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The Role of Consumer Anticipated Regret**

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Vertical Probabilistic Selling under Competition: the Role of Consumer Anticipated Regret^{*}

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ABSTRACT

This paper studies probabilistic selling with vertically differentiated products when firms compete and consumers anticipate the potential post-purchase regret raised by possibly obtaining the inferior products. Intuitively, anticipated regret hurts the attractiveness of probabilistic selling. However, we find that probabilistic selling can be more profitable, and more likely to arise with anticipated regret than without it. This is due to the “reverse quality discrimination” (*perceived* quality of the random product becomes decreasing in consumer type at the competition margin), which increases the perceived differentiation, and may still maintain sufficient attractiveness of the random product for infra-marginal consumers. Meanwhile, it *may* hurt the competitor.

Keywords: reverse quality discrimination, probabilistic selling, vertical differentiation, anticipated regret, competition

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1. Introduction

Probabilistic selling is an innovative business practice of selling a random product that mixes several products whose exact identity or attributes are (partially) hidden until the purchase has been made. The probabilistic selling strategy was introduced by some online travel sites (e.g., Hotwire and Priceline) and since then has become popular (e.g. Expedia's Special Cars, Travelocity's Top Secret Hotels, Bookit's Mystery Hotel, Booking's Hidden Hotel, Ctrip's Secret Hotels, etc.) in the industry.¹ The probabilistic selling has received much attention recently, and researchers have mostly focused on its *horizontal* features (Fay and Xie 2008, 2010, Jerath et al. 2010), e.g., product colors or hotel locations.

In many situations, however, a seller mixes products with different *qualities* in probabilistic selling. For example, a hotel can create a “random hotel” by mixing its suite rooms with ordinary rooms on Hotwire. A car rental company can use full-size cars and compact cars to create a “random car” whose identity is uncovered upon pick-up. A cruise company can mix ocean-view staterooms with different square footage to create a “secret stateroom.” In all of these examples, products involved in probabilistic selling are *vertically* differentiated, implying that after purchase it is possible for a consumer to eventually obtain a lower quality product than her expectation.

Once the random product turns out to be a low quality one, unfortunately, the consumer usually cannot return it for a refund, due to the prevalent “no return” policy.² As a result, she may regret her purchase of the random product.³ Specifically, there are two possible situations: first, she might say “I should not make any purchase”; second, she might say “I should purchase the most favorable transparent product”. We refer to the former as *purchase regret* and the later as *selection regret*. If the consumer can anticipate such a potential post-purchase regret before

buying, she will incorporate it in her purchase decisions. Since both purchase regret and selection regret reduce the attractiveness of random products to consumers, this constitutes an important drawback to random products, and intuitively, should discourage the use of probabilistic selling. However, it seems that this self-deficiency of probabilistic selling has been largely ignored from the previous studies, which might call into question the earlier insights (e.g., merits) of probabilistic selling in the literature. In this study, we explore consumers' anticipated regret and its role in a competitive market consisted of a *vertical* random product and its transparent rival. Our results suggest that, rather than being a curse, consumers' anticipated regret can be a blessing for the random product provider. Probabilistic selling can be more profitable, and more likely to arise with anticipated regret than without it. Moreover, it *may* hurt its competitor's profit.

In our setting, we incorporate some other important features of probabilistic selling in a vertical market. Industrial evidence suggests that firms with high quality normally do not participate in probabilistic selling, because their image may get hurt by the discounted prices associated with random products (See Özer and Phillips, 2012). This concern has become more salient recently since the identity of products involved in probabilistic selling might be revealed online to consumers (e.g. Hotwire). Accordingly, in our two-firm model, one firm (Firm H) provides a product with high quality (product H) and sells it transparently. The other firm (Firm R) provides two products with lower and different qualities (products M and L) and can mix them to create any possible random products, in addition to transparent products M and L .

We start with the benchmark case in which consumers have no regret. We show that Firm R offers the random product only when the quality of product H is intermediate. When product H 's quality is too high, Firm R offers product M because the product differentiation is large

enough and it can extract more surplus from the consumers who value quality without worrying much about competition. When product H 's quality is too low, Firm R will only offer product L to maximize differentiation from product H . Therefore, when the quality of product H is intermediate, a random product that mixes M and L should be offered to better balance surplus extraction and product differentiation by adjusting the probability of obtaining L .

We then explore the case in which consumers can anticipate the potential-post purchase regret. Intuitively, because of the anticipated regret, the random product looks less appealing to consumers, implying that the probabilistic selling strategy should be unattractive to both consumers and firms. However, our results suggest that the consumers' anticipated regret can actually incentivize the firm to adopt probabilistic selling, depending on the relative magnitude of consumers' sensitivity to purchase regret and selection regret. Specifically, we show that purchase regret makes the perceived quality of the random product follow the nature order (increase in taste for quality), while selection regret makes this order reversed (*non-increasing* in taste for quality). We call the latter situation as "reverse quality discrimination" and our results show that, when consumers are more sensitive to selection regret, a creative strategy "reverse quality discrimination" can be used by the random product provider: the anticipated regret deteriorates the perceived quality of the random product to a greater extent for higher type consumers. Such reverse discrimination can increase perceived product differentiation for consumers at competition margin, and maintain the attractiveness of the random product for infra-marginal consumers. That is, under this situation, probabilistic selling can both increase perceived product differentiation and better extract surplus. Thus, it is indeed more encouraged than in the benchmark case when consumers have no regret.⁴ Moreover, probabilistic selling *may* hurt its competitor's profit. However, when consumers are more sensitive to purchase regret, we

show that probabilistic selling with anticipated regret might yield lower profits than in the benchmark case when consumers have no regret because the effect of “reverse quality discrimination” vanishes.

Furthermore, even when consumers are extremely averse to selection regret, the random product should still be provided because of the benefits from the “reverse quality discrimination.” In fact, as long as the selection regret sensitivity is sufficiently large, probabilistic selling *always* arises. As the selection regret sensitivity increases, the random product provider increases the quality of the random product towards M , which makes the competing firms’ *actual* quality levels closer to each other, but *never* reaches M . This is because the benefit of the “reverse quality discrimination” will disappear once a random product is degenerated to a transparent one (i.e., the random product’s quality is increased to M for sure).

2. Literature Review

Our research connects to the recent growing literature of probabilistic selling. Some studies explore how a firm uses its existing distinct products in probabilistic selling (Fay and Xie 2010, 2015) while others examine the use of probabilistic selling in competitive markets (Fay 2008, Shapiro and Shi 2008, Jerath et al. 2010, Chen et al. 2014). However, they all focus on the *horizontal* feature of random products. Interestingly, the most recent literature on probabilistic selling seems to shift the focus on the vertical feature of random products (Huang and Yu 2014, Zhang et al. 2015). Although the literature has explored the use of probabilistic selling strategy under different situations, the potential post-purchase regret is largely ignored, which might challenge the merits of this strategy. To the best of our knowledge, we are among the first to explore anticipated regret in probabilistic selling. More importantly, we discover an interesting mechanism associated with probabilistic selling to increase the profit of the random product

provider and might hurt its competitor in the vertical market: the reverse quality discrimination, which is new to the literature. Thus, our study shows that, rather than being a curse, consumers' anticipated regret can actually be a blessing to the probabilistic selling strategy.

