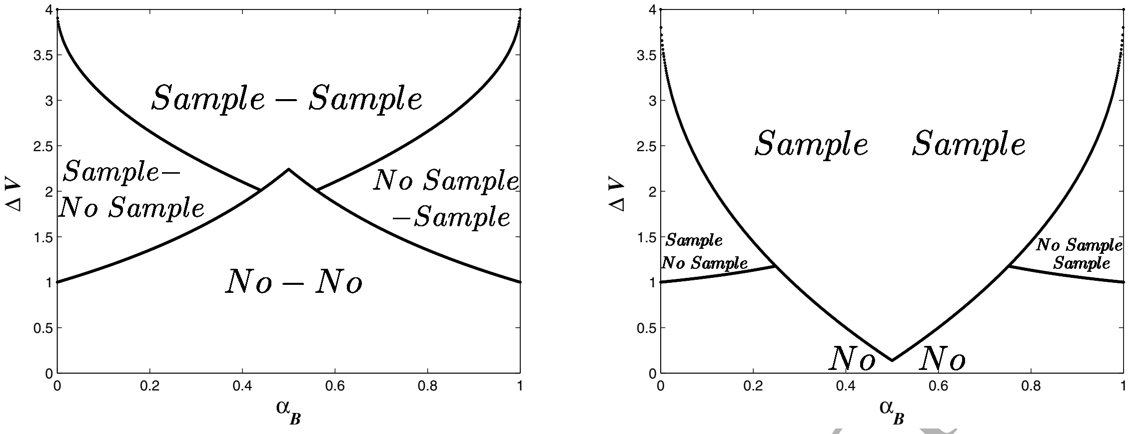
We also find that, in the case with an intermediate competition intensity, competing retailers may not fall into the prisoner's dilemma upon reaching the Sample–Sample equilibrium if consumer switching behavior exists. This result is different from that in the case with a strong intensity of competition, where retailers fall into the prisoner's dilemma when reaching the Sample–Sample equilibrium (see Proposition 6). That's because in the market with an intermediate competition intensity, the degree of product differentiation is relatively high, the switching consumers who find the focal product bad fits may realize good fits with the other product. The consumer switching behavior thus can benefit both retailers in the Sample–Sample equilibrium and may make this equilibrium become dominant.

4.2.3. Weak Intensity of Competition

When the intensity of competition is weak, i.e., the degree of product differentiation is high and the Pearson correlation coefficient is $r = -1$, we can follow a similar logic to the case with a strong intensity of competition to derive the retailers' Nash equilibrium sampling strategy, as shown in Figure 5.

Figures 5a and 5b illustrate the competing retailers' Nash equilibrium sampling strategy in different $(\alpha_B, \Delta V)$ parameter regions for $\beta = 0$ and $\beta = 0.5$, respectively, where $t = 1, c_s = 1, \alpha_A = 1 - \alpha_B$, and $r = -1$. With large values of ΔV, sampling becomes highly appealing to both retailers. Therefore, when ΔV becomes large, the Nash equilibrium shifts from No–No to Sample–No Sample (or No Sample–Sample) and then to Sample–Sample. As for the impact of α_B on sampling strategy, it is quite different from that in the case of strong competition. Only when α_B is small or large, the Nash equilibrium takes the asymmetric solution. This is because the two products are complementary. If the probability of consumer realizing a good fit with one product is so large that the corresponding retailer offers sampling, then the other retailer would rather not offer sampling and avoid losing consumers that dislike his products because anyway his market is small.

Note that the Sample–Sample equilibrium in Figure 5b occupies a larger region than that in Figure 5a, that's because when the intensity of competition is weak, consumer switching behavior benefits both retailers in the Sample–Sample equilibrium, as revealed in Proposition 4. Therefore, with a larger consumer switching rate, a Sample–Sample equilibrium is more likely to exist. We conclude this result as follows.



(a) $\beta = 0$ (b) $\beta = 0.5$

Figure 5: *Nash equilibrium in* $[\alpha_B, \Delta V]$ *parameter space with* $r = -1, \alpha_A = 1 - \alpha_B$.

Proposition 8. *When the intensity of competition is weak, that is, the degree of product differentiation is high, retailers are more likely to reach the Sample–Sample Nash equilibrium with a larger consumer switching rate.*

Proposition 8 shows that consumer switching behavior may motivate retailers to facilitate fit revelation. This is because when the two competitors' products are highly horizontally differentiated, a consumer who realizes a bad fit with one product is likely to find the other product a good fit when switching to the other retailer. With a larger switching rate, more consumers can find their best fit products. As a result, both retailers prefer revealing fit information to only serve consumers who suit their products.

When the intensity of competition is weak, competing retailers may adopt asymmetric sampling strategies even if no consumer switching behavior occurs (i.e., $\beta = 0$), as shown in the left and right regions of Figure 5a. This finding is different from that revealed in Corollary 1, where competing retailers can reach asymmetric equilibria only if consumer switching behavior exists. Furthermore, in the case with a weak intensity of competition, a Sample–Sample strategy may dominate a No–No strategy for competing retailers and there can be no prisoner's dilemma. This is in contrast to the result in Proposition 6 where the competition is strong. The explanations and insights are similar to those in the case with an intermediate intensity of competition.

5. Equilibrium Sampling Strategy under Sequential Decisions

In the previous section, we discuss the situation when competing retailers make their decisions simultaneously. In this part, we consider the alternative situation of sequential price competition that retailers play a Stackelberg game. We assume retailer A acts as a Stackelberg leader and retailer B is the follower. That is, retailer A chooses his sampling and pricing decisions first, and then retailer B decides his sampling and pricing decisions. After both retailers set their sampling and price strategies, consumers decide which retailer to visit first.

To solve the Stackelberg game, we first find the follower B's optimal sampling and pricing strategies for any given pricing and sampling decisions by the leader A. Based on the follower's sampling and pricing responses, we solve the leader's optimal sampling and pricing strategies. Our results show that the results in Proposition 1-4 still hold in the Stackelberg game. In addition, both retailers may obtain larger profits in a sequential game than that in a simultaneous game. This phenomenon happens in the scenarios of a No–No strategy and a Sample–Sample strategy with a strong competition intensity. That's because in these scenarios, retailers compete head-to-head under the simultaneous game so that neither of them can charge a high price. But in a sequential game, one of the retailers—the follower, can observe the leader's pricing strategy and follow suit. Given such a response from the follower, the leader would charge a higher price and induce the follower to charge a higher price as well. We focus on the retailers' equilibrium sampling strategy in a sequential game and compare it with that of a simultaneous game. Thus, we provide the solution procedure in Appendix B.

