Dynamic Pricing in Experience Good Markets with Demand Uncertainty

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Abstract

This paper develops a dynamic model to examine how a firm with a new, non-durable experience good should use its pricing strategy to signal its high quality in the market with demand uncertainty. Our analysis shows that when there is no demand uncertainty, the high-quality firm prefers to pool with the low-quality firm, due to the high signaling cost required to separate given that both types of firm are assumed to have the same costs. However, we find that, when the fraction of high-valuation consumers in the market is uncertain, the high-quality firm may prefer to separate from the low-quality firm. Intuitively, demand uncertainty gives the firm an additional dimension to separate. We identify two types of separating outcomes. First, the high-quality firm can separate from the low-quality firm by skimming pricing, i.e., setting a high initial price to target fewer customers making it unprofitable for the low-quality firm to mimic. Second, the high-quality firm can separate by penetration pricing, i.e. setting a low initial price to target all consumers, hence removing the firm's ability to learn the demand distribution, which deters the low-quality firm from mimicking. We also find that under some conditions, the high-quality firm's profit may be higher in the market with demand uncertainty than one without because demand uncertainty lowers the high-quality firm's signaling cost for revealing its high quality. By contrast, demand uncertainty always makes the low-quality firm worse off.

Key words: dynamic signaling, experience goods, demand uncertainty, pricing, learning

1. Introduction

An experience good (Nelson 1970) is one whose quality consumers cannot observe prior to purchase but can learn through post-purchase use experience. For example, in the market for new pharmaceuticals, especially therapeutically innovative drugs, consumers have limited knowledge about those new drugs. Consumers would like to know the product quality (e.g. effectiveness and side effects), but they can only realize quality after taking this drug. For a firm selling a new experience good, one important issue is whether and how the firm can credibly reveal its high quality. Since product quality is *ex ante* unknown, consumers are unwilling to pay high price for this new product. If a firm can reveal its high quality, it can charge a price based on the high quality and benefit from their repeat purchase.

Furthermore, when a firm introduces a new product to the market, it typically does not know the exact market demand, e.g., the fraction of consumers having high willingness to pay for quality. In the pharmaceutical industry, patients' willingness to pay is their private information. Although a firm potentially knows the numbers of patients, it is hard for the firm to estimate their willingness to pay by conducting market research because patients have less incentive to admit their true willingness to pay. The firm may be able to estimate the market demand from initial sales. However, the firm needs to balance a trade-off between exploration (learning) and exploitation (earning): The firm can potentially benefit from learning the market demand to be able to optimally adjust its future prices accordingly, but demand learning requires the firm to charge a high initial price, which can hurt its initial profit when there is only a small fraction of high-valuation consumers in the market.

In this new experience good market with demand uncertainty, our research questions focus on whether the high-quality firm can use prices to credibly signal its true quality to all consumers. If so, what is the pricing strategy used for the high-quality firm successfully to separate from the

low-quality firm? We also focus on in equilibrium whether the high- or low-quality firm learns the market demand. It is clear that the firm with higher quality benefits more from learning the market demand. However, is the high-quality firm still more willing to learn the market demand when considering signaling its true quality? Can the high-quality firm not only reveal its true quality but also learn the market demand? Will the high-quality firm give up learning the market demand, but the low-quality firm learns demand? Finally, it seems that demand uncertainty hurts the firm since it cannot adjust its price according to the exact market demand. But in this experience good market, is it possible that the firm benefits from demand uncertainty? We will further explain whether the high- or low-quality firm earns more profit in the market with demand uncertainty than without.

We develop a dynamic analytical model to study a firm's optimal pricing strategies in such experience good market with demand uncertainty. We examine how a firm selling a new, non-durable experience good to heterogeneous consumers can credibly reveal its high quality to consumers and whether it can and will learn the market demand through its pricing strategy. There are three salient characteristics in this type of market. First, a firm can signal its product quality through prices to rational consumers. Since a firm with different quality may charge different prices because of its profitable incentive, a high-quality firm may use its price as a signal to convey the information about its quality that rational consumers are able to infer after observing prices. Second, consumers' willingness to pay about quality is either high or low, and the exact market demand (e.g. the population of high- and low-valuation consumers) is unknown to the firm. By setting a high price to target only high-valuation consumers, a firm can infer their population from the realized sales. But their population is still unknown if a firm attracts all consumers. Third, pricing can also affect the fraction of consumers attracted to buy and thereby learn the quality through use experience.

This paper examines that either skimming or penetration pricing may be an optimal pricing strategy. The firm can charge high first-period price to skim only high-valuation consumers and adjusts its future price depending on the realized market demand. Although market demand (i.e. the population of high-valuation consumers) is realized, only those high-valuation consumers learn the true quality through use experience. By contrast, the firm, adopting penetration pricing, sets low price to target the whole market. Market demand is still unknown, but firm's product quality will be learned to all customers.

We highlight our main results. First, if the difference of product quality is too large, the high-quality firm gives up signaling its true type because the incentive for the low-quality firm to pretend as a high-quality firm is too strong. In this scenario, both types of firm adopt the same pricing strategy. A firm prefers to adopt skimming pricing if the difference of willingness to pay between two types of consumers is large and so as the expected revenue from only high-valuation consumers. Because of this high expected revenue, the firm benefits from not only earning high immediate revenue but also learning market demand when skimming high-valuation consumers. By contrast, if this expected revenue from high-valuation consumers is lower, a firm is more likely to adopt penetration pricing. The reason is the immediate revenue from the whole market is higher and the high-quality firm can additionally benefit from charging a high future price based on its high quality since all consumers will become informed through experience. Although market demand is still unknown, the benefit of attracting more consumers to be informed dominates that of learning market demand when the difference of willingness to pay between two types of consumers is too low.

Second, the high-quality firm can use a pricing strategy different from the low-quality firm to signal its true quality. One equilibrium outcome is that the high-quality firm skims high-valuation consumers with a downward distorted first-period price and sets its second-period

price based on realized market demand, while the low-quality firm uses penetration pricing to attract all consumers in both periods. It is convincing for the high-quality firm to charge a high price to skim only high-valuation because a high-quality firm benefits more from learning market demand than a low-quality firm. In this equilibrium, the high-quality firm not only successfully reveals its high quality but also learns market demand because this downward distorted first-period price eliminates the low-quality firm's incentive to mimic.

Third, we explain how the high-quality firm signals it true quality by penetration pricing. In this case, the high-quality firm sets a low initial price to attracting all consumers, while the low-quality firm charges a high price to skim high-valuation consumers. It is plausible for the high-quality firm to attract all consumers with a low price since the low-quality firm is more willing to hide its true quality. Although the high-quality firm gives up learning market demand, this penetration pricing prevents the high-quality firm to downward distort its first-period price too much to avoid the mimicking. The reason is the low-quality firm has less incentive to pretend as the high-quality firm by this penetration pricing since its low quality will be learned by all consumers and market demand is also unknown. It would rather skim only high-valuation consumers and benefit from learning market demand.

Finally, we show that the high-quality firm may gain more in the market with demand uncertainty than without. It is because the high-quality firm can separate from the low-quality firm and charge its first-period price based on its high quality. When there is no demand uncertainty, it is inevitable for the high-quality firm to pool with the low-quality firm in the first period. However, when there is demand uncertainty, because the benefit from learning market demand is different from two types of firm, the high-quality firm can sacrifice part of its benefit to force the low-quality firm not to mimic. The high-quality firm benefits from revealing its high quality and will not be undervalued as the average quality. In contrast, the low-quality firm

becomes worse off because not only its low quality will be revealed but also its price cannot be set according to the exact market demand.