Our work builds off the literature relating to consumers' anticipated regret.⁵ Zeelenberg et al. (1996) suggest that consumers may anticipate the possible post-purchase regret and incorporate it when making a choice before purchase. Filiz-Ozbay and Ozbay (2007) investigate the role of anticipated regret in bidding behavior. Jiang et al. (2015) study the effect of anticipated regret on product innovation. Nasiry and Popescu (2012) focus on how anticipated regret affects advance purchase decision. Our paper focuses on the role of anticipated regret in the adoption of probabilistic selling strategy.

In addition, random products usually consist of unsold units. The previous literature often explains random products as an inventory management strategy subject to capacity constraints. Interestingly, data show that the unsold units/services in the travel industry have been overwhelming in the recent years (e.g. more than 40% of hotel rooms in North America and more than 50% in China were vacant each year from 2006 to 2014). Thus, some research (Shapiro and Shi 2008, Fay and Xie 2010, Huang and Yu 2014) as well as this paper offer different rationales for probabilistic selling in the absence of capacity constraints.

Finally, our work is also related to the growing literature of behavioral economics and its implications in marketing research (Cui et al. 2007, Chen et al. 2010, Chen and Cui 2013, Chen and Turut 2013, Chioveanu and Zhou 2013, Narasimhan and Turut 2013, Huang and Yu 2014, Jiang et al. 2014, Guo 2015, Guo and Jiang 2015, Jiang et al. 2015). Our paper provides contributions to the literature in three ways. First, we are among the first to explore the implications of anticipated regret in vertical probabilistic selling strategy and study how this self-

deficiency of probabilistic selling affects the use of this strategy. Second, we identify a new mechanism associated with vertical probabilistic selling: the “reverse quality discrimination,” which can simultaneously increase product differentiation and extract consumer surplus. Third, our paper provides potential behavioral implications of the “no return” policy in probabilistic selling: making some consumers feel regret yields higher profit to the random product provider.

The paper is organized as follows. Section 3 sets up the model for consumer anticipated post-purchase regret. Section 4 analyzes the benchmark case in which consumers have no regret; Sections 5 explores the situation in which consumers can anticipate the regret. Section 6 discusses the implications of our main results, and Section 7 concludes. Notations are summarized in Table 1.

Table 1: Notation

Definition	Symbol	
	No Regret	With Anticipated Regret
Regret Intensity on buying	NA	γ_0
Regret Intensity on not buying H	NA	γ_1
Quality of Product H, M, R, L	$q_H, q_M, q_R, q_L = 1$	
Prices of Product H, M, R, L	p_H, p_M, p_R, p_L	
Profits of Firms H and R	π_H, π_R	
Mixing Probability of Product R	α_R	
Cutoff between No-Purchase and Purchase from Firm R	θ_0	$\hat{\theta}_0$
Cutoff between Purchase from Firms H and R	θ_R	$\hat{\theta}_R$
Cutoff between Regret or Not Regret on not Buying H	NA	θ_1
Cutoff between Regret on Buying and on not Buying H	NA	$\begin{cases} NA & \text{if } \theta_1 \geq p_R \\ \theta_2 & \text{if } \theta_1 < p_R \end{cases}$
Perceived Quality of Product R	q_R	q_{Rpd}
Equilibrium Quality of Product R	q_R^*	$\hat{q}_R^*$
Equilibrium Prices	p_H^*, p_R^*	$\hat{p}_H^*, \hat{p}_R^*$
Equilibrium Profits	π_H^*, π_R^*	$\hat{\pi}_H^*, \hat{\pi}_R^*$
Equilibrium Mixing Probability	α_R^*	$\hat{\alpha}_R^*$

3. Model

There are two firms, H and R , each selling one product. Firm H offers a transparent product H with quality level q_H . Firm R can offer a transparent product M with quality level q_M , or a transparent product L with quality level q_L , or a random product R that mixes products M and L with a self-select probability. Here $0 < q_L < q_M < q_H$. Without loss of generality, we normalize q_L to one. Denote by $\alpha_R \in [0,1]$ the probability that consumers obtain L when purchasing random product R . Thus, the expected quality of random product R is given by

$$q_R(\alpha_R) = \alpha_R + (1 - \alpha_R) \cdot q_M.$$

Note that transparent product L or M can be viewed as the special case of random product R respectively when $q_R = 1$ or $q_R = q_M$. Since we focus on offering random product as a marketing/sale strategy, given the products are already produced, we abstract away from production stage, and assume that the marginal cost of production is zero.⁶

There is a unit mass of consumers and each consumer at most buys one product. A consumer's quality taste θ is uniformly distributed on a unit interval $[0,1]$. For a consumer with taste θ buying product i ($i = H, M, L, \text{ or } R$) at price p_i , she enjoys a standard utility

$$u = \theta \cdot q_i - p_i \quad (i = H, M, L, R)$$

when she has *no* regret. However, when she can anticipate the regret, her utility is given by

$$u = \begin{cases} \theta \cdot q_i - p_i & \text{if } i = H, M, L \\ \theta \cdot q_i - p_i - \text{regret} & \text{if } i = R \end{cases}.$$

Note that none of the transparent products ($i = H, M, L$) would result in any disutility from regret, because buying them does not involve any uncertainty. But for random product R , the utility function has a disutility term (denoted by *regret*) that represents the potential post-purchase regret.

The timeline of the game is as follows. At Date 0, Firm R chooses whether to offer a random product and the corresponding expected quality q_R if it chooses to offer R . At Date 1, both firms compete in prices simultaneously. At Date 2, consumers make their purchase decisions. Throughout the whole game, we assume complete information. That is, when firms set their prices, they are fully aware of each other's product (expected) quality; when consumers make choices, they observe the prices for all the products. In addition, they also observe the quality for the transparent products and rationally deduce the expected quality of the random product, if any. We will determine the subgame-perfect equilibrium of the game in the next section.

4. Benchmark: No Regret

First, we consider a benchmark case in which consumers have no regret associated with the random product.

Since it is a sequential-move, complete information game, we solve it by backward induction. Starting from consumers' product choices in the last stage, given quality-price pairs (q_i, p_i) ($i = R, H$), we can obtain two cutoff tastes for quality: one for the consumer who is indifferent between no buy and buying product R ; and the other for the consumer who is indifferent between buying R and buying H . They are, respectively,

$$\theta_0 = \frac{p_R}{q_R}, \quad \theta_R = \frac{p_H - p_R}{q_H - q_R}. \quad (1)$$

The corresponding demand for Firm R and Firm H are given by $(\theta_R - \theta_0)$ and $(1 - \theta_R)$. Thus, the profits of Firm R and Firm H are

$$\pi_R = p_R \cdot (\theta_R - \theta_0), \quad \pi_H = p_H \cdot (1 - \theta_R).$$

We can solve their equilibrium prices as a function of any quality pair (q_R, q_H) . Then in the first stage, Firm R will choose its optimal q_R from the range $[1, q_M]$. The equilibrium for no regret case is given by the following proposition.