Based on the analyses in Appendix B, we can derive the retailers' equilibrium sampling strategy in the Stackelberg game, as presented in Proposition 9 below.

Proposition 9. *In a sequential move game, when the intensity of product competition is strong, the equilibrium sampling strategy is as follows,*

(1) In the case when all consumers occur high switching costs (i.e., $\beta = 0$), the equilibrium is a Sample–Sample equilibrium if $\Delta V > \Delta V_{21}^{sst*}$; it's a Sample–No Sample equilibrium if $\Delta V \in [\Delta V_{11}^{sst*}, \Delta V_{22}^{sst*}]$; otherwise it's a No–No equilibrium.

(2) In the case when some parts of consumers occur high switching costs (i.e., $\beta > 0$), the equilibrium sampling strategy is shown in Table 3 below.

Table 3: Equilibrium Sampling Strategy in a Sequential Game

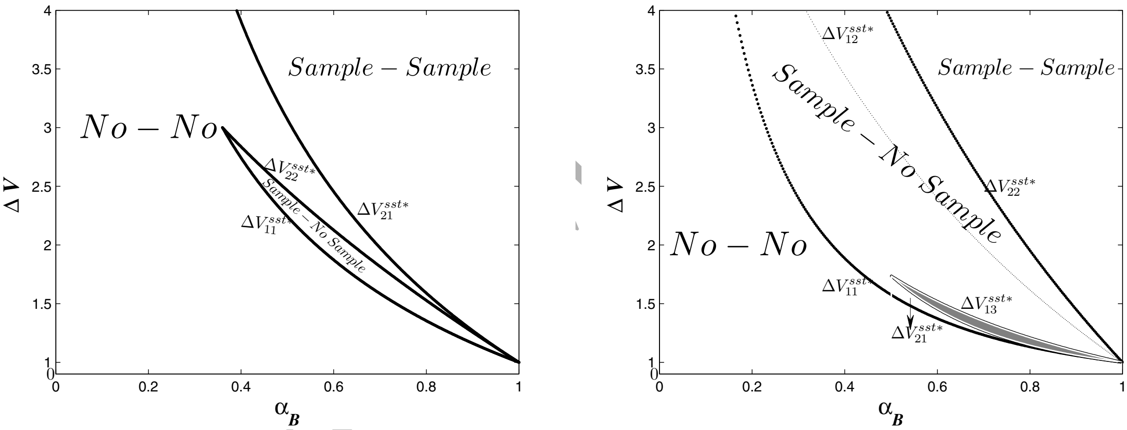
Condition	Equilibrium Sampling Strategy
$\Delta V > \max\{\Delta V_{22}^{sst*}, \Delta V_{21}^{sst*}, \Delta V_{12}^{sst*}\}$	Sample–Sample equilibrium
$\Delta V \in [\max\{\Delta V_{22}^{sst*}, \Delta V_{21}^{sst*}\}, \Delta V_{12}^{sst*}]$ or $\Delta V \in [\Delta V_{21}^{sst*}, \min\{\Delta V_{22}^{sst*}, \Delta V_{13}^{sst*}\}]$	No Sample–Sample equilibrium
$\Delta V \in [\Delta V_{11}^{sst*}, \min\{\Delta V_{21}^{sst*}, \Delta V_{22}^{sst*}\}]$ or $\Delta V \in [\max\{\Delta V_{21}^{sst*}, \Delta V_{13}^{sst*}\}, \Delta V_{22}^{sst*}]$	Sample–No Sample equilibrium
$\Delta V < \min\{\Delta V_{11}^{sst*}, \Delta V_{21}^{sst*}, \Delta V_{22}^{sst*}\}$ or $\Delta V \in [\Delta V_{22}^{sst*}, \Delta V_{21}^{sst*}]$	No–No equilibrium

where $\Delta V_{11}^{sst*} = c_s + \frac{3t}{\sqrt{\alpha_A}} - \frac{3t-\beta(1-\alpha_A)t}{1-\beta(1-\alpha_A)}$, $\Delta V_{12}^{sst*} = c_s + \frac{1}{1-\beta(1-\alpha_B)}((3+\beta(1-\alpha_B))t - \sqrt{9\alpha_A(1-\beta(1-\alpha_B))t^2})$, $\Delta V_{13}^{sst*} =$

$c_s + \frac{t}{1-\beta(1-\alpha_B)+\sqrt{\alpha_A(1-\beta(1-\alpha_B))}}\left(3+\beta(1-\alpha_B) - \frac{\sqrt{\alpha_A(1-\beta(1-\alpha_B))}\big(3-\beta(1-\alpha_A)\big)}{1-\beta(1-\alpha_A)}\right)$, $\Delta V_{21}^{sst*} = c_s + \frac{5t}{\sqrt{\alpha_B}} - \frac{5t-\beta(1-\alpha_B)t}{1-\beta(1-\alpha_B)}$, $\Delta V_{22}^{sst*} = c_s + \frac{1}{1-\beta(1-\alpha_A)}((5+\beta(1-\alpha_A))t - \sqrt{25\alpha_B(1-\beta(1-\alpha_A))t^2})$.

Especially, ΔV_{11}^{sst*} is the threshold at which it makes no difference for the leader to adopt a Sample–No Sample strategy or to adopt a No–No strategy; ΔV_{12}^{sst*} is the threshold at which the leader's profit in a Sample–Sample strategy is the same as that in a No Sample–Sample strategy; ΔV_{13}^{sst*} is the threshold at which the leader achieves the same profit in a Sample–No Sample strategy as that in a No Sample–Sample strategy; ΔV_{21}^{sst*} is the threshold at which it makes no difference for the follower to provide sampling or no sampling given the leader adopting no sampling; ΔV_{22}^{sst*} is the threshold at which it makes no difference for the follower to provide sampling or no sampling given the leader providing sampling.

Proposition 9 shows that competing retailers still prefer to provide sampling when the goodwill effect is strong, regardless of the decision sequence. However, retailers should note that the decision sequence does affect the specific conditions under which retailers reach symmetric or asymmetric sampling equilibria.