1.1. Related Literatures

This paper contributes to the literature on dynamic pricing of new experience goods. When selling an experience good, a firm faces the tradeoff between exploiting past customers (informed) and attracting new ones (uninformed) (Bils 1989). In the previous literature, some conclude that a firm selects between skimming and penetration pricing strategies based on different market conditions: Shapiro (1983) argues that the condition is whether a firm's reputation is below or above its true quality, while Bergemann and Välimäki (2006) find that the condition is whether a firm is in a niche or mass market. Those papers do not consider that rational consumers not only learn product quality through use experience but also infer a firm's quality through its pricing strategies. In this paper, we consider a firm can signal its product quality to consumers. In addition, we categorize the market relying on consumers' private demand and figure out when a firm adopts skimming or penetration pricing. We further show that a firm can reveal its high quality by its pricing strategy prior to initial purchase so that a high-quality firm can exploit both past and new consumers.

Our research contributes to the literature on signaling in asymmetric-information games (Desai and Srinivasan 1995, Moorthy and Srivinvsan 1995, Desai 2000, Shin 2005, and Jiang et al. 2014). When product quality is a firm's private information, the firm can potentially convey to rational consumers its quality using signals such as prices (Wolinsky 1983, Gerstner 1985, Milgrom and Roberts 1986, and Bagwell 1987). In those papers, to credibly signal a firm's high quality, it is necessary for the firm with different types of quality having different cost structure so that the high-quality firm can reduce the low-quality firm's incentive of mimicking. However, in some markets, the marginal cost is tiny and almost regardless of qualities. In this paper, we

intentionally assume there is no cost differences among qualities and show that a high-quality firm can still separate from a low-quality firm by its pricing strategy. We also explore the literature that prices signal qualities when a firm sells experience good (Riordan 1986 and Bagwell and Riordan 1991) and further consider the possibility that a firm can dynamically signal its quality in each period. In this setting, we can examine how a price path influences consumers' belief about quality and the signaling effect of a firm's dynamic pricing strategy.

This paper contributes the literature when a firm confronts demand uncertainty in new markets. To examine how a firm learns the market demand, we follow the parametric approach (Lobo and Boyd 2003, Besbes and Zeevi 2009, Broder and Rusmevichientong 2012, and den Boer and Zwart 2014): there is an unknown parameter in the demand function and a firm can experimentally estimate this parameter with its pricing strategy. The idea is a firm faces the trade-off between learning and earning (Rothschild 1974, Easley and Kiefer 1988, and Aghion et al. 1991) when deciding its price in each period. However, we additionally consider the high-quality firm's trade-off between learning market demand and revealing its high quality. Furthermore, we account for how the high-quality firm uses pricing strategies to signal its quality when facing demand uncertainty.

This paper also contributes the optimal pricing strategies in the market for new pharmaceuticals. By exploiting a data set on anti-ulcer drug prescriptions, Crawford and Shum (2005) indicate that patients learning from prescription experience reduce the cost of uncertainty in experience good markets. We model not only consumers learning product quality but also a firm learning market demand through consumption experience and further explain how a firm selling a new drug adopts its pricing strategy. Lu and Comanor (1998) provide empirical evidence on the factors affecting the price of new pharmaceuticals. An important factor is whether drugs are designed for acute or chronic ailments. The authors show that skimming strategies are more

likely to apply in acute circumstances, while products for chronic ailment are more likely to follow a penetration strategy. In this paper, we can categorize drugs according to the difference of willingness to pay to quality between heterogeneous consumers. If drugs are designed for acute condition, consumers' willingness to pay tends to be similar. In this circumstance, we argue that the high-quality firm can signal its true quality with a skimming strategy, which is consistent with this empirical finding.

The rest of this paper is organized as follows. In Section 2, we set up the base model. In Section 3, we find the equilibrium outcome when a firm sells a search good, which product quality is *ex ante* known to all consumers, as our benchmark. In Section 4, we derive the equilibrium outcome when a firm sells a new experience good. In addition, we compare the outcomes with and without demand uncertainty. Section 5 concludes.

2. Model Setup

We develop a dynamic model that a firm sells a new product to consumers in two periods $(t \in \{1,2\})$. The product quality is either high (q^H) or low $(q^L < q^H)$ with probability $\alpha \in (0,1)$ and $1-\alpha$, respectively. The product quality is the firm's private information and is constant within two periods. In this paper, we discuss two kinds of product: search good and experience good. For the search good, the product quality is known to consumers when they decide to purchase or not. For the experience good, consumers *ex ante* know only the prior distribution of the quality, but they will learn the true quality at the beginning of second period if they bought the product in the first period. The marginal costs of the product are c^H and c^L depending on its quality, which are also not observed by consumers. We assume that the marginal cost of production is the same between the high and low quality product $(c^H = c^L \equiv c)$. Without loss of generality, we normalize $c = 0$. The firm is risk neutral and dynamically charges the price p_t in both periods to maximize its total expected profit whereas the profit in each period is the

price times the fraction of consumers purchasing the product.

Every consumer has a unit demand for the product in each period and her net utility from a product of quality q^i with a price p_t is $u_t(q^i, p_t) = q^i\theta - p_t$, where θ represents the consumer's willingness to pay for quality of the product. The consumer's willingness to pay is either high (θ_h) or low $(\theta_l < \theta_h)$. The fraction of high-valuation consumers $(\theta = \theta_h)$ is $\beta \in (0,1)$ and the rest are low-valuation consumers. All consumers know only their own θ but not others. In each period, consumers decide to purchase after observing the current price. In each period, if a consumer can acquire a utility higher than her reservation value, which is normalized to zero, she will purchase the product; otherwise, she refuses to buy it and gets zero utility.[1] Without loss of generality, we normalize the total number of consumers to one.

There is uncertainty about the distribution of consumers' willingness to pay in the market (e.g. β). The market is either good (β_g) or bad $(\beta_b < \beta_g)$ with probability $\lambda \in (0,1)$ and $1-\lambda$, respectively. The fraction of high-valuation consumers is larger in the good market than in the bad market. Both the firm and consumers *ex ante* know only the prior distribution of the market structure but not the exact distribution of consumers.[2] The firm can estimate β by experimentally setting its price. When the firm charges a high price and attracts only the high-valuation consumers in the first period, it can then infer β at the beginning of the second period by the realized first-period profit. By contrast, if the firm appeals to all consumers in the first period, β is still unknown to the firm.

3. Search Good

[1] Shapiro (1983) also imposes this assumption that the consumer acts myopically. Note that by assumption, myopic consumers do not consider the option value of overpaying in the first period simply to learn about quality for their future purchase decisions. We find that the firm's equilibrium strategy will actually eliminate this option value. That is, in our model, the myopic consumers will in equilibrium make the same choices as forward-looking consumers. For simplicity, we adopt this myopic-consumer framework.

[2] Since consumers themselves do not know in which market they are, it hard for them to collude and manipulate the information by intentionally buying or not buying product.