Proposition 1 (No Regret): *With no regret,*

- (i) *When $q_H \leq \frac{7}{4} (\frac{7}{4} q_M \leq q_H)$, Firm R sells product L (M).*
- (ii) *When $\frac{7}{4} < q_H < \frac{7}{4} q_M$, Firm R offers a random product.*

This proposition suggests that, when consumers have no regret associated with the random product, the necessary and sufficient condition for Firm R to use probabilistic selling is that the quality differentiation between Firm H and Firm R is neither too large nor too small, i.e., $\frac{7}{4} < q_H < \frac{7}{4} q_M$. If q_H is too low, Firm R will offer product L in order to maximize differentiation. Alternatively, if q_H is too high, Firm R will offer product M to extract more surplus from consumers without worrying much about competition. The random product will emerge only when q_H is neither too high nor too low as compared to $q_L = 1$ and q_M . Indeed, given q_H , there exists an optimal quality level $(\frac{4}{7} q_H)$ that Firm R would like to achieve in order to balance product differentiation and surplus extraction. When such an ideal quality falls within $[1, q_M]$, the random product will be offered; when it falls outside of the interval, only the transparent product, either L or M , will be provided.⁷ By adopting probabilistic selling, Firm R chooses the mixing probability (α_R) to control its product design (the expected quality q_R).

An immediate result following from the proposition is how the optimal mixing probability α_R^* changes when qualities vary.

Corollary 1: *With no regret, the optimal mixing probability α_R^* is non-decreasing (non-increasing) in q_M (q_H).*

This corollary regards the design of the random product, operationalized by the mixing probability, when consumers have no regret. In particular, when the random product is offered, i.e., $\frac{7}{4} < q_H < \frac{7}{4} q_M$, the mixing probability increases with q_M . That is, Firm R would like to make it more likely for consumers to eventually obtain product L as q_M improves. This is because as q_M improves, in order to keep expected quality exactly equal to the ideal quality level $\frac{4}{7} q_H$, Firm R needs to downwardly adjust the expected quality of the random product. By contrast, as q_H increases, Firm R wants to upwardly adjust the expected quality by making product M more likely to occur in the random product.

5. Equilibrium Analysis of Anticipated Regret

We now turn to the case when consumers can anticipate the regret associated with a random product. Intuitively, when consumers can anticipate regret from a random product, Firm R should be less likely to use probabilistic selling strategy compared with the benchmark case in which regret is not involved, because the random product will become less attractive to consumers when it is associated with regret. However, our findings challenge this intuition.

5.1. Definition of Anticipated Regret

We model the anticipated regret following the literature (Syam et al. 2008, Nasiry and Popescu 2012, Jiang et al. 2015). Specifically, we adopt a linear term for anticipated regret, which is defined as follows.

Definition (Anticipated Regret):

$$regret = \alpha_R \cdot \max \left\{ \underbrace{\gamma_0 \cdot [0 - (\theta - p_R)]^+}_{regret \text{ on buying}}, \quad \underbrace{\gamma_1 \cdot [(\theta q_H - p_H) - (\theta - p_R)]^+}_{regret \text{ on not buying } H} \right\}, \quad (2)$$

where $\gamma_i > 0$ ($i = 0, 1$) is a measure of consumer regret intensity, respectively, on buying behavior and on not buying transparent product H . And $[x]^+ \equiv \max\{0, x\}$.

In the above definition, the regret occurs only if a consumer receives product L after purchasing the random product. Indeed, this is a natural result from consumer's rational choice. That is, even if we include a similar regret term for product M , we have shown that that term will disappear *endogenously* (see Claim 1 in Appendix): consumers choosing the random product will never feel regret if obtaining product M under random product R . It is because, if they feel regret even when receiving the best possible outcome under the random product: product M , they would never choose product R in the first place. Thus, for simplicity, in our definition we do not incorporate the redundant regret term for the possible situation when R turns out to be M *ex post*.

It is possible that consumers regret on (i) buying behavior itself (e.g., after getting a bad hotel from a random product purchase, she may think “if I had known I was going to get the low quality hotel, I would have made no purchase and saved my money”); (ii) not buying the transparent product alternative (e.g., after getting a bad hotel from a random product purchase, she may think “if I had known I was going to get the low quality hotel, I would have gone for a transparent hotel, even though this would cost more”). Our definition of regret above allows for both types of regrets, with possibly different regret intensities: γ_0 for the former and γ_1 for the latter. More importantly, as we shall see, these two benchmarks and two intensities will play different roles in vertical probabilistic selling.

5.2. Perceived Quality and Consumer Segmentation

According to (2), the first regret term in the bracket will be positive if and only if $\theta < p_R$; and the second term will be positive if and only if

$$\theta > \theta_1 \equiv \frac{p_H - p_R}{q_H - 1}. \quad (3)$$

It is possible to have $\theta_1 < p_R$, in which case the consumer will regret both on buying itself and on not buying product H . It is easy to calculate, for this case, the first regret term dominates the second one if and only if

$$\theta < \theta_2 \equiv \frac{\gamma_0 \cdot p_R + \gamma_1 \cdot (p_H - p_R)}{\gamma_0 + \gamma_1 \cdot (q_H - 1)}. \quad (4)$$

Accordingly, under anticipated regret, we can define the *perceived* quality of product R for a consumer with taste θ as

$$q_{R_{pd}}(\theta) \equiv q_R - \frac{\text{regret}(\theta)}{\theta},$$

which becomes

$$\begin{aligned} \bullet \quad \text{when } \theta_1 \geq p_R, q_{R_{pd}}(\theta) &= \begin{cases} q_R - \alpha_R \cdot \gamma_0 \cdot \left(\frac{p_R}{\theta} - 1\right) & \text{if } \theta < p_R \\ q_R & \text{if } p_R \leq \theta \leq \theta_1; \\ q_R - \alpha_R \cdot \gamma_1 \cdot \left(q_H - 1 - \frac{p_H - p_R}{\theta}\right) & \text{if } \theta_1 < \theta \end{cases} \\ \bullet \quad \text{when } \theta_1 < p_R, q_{R_{pd}}(\theta) &= \begin{cases} q_R - \alpha_R \cdot \gamma_0 \cdot \left(\frac{p_R}{\theta} - 1\right) & \text{if } \theta < \theta_2 \\ q_R - \alpha_R \cdot \gamma_1 \cdot \left(q_H - 1 - \frac{p_H - p_R}{\theta}\right) & \text{if } \theta \geq \theta_2 \end{cases}. \end{aligned}$$

By introducing $q_{R_{pd}}(\theta)$, we make a consumer's utility under anticipated regret congruent to that

with no regret as $u_R(\theta) = \theta \cdot q_{R_{pd}}(\theta) - p_R$.