(a) $\beta = 0$ (b) $\beta = 0.5$

Figure 6: *Nash equilibrium in $[\alpha_B, \Delta V]$ parameter space with $r = 1, \alpha_A = \alpha_B$ in a Stackelberg Game.*

Figures 6a and 6b illustrate the competing retailers' Nash equilibrium sampling strategy in different $(\alpha_B, \Delta V)$ parameter regions for $\beta = 0$ and $\beta = 0.5$, respectively, where $t = 1, c_s = 1, \alpha_A = \alpha_B$, and $r = 1$. In the grey region of Figure 6b, a No Sample–Sample equilibrium is reached. Similar to the results in a simultaneous game, retailers are more likely to reach the Sample–Sample equilibrium when the goodwill effect of sampling is strong, and they tend to reach asymmetric equilibria when the probability of realizing a good fit is in a middle interval.

Interestingly, Figure 6a and Proposition 9 show that when the intensity of competition is strong, retailers can reach an asymmetric equilibrium (i.e., Sample–No Sample) even without consumer switching behavior (i.e., $\beta = 0$). This result is quite different from that in a simultaneous price competition, where retailers can reach asymmetric equilibria only if consumer switching behavior exists (see Proposition 5). The difference occurs because in this Stackelberg game, the follower has a *second mover advantage*, specifically, the follower can undercut the price of the leader and earn higher profits. Gal-Or (1985) and Amir and Stepanova (2006) show that the second mover advantage occurs when the players' reaction functions slope upwards, which is the case in this model. With the existence of second mover advantage, the leader has more but the follower has less incentive to make use of the goodwill effect of sampling to attract consumers to first visit his store. They thus may reach a Sample–No Sample equilibrium. In a simultaneous game, however, no second mover advantage occurs. We conclude this point as follows.

Corollary 2. *In a sequential game, retailers can reach an asymmetric equilibrium even if the intensity of product competition is strong and consumers do not switch between retailers.*

In a sequential game, when competing retailers reach asymmetric equilibria, it's more likely for the leader to adopt sampling while the follower to adopt no sampling, as shown in Figure 6 that the region where a Sample–No Sample equilibrium exists is larger than that of a No Sample–Sample equilibrium. This is in contrast to the result in a simultaneous game, where the retailers' sampling game may be viewed as a chicken game, in which both retailers are equally likely to provide sampling in the asymmetric equilibria (see Figure 3b).

When the intensity of competition is intermediate or weak, the managerial insights derived under sequential price competition are similar to those under simultaneous price competition. We omit the details to avoid redundancy.

6. CONCLUSION

In this paper, we provide a possible explanation for why we observe competing retailers choosing different sampling strategies when consumers hold fit uncertainty toward products. Actually, this paper also applies to many other fit-revealing mechanisms such as training seminars, satisfaction guarantees, and product demonstrations. Our findings reveal that the goodwill effect of sampling, the probability of realizing good fits with products, consumer switching behavior, and the intensity of product competition play different roles in determining the retailers' sampling and pricing strategies. Managers should make a trade-off among these effects to properly choose the fit-revelation strategy and the corresponding pricing strategy.

Another point needs to be mentioned is that, with a strong product competition, competing retailers actually fall into the prisoner's dilemma when reaching a Sample–Sample Nash equilibrium, so retailers should exercise much caution when implementing the sampling strategy.

Our finding further suggests that competing firms should keep a close eye on the decision sequence when choosing the sampling strategy. In particular, when the intensity of competition is strong, if competing retailers simultaneously make the sampling decisions, their game may be regarded as a chicken game, in which both retailers are equally likely to provide sampling in the asymmetric equilibria. However, if retailers sequentially make the decisions, the leader tends to provide sampling while the follower is more likely to do no sampling in the asymmetric equilibria. Interestingly, both retailers may be better off in the sequential moves than in the simultaneous moves.

Moreover, in contrast to the existing results and intuition, we show that consumer switching behavior can soften price competition when retailers adopt asymmetric sampling strategies. This is because the asymmetric sampling strategies create perceived product differentiation while consumer switching behavior helps to achieve the benefit of product differentiation. This point reveals that a firm may sometimes prefer to facilitate consumers' switching behavior, for example, recommending his competitor to consumers who have experienced bad fits with his own product.

In future research, it would be interesting to investigate the firm's fit-revealing and pricing strategies when consumers have different risk attitudes. Other characteristics of sampling such as limited trial time or limited functionalities can also be incorporated in the firms' sampling strategies under competition.

Acknowledgement

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Appendix A.

PROOF OF PROPOSITION 1.

In the No Sample–Sample strategy, the optimal prices are $p^*_{nsA} = t+\frac{c_s-\Delta V}{3}+\frac{4\beta(1-\alpha_B)t}{3(1-\beta(1-\alpha_B))}$, $p^*_{nsB} = t+\frac{2c_s+\Delta V}{3}+\frac{2\beta(1-\alpha_B)t}{3(1-\beta(1-\alpha_B))}$. Take the derivative of the optimal price p^*_{nsi} at the switching rate β, we have $\frac{\partial p^*_{nsA}}{\partial\beta} = \frac{4(1-\alpha_B)t}{3(1-\beta(1-\alpha_B))^2} > 0$ and $\frac{\partial p^*_{nsB}}{\partial\beta} = \frac{2(1-\alpha_B)t}{3(1-\beta(1-\alpha_B))^2} > 0$. Therefore, the optimal prices p^*_{nsA} and p^*_{nsB} increase with β.

Take the derivative of optimal profit π^*_{nsi} at the switching rate β, $\frac{\partial \pi^*_{nsA}}{\partial\beta} = \frac{1-\alpha_B}{2t}(t+\frac{c_s-\Delta V}{3}+\frac{4\beta(1-\alpha_B)t}{3(1-\beta(1-\alpha_B))})(\frac{8t-4(1-\alpha_B)\beta t}{3(1-\beta(1-\alpha_B))}-t+\frac{\Delta V-c_s}{3}) = \frac{1-\alpha_B}{2t}(t+\frac{c_s-\Delta V}{3}+\frac{4\beta(1-\alpha_B)t}{3(1-\beta(1-\alpha_B))})(\frac{5t-(1-\alpha_B)\beta t}{3(1-\beta(1-\alpha_B))}+\frac{\Delta V-c_s}{3}))$ and $\frac{\partial \pi^*_{nsB}}{\partial\beta} = \frac{2\alpha_B(1-\alpha_B)}{3(1-\beta(1-\alpha_B))^2}(t+\frac{\Delta V-c_s}{3}+\frac{2\beta(1-\alpha_B)t}{3(1-\beta(1-\alpha_B))}) > 0$. With $x_{ns} \in [0,1]$, we can derive $\frac{\Delta V-c_s}{3} \in [-t-\frac{2\beta(1-\alpha_B)t}{3(1-\beta(1-\alpha_B))}, t-\frac{2\beta(1-\alpha_B)t}{3(1-\beta(1-\alpha_B))}]$, thus $\frac{\partial \pi^*_{nsA}}{\partial\beta} = \frac{1-\alpha_B}{2t}(t+\frac{c_s-\Delta V}{3}+\frac{4\beta(1-\alpha_B)t}{3(1-\beta(1-\alpha_B))})(\frac{5t-(1-\alpha_B)\beta t}{3(1-\beta(1-\alpha_B))}+\frac{\Delta V-c_s}{3})) \geq \frac{1-\alpha_B}{3(1-\beta(1-\alpha_B))}(t+\frac{c_s-\Delta V}{3}+\frac{4\beta(1-\alpha_B)t}{3(1-\beta(1-\alpha_B))}) > 0$. Therefore, the optimal profits π^*_{nsA} and π^*_{nsB} increase with β.