In this section, we analyze that the firm sells a search good: product quality (q^i) is known to consumers before they make a purchase. We first focus on the complete information case, where the market distribution (β) is known to the firm, as our benchmark. Let $\bar{p}_t^{i*}$ denote the corresponding price in equilibrium with complete information. The equilibrium price of the i-type firm maximizing its profit is

$$\bar{p}_t^{i*} = \begin{cases} q^i\theta_h \text{ if} \frac{\theta_l}{\theta_h} \leq \beta \\ q^i\theta_l \text{ if} \frac{\theta_l}{\theta_h} \geq \beta \end{cases} \text{ for } i \in \{H, L\} \text{ and } t \in \{1,2\}$$

and the corresponding profit is $\bar{\pi}_t^{i*} = \max\{\beta q^i\theta_h, q^i\theta_l\}$.

The firm can either target only high-valuation consumers or all consumers. When the i-type firm targets only high-valuation consumers, it is optimal to exploit all their willingness to pay for quality q^i by charging $q^i\theta_h$. Otherwise, targeting the whole market, the firm will charge the price equal to the low-valuation consumers' willingness to pay $(q^i\theta_l)$. Whether the firm targets the whole market or part of the market depends on the population of high-valuation consumers and the relative willingness to pay $(\frac{\theta_l}{\theta_h})$. It is more attractive for the firm to target only the high-valuation consumers when their population is larger or the difference of willingness to pay between two types of consumers is bigger. In the following sections, we assume $\beta_b < \frac{\theta_l}{\theta_h} < \beta_g$. It implies that, in the good market, the fraction of consumers with higher willingness to pay is larger so that the firm will abandon the low-valuation consumers. While in the bad market, this population is too small so that the firm prefers to target the whole market. Therefore, we can rewrite the equilibrium price in different markets

$$\bar{p}_t^{i*} = \begin{cases} q^i\theta_h \text{ if } \beta = \beta_g \\ q^i\theta_l \text{ if } \beta = \beta_b \end{cases} \text{ for } i \in \{H, L\} \text{ and } t \in \{1,2\}$$

We have already derived the optimal pricing strategy under complete information as our benchmark and the case under incomplete information is then discussed. Note that although the

firm *ex ante* just knows the prior distribution of market structure, it can correctly infer β by attracting only the high-valuation consumers. Let $\hat{p}_t^i$ denote the corresponding price in this incomplete-information case. In the second period, the firm benefits from learning market structure by charge its first-best price in different markets.

$$\hat{p}_2^i = \begin{cases} q^i\theta_h \text{ if } \beta = \beta_g \\ q^i\theta_l \text{ if} \beta = \beta_b \end{cases} \text{ for } i \in \{H, L\}$$

On the contrary, if β is unknown to the firm, it can only charge the second-period price based on the expected population of high-valuation consumers: $\bar{\beta} \equiv \lambda\beta_g + (1-\lambda)\beta_b$. It means that if the firm targets the whole market in the first period, the second-period price will be

$$\hat{p}_2^i = \begin{cases} q^i\theta_h \text{ if} \frac{\theta_l}{\theta_h} \leq \bar{\beta} \\ q^i\theta_l \text{ if} \frac{\theta_l}{\theta_h} \geq \bar{\beta} \end{cases} \text{ for } i \in \{H, L\}$$

By backward induction, we first argue that it is optimal for the firm to target only the high-valuation consumers in the first period if $\frac{\theta_l}{\theta_h} \leq \bar{\beta}$. Because the expected population of high-valuation consumers is large enough, in the first period, the firm earns more from targeting only high-valuation consumers than from all consumers; furthermore, in the second period, it earns first-best profit after learning the true population. However, if $\frac{\theta_l}{\theta_h} \geq \bar{\beta}$, the firm faces a trade-off between learning and earning. Since the expected population of high-valuation consumers is small, the cost of learning market demand is the profit difference between targeting the whole market and only high-valuation consumers

$$q^i(\theta_l - \bar{\beta}\theta_h)$$

While the benefit of learning market demand is from the first-best profit in the second period. If β is unknown, the optimal second-period price is $q^i\theta_l$ due to this small $\bar{\beta}$, even if the firm is in the good market. But, if the firm learns $\beta = \beta_g$, it can earn more by selling to only high-valuation consumers instead of targeting all consumers. Thus, the benefit of learning β is

$$\lambda q^i(\beta_g \theta_h - \theta_l)$$

After comparing the cost and benefit of learning market demand, we show the optimal pricing strategy as follows:

PROPOSITION 1. *When β is ex ante unknown to the firm selling a search good, if $\frac{\theta_l}{\theta_h} \leq \frac{\lambda\beta_g+\overline{\beta}}{\lambda+1}$, the equilibrium price of the i-type firm is*

$$\hat{p}_1^{i*} = q^i\theta_h \text{ and } \hat{p}_2^{i*} = \begin{cases} q^i\theta_h \text{ if } \beta = \beta_g \\ q^i\theta_l \text{ if } \beta = \beta_b \end{cases}$$

And if $\frac{\theta_l}{\theta_h} \geq \frac{\lambda\beta_g+\overline{\beta}}{\lambda+1}$, the equilibrium price is $\hat{p}_1^{i*} = \hat{p}_2^{i*} = q^i\theta_l$

According to Proposition 1, the firm is more willing to learn β when the probability of being in the good market is higher. If λ is higher, it is more likely to face the market with more high-valuation consumers. Therefore, the expected loss in the first period becomes less and the benefit of learning β in the second period becomes larger when the firm targets high-valuation consumers. Furthermore, if the difference of willingness to pay is larger, the firm relatively earns more from exploiting high-valuation consumers' surplus so that it prefers to learn market demand by targeting them. However, we show that the incentive to learn β is irrelevant with product quality. Although the *H*-type firm's benefit from learning β is larger than the *L*-type firm's, the cost is also higher for the *H*-type firm to charge a high first-period price. Since product quality has no effect on whether to learn, both types of firm target the same market at the same time.

4. Experience Good

In this section, the firm sells a new experience good which consumers cannot observe product quality before purchase, but they will learn the true quality after buying and using it. Consumers *ex ante* know only the prior distribution of product quality, but they update their belief about quality by observing the price(s). In each period, the firm sets the spot price and conveys the

information of product quality through price signal. Rational consumers then decide to purchase based on both the current price and their updated belief about quality.

In this dynamically signaling game, three types of equilibrium outcomes are possible. First, the first-period price (p_1^i) is separating: each type of firm chooses a different price. After observing this separating first-period price, all consumers can correctly infer the firm's type and so as its product quality in both periods. Second, both the first- and second-period price (p_2^i) are pooling: two types of firm choose the same price. In this case, consumers cannot correctly infer the firm's type in the first period. In the second period, the first-period buyers become informed from use experience, while non-buyers remain uninformed about product quality. In addition, non-buyers cannot infer the firm's type by observing p_1^i and p_2^i, either. Third, the first-period price is pooling but the second-period price is separating. Even though consumers cannot correctly infer the firm's type in the first period, both buyers and non-buyers can infer the firm's type after observing the separating second-period price.

4.1. Equilibrium Refinement

In signaling games with incomplete information, there are always multiple perfect Bayesian equilibria (PBE) since this equilibrium concept does not impose any restrictions on out-of-equilibrium beliefs. In a multi-period dynamically signaling setting, it is more severe that even the intuitive criterion refinement (Cho and Krep 1987) still leaves infinitely many possible equilibria in some parameter regions. To further refine and characterize plausible outcomes, we adopt the lexicographically maximum sequential equilibrium (LMSE) concept introduced by Mailath et al. (1993), which is used as an alternative equilibrium-selection criterion (e.g., Taylor 1999, Gomes 2000, and Schmidt et al. 2012) and define below.