Figure 1: Consumers' Perceived Quality under Anticipated Regret

Figure 1 illustrate that, when random product R is offered, different consumers perceive its quality level differently due to their heterogeneous tastes, which is summarized in the following lemma.

Lemma 1 (Perceived Quality): *Consumers' perceived quality of product R is inverted U/V-shaped:*

$$\begin{array}{cc}
 \text{when } \theta_1 \geq p_R & \text{when } \theta_1 < p_R \\
 q'_{Rpd}(\theta) \begin{cases} > 0 & \text{if } \theta < p_R \\ = 0 & \text{if } p_R \leq \theta \leq \theta_1 \\ < 0 & \text{if } \theta_1 < \theta \end{cases} & q'_{Rpd}(\theta) \begin{cases} > 0 & \text{if } \theta < \theta_2 \\ < 0 & \text{if } \theta \geq \theta_2 \end{cases}
 \end{array}$$

where θ_1 and θ_2 are, respectively, given by (3) and (4).

Lemma 1 demonstrates that (i) the anticipated regret deteriorates the perceived quality, as intuition suggested; (ii) however, it impacts heterogeneous consumers to different extents: it deteriorates more to the two ends of consumers than to the medium ones.

For consumers with relatively low tastes (i.e., $\theta < p_R$), they are not bothered by the option of buying transparent product H because they cannot afford H anyway. Instead, they will regret on buying behavior itself when the random product R turns out to be the low quality

product L , but will regret less on that as θ increases. So their perceived quality of random product R is downwardly adjusted by $\alpha_R \cdot \gamma_0 \cdot \left(\frac{p_R}{\theta} - 1\right)$. Such downward adjustment shrinks toward zero as θ increases toward p_R , which implies their perceived quality is increasing in θ .

For consumers with relatively high tastes (i.e., $\theta > \theta_1$), they will not regret on buying even when R turns out to be L , because their tastes for the product are sufficiently high. Nevertheless, they will regret not buying transparent product H when R turns out to be the less desirable outcome L . Consequently, their perceived quality of product R will be downwardly adjusted by the potential post-purchase regret $\alpha_R \cdot \gamma_1 \cdot \left(q_H - 1 - \frac{p_H - p_R}{\theta}\right)$. In contrast to that for consumers with relatively low tastes, the downward adjustment is strictly increasing in θ , which yields a *decreasing* perceived quality for relatively high taste consumers.

As we shall see, the intuitive natural ordering of the deteriorated perceived quality for low taste consumers conforms to the intuition that anticipated regret will reduce the attractiveness of the random product, which results a negative effect on Firm R 's profit. Nevertheless, the “reverse ordering” of the deteriorated perceived quality for relatively high taste consumers will work *in favor of*, not against, Firm R , because it amplifies the product differentiation between R and H .

Next, we determine who will buy nothing, who will choose random product R , and who will buy product H . The cutoff quality taste for consumers who are indifferent between buying product R and buying nothing is determined by $\theta \cdot \left[q_R - \alpha_R \cdot \gamma_0 \cdot \left(\frac{p_R}{\theta} - 1\right)\right] = 0$. That is,

$$\hat{\theta}_0 \equiv \frac{(1 + \gamma_0 \cdot \alpha_R) \cdot p_R}{\gamma_0 \cdot \alpha_R + q_R}. \quad (5)$$

The consumer choosing between product R and product H is guided by a cutoff quality taste that is obtained by $\theta \cdot \left[q_R - \alpha_R \cdot \gamma_1 \cdot \left(q_H - 1 - \frac{p_H - p_R}{\theta} \right) \right] = \theta \cdot q_H - p_H$. That is,

$$\hat{\theta}_R \equiv \frac{(1 + \gamma_1 \cdot \alpha_R) \cdot (p_H - p_R)}{\gamma_1 \cdot \alpha_R \cdot (q_H - 1) + q_H - q_R}. \quad (6)$$

Note that when $\gamma_i = 0$ ($i = 1, 2$), these cutoffs are reduced to those when consumers have no regret in (1), i.e., $\hat{\theta}_0 = p_R/q_R = \theta_0$, and $\hat{\theta}_R = (p_H - p_R)/(q_H - q_R) = \theta_R$. Thus, the no regret benchmark case in Section 4 can be considered as a special case nested in this section.

The above results can be summarized in the lemma below.

Lemma 2 (Consumer Segmentation): *Consumers with $\theta \in [\hat{\theta}_0, \hat{\theta}_R)$ will choose product R , while those with $\theta \in [\hat{\theta}_R, 1]$ will choose product H , where $\hat{\theta}_0$ and $\hat{\theta}_R$ are, respectively, given by (5) and (6).*

Lemma 2 illustrates that consumers with sufficiently high tastes $[\hat{\theta}_R, 1]$ buy product H , those with intermediate tastes $[\hat{\theta}_0, \hat{\theta}_R)$ buy product R , and those with low tastes $[0, \hat{\theta}_0)$ leave the market without any purchase. Moreover, it can be readily verified that $\hat{\theta}_R > \theta_1$, and $\hat{\theta}_R > \theta_2$ whenever $\theta_1 < p_R$. That is, the marginal consumer who is indifferent between product R and product H must lie to the right side of the peak of the inverted-U/V shaped perceived quality. Therefore, the “battle field” between Firm H and Firm R is the high end interval $[\max\{\theta_1, \theta_2\}, 1]$, where $q_{R_{pd}}(\theta)$ is less than q_M , and more importantly, is strictly *decreasing* in θ . Since q_H is constant for all consumers in this interval, the gap between the perceived quality of random product R and the quality of transparent product H at the battle field becomes larger than that between M and H , and moreover, increases as θ increases. Hence, Firm R ’s probabilistic selling creates a “moat defensive” to Firm H .

5.3. Equilibrium Characterization

The consumer segment in Lemma 1 implies that the profits of the two firms are

$$\hat{\pi}_R = p_R \cdot (\hat{\theta}_R - \hat{\theta}_0), \quad \hat{\pi}_H = p_H \cdot (1 - \hat{\theta}_R).$$

Firm H chooses p_H to maximize π_H and Firm R chooses p_R to maximize π_R . After substituting the optimal prices as a function of q_R and q_H , Firm R chooses its optimal q_R . The equilibrium outcomes are summarized in Proposition 2.