PROOF OF PROPOSITION 2.

Take the derivative of the price p^*_{nsi} and profit π^*_{nsi} at the goodwill effect ΔV, $\frac{\partial p^*_{nsA}}{\partial\Delta V} = -\frac{1}{3} < 0$, $\frac{\partial p^*_{nsB}}{\partial\Delta V} = \frac{1}{3} > 0$, $\frac{\partial \pi^*_{nsA}}{\partial\Delta V} = -\frac{(p^*_1-c)(1-\beta(1-\alpha_B))}{3t} < 0$ and $\frac{\partial \pi^*_{nsB}}{\partial\Delta V} = \frac{\alpha_B(p^*_2-c-c_s)}{3t} > 0$. Therefore, the prices and profits of the retailer with sampling increases with the goodwill effect ΔV, while the the prices and profits of the retailer without sampling decreases with the goodwill effect ΔV.

PROOF OF PROPOSITION 3

Take the derivative of the price p^*_{nsi} at the probability of realizing a good fit α_B, $\frac{\partial p^*_{nsA}}{\partial\alpha_B} = -\frac{4\beta t}{3(1-\beta(1-\alpha_B))^2} < 0$, $\frac{\partial p^*_{nsB}}{\partial\Delta V} = -\frac{2\beta t}{3(1-\beta(1-\alpha_B))^2} < 0$. Therefore, the two retailers' prices both decrease with the probability of realizing a good fit α_B.

PROOF OF PROPOSITION 4

When both retailers offer samples and the intensity of competition is weak, the retailers' optimal prices are $p^{wk*}_{ssA} = p^{ne*}_{ssB} = c + c_s + \frac{(1+\beta)t}{1-\beta}$. Take the derivative of p^{wk*}_{ssi} and profit π^{wk*}_{ssi} at the switching rate β, $\frac{\partial p^{wk*}_{ssA}}{\partial\beta} = \frac{\partial p^{wk*}_{ssB}}{\partial\beta} = \frac{2t}{(1-\beta)^2} > 0$,

$\frac{\partial \pi^{wk*}_{ssA}}{\partial \beta} = \frac{2\alpha_A t(\beta+1)(3-\beta)}{4(1-\beta)^2} > 0$ and $\frac{\partial \pi^{wk*}_{ssB}}{\partial \beta} = \frac{2\alpha_B t(\beta+1)(3-\beta)}{4(1-\beta)^2} > 0$.

PROOF OF PROPOSITION 5

For retailer A, given that retailer B adopts no sampling, retailer A adopts no sampling if $\pi^*_{nnA} \geq \pi^*_{snA}$, otherwise sampling; given that retailer B adopts sampling, A adopts no sampling if $\pi^{st*}_{ssA} \leq \pi^*_{nsA}$, otherwise sampling. For retailer B, given that retailer A adopts no sampling, retailer B adopts no sampling if $\pi^*_{nnB} \geq \pi^*_{nsB}$, otherwise sampling; given that retailer A adopts sampling, he adopts no sampling if $\pi^{st*}_{ssB} \leq \pi^*_{snB}$, otherwise sampling. In the case with $r = 1$, we have $\alpha_A = \alpha_B$. Thus, the game is symmetric, and the two inequalities $\pi^*_{nnB} \geq \pi^*_{nsB}$ and $\pi^{st*}_{ssB} \geq \pi^*_{snB}$ are enough to derive the Nash equilibrium sampling strategy. By equating π^{st*}_{ssB} and π^*_{snB}, we get the threshold value $\Delta V^*_1 = c_s - \frac{2\beta(1-\alpha_B)t}{1-\beta(1-\alpha_B)} + 3t(\frac{1}{\sqrt{\alpha_B}} - 1)$; by equating π^*_{nnB} and π^*_{nsB}, we get $\Delta V^*_2 = c_s + \frac{4\beta(1-\alpha_B)t}{1-\beta(1-\alpha_B)} + 3t(1 - \sqrt{\frac{\alpha_B}{1-\beta(1-\alpha_B)}})$.

We first consider the case of $\Delta V^*_1 \geq \Delta V^*_2$. If $\Delta V \leq \Delta V^*_2$, retailer A (B) always chooses no sampling regardless of the choice of retailer B (A), thus competing retailers reach the No–No Nash equilibrium. If $\Delta V^*_2 < \Delta V < \Delta V^*_1$, retailer A chooses no sampling (sampling) once retailer B chooses no sampling (sampling), and the same decision rule applies to retailer B, thus competing retailers reach either the No–No or Sample–Sample equilibrium. It's easy to show that the No–No equilibrium always dominates the Sample–Sample equilibrium in the case with $r = 1$. Therefore, they would reach the No–No Nash equilibrium in the region of $\Delta V^*_2 < \Delta V < \Delta V^*_1$. If $\Delta V \geq \Delta V^*_1$, retailer A (B) always chooses sampling regardless of the choice of retailer B (A), thus competing retailers reach the Sample–Sample Nash equilibrium in this region.

We then consider the case of $\Delta V^*_1 < \Delta V^*_2$. If $\Delta V \leq \Delta V^*_1$, retailer A (B) always chooses no sampling regardless of the choice of retailer B (A), thus competing retailers reach the No–No Nash equilibrium. If $\Delta V^*_1 < \Delta V < \Delta V^*_2$, retailer A chooses sampling (no sampling) once retailer B chooses no sampling (sampling), and the same decision rule applies to retailer B. Thus, competing retailers reach either the No Sample–Sample or Sample–No Sample equilibrium. If $\Delta V \geq \Delta V^*_1$, retailer A (B) always chooses sampling regardless of the choice of retailer B (A), thus competing retailers reach the Sample–Sample Nash equilibrium in this region.