DEFINITION. *(Lexicographically Maximum Sequential Equilibrium, LMSE) In a signaling*

game G, we denote the set of types by $\{H, L\}$, the i-type player's payoffs by $\pi_i(\cdot)$, and the set of pure-strategy perfect Bayesian equilibria by $PBE(G)$. The strategy profile $\sigma' \in PBE(G)$ lexicographically dominates (l-dominates) $\sigma \in PBE(G)$ if $\pi_H(\sigma') > \pi_H(\sigma)$, or $\pi_H(\sigma') = \pi_H(\sigma)$ and $\pi_L(\sigma') > \pi_L(\sigma)$. The strategy profile $\sigma \in PBE(G)$ is a LMSE if there does not exist $\sigma' \in PBE(G)$ that l-dominates σ.

In our model, a PBE is an LMSE if it is the *H*-type firm's most profitable outcome among all PBE and if, conditional on it being the most profitable for the *H*-type firm, it is also the *L*-type firm's most profitable outcome. One property of this equilibrium refinement concept is that a unique LMSE outcome always exists among all PBE when the payoff function is concave.[3] It is desired to identify a unique PBE and since the intuitive criterion in many cases fails to identify a unique PBE, we analyze our model by considering this alternative refinement.

In addition, using this equilibrium concept is intuitively appealing. Because consumers are willing to pay more for the high-quality product, the *L*-type firm has an incentive to mimic an *H*-type firm but not vice versa. Thus, the LMSE selects the *H*-type firm's most profitable equilibrium (either separating or pooling) since the *H*-type firm is the one having an incentive to separate and reveal its identity. In a dynamic signaling setting where the strategy set is continuous, the intuitive criterion can eliminate all pooling equilibria and select separating equilibria that are Pareto dominated by a pooling equilibrium. By contrast, when the *H*-type firm makes a higher profit under the pooling PBE than under the separating PBE, the LMSE selects pooling PBE, which would seem more plausible since the separating PBE must be based on some "unreasonable" out-of-equilibrium belief that "forces" the *H*-type firm to separate rather than pool. Finally, we also apply the LMSE refinement to all continuation games in our dynamic

[3] There are typically multiple LMSEs, but the LMSE outcome turns out to be unique.

model. It implies that the second-period outcome should be an LMSE in the continuation games conditional on the first-period outcome.

4.2. No Demand Uncertainty

In this section, we analyze the signaling model without demand uncertainty, that is, β is *ex ante* known to the firm. In this environment, the firm has conducted market research to recognize whether it is in the good or bad market. Based on which market it is in, the firm dynamically sets the spot price in both periods. Consumers update their belief about product quality after observing the price(s) and decide to purchase or not in each period.

By backward induction, we first find the second-period price in the continuation game based on the first-period outcome. According to which types of consumers have learned the true product quality, there are three cases in the second period. First, all consumers know the true quality. It happens if the first-period price is separating or the first-period pooling price is low enough to attract all consumers. Because the product quality is common knowledge, the second-period price is equal to a firm's first-best price. Second, no consumers know the true quality, which results from the too high pooling first-period price attract no consumer. Since they are all uninformed, the *L*-type firm has strong incentive to mimic the *H*-type firm, which leads to a pooling second-period price.[4]

Third, only high-valuation consumers are informed. This case comes after a pooling first-period that only high-valuation consumers are willing to purchase. In this continuation game, the second-period price is either separating or pooling. Let $\tilde{p}_t^i$ denote the corresponding price in the case when there is no demand uncertainty. Suppose that the second-period price is separating ($\tilde{p}_{2,sep}^H \neq \tilde{p}_{2,sep}^L$), all consumers can correctly infer the firm's true type by observing the price so

[4] However, it is clearly a dominated strategy for the *H*-type firm to charge such a high first-period price. The *H*-type firm will find it more profitable to charge a lower first-period price such that high-valuation consumers buy its product and become informed consumers in the second period. Therefore, we will not discuss such dominated pricing strategies in the following sections.

that the *L*-type firm will charge its first-best price. Although the *H*-type firm can reveal its true quality to all consumers, its price should avoid the *L*-type firm's mimicking. Since the *L*-type firm cannot mislead high-valuation consumers, the *H*-type firm in the good market can target only high-valuation consumers with its first-best price. However, in the bad market, the *H*-type firm may not costlessly separate from the *L*-type firm. If so, the *H*-type firm needs to either downward distort its second-period price ($\tilde{p}^H_{2,sep} = \frac{q^L\theta_l}{1-\beta}$) or attract only those informed high-valuation consumers with $\tilde{p}^H_{2,sep} = q^H\theta_h$ to reduce the *L*-type firm's incentive of mimicking.

Suppose that the second-period price is pooling ($\tilde{p}^H_{2,pool} = \tilde{p}^L_{2,pool} \equiv \tilde{p}_{2,pool}$), the high-valuation consumers are informed but low-valuation consumers evaluate this product as the average quality. Both types of firm targets either only high-valuation consumers or the whole market. The firm charges $\tilde{p}_{2,pool} = q^L\theta_h$ to target only high-valuation consumers so that the *L*-type firm can also appeal to those informed consumers. If the firm targets the whole market, it charges $\tilde{p}_{2,pool} = \bar{q}\theta_l$ to attract the uninformed low-valuation consumers.

According to the LMSE refinement, whether the second-period price is separating or pooling depends on which one yields the highest *H*-type firm's second-period profit. In Lemma 1, we show the equilibrium price conditional on only high-valuation consumers know the true quality.

LEMMA 1. *Suppose that only high-valuation consumers know the true product quality in the second period, the equilibrium price is*

(i) *In the good market* ($\beta = \beta_g$), $\tilde{p}^H_{2,sep} = q^H\theta_h$ *and* $\tilde{p}^L_{2,sep} = q^L\theta_h$.

(ii) *In the bad market* ($\beta = \beta_b$), *the price is pooling in (R1):* $\tilde{p}_{2,pool} = \bar{q}\theta_l$. *Otherwise, the price is separating:* $\tilde{p}^H_{2,sep} = q^H\theta_l$ *in (R2),* $\tilde{p}^H_{2,sep} = \frac{q^L\theta_l}{1-\beta_b}$ *in (R3), and* $\tilde{p}^H_{2,sep} = q^H\theta_h$

in (R4), respectively; $\tilde{p}_{2,sep}^{L} = q^{L}\theta_{l}$.[5]

The corresponding parameter regions are defined as follows:

Region 1 (R1): $\frac{\bar{q}}{q^{H}}\frac{\theta_{l}}{\theta_{h}} \geq \beta_{b}$ and $\{\frac{\theta_{l}}{\theta_{h}} \leq \frac{q^{L}}{q^{H}}$ or $\frac{q^{L}}{\bar{q}} \leq 1-\beta_{b} \leq \frac{\theta_{l}}{\theta_{h}}$ or $\frac{\theta_{l}}{\theta_{h}} \leq 1-\beta_{b}\}$

Region 2 (R2): $1-\beta_{b} \leq \frac{q^{L}}{q^{H}} < \frac{\theta_{l}}{\theta_{h}}$