Proposition 2 (Anticipation of Regret): *With anticipated regret,*

(i) *When $q_H \leq \frac{7}{4}$ ($q_H \geq \frac{7}{4}q_M$), there exists a unique threshold level $\Gamma_1(\gamma_1)$, and $\Gamma_1(\gamma_1) \leq \gamma_1$, such that for any $\gamma_0 < \Gamma_1(\gamma_1)$, Firm R offers a random product; otherwise, Firm R only sells transparent product L (M).*

(ii) *When $\frac{7}{4} < q_H < \frac{7}{4}q_M$, there exists a unique threshold level $\Gamma_2(\gamma_1)$, and $\Gamma_2(\gamma_1) \geq \gamma_1$, such that for any $\gamma_0 < \Gamma_2(\gamma_1)$, Firm R offers a random product; otherwise, Firm R only sells a transparent product.*

Moreover, $\Gamma_1(\gamma_1)$ and $\Gamma_2(\gamma_1)$ are increasing in γ_1 .

As compared with Firm R 's profit with no regret,

$$\hat{\pi}_R^* \gtrless \pi_R^* \text{ if and only if } \gamma_1 \gtrless \gamma_0. \quad (7)$$

This proposition establishes two results. First, with anticipated regret, as long as γ_0 is sufficiently small as compared to γ_1 , i.e., γ_0 is below certain cutoff as an increasing function of γ_1 , random product will *always* be offered. Intuitively, when consumers anticipate the potential post-purchase regret from buying the random product, the probabilistic selling strategy seems less attractive, which should be less likely to emerge in equilibrium. However, we find the opposite (anticipated regret can encourage probabilistic selling) is possible, too. Specifically,

when $\gamma_1 > \gamma_0$, in Case (i), if $\gamma_0 < \Gamma_1(\gamma_1)$, random product is *always* offered while it is *never* offered in Case (i) of Proposition 1; in Case (ii), since $\gamma_0 \leq \gamma_1 \leq \Gamma_2(\gamma_1)$, so random product is always offered, the same as Case (ii) of Proposition 1. Compared with Proposition 1, Firm R is *more likely* to offer random product when $\gamma_1 > \gamma_0$. In contrast, when $\gamma_1 \leq \gamma_0$, in Case (i), since $\gamma_0 \geq \gamma_1 \geq \Gamma_1(\gamma_1)$, random product is never offered, the same as Case (i) of Proposition 1; in Case (ii), random product is offered *only when* $\gamma_0 < \Gamma_2(\gamma_1)$ while it is *always* offered in Case (ii) of Proposition 1. Compared with Proposition 1, Firm R is *less likely* to offer random product when $\gamma_1 \leq \gamma_0$.

Second, Firm R 's profit under anticipated regret will be higher than that under no regret if and only if the regret intensity on buying itself is smaller than that on not buying H , i.e., $\gamma_0 < \gamma_1$. Recall from Lemmas 1 and 2 that, the consumers' perceived quality is inverted-U/V shaped. Hence, the random product hurts consumers more on two ends: those with low taste due to their regret on buying itself, and those with high taste because of their regret on not buying H . The former, whose regret is affected by γ_0 , perceives the quality in a natural order (increasing in θ). The deteriorated perceived quality discourages them from purchasing, which forces Firm R to lower its price to retain those consumers, and hence tends to *reduce* the profitability of probabilistic selling. The latter, whose regret hinges on γ_1 , perceives the quality in a "reverse order" (decreasing in θ). We refer to this as to "reverse quality discrimination." These high end "regret consumers" ($\theta \in [\max\{\theta_1, \theta_2\}, 1]$) are at the competition "battlefield" between the two firms. Such a lowered perceived quality on the random product increases the product differentiation between random product R and transparent product H , which leaves some room for Firm R to increase its price to take advantage of the increased product differentiation at the margin, and so tends to *increase* the profitability of probabilistic selling. Consequently, whether

probabilistic selling with anticipated regret will be more profitable than that without regret depends on whether the latter effect dominates the former one.

We can define a uniform threshold

$$\Gamma(\gamma_1) \equiv \begin{cases} \Gamma_1(\gamma_1), & \text{if } q_H \leq \frac{7}{4} \text{ or } q_H \geq \frac{7}{4} q_M \\ \Gamma_2(\gamma_1), & \text{if } \frac{7}{4} < q_H < \frac{7}{4} q_M \end{cases}.$$

From the proposition we know that keeping γ_1 unchanged, when γ_0 increases to a threshold $\Gamma(\gamma_1)$, Firm R stops providing random products. The next question is if we keep γ_0 unchanged, what would happen as the γ_1 increases? The answer is summarized in the following corollary.

Corollary 2 (Limiting Property):

$\Gamma(\gamma_1)$ is increasing in γ_1 . For any $\gamma_0 \geq 0$, define $\Gamma^{-1}(\gamma_0)$ as the inverse function of $\gamma_0 = \Gamma(\gamma_1)$ if $\gamma_0 \geq \Gamma(0)$; otherwise, define $\Gamma^{-1}(\gamma_0) = 0$. If $\gamma_1 \leq \Gamma^{-1}(\gamma_0)$, Firm R sells transparent products; otherwise, it always sells random products. We have the following limiting results:

$$\begin{aligned} \lim_{\gamma_1 \rightarrow \infty} \hat{q}_R^* &= q_M, \quad q_M - \hat{q}_R^* = O\left(\gamma_1^{-\frac{1}{2}}\right). \\ \lim_{\gamma_1 \rightarrow \infty} \hat{\pi}_R^* &= \frac{q_M \cdot (q_H + q_M - 1) \cdot (q_H - 1)}{(4q_H + 3q_M - 4)^2}. \\ \lim_{\gamma_0 \rightarrow \infty} \hat{q}_R^* &= \begin{cases} q_M, & \text{if } q_M \leq \frac{16(q_H - 1)q_H}{16q_H - 7} \\ 1, & \text{otherwise} \end{cases} \\ \lim_{\gamma_0 \rightarrow \infty} \hat{\pi}_R^* &= \begin{cases} \frac{q_H(q_H - q_M)q_M}{(4q_H - q_M)^2}, & \text{if } q_M \leq \frac{16(q_H - 1)q_H}{16q_H - 7} \\ \frac{q_H(q_H - 1)}{(4q_H - 1)^2}, & \text{otherwise} \end{cases} \end{aligned}$$

This corollary delivers an important message: keeping γ_0 unchanged, even as the regret intensity γ_1 goes to infinity, Firm R still provides the random product. This is because the only way to implement the “reverse quality discrimination” is to adopt the probabilistic selling. In particular, as γ_1 becomes larger, Firm R chooses lower mixing probability (but never down to zero) to reduce the chance that consumers eventually obtain product L from the random product. This keeps the product random so that it can lower the perceived quality for those consumers at the competition margin. That is, the provision of random products reduces the competition between firms because consumers at the competition margin view products in the market have greater perceived product differentiation, even though the actual quality levels are not that different.

5.4. Comparative Statics

As suggested by Proposition 2, the profit of Firm R is increasing in γ_1 , and decreasing in γ_0 . We further analyze how regret intensity γ_1 and γ_0 affect the expected quality of product R ($\hat{q}_R^*$), and the profit of Firm H ($\hat{\pi}_H^*$).