With $\beta = 0$, ΔV^*_2 is always no bigger than ΔV^*_1, therefore, Proposition 5 (1) holds. With $\beta = 0.5$, ΔV^*_2 can become bigger than ΔV^*_1, therefore, Proposition 5 (2) holds.

PROOF OF COROLLARY 1

Based on the analysis given in the proof of Proposition 5, we find that in the case with $r = 1$, if $\Delta V^*_1 \geq \Delta V^*_2$, retailers never reach the No Sample–Sample or Sample–No Sample equilibrium. They can reach the No Sample–Sample or Sample–No Sample equilibrium only if $\Delta V^*_1 < \Delta V^*_2$. With $\beta = 0$, there always exist $\Delta V^*_1 \geq \Delta V^*_2$; and $\Delta V^*_1 < \Delta V^*_2$ exist only if $\beta > 0$. This concludes the proof.

PROOF OF PROPOSITION 6

Compare the retailers' profits of the No–No strategy (2) with those of the Sample–Sample strategy (12), we have $\pi^*_{nni} - \pi^{st*}_{ssi} = \frac{t}{2} - \frac{\alpha_B t}{2} \geq 0$ ($i = A, B$).

PROOF OF PROPOSITION 7

Similar to the analysis in the proof of Proposition 5, we get four threshold values in the case with $r = 0$, specifically, $\Delta V_{11}^{im*} = c_s - \frac{2\beta(1-\alpha_A)t}{1-\beta(1-\alpha_A)} + 3t(\frac{1}{\sqrt{\alpha_A}} - 1)$, $\Delta V_{12}^{im*} = c_s + \frac{4\beta(1-\alpha_B)t}{1-\beta(1-\alpha_B)} + 3t - 3\sqrt{\frac{2t\pi_{ssA}^{im*}}{1-\beta(1-\alpha_B)}}$, $\Delta V_{21}^{im*} = c_s - \frac{2\beta(1-\alpha_B)t}{1-\beta(1-\alpha_B)} + 3t(\frac{1}{\sqrt{\alpha_B}} - 1)$, $\Delta V_{22}^{im*} = c_s + \frac{4\beta(1-\alpha_A)t}{1-\beta(1-\alpha_A)} + 3t - 3\sqrt{\frac{2t\pi_{ssB}^{im*}}{1-\beta(1-\alpha_A)}}$. We find the Sample–No Sample Nash equilibrium exists in the region of $\Delta V_{11}^{im*} \le \Delta V \le \Delta V_{22}^{im*}$, and the No Sample–Sample Nash equilibrium exists in the region of $\Delta V_{21}^{im*} \le \Delta V \le \Delta V_{12}^{im*}$. With $\beta = 0.5$, the region where the Sample–No Sample Nash equilibrium exists is overlapped with the region where the No Sample–Sample Nash equilibrium exists. In this overlapped region, it makes no difference for competing retailers to reach the Sample–No Sample or No Sample–Sample Nash equilibrium.

When the intensity of competition is relatively weak, i.e., the intensity is intermediate, we show that with $\beta = 0$, there still exist $\Delta V_{11}^{im*} \le \Delta V_{22}^{im*}$ and $\Delta V_{21}^{im*} \le \Delta V_{12}^{im*}$. The Sample–No Sample Nash equilibrium exists in the region of $\Delta V_{11}^{im*} \le \Delta V \le \Delta V_{22}^{im*}$, and the No Sample–Sample Nash equilibrium exists in the region of $\Delta V_{21}^{im*} \le \Delta V \le \Delta V_{12}^{im*}$.

PROOF OF PROPOSITION 8

Similar to the analysis in the proof of Proposition 5, we get four threshold values in the case with $r = -1$, specifically, $\Delta V_{11}^{wk*} = c_s - \frac{2\beta(1-\alpha_A)t}{1-\beta(1-\alpha_A)} + 3t(\frac{1}{\sqrt{\alpha_A}} - 1)$, $\Delta V_{12}^{wk*} = c_s + \frac{4\beta(1-\alpha_B)t}{1-\beta(1-\alpha_B)} + 3t - 3\sqrt{\frac{2t\pi_{ssA}^{wk*}}{1-\beta(1-\alpha_B)}}$, $\Delta V_{21}^{wk*} = c_s - \frac{2\beta(1-\alpha_B)t}{1-\beta(1-\alpha_B)} + 3t(\frac{1}{\sqrt{\alpha_B}} - 1)$, $\Delta V_{22}^{wk*} = c_s + \frac{4\beta(1-\alpha_A)t}{1-\beta(1-\alpha_A)} + 3t - 3\sqrt{\frac{2t\pi_{ssB}^{wk*}}{1-\beta(1-\alpha_A)}}$. In the region of $\Delta V_{12}^{wk*} < \Delta V < \Delta V_{11}^{wk*}$ &$\Delta V_{22}^{wk*} < \Delta V < \Delta V_{21}^{wk*}$, either Sample–Sample or No–No equilibrium exists. With calculation, when $\beta = 0$, the No–No equilibrium dominates the Sample–Sample equilibrium; and the reverse is true when β is large. Thus, in the region of $\Delta V_{12}^{wk*} < \Delta V < \Delta V_{11}^{wk*}$ &$\Delta V_{22}^{wk*} < \Delta V < \Delta V_{21}^{wk*}$, the Nash equilibrium is more likely to be the Sample–Sample equilibrium with a larger β.

Moreover, the Nash equilibrium is the Sample–Sample equilibrium in the region of $\Delta V \ge \Delta V_{11}^{wk*}$ &$\Delta V \ge \Delta V_{12}^{wk*}$ and in the region of $\Delta V \ge \Delta V_{21}^{wk*}$ &$\Delta V \ge \Delta V_{22}^{wk*}$. It's easy to show that ΔV_{11}^{wk*} and ΔV_{21}^{wk*} decrease with β. We can also prove ΔV_{12}^{wk*} and ΔV_{22}^{wk*} decrease with β as below, especially, $t > 0, \beta \in [0, 1]$, $\alpha_B \in [0, 1]$, and $\alpha_A \in [0, 1]$.