Region 3 (R3): $\frac{q^{L}}{q^{H}} \leq 1-\beta_{b} < \frac{\theta_{l}}{\theta_{h}}$ and $\frac{q^{L}}{q^{H}}\frac{\theta_{l}}{\theta_{h}} \geq \beta_{b}(1-\beta_{b})$ and $\frac{q^{L}}{\bar{q}} \geq 1-\beta_{b}$

Region 4 (R4): other than (R1), (R2), and (R3)

In the good market, the *H*-type firm costlessly separates from the *L*-type firm by targeting only those informed high-valuation consumers. In the bad market, the *H*-type firm may costlessly separate from the *L*-type firm and attract all consumers (in R2). However, if this first-best price is profitable for the *L*-type firm to mimic, the *H*-type firm needs to downward distort its price (in R3) or target only the informed high-valuation consumers (in R4) so that it can separate from the *L*-type firm. If the signaling cost is too large, that is, the price is distorted too much $(\frac{q^{L}\theta_{l}}{1-\beta_{b}} \leq \bar{q}\theta_{l})$ or the profit from only high-valuation consumers is too small $(\beta_{b}q^{H}\theta_{h} \leq \bar{q}\theta_{l})$, the *H*-type firm would rather not to reveal its true type and the equilibrium second-period price becomes pooling (in R4). Note that when α is larger, the high-quality product is less undervalued by those uninformed consumers observing the pooling price. The *H*-type firm is less likely to bear the cost of signaling and is more reluctant to reveal its true type to all consumers.

We have found the second-period price in the continuation game based on the three possible first-period outcomes. By backward induction, we show the LMSE which consists of the equilibrium first- and second-period prices of both types of firm in Proposition 2.

PROPOSITION 2. *When* β *is ex ante known to the firm selling an experience good, the LMSE*

[5] In this paper, the beliefs off the equilibrium path are that all deviations result from the *L*-type firm.

is:

(i) *In the good market* $(\beta = \beta_g)$, $\tilde{p}_{1,pool}^{i*} = \bar{q}\theta_h$ *and* $\tilde{p}_{2,sep}^{i*} = q^i\theta_h$ *for* $i \in \{H, L\}$

(ii) *In the bad market* $(\beta = \beta_b)$, $\tilde{p}_{1,pool}^{i*} = \bar{q}\theta_l$ *and* $\tilde{p}_{2,sep}^{i*} = q^i\theta_l$ *for* $i \in \{H, L\}$

If there is no demand certainty, the equilibrium first-period price is pooling while, in the second period, the price is separating and both types of firm achieve the first-best outcome no matter whether in the good or bad market. The idea that the *H*-type firm can costlessly separate from the *L*-type firm in the second period with a pooing first-period price is to generate enough informed consumers. In the good market, a firm prefers to target only high-valuation consumers. Thus, the *H*-type firm would charge a high first-period price ($\tilde{p}_{1,pool}^{i*} = \bar{q}\theta_h$) to attract only high-valuation consumers and exploit informed customers' surplus with the first-best price in the second period. In the bad market, it is more profitable to target the whole market so that the *H*-type firm charges a low first-period price ($\tilde{p}_{1,pool}^{i*} = \bar{q}\theta_l$) to make all consumers become informed.

Note that it is not profitable enough for the *H*-type firm to separate from the *L*-type firm in the first period even though it can also costlessly attain its first-best profit in the second period. The reason is the signaling cost for the *H*-type firm to reveal its true type in the first period is very high. It should decrease (or increase) the first-period price enormously to reduce the *L*-type firm's the incentive of mimicking. Because its price should be distorted far from the first-best price, the *H*-type firm would rather pool with the *L*-type firm and bear the loss of being undervalued as the average quality in the first period.

4.3. Demand Uncertainty

In this section, we examine the case that the firm sells a new experience good in the market with demand uncertainty. There is a two-sided asymmetric information problem. On the one hand, the

consumers *ex ante* do not know the product quality, but they will learn the true quality through use experience or update their belief about the quality after observing the price(s) in each period. On the other hand, the firm *ex ante* does not know whether it is in the good or bad market. By charging a high first-period price to attract only high-valuation consumers, the firm can infer their population in the second period from the realized first-period profit. The firm dynamically sets its spot price, which may facilitate the firm to learn market demand or reveal its true quality, to maximize its expected profit.

We argue that the following two pricing strategies may be optimal. The first is skimming pricing strategy that a firm charges a high enough first-period price to attract only high-valuation consumers, who will become informed, and adjust its second-period price depending on the realized market demand (e.g. the population of high-valuation consumers). The second is penetration pricing strategy that a firm charges low initial price to appeal to all consumers. Although the firm does notmarket know whether it is in the good or bad market, all consumers become informed in the second period.

4.3.1. Pooling First-Period Price

By backward induction, we derive the second-period outcome conditional on first-period outcome. Let $\check{p}_t^i$ denote the corresponding price in the case that there is demand uncertainty. We start from the continuation game that the first-period price is pooling $(\check{p}_{1,pool}^H = \check{p}_{1,pool}^L \equiv \check{p}_{1,pool}^H)$ so that consumers cannot correctly infer the firm's type by observing this price. The firm may adopt either penetration or skimming pricing. If the first-period pooling price is low enough that all consumers are willing to purchase (penetration pricing), every consumer becomes the informed but β is still unknown to the firm in the second period. Although the *H*-type firm can costlessly separate from the *L*-type firm, it can only set its second-period price based on the expected population of high-valuation consumers $(\bar{\beta})$:

$$\check{p}_{2,sep}^{i} = \begin{cases} q^i\theta_h \text{ if } \frac{\theta_l}{\theta_h} \leq \bar{\beta} \\ q^i\theta_l \text{ if } \frac{\theta_l}{\theta_h} \geq \bar{\beta} \end{cases} \text{ for } i \in \{H, L\}$$

In contrast, if the first-period pooling price is high enough to attract only high-valuation consumers (skimming pricing), β will be known to the firm but only high-valuation consumers become informed. The equilibrium second-price in this continuation game is equal to what we have showed in Lemma 1, which is the case that only high-valuation consumers know the true quality without demand uncertainty. That is, in the good market, the *H*-type firm can costlessly separate from the *L*-type firm. However, in the bad market, there are four scenarios. We denote $(\check{p}_{2b}^{H}, \check{p}_{2b}^{L})$ as this equilibrium second-period price for the *H*-type and *L*-type firm, respectively and the corresponding parameter regions were identified in Lemma 1.

In the first period, suppose that the *H*-type firm gives up signaling its true type, its product is evaluated as the average quality. Thus, the most profitable first-period price is $\check{p}_{1,pool} = \bar{q}\theta_h$ if the *H*-type firm adopts skimming pricing, while it is $\check{p}_{1,pool} = \bar{q}\theta_l$ if the *H*-type firm adopts penetration pricing. Conditional on second-period equilibrium prices, we examine whether a firm adopts skimming or penetration pricing.

From the similar argument in Section 3, if $\frac{\theta_l}{\theta_h} \leq \bar{\beta}$, the *H*-type firm prefers to adopt skimming pricing because of the large expected population of high-valuation consumers and the benefit from learning β. But if $\frac{\theta_l}{\theta_h} \geq \bar{\beta}$, the *H*-type firm, adopting skimming pricing, bears the cost of exploration:

$$\bar{q}(\theta_l - \bar{\beta}\theta_h)$$

since the *H*-type firm earns a lower first-period profit when selling its product to only high-valuation consumers than to all consumers. The benefit of exploitation due to the known β is

$$\lambda q^H(\beta_g\theta_h - \theta_l) - (1-\lambda)(q^H\theta_l - \check{p}_{2b}^H)$$

The first term is incremental profit after knowing it is in the good market so that the *H*-type firm will target only high-valuation consumers with its first-best price instead of all consumers. The second term is signaling cost that the *H*-type firm may not costlessly separate from the *L*-type firm in the bad market where only high-valuation consumers become informed under skimming pricing. After comparing the profit of the *H*-type firm between skimming and penetration pricing, we show the most profitable pooling first-period price in Lemma 2.