Keeping q_R and γ_1 unchanged, increasing γ_0 decreases the attractiveness of product R to the low-end consumers. Therefore, Firm R has to lower price and increase q_R , which intensifies the competition with Firm H . Both Firm's profits decrease. In fact, we have the following Lemma.

Lemma 3 (Impact of γ_0):

Keeping γ_1 unchanged, the prices, demands and profits of both firms are decreasing in γ_0 .

When $\gamma_0 \geq \Gamma(\gamma_1)$, Firm R chooses not to sell random products. Therefore, as γ_0 goes large, q_R may increase to q_M or decrease to q_L , depending on which deterministic product gives larger profit. See Figure 2.

Figure 2. The equilibrium product quality of Firm R as γ_0 varies

Note. Blue line $\gamma_1 = 0$, orange line $\gamma_1 = 2$.

Keeping γ_2 unchanged, we do not have nice property the profit of Firm H as Lemma when varying γ_1 . Keeping q_R and γ_2 unchanged, increasing γ_1 softens competition between Firm R and Firm H . This benefits both Firm R and Firm H . However, Firm R can adjust q_R to further increase its profit. When Firm R increases q_R , the competition could be intensified to hurt of the profit of Firm H , as shown in Figure 4.

Figure 3. $\hat{q}_R^*$ and π_H as γ_1 varies when $q_H = 3, q_M = 2$

Note. Blue line $\gamma_0 = 0$, orange line $\gamma_0 = 2$.

Figure 4. $\hat{q}_R^*$ and π_H as γ_1 varies when $q_H = 1.5, q_M = 1.2$

Note. Blue line $\gamma_0 = 0$, orange line $\gamma_0 = 2$.

We know that as $\gamma_1 \rightarrow \infty$, $q_R \rightarrow q_M$. When γ_1 is large enough, as γ_1 increases, Firm R needs to increase q_R to keep product R attractive to consumers but never reaches q_M , otherwise it loses the advantage of reverse quality discrimination. In Figure 3, product H 's quality is low, so Firm R offers product L when γ_1 is low. As γ_1 increases, Firm R keeps increasing q_R . In contrast, Figure 2 shows when product H 's quality is high, Firm R offers q_M or $q_R > q_L$ when $\gamma_1 = 0$. The competition is intense when $\gamma_1 = 0$. As γ_1 increases, firm R may want to decrease q_R first to further soften competition. Eventually, when γ_1 large enough, q_R increases in γ .

6. Implications and Discussions

Our main results indicate overall that the probabilistic selling strategy can obtain higher profits, even though the possibility of obtaining an unfavorable outcome can yield post-purchase regret and consumers can anticipate such potential regret before purchase. Specifically, our results suggest that, when consumers are more sensitive to selection regret (“I should have purchased the best transparent product”) over purchase regret (“I should not have made any purchase”), consumers’ anticipated post-purchase regret can be a blessing, rather than being a curse. In

practice, the probabilistic selling strategy was introduced by Hotwire and Priceline, and prevails more in the travel industry than in others. Dellaert et al. (1998) show that people normally decide whether or not to travel several months *before* sort out travel logistics (e.g. reserving hotels). Thus, once an unfavorable outcome presents, they feel more regret in their travel logistics selection over the decision on whether or not to travel because people's regret is more sensitive to the available alternatives (e.g., available hotel options) right before the revelation of the random outcome (e.g., purchasing a random hotel) than to the decision several months ago (e.g., deciding whether to travel) (see Zeelenberg 1999). Therefore, our results might explain why probabilistic selling strategy has been popular in the travel industry.

In addition, we show that greater selection regret sensitivity can always yield higher profit to the random product provider. Thus, a random product provider can find potential ways to increase consumers' selection regret sensitivity: random product providers often share posts with consumers on *TripAdvisor* (a main third-party online travel forum) about the potential risk associated with the purchase of random products, and the "no return" policy are highlighted right beside the purchase button on Hotwire.

Last but not least, according to our results, no matter whether regret is considered or not, there exists an "ideal" quality for the random product to benefit its provider in the vertical market. However, a firm may find that its current production capabilities do not match up with the "ideal" quality. This is normally because the infrastructure/fixed investment costs (e.g. staterooms of a cruise ship) in the travel industry are normally sunk and hard to renovate. Interestingly, our results show that a random product can achieve this "ideal" quality as long as it is between the two extreme qualities being produced already. Importantly, *offering a random product with an expected quality at this "ideal" level is more profitable than offering a*

transparent product of this “ideal” quality. For example, suppose that a cruise ship has two types of staterooms, 150 sq. ft. and 450 sq. ft., but that the “ideal” quality is 300 sq. ft. Renovating the cruise ship to make all the rooms 300 sq. ft. would be an extremely costly endeavor. But, mixing the two room types to create a random stateroom is much easier to do. And our results suggest that whenever the “ideal” quality is 300 sq. ft., selling probabilistic staterooms with an expected square footage of 300 sq. ft. would be more profitable than having a cruise ship with all the staterooms exactly 300 sq. ft. for certain.

7. Conclusion and Limitations

Random products often consist of alternatives that differ in quality, and consumers may obtain less desirable ones whose identity is revealed only after purchase. Because they cannot return their purchase due to the “no return” policy, they might feel regret buying them. In this paper, we study the role of consumers’ potential post-purchase regret in the use of probabilistic selling strategy, when they can anticipate the regret before purchase. We find that the role of anticipated regret is not straightforward. Specifically, the anticipated regret can be either a blessing or a curse to the random product provider, depending on whether consumers are more sensitive to selection regret or not. If consumers are more sensitive to selection regret, we identify a new mechanism associated with vertical probabilistic selling: “reverse quality discrimination” which increases random product provider’s profit by extracting more consumer surplus, and meanwhile may hurt its competitor’s profit. Thus, anticipated regret is a blessing under this situation. However, if consumers are less sensitive to selection regret, the effect of “reverse quality discrimination” vanishes and we show that anticipated regret becomes a curse to the random product provider.

This paper is only the first attempt to study the interactions between consumer anticipated regret and the vertical probabilistic selling. There are many omitted factors in this paper that leave several possible and interesting avenues for future research. First, we focus on the situation in which the marginal cost of production is negligible, because the infrastructure/fixed investment costs (e.g., hotel rooms) are significant but often sunk in the travel industry in which probabilistic selling is mainly applied, while the maintenance costs are marginal and less salient. Future studies can explore the situation with non-negligible marginal cost of production. By continuity, our main results are expected to remain valid when the marginal cost is close to zero. However, with large marginal cost, firms might choose a different product line. Note that Johnson and Myatt (2003) considered product line design with a focus on the discussions of marginal cost and quality competition. They show that a firm might provide multiple products with different quality levels under certain conditions. In the context of probabilistic selling, a different product line will affect the alternatives that consumers may forgo when selecting products, thus in turn influence her regret benchmarks. The possibility of multiple regret benchmarks will make the analysis much more involved. And general product line design with general cost function is beyond the scope of this paper.