$$
\begin{aligned}
\Delta V_{12}^{wk*} &= c_s + \frac{4\beta(1-\alpha_B)t}{1-\beta(1-\alpha_B)} + 3t - 3t\sqrt{\frac{(\beta+1)^2\alpha_A}{(1-\beta)(1-\beta(1-\alpha_B))}}, \\
\frac{\partial \Delta V_{12}^{*}}{\partial \beta} &= \frac{4(1-\alpha_B)t}{(1-\beta(1-\alpha_B))^2} - 3t\sqrt{\alpha_A}(1-\beta)^{-\frac{1}{2}}(1-\beta(1-\alpha_B))^{-\frac{1}{2}} \\
&- 3t\sqrt{\alpha_A}(\beta+1)\left(\frac{1}{2}(1-\beta)^{-\frac{3}{2}}(1-\beta(1-\alpha_B))^{-\frac{1}{2}} + \frac{1-\alpha_B}{2}(1-\beta)^{-\frac{1}{2}}(1-\beta(1-\alpha_B))^{-\frac{3}{2}}\right) \\
&= \frac{4(1-\alpha_B)t}{(1-\beta(1-\alpha_B))^2} - \frac{3(4-4\beta+3\alpha_B\beta-\alpha_B)t\sqrt{\frac{\alpha_A}{(1-\beta)(1-\beta(1-\alpha_B))}}}{2(1-\beta)(1-\beta(1-\alpha_B))}.
\end{aligned}
$$

With $4 - 4\beta + 3\alpha_B\beta - \alpha_B = 3(1-\beta) + (1-\alpha_B)(1-\beta) + 2\alpha_B\beta \ge 0$, $1 - \beta(1-\alpha_B) \ge 1 - \beta$ and $\alpha_B = 1 - \alpha_A$, we have:

$$
\begin{aligned}
\frac{\partial \Delta V_{12}^{wk*}}{\partial \beta} &\le \frac{4(1-\alpha_B)t}{(1-\beta(1-\alpha_B))^2} - \frac{3\sqrt{\alpha_A}(4-4\beta+3\alpha_B\beta-\alpha_B)t}{2(1-\beta)(1-\beta(1-\alpha_B))^2} \\
&\le \frac{t}{2(1-\beta)(1-\beta\alpha_A)^2}\Big(8\alpha_A(1-\beta) - 3\sqrt{\alpha_A}(4-4\beta+3(1-\alpha_A)\beta-(1-\alpha_A))\Big) \\
&\le \frac{t\sqrt{\alpha_A}}{2(1-\beta)(1-\beta\alpha_A)^2}\Big((\sqrt{\alpha_A}-1)(6+6\beta\sqrt{\alpha_A}+2(1-\beta)) + (\beta-1)(3\alpha_A+1)\Big) \\
&\le 0.
\end{aligned}
$$

Hence, ΔV_{12}^{wk*} decreases with β. Following similar steps, we can prove ΔV_{22}^{wk*} decreases with β.

With a larger value of β, ΔV_{11}^{wk*}, ΔV_{12}^{wk*}, ΔV_{21}^{wk*} and ΔV_{22}^{wk*} become smaller. Therefore, the regions $\Delta V \geq \Delta V_{11}^{wk*}$ &$\Delta V \geq \Delta V_{12}^{wk*}$ and $\Delta V \geq \Delta V_{21}^{wk*}$ &$\Delta V \geq \Delta V_{22}^{wk*}$ where the Sample–Sample Nash equilibrium exists are expanded with a large β.

For the above mentioned two reasons, retailers are more likely to reach the Sample–Sample Nash equilibrium with a larger β.

Appendix B.

Equilibrium Sampling and Pricing Strategy under Sequential Game

To solve the Stackelberg game, we first find the follower B's optimal sampling and pricing strategy for any given pricing and sampling decisions by the leader A. Based on the follower's sampling and pricing responses, we solve the leader optimal sampling and pricing strategies. We first illustrate the follower B's optimal sampling and pricing strategies in response to the retailer A's strategies below.

(1) No–No Strategy

Given the leader A adopts no sampling, if the follower B adopts no sampling, i.e., a No–No strategy, the retailers' optimal prices and profits are:

$$p_{nnA}^{s*} = \frac{3t}{2}, \tag{B.1}$$

$$p_{nnB}^{s*} = \frac{5t}{4}, \tag{B.2}$$

$$\pi_{nnA}^{s*} = \frac{9t}{16}, \tag{B.3}$$

$$\pi_{nnB}^{s*} = \frac{25t}{32}. \tag{B.4}$$

Note that in the case with a No–No strategy, both retailers can charge higher prices and achieve larger profits in a sequential game than in a simultaneous game, i.e., $p_{nnA}^{s*} = \frac{3t}{2} > p_{nnA}^{*} = t$, $p_{nnB}^{s*} = \frac{5t}{4} > p_{nnB}^{*} = t$, $\pi_{nnA}^{s*} = \frac{9t}{16} > \pi_{nnA}^{*} = \frac{t}{2}$, $\pi_{nnB}^{s*} = \frac{25t}{32} > \pi_{nnB}^{*} = \frac{t}{2}$. That's because retailers compete head-to-head in the simultaneous game that neither of them charges a premium price. But in the sequential game, the follower can observe the leader's pricing strategy and follow suit. Expecting this response of the follower, the leader would charge a higher price and thus induce the follower to charge a higher price as well. By doing do, both retailers benefit from the sequential game. Our following result would show that, for the Sample–Sample strategy with a strong competition intensity, both retailers can be better off in the sequential game than in the simultaneous game. The underlying mechanism behind the result is the same.

(2) No Sample–Sample Strategy

Given the leader A adopts no sampling, if the follower B adopts sampling,the retailers' optimal prices and profits are:

$$x_{ns}^{s*} = \frac{c_s - \Delta V}{8t} - \frac{1}{2(1-\beta(1-\alpha_B))} + \frac{7}{8}, \tag{B.5}$$

$$p_{nsA}^{s*} = \frac{1}{2(1-\beta(1-\alpha_B))}((1-\beta(1-\alpha_B))(c_s - \Delta V) + (3+\beta(1-\alpha_B))t), \tag{B.6}$$

$$p_{nsB}^{s*} = \frac{1}{4}(\Delta V - c_s + t + \frac{4t}{1-\beta(1-\alpha_B)}) + c_s, \tag{B.7}$$

$$\pi_{nsA}^{s*} = \frac{1}{16(1-\beta(1-\alpha_B))t}((1-\beta(1-\alpha_B))(c_s - \Delta V) + (3+\beta(1-\alpha_B))t)^2, \tag{B.8}$$

$$\pi_{nsB}^{s*} = \frac{\alpha_B}{32t}(\Delta V - c_s + t + \frac{4t}{1-\beta(1-\alpha_B)})^2. \tag{B.9}$$