LEMMA 2. *When* β *is ex ante unknown to the firm selling an experience good, the most profitable pooling first-period price* $(\check{p}_{1,pool}^H = \check{p}_{1,pool}^L \equiv \check{p}_{1,pool})$ *of the H-type firm is*

$$\check{p}_{1,pool} = \begin{cases} \bar{q}\theta_l \ \ if\ \bar{q}\theta_l + q^H\theta_l \geq \bar{\beta}\bar{q}\theta_h + \lambda\beta_g q^H\theta_h + (1-\lambda)\check{p}_{2b}^H \\ \bar{q}\theta_h \qquad\qquad otherwise \end{cases}$$

Given the pooling first-period price, the *H*-type firm cannot reveal its true type prior to purchase. The *H*-type firm prefers to skim only high-valuation consumers if it does not have to distort $\check{p}_{2b}^H$ from its first-best price too much. The reason is the *H*-type firm may not attain its first-best profit in the bad market where only high-valuation consumers are informed so that this signaling cost reduces its incentive to adopt skimming pricing. Furthermore, as we mention in Section 3, a firm is more willing to adopt skimming pricing if either λ or the difference of willingness to pay is larger. Finally, if α becomes smaller, because the high-quality product is undervalued more, the cost of attracting only high-valuation consumers is lower; thus, the *H*-type firm is more likely to charge a high pooling first-period price.

4.3.2. Separating First-Period Price

An interesting result when there is demand uncertainty is now the *H*-type firm may separate from the *L*-type firm prior to purchase and earn higher profit than that from pooling first-period price. Suppose that the first-period price is separating $(\check{p}_{1,sep}^H \neq \check{p}_{1,sep}^L)$ since both types of firm charge

different prices, all consumers can correctly infer the true quality. In the second period, the *L*-type firm cannot pretend as the *H*-type firm since all consumers are informed. It implies that the equilibrium second-period outcome is similar to a firm selling a search good: If β is known, a firm will charge a high price in the good market and a low price in the bad market. But if β is unknown, a firm can only charge its second-period price based on the expected population of high-valuation consumers.

Conditional on second-period outcomes, we can derive the separating first-period price by backward induction. After comparing the *H*-type firm's profit under the pooling and separating first-period price, we show in Proposition 3 that under LMSE refinement the *H*-type firm can separate from the *L*-type firm by skimming pricing strategy.

PROPOSITION 3. *When β is ex ante unknown to the firm selling an experience good, if α is small enough, there exists an LMSE that the H-type firm adopts skimming pricing strategy with separating first-period price:*

$$\check{p}_{1,sep}^{H*} = \frac{(1+\lambda)q^L\theta_l - \lambda\beta_g q^L\theta_h}{\bar{\beta}} \text{ and } \check{p}_{2,sep}^{H*} = \begin{cases} q^H\theta_h \text{ if } \beta = \beta_g \\ q^H\theta_l \text{ if } \beta = \beta_b \end{cases}$$

While the L-type firm adopts penetration pricing strategy: $\check{p}_{1,sep}^{L*} = \check{p}_{2,sep}^{L*} = q^L\theta_l$.

There are two concepts for the *H*-type firm to signal its true quality. The first is that it should adopt the different pricing strategy from the *L*-type firm.[6] According to Proposition 1, when the *L*-type firm's true quality is known, it adopts penetration pricing strategy if $\frac{\theta_l}{\theta_h} \geq \frac{\lambda\beta_g + \bar{\beta}}{\lambda+1}$. It means that in this region the *H*-type firm can potentially use skimming pricing to separate from the *L*-type firm.

The second is it should distort its first-period price to reduce the incentive of mimicking

[6] If the *H*-type and *L*-type firm target the same consumers, the *H*-type firm needs to distort its price too much, leading to a very low profit.

from the *L*-type firm. To highlight our interesting results, we focus on the scenario that the *H*-type firm can costlessly separate from the *L*-type firm in the bad market where only high-valuation consumers are informed: $\check{p}_{2b}^{H} = q^{H}\theta_{l}$ (in Region 2). When mimicking $\check{p}_{1,sep}^{H}$, the *L*-type firm also appeals to all high-valuation consumers so that only high-valuation consumers are informed and both types of firm learn market demand in the second period. As Lemma 1 shows, the *L*-type firm's second-period price will be $q^{L}\theta_{h}$ and $q^{L}\theta_{l}$ in the good and bad market, respectively, so that the incentive compatible constraint for the *L*-type firm not to mimic is

$$\bar{\beta}\check{p}_{1,sep}^{H} + \lambda\beta_{g}q^{L}\theta_{h} + (1-\lambda)q^{L}\theta_{l} \leq 2q^{L}\theta_{l}$$

With this downward distorted first-period price under binding constraint, the *H*-type firm can separate from the *L*-type firm by targeting only high-valuation consumers.[7] Although the distorted price results in a lower first-period profit, it is still profitable for the *H*-type firm to use it to signal its true type. Note that the *H*-type firm will benefit from both being evaluated as high quality and learning β in the second period. Furthermore, because a firm with higher quality benefits more from knowing market demand, this distorted price scarifies only part of the *H*-type firm benefit from learning β but totally reduces the *L*-type firm's incentive of mimicking.

Adopting this skimming pricing, the *H*-type firm's profit ($\check{\pi}_{sep}^{H}$) may be higher than that from all the other pooling pricing strategies. From Lemma 2, if $\check{p}_{2b}^{H} = q^{H}\theta_{l}$, the *H*-type firm's profit under pooling first-period price is

$$\check{\pi}_{pool}^{H} = \begin{cases} \bar{\beta}\bar{q}\theta_{h} + \lambda\beta_{g}q^{H}\theta_{h} + (1-\lambda)q^{H}\theta_{l} & \text{if } \dfrac{\theta_{l}}{\theta_{h}} \geq \dfrac{\alpha\bar{\beta} + \lambda\beta_{g} + (1-\alpha)\bar{\beta}\dfrac{q^{L}}{q^{H}}}{\alpha + \lambda + (1-\alpha)\dfrac{q^{L}}{q^{H}}} \\ \bar{q}\theta_{l} + q^{H}\theta_{l} & \text{if } otherwise \end{cases}$$

After comparing the *H*-type firm's profit between separating and pooling pricing, we show

[7] To highlight our interesting results, we assume this price under the binding constraint appeals to only high-valuation consumers, that is, $q^{H}\theta_{l} < \frac{(1+\lambda)q^{L}\theta_{l} - \lambda\beta_{g}q^{L}\theta_{h}}{\bar{\beta}} \leq q^{H}\theta_{h}$.

the parameter region that $\breve{\pi}_{sep}^{H} > \breve{\pi}_{pool}^{H}$ and illustrate it in Figure 1