Second, another important issue related to large marginal cost is credible quality commitment in vertical probabilistic selling: when the marginal cost is correlated with quality, the random product provider would like consumers to think that buying a random product can give them a higher quality product at a low price. But at the same time, the provider may be tempted to “cheat” by mixing with lower cost/quality products more frequently. Although nowadays most of the random product providers have delegated the probabilistic selling through online travel intermediaries (e.g., Hotwire), this still cannot guarantee that there is no collusion

between the random product providers and intermediaries because the latter might need to keep the former's competition in check (some studies have explored the provision of transparent products on online intermediaries, e.g., Chen et al. 2002, Iyer and Pazgal 2003, Iyer and Padmanabhan 2006, Dukes and Liu 2016). Future research could focus on these issues related to marginal costs.

Third, we assume that the high quality firm does not use probabilistic selling due to image concern. Future research might explore the incentive for a high quality multiproduct seller in using probabilistic selling strategy. Intuitively, the high quality seller, who mainly serves high valuation consumers, would like to choose to offer only the high quality product transparently if the marginal cost is minimal, because the reverse quality discrimination associated with probabilistic selling implies that high valuation consumers dislike random products more than low valuation consumers.

Fourth, it might be interesting to discuss how anticipated regret differs from risk aversion. The similarity of these two concepts is that both reduce the expected quality of the random product, and the loss becomes larger as the quality difference of the component products increases. However, one key difference is that anticipated regret is built off the best forgone alternative in regret benchmarks, while risk aversion's materialization, instead, is defined over the random product's own uncertainty, which could be independent of foregone alternatives. This might bring a new angle to explore probabilistic selling strategy in a vertical market. Last, we have focused on the vertical dimension of probabilistic selling strategy. It is well known in the literature that random products involve many horizontal features (e.g., hotel location). It might be interesting to explore a random product provider's product line design when both horizontal and vertical features are considered (some studies in the literature have explored

firms' product line design for transparent products, e.g., Moorthy 1984, Desai 2001, Villas-Boas 2009, Kuksov and Villas-Boas 2010, Guo and Zhang 2012, Liu and Dukes 2013 & 2016).

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APPENDIX

Claim 1 (Never Regret if Getting M from R): *Whenever random product R is chosen,*

$$\theta q_M - p_R \geq \max\{0, \theta q_H - p_H\}.$$

Proof of Claim 1. Since $u = \theta q_R - p_R - \text{regret}$ and $\text{regret} \geq 0$, we must have $u \leq \theta q_R - p_R$.

Thus, in the presence of transparent product alternative and no buy option, product R will be chosen only if $\theta q_R - p_R \geq \max\{0, \theta q_H - p_H\}$. It follows that $\theta q_M - p_R \geq \theta q_R - p_R \geq \max\{0, \theta q_H - p_H\}$. ■

Claim 1 guarantees that, whenever random product R is chosen, the term

$$(1 - \alpha_R) \cdot \max\{\gamma_0 \cdot [0 - (\theta q_M - p_R)]^+, \gamma_1 \cdot [(\theta q_H - p_H) - (\theta q_M - p_R)]^+\} = 0.$$

So our definition of $\text{regret} = \alpha_R \cdot \max\{\gamma_0 \cdot [0 - (\theta - p_R)]^+, \gamma_1 \cdot [(\theta q_H - p_H) - (\theta - p_R)]^+\}$ is justified.

Proof of Proposition 1. In the last stage, given q_R , we can solve the equilibrium prices in the pricing stage as a function of q_R :

$$p_R(q_R) = \frac{q_R \cdot (q_H - q_R)}{4q_H - q_R}, \quad p_H(q_R) = \frac{2q_H \cdot (q_H - q_R)}{4q_H - q_R}.$$

So Firm R and Firm H 's profits are

$$\pi_R(q_R) = \frac{q_H \cdot q_R \cdot (q_H - q_R)}{(4q_H - q_R)^2}, \quad \pi_H(q_R) = \frac{4q_H^2 \cdot (q_H - q_R)}{(4q_H - q_R)^2}.$$

In the first stage, Firm R chooses $q_R \in [1, q_M]$ to maximize π_R , and

$$\frac{d\pi_R}{dq_R} = \frac{q_H \cdot (4q_H - 7q_R)}{(4q_H - q_R)^3}.$$

Hence, we have an interior solution $q_R^* = \frac{4}{7}q_H$ if and only if $1 < \frac{4}{7}q_H < q_M$; otherwise we will have a corner solution $q_R^* = 1$ when $\frac{4}{7}q_H \leq 1 < q_M$, or a corner solution $q_R^* = q_M$ when $1 < q_M \leq \frac{4}{7}q_H$. The equilibrium mixing probability α^* and profits then follow. ■

Proof of Corollary 1. It follows from direct differentiations. ■

Proof of Lemma 1. It directly follows from (4). ■

Proof of Lemma 2. The analysis is in the main text near (5) and (6). ■

Proof of Proposition 2. Define

$$A(q_R) \equiv \frac{(q_H - q_R) \cdot (q_M - 1) + \gamma_1 \cdot (q_M - q_R) \cdot (q_H - 1)}{q_M - 1 + \gamma_1 \cdot (q_M - q_R)} > 0, \quad (\text{A.1})$$

and

$$B(q_R) \equiv \frac{q_R \cdot (q_M - 1) + \gamma_0 \cdot (q_M - q_R)}{q_M - 1 + \gamma_0 \cdot (q_M - q_R)} > 0. \quad (\text{A.2})$$

Using notations above, from (5), we have $\hat{\theta}_0 = \frac{p_R}{B(q_R)}$; from (6), we have $\hat{\theta}_R = \frac{p_H - p_R}{A(q_R)}$. It follows

that

$$\hat{\pi}_R = p_R \cdot (\hat{\theta}_R - \hat{\theta}_0) = p_R \cdot \left(\frac{p_H - p_R}{A} - \frac{p_R}{B} \right),$$

and

$$\hat{\pi}_H = p_H \cdot (1 - \hat{\theta}_R) = p_H \cdot \left(1 - \frac{p_H - p_R}{A} \right).$$

The first-order conditions for $\frac{\partial \hat{\pi}_R}{\partial p_R} = 0$ and $\frac{\partial \hat{\pi}_H}{\partial p_H} = 0$ can be simplified to $p_R = \frac{p_H \cdot B}{2(A+B)}$ and $p_H =$

$\frac{p_R + A}{2}$. We can solve for $p_R = \frac{A \cdot B}{4A+3B}$ and $p_H = \frac{2A \cdot (A+B)}{4A+3B}$. Plugging them in to $\hat{\pi}_R$, we get

$$\hat{\pi}_R(q_R) = \frac{A \cdot B \cdot (A + B)}{(4A + 3B)^2}. \quad (\text{A.3})$$