(3) Sample–No Sample Strategy

Given the leader A adopts sampling, if the follower B adopts no sampling, the retailers' optimal prices and profits are:

$$x_{sn}^{s*} = \frac{\beta(1-\alpha_A)+1}{8(1-\beta(1-\alpha_A))} + \frac{\Delta V - c_s - 2t}{8t} + \frac{1}{2}, \tag{B.10}$$

$$p_{snA}^{s*} = \frac{t}{2}(\frac{\beta(1-\alpha_A)+1}{1-\beta(1-\alpha_A)} + \frac{\Delta V - c_s + 2t}{t}) + c_s, \tag{B.11}$$

$$p_{snB}^{s*} = \frac{1}{4(1-\beta(1-\alpha_A))t}((1-\beta(1-\alpha_A))(c_s - \Delta V) + (\beta(1-\alpha_A)+5)t), \tag{B.12}$$

$$\pi_{snA}^{s*} = \frac{\alpha_A t}{16}(\frac{\beta(1-\alpha_A)+1}{1-\beta(1-\alpha_A)} + \frac{\Delta V - c_s + 2t}{t})^2, \tag{B.13}$$

$$\pi_{snB}^{s*} = \frac{1}{32(1-\beta(1-\alpha_A))t}((1-\beta(1-\alpha_A))(c_s - \Delta V) + (\beta(1-\alpha_A)+5)t)^2. \tag{B.14}$$

(4) Sample–Sample Strategy

Given the leader A adopts sampling, if the follower B adopts sampling, i.e., a Sample–Sample strategy, we consider three cases with different intensities of competition as follows:

Strong Intensity of Competition: In this case, the retailers' optimal prices and profits are:

$$p_{ssA}^{sst*} = \frac{3t}{2} + c_s, \tag{B.15}$$

$$p_{ssB}^{sst*} = \frac{5t}{4} + c_s, \tag{B.16}$$

$$\pi_{ssA}^{sst*} = \frac{9\alpha_B t}{16}, \tag{B.17}$$

$$\pi_{ssB}^{sst*} = \frac{25\alpha_B t}{32}. \tag{B.18}$$

Intermediate Intensity of Competition: In this case, the retailers' optimal prices and profits are:

$$p_{ssA}^{sim*} = (\frac{1+\beta(1-\alpha_B)}{1-\beta(1-\alpha_B)} + \frac{1+\beta(1-\alpha_A)}{2(1-\beta(1-\alpha_A))})t + c_s, \tag{B.19}$$

$$p_{ssB}^{sim*} = \frac{t}{2}(\frac{3(1+\beta(1-\alpha_A))}{2(1-\beta(1-\alpha_A))} + \frac{1+\beta(1-\alpha_B)}{1-\beta(1-\alpha_B)}) + c_s, \tag{B.20}$$

$$\pi_{ssA}^{sim*} = \frac{(1-\beta(1-\alpha_B))\alpha_A t}{4}(\frac{1+\beta(1-\alpha_B)}{1-\beta(1-\alpha_B)} + \frac{1+\beta(1-\alpha_A)}{2(1-\beta(1-\alpha_A))})^2, \tag{B.21}$$

$$\pi_{ssB}^{sim*} = \frac{\alpha_B t(1-\beta(1-\alpha_A))}{8}(\frac{3(1+\beta(1-\alpha_A))}{2(1-\beta(1-\alpha_A))} + \frac{1+\beta(1-\alpha_B)}{1-\beta(1-\alpha_B)})^2. \tag{B.22}$$

Weak Intensity of Competition: In this case, the retailers' optimal prices and profits are:

$$p^{swk*}_{ssA} = \frac{3t(\beta+1)}{2(1-\beta)} + c_s, \tag{B.23}$$

$$p^{swk*}_{ssB} = \frac{5t(\beta+1)}{4(1-\beta)} + c_s, \tag{B.24}$$

$$\pi^{swk*}_{ssA} = \frac{9\alpha_A t(\beta+1)^2}{16(1-\beta)}, \tag{B.25}$$

$$\pi^{swk*}_{ssB} = \frac{25\alpha_B t(\beta+1)^2}{32(1-\beta)}. \tag{B.26}$$

Based on the above mentioned follower's sampling and pricing responses, we next solve the leader A optimal sampling and pricing strategies. Suppose the retailer A's profit function is $\pi_A(S, p_A)$, which is a function of the sampling decision of S and the pricing decision p_A. $S = 1$ represents the case retailer A offers sampling, $S = 0$ otherwise. The profit function of the leader A in the case of a strong product competition is illustrated as below:

$$\pi_A(1, p_A) = \begin{cases} \pi^{sst*}_{ssA} = \dfrac{9\alpha_B t}{16},\ if\ \pi^{sst*}_{ssB} \geq \pi^{s*}_{snB}, & \text{(B.27)} \\ \pi^{s*}_{snA} = \dfrac{\alpha_A t}{16}\left(\dfrac{\beta(1-\alpha_A)+1}{1-\beta(1-\alpha_A)} + \dfrac{\Delta V - c_s + 2t}{t}\right)^2,\ if\ \pi^{sst*}_{ssB} < \pi^{s*}_{snB}. & \text{(B.28)} \end{cases}$$

$$\pi_A(0, p_A) = \begin{cases} \pi^{s*}_{nnA} = \dfrac{9t}{16},\ if\ \pi^{s*}_{nsB} < \pi^{s*}_{nnB}, & \text{(B.29)} \\ \pi^{s*}_{nsA} = \dfrac{1}{16(1-\beta(1-\alpha_B))t}((1-\beta(1-\alpha_B))(c_s - \Delta V) + (3+\beta(1-\alpha_B))t)^2,\ if\ \pi^{s*}_{nsB} \geq \pi^{s*}_{nnB}. & \text{(B.30)} \end{cases}$$

Comparing the leader A's profit in the case with sampling (i.e., $\pi_A(1, p_A)$) with that in the case without sampling (i.e., $\pi_A(0, p_A)$), we can derive the leader A's optimal sampling and pricing strategies.

The above sampling and pricing strategies are in the case of strong intensity of product competition. Following the similar logic and procedure, we can derive the retailers' sampling and pricing strategies in the case of intermediate and weak intensity of product competition.