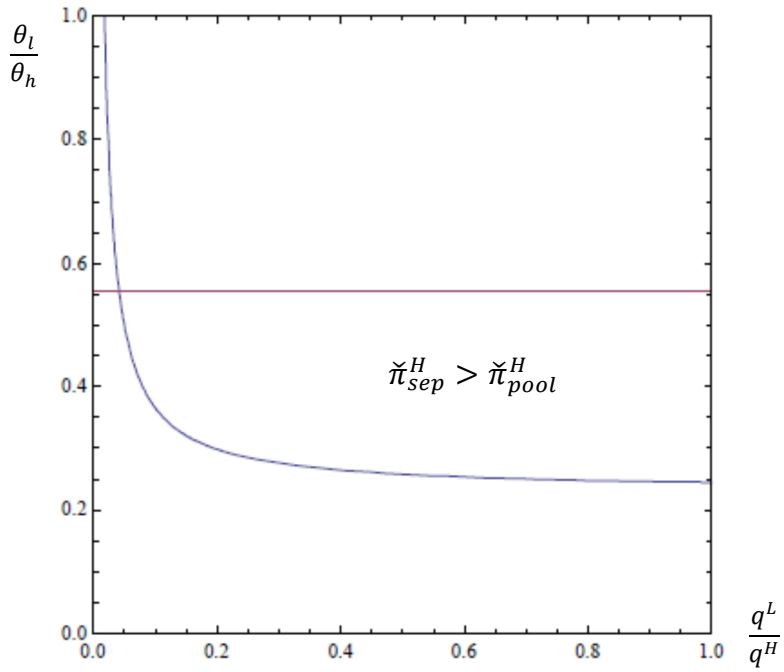
$$\frac{\alpha\bar{\beta} + ((1-\alpha)\bar{\beta} + \lambda\beta_g)\frac{q^L}{q^H}}{(1+\lambda)\frac{q^L}{q^H}} < \frac{\theta_l}{\theta_h} < \frac{\lambda\beta_g}{\alpha+\lambda}$$

We first argue that it is possible for the *H*-type firm being willing to reveal its true quality only when α is small enough:

$$\alpha < \frac{\lambda(1-\lambda)(\beta_g - \beta_b)}{2\lambda\beta_g + (1-\lambda)\beta_b}$$

The *H*-type firm needs to distort its price when skimming only high-valuation consumers, while its product is undervalued as the average quality with pooling pricing. If α is small, this undervaluation is more severe so that the *H*-type firm is more likely to bear the signaling cost to reveal its true type.

Figure 1. Parameter Region for $\breve{\pi}_{sep}^{H} > \breve{\pi}_{pool}^{H}$ under Separating Skimming Pricing



As Figure 1 shows, if the difference of quality becomes larger, the *H*-type firm is more likely to reveal its true type with skimming pricing. If the *H*-type firm's quality is relatively

higher, the *L*-type firm's incentive to mimic is stronger. To separate from the *L*-type firm, the *H*-type firm needs to further distort its first-period price, which leads to a lower profit. In addition, if the difference of willingness to pay is too small or too large, the *H*-type firm prefers not to reveal its true type. Note that when this difference is larger, the benefit of learning β becomes larger. If it is too small, the benefit from learning β is too small so that the *H*-type firm prefers to pool with penetration pricing. But if it is too large, the *H*-type firm needs to distort its price too much to reduce the L-type firm's incentive of mimicking; thus, the *H*-type firm would rather pool with skimming pricing, which also benefit from learn marked demand.

In Proposition 4, we then show how the *H*-type firm in equilibrium separates from the *L*-type firm with penetration pricing strategy.

PROPOSITION 4. *When β is ex ante unknown to the firm selling an experience good, if* α *is small enough, there exists an LMSE that the H-type firm adopts penetration pricing strategy with separating first-period price:*

$$\check{p}_{1,sep}^{H*} = q^L\theta_l + \lambda q^L(\beta_g\theta_h - \theta_l) \text{ and } \check{p}_{2,sep}^{H*} = q^H\theta_h \text{ if } \frac{\theta_l}{\theta_h} \le \bar{\beta}$$

$$\check{p}_{1,sep}^{H*} = \bar{\beta}q^L\theta_h + \lambda q^L(\beta_g\theta_h - \theta_l) \text{ and } \check{p}_{2,sep}^{H*} = q^H\theta_l \text{ if } \frac{\theta_l}{\theta_h} \ge \bar{\beta}$$

While the L-type firm adopts skimming pricing strategy:

$$\check{p}_{1,sep}^{L*} = q^L\theta_h \text{ and } \check{p}_{2,sep}^{L*} = \begin{cases} q^L\theta_h \text{ if } \beta = \beta_g \\ q^L\theta_l \text{ if } \beta = \beta_b \end{cases}$$

From the similar argument above, the *H*-type firm adopts penetration pricing with a downward distorted first-period price to reveal its true type. Notice that it potentially works when the *L*-type firm prefers to skim only high-valuation consumers if its type is known (that is, $\frac{\theta_l}{\theta_h} \le \frac{\lambda\beta_g+\bar{\beta}}{\lambda+1}$). Suppose the *L*-type firm pretends as the *H*-type firm by adopting this penetration

pricing, all consumers evaluate its product as high quality. But all consumers will learn its low quality and β is still unknown in the second period so that the *L*-type firm can only charge its second-period price based on the expected population of high-valuation consumers. Since the *L*-type firm has less incentive to mimic this penetration pricing, the *H*-type firm need not distort its price too much, which saves signaling cost. The incentive compatible constraint for the *L*-type firm not to deviate from its own skimming pricing is

$$\begin{cases} \check{p}_{1,sep}^{H} + \bar{\beta} q^L \theta_h \le \bar{\beta} q^L \theta_h + \lambda \beta_g q^L \theta_h + (1-\lambda) q^L \theta_l \text{ if } \dfrac{\theta_l}{\theta_h} \le \bar{\beta} \\ \check{p}_{1,sep}^{H} + q^L \theta_l \le \bar{\beta} q^L \theta_h + \lambda \beta_g q^L \theta_h + (1-\lambda) q^L \theta_l \quad \text{if } \dfrac{\theta_l}{\theta_h} \ge \bar{\beta} \end{cases}$$

The *H*-type firm signals its true type with this low first-period price under this binding constraint targeting all consumers.[8] However, the *H*-type firm may not be willing to separate from the *L*-type firm. Note that this separating penetration pricing is never an LMSE when $\check{p}_{2b}^{H} = q^H \theta_l$ (in Region 2). It is because the *H*-type firm, from its distorted first-period price, is kind of just getting the same benefit from learning β as the *L*-type firm: $\lambda q^L (\beta_g \theta_h - \theta_l)$. But if $\check{p}_{2b}^{H} = q^H \theta_l$, the *H*-type firm can charge a pooling price to attract only high-valuation consumers and enjoy the *H*-type firm's benefit of learning β without bearing any signaling cost. Therefore, it will earn a higher profit than this separating penetration pricing even if α approaches zero (almost being undervalued as the low quality)

We then examine this separating penetration pricing may be an LMSE when there is signaling cost under a pooling price. To highlight our result, we focus on the case that the *H*-type firm costly separates from the *L*-type firm by attracting only high-valuation consumers in the bad market where only high-valuation consumers learn the product quality: $\check{p}_{2b}^{H} = q^H \theta_h$ (in Region