PROOF OF PROPOSITION 9

In the case with a strong intensity of product competition, we show that in the region of $\pi^{s*}_{nsB} \geq \pi^{s*}_{nnB}$ and $\pi^{sst*}_{ssB} \geq \pi^{s*}_{snB}$, i.e., $\Delta V \geq \max\{\Delta V^{sst*}_{21}, \Delta V^{sst*}_{22}\}$, where $\Delta V^{sst*}_{21} = c_s + \frac{5t}{\sqrt{\alpha_B}} - \frac{5t-\beta(1-\alpha_B)t}{1-\beta(1-\alpha_B)}$ is derived through $\pi^{s*}_{nsB} = \pi^{s*}_{nnB}$, and $\Delta V^{sst*}_{22} = c_s + \frac{1}{1-\beta(1-\alpha_A)}((5+\beta(1-\alpha_A))t - \sqrt{32(1-\beta(1-\alpha_A))t\,\pi^{sst*}_{ssB}})$ is derived through $\pi^{sst*}_{ssB} = \pi^{s*}_{snB}$, the follower B always prefer sampling. As for the leader A, he prefers sampling if $\pi^{sst*}_{ssA} > \pi^{s*}_{nsA}$, i.e., $\Delta V > \Delta V^{sst*}_{12}$, where $\Delta V^{sst*}_{12} = c_s + \frac{1}{1-\beta(1-\alpha_B)}((3+\beta(1-\alpha_B))t - \sqrt{16(1-\beta(1-\alpha_B))t\,\pi^{sst*}_{ssA}})$ is derived through $\pi^{sst*}_{ssA} = \pi^{s*}_{nsA}$); and if $\Delta V \leq \Delta V^{sst*}_{12}$, the leader A prefers no sampling. Therefore, when $\Delta V \geq \max\{\Delta V^{sst*}_{21}, \Delta V^{sst*}_{22}, \Delta V^{sst*}_{12}\}$ exist, a Sample–Sample equilibrium is reached; and when $\Delta V \in [\max\{\Delta V^{sst*}_{21}, \Delta V^{sst*}_{22}\}, \Delta V^{sst*}_{12}]$ exist, a No Sample–Sample equilibrium is reached.

In the region of $\pi^{s*}_{nsB} < \pi^{s*}_{nnB}$ and $\pi^{sst*}_{ssB} < \pi^{s*}_{snB}$, i.e., $\Delta V \leq \min\{\Delta V^{sst*}_{21}, \Delta V^{sst*}_{22}\}$, the follower B always prefers no sampling. As for the leader A, he prefers sampling if $\pi^{s*}_{snA} \geq \pi^{s*}_{nnA}$, i.e., $\Delta V > \Delta V^{sst*}_{11}$, where $\Delta V^{sst*}_{11} = c_s + \frac{3t}{\sqrt{\alpha_A}} - \frac{3t-\beta(1-\alpha_A)t}{1-\beta(1-\alpha_A)}$ derived through $\pi^{s*}_{snA} = \pi^{s*}_{nnA}$, and if $\Delta V \leq \Delta V^{sst*}_{11}$, the leader A prefers no sampling. Therefore, a Sample–No Sample equilibrium is reached when $\Delta V \in [\Delta V^{sst*}_{11}, \min\{\Delta V^{sst*}_{21}, \Delta V^{sst*}_{22}\}]$, and when $\Delta V \leq \min\{\Delta V^{sst*}_{21}, \Delta V^{sst*}_{22}, \Delta V^{sst*}_{11}\}$, a No–No equilibrium is reached.

In the region of $\pi^{s*}_{nsB} < \pi^{s*}_{nnB}$ and $\pi^{sst*}_{ssB} > \pi^{s*}_{snB}$, i.e., $\Delta V \in [\Delta V^{sst*}_{22}, \Delta V^{sst*}_{21}]$, the leader A always prefer no sampling, i.e., $\pi^{s*}_{nnA} \geq \pi^{s*}_{ssA}$. Therefore, retailers reach a No–No equilibrium in this region of $\Delta V \in [\Delta V^{sst*}_{22}, \Delta V^{sst*}_{21}]$.

In the region of $\pi^{s*}_{nsB} > \pi^{s*}_{nnB}$ and $\pi^{sst*}_{ssB} < \pi^{s*}_{snB}$, i.e., $\Delta V \in [\Delta V^{sst*}_{21}, \Delta V^{sst*}_{22}]$, the leader A prefers sampling if $\pi^{s*}_{snA} \geq \pi^{s*}_{nsA}$, i.e., $\Delta V \geq \Delta V^{sst*}_{13}$, where $\Delta V^{sst*}_{13} = c_s + \frac{t}{1-\beta(1-\alpha_B)+\sqrt{\alpha_A(1-\beta(1-\alpha_B))}}\left(3+\beta(1-\alpha_B) - \frac{\sqrt{\alpha_A(1-\beta(1-\alpha_B))}\left(3-\beta(1-\alpha_A)\right)}{1-\beta(1-\alpha_A)}\right)$ is derived through $\pi^{s*}_{snA} = \pi^{s*}_{nsA}$, and if $\Delta V < \Delta V^{sst*}_{13}$, the leader prefers no sampling. Therefore, a Sample–No Sample equilibrium is reached if $\Delta V \in [\max\{\Delta V^{sst*}_{13}, \Delta V^{sst*}_{21}\}, \Delta V^{sst*}_{22}]$, and if $\Delta V \in [\Delta V^{sst*}_{21}, \min\{\Delta V^{sst*}_{13}, \Delta V^{sst*}_{22}\}]$, a No Sample–Sample equilibrium is reached.

In the case with $\beta = 0$, we show that (1), $\Delta V^{sst*}_{12} < \max\{\Delta V^{sst*}_{21}, \Delta V^{sst*}_{22}\}$ always exists. Therefore, a Sample–Sample equilibrium in region of $\Delta V \geq \max\{\Delta V^{sst*}_{21}, \Delta V^{sst*}_{22}\}$. (2), $\Delta V^{sst*}_{21} \geq \Delta V^{sst*}_{22}$ always exists. Therefore, in the region of $\Delta V \in [\Delta V^{sst*}_{22}, \Delta V^{sst*}_{21}]$, a No–No equilibrium exists. (3), $\Delta V^{sst*}_{22} \geq \Delta V^{sst*}_{11}$ exists in the region with $\alpha_B \geq 0.36$. Therefore, in the region of $\Delta V \in [\Delta V^{sst*}_{11}, \Delta V^{sst*}_{22}]$, they reach a Sample–No Sample equilibrium. In the region of $\Delta V < \min\{\Delta V^{sst*}_{11}, \Delta V^{sst*}_{22}\}$, the retailers reach a No–No equilibrium.

PROOF OF COROLLARY 2

Based on the illustration in the proof of Proposition 9, we show that with $\beta = 0$, an asymmetric equilibrium, i.e., the Sample–No Sample equilibrium can exist in the region of $\Delta V \in [\Delta V^{sst*}_{11}, \Delta V^{sst*}_{22}]$.

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