[8] We also assume this price under the binding constraint is low enough to attract all consumers:
$\begin{cases} \lambda \beta_g q^L \theta_h + (1-\lambda) q^L \theta_l \le q^H \theta_l \quad \text{if } \dfrac{\theta_l}{\theta_h} \le \bar{\beta} \\ \bar{\beta} q^L \theta_h + \lambda \beta_g q^L \theta_h - \lambda q^L \theta_l \le q^H \theta_l \text{ if } \dfrac{\theta_l}{\theta_h} \ge \bar{\beta} \end{cases}$

4). From Lemma 2, the *H*-type firm's profit under pooling first-period price is

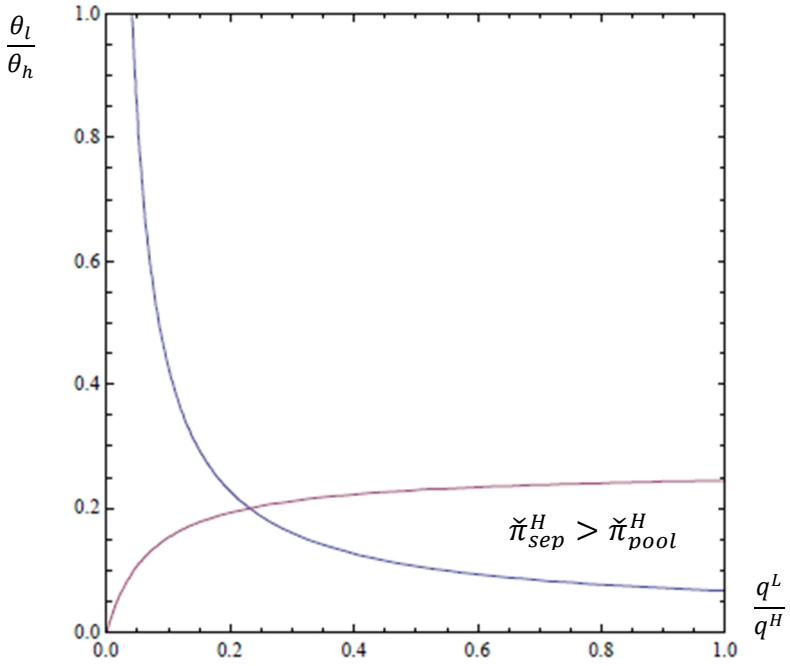
$$\breve{\pi}^H_{pool} = \begin{cases} \bar{\beta}\bar{q}\theta_h + \bar{\beta}q^H\theta_h \text{ if } \frac{\theta_l}{\theta_h} \le \bar{\beta} \\ \bar{q}\theta_l + q^H\theta_l \quad \text{if } \frac{\theta_l}{\theta_h} \ge \bar{\beta} \end{cases}$$

We also compare the profit from separating and pooling pricing, show the parameter region that $\breve{\pi}^H_{sep} > \breve{\pi}^H_{pool}$:

$$\frac{\alpha\bar{\beta} + ((1-\alpha)\bar{\beta} - \lambda\beta_g)\frac{q^L}{q^H}}{(1-\lambda)\frac{q^L}{q^H}} < \frac{\theta_l}{\theta_h} < \frac{(\bar{\beta} + \lambda\beta_g)\frac{q^L}{q^H}}{\alpha + (1-\alpha+\lambda)\frac{q^L}{q^H}}$$

and illustrate it in Figure 2.

Figure 2. Parameter Region for $\breve{\pi}^H_{sep} > \breve{\pi}^H_{pool}$ under Separating Penetration Pricing



From the similar argument above, the separating pricing dominates the pooling pricing only when α is small enough, that is,

$$\alpha < \frac{\lambda(\beta_g - \bar{\beta})}{2\bar{\beta}}$$

In addition, the *H*-type firm is more likely to adopt the separating pricing when the difference of

quality becomes smaller. Finally, the separating price is more profitable if the difference of willingness to pay is not too large or too small.

Although both skimming and penetration pricing can be used to signal a firm's high quality, penetration pricing is less attractable for the *H*-type firm. The reason is the *H*-type firm cannot directly benefit from learning market demand. With penetration pricing, the *H*-type firm gives up learning market demand to reduce the incentive of mimicking from the *L*-type firm. Therefore, it just saves the signaling cost because the first-period price is not downward distorted too much. It implies that the *H*-type firm is willing to signal its true quality only when its profit from pooling pricing strategy is too low, that is, its quality is severely undervalued (α is too small) and it cannot attain costlessly separation in the bad market where only high-valuation consumers are informed ($\check{p}_{2b}^{H} \neq q^{H}\theta_{l}$).

4.3.3. Comparison

We have discussed the equilibrium outcome when a firm is in the market with and without demand uncertainty. It is clear that when a firm sells a search good, both types of firm always want to *ex ante* learn market demand so that it can exploit consumers without bearing any cost of exploration. However, when a firm sells an experience good, even though a firm still benefits from learning market demand, we argue that the *H*-type firm would rather be in the market with demand uncertainty than without.

PROPOSITION 5. *The H-type firm selling an experience good may earn more profit when* β *is ex ante unknown than when* β *is ex ante known. Furthermore, the L-type firm is always worse off.*

Although a firm benefits from knowing β, in Proposition 5, we show that the *H*-type firm may earn more profit when a firm *ex ante* faces demand uncertainty. The idea is that the *H*-type

firm in the market with demand uncertainty may successfully reveal its true type in the first period and be evaluated as high-quality in both periods. Note that when β is *ex ante* known to the firm, the *H*-type firm inevitably pools with the *L*-type firm and is regarded as the average quality in the first period. Thus, the *H*-type firm's profit is extremely low if its product is undervalued severely (e.g., α is very small). However, we have shown that, when β is *ex ante* unknown to the firm, the *H*-type firm may separate from the *L*-type firm by penetration or skimming pricing. The *H*-type firm can avoid being undervalued in the first period and earn more profit from revealing its high quality. It implies that if the benefit from charging its price based on high quality dominates the benefit from knowing market demand, the *H*-type firm's profit will be higher in the market with demand uncertainty than without.

In contrast, the *L*-type firm always earns less profit when it is in the market with demand uncertainty. The idea is that when there is no demand uncertainty, the *L*-type firm can at least be regarded as the average quality in the first period and benefit from knowing market demand. But if market demand is *ex ante* known, the *L*-type firm becomes worse off. First, if the *H*-type firm can avoid the mimicking, the *L*-type firm's true quality is known so that it can only charge its price based on its low quality. Second, if the *H*-type firm gives up revealing it true type, although the *L*-type firm's quality is overvalued, it cannot derive the benefit from knowing market demand is the first period. Therefore, the *L*-type firm always prefers the market without demand unceratinty.

5. Conclusion

This paper examines how a firm signals its high quality of a new experience good in the market with demand uncertainty. When market demand is known, it is difficult for the high-quality firm to separate from the low-quality firm since both types of firm would like to be regarded as the high-quality one. If both types of firm have the same marginal cost, the high-quality firm is

inevitable to pool with the low-quality firm in the first period since all consumers are uninformed about product quality. If market demand is *ex ante* unknown, however, the high-quality firm may separate from the low-quality firm prior to purchase. It is because now both types of firm have different benefit from knowing market demand. To signal its true quality, a high-quality firm can use either skimming or penetration pricing. By adopting the different pricing strategy from the low-quality firm, the high-quality firm can attain costly separation. Finally, we show that the high-quality firm may be better off in the market with demand uncertainty than without since it benefits from revealing its true type to all consumers, while the low-quality firm is worse off.

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