To determine the optimal quality level $\hat{q}_R^*$, we differentiate Firm R's profit function with respect to q_R

$$\frac{d\hat{\pi}_R}{dq_R} = \frac{B^2 \cdot (2A + 3B) \cdot (q_M - 1)^2 \cdot (1 + \gamma_0)}{(4A + 3B)^3 \cdot [q_M - 1 + \gamma_0 \cdot (q_M - q_R)]^2} \cdot f(q_R),$$

where

$$f(q_R) \equiv \frac{A^2 \cdot (4A + 5B)}{B^2 \cdot (2A + 3B)} - \frac{1 + \gamma_1}{1 + \gamma_0} \cdot \frac{[q_M - 1 + \gamma_0 \cdot (q_M - q_R)]^2}{[q_M - 1 + \gamma_1 \cdot (q_M - q_R)]^2}. \quad (\text{A.4})$$

(Equilibrium Characterization) We prove this part in the following 3 steps.

Step 1: The signs of $f(1)$ and $f(q_M)$.

From (A.4), $f(1) = \frac{1}{4} \cdot \left[13 - \frac{4 \cdot (1 + \gamma_0)}{1 + \gamma_1} - 18q_H + 8q_H^2 - \frac{9}{1 + 2q_H} \right]$. It follows that

$$f(1) \gtrless 0 \text{ if and only if } \gamma_0 \gtrless L(\gamma_1),$$

where $L(\gamma_1) \equiv \gamma_1 + (1 + \gamma_1) \cdot \frac{(4q_H - 7) \cdot q_H^2}{2q_H + 1}$.

Similarly, $f(q_M) = -\frac{1 + \gamma_1}{1 + \gamma_0} + \frac{(q_H - q_M)^2 (4q_H + q_M)}{q_M^2 (2q_H + q_M)}$. We can show that

$$f(q_M) \gtrless 0 \text{ if and only if } \gamma_0 \gtrless M(\gamma_1),$$

where $M(\gamma_1) \equiv \gamma_1 + (1 + \gamma_1) \cdot \frac{(7q_M - 4q_H) \cdot q_H^2}{(q_H - q_M)^2 (4q_H + q_M)}$.

Clearly, $L(\gamma_1) \gtrless \gamma_1$ if and only if $q_H \gtrless \frac{7}{4}$, and $M(\gamma_1) \gtrless \gamma_1$ if and only if $q_H \gtrless \frac{7}{4} q_M$.

Step 2: Property of $f'(q_R)$.

From (A.4), if we denote $\varphi(q_R) \equiv \frac{A^2 \cdot (4A + 5B)}{B^2 \cdot (2A + 3B)}$ and $\mu(q_R) \equiv \frac{1 + \gamma_1}{1 + \gamma_0} \cdot \frac{[q_M - 1 + \gamma_0 \cdot (q_M - q_R)]^2}{[q_M - 1 + \gamma_1 \cdot (q_M - q_R)]^2}$, then

$f(q_R) = \varphi(q_R) - \mu(q_R)$. It is easy to see that $\frac{\partial \varphi}{\partial A} > 0$, $A'(q_R) < 0$, $\frac{\partial \varphi}{\partial B} < 0$, and $B'(q_R) > 0$.

Thus, we have $\varphi'(q_R) < 0$. Note that $\mu'(q_R) = (\gamma_1 - \gamma_0) \cdot \frac{1 + \gamma_1}{1 + \gamma_0} \cdot \frac{2(q_M - 1)[q_M - 1 + \gamma_0 \cdot (q_M - q_R)]}{[q_M - 1 + \gamma_1 \cdot (q_M - q_R)]^3} \gtrless$

0 if and only if $\gamma_0 \gtrless \gamma_1$.

So when $\gamma_0 \leq \gamma_1$, we must have $f'(q_R) < 0$. In this case, the equilibrium $\hat{q}_R^*$ is either at the endpoint 1 or q_M or satisfies $f(q_R) = 0$ (FOC). When $\gamma_0 > \gamma_1$, we may not always have $f'(q_R) < 0$, but we are still able to characterize the equilibrium with the help of a property of $\hat{\pi}_R$.

Step 3: Property of $\hat{\pi}_R(q_R)$.

We show how $\hat{\pi}_R$ and thus $\hat{\pi}_R^*$ change when γ_0 and γ_1 vary. That is,

$$\frac{\partial \hat{\pi}_R^*}{\partial \gamma_0} \leq 0, \text{ and } \frac{\partial \hat{\pi}_R^*}{\partial \gamma_1} \geq 0.$$

From (A.3), $\frac{\partial \hat{\pi}_R}{\partial \gamma_0} = \frac{\partial \hat{\pi}_R}{\partial A} \cdot A'(\gamma_0) + \frac{\partial \hat{\pi}_R}{\partial B} \cdot B'(\gamma_0)$. Note that $A'(\gamma_0) = 0$, $\frac{\partial \hat{\pi}_R}{\partial B} = \frac{A^2 \cdot (4A+5B)}{(4A+3B)^3} > 0$, and $B'(\gamma_0) = -\frac{(q_R-1) \cdot (q_M-1) \cdot (q_M-q_R)}{[q_M-1+\gamma_0 \cdot (q_M-q_R)]^2} < 0$ for $q_R \in (1, q_M)$. Thus, we have $\frac{\partial \hat{\pi}_R}{\partial \gamma_0} < 0$ for $q_R \in (1, q_M)$, which implies $\frac{\partial \hat{\pi}_R^*}{\partial \gamma_0} \leq 0$. Parallel, we can show $\frac{\partial \hat{\pi}_R}{\partial \gamma_1} > 0$ for $q_R \in (1, q_M)$, which implies $\frac{\partial \hat{\pi}_R^*}{\partial \gamma_1} \geq 0$. Therefore, the curve $\hat{\pi}_R$ between 1 and q_M falls as γ_0 increases. Note that $\hat{\pi}_R(1)$ and $\hat{\pi}_R(q_M)$ are independent of γ_0 or γ_1 , because the transparent products do not involve any regret.

Step 4: Characterize the thresholds on γ_0

$$\text{Define } \Gamma_1(\gamma_1) \equiv \begin{cases} L(\gamma_1), & \text{if } q_H \leq \frac{7}{4} \\ M(\gamma_1), & \text{if } q_H \geq \frac{7}{4} q_M \end{cases}.$$

(1) If $q_H \leq \frac{7}{4}$,

From Step 1, we know that $L(\gamma_1) \leq \gamma_1 \leq M(\gamma_1)$. Thus, for $\gamma_0 < \Gamma_1(\gamma_1) = L(\gamma_1)$, we have $f(1) > 0$ and $f(q_M) < 0$, and hence we must have a unique $\hat{q}_R^* \in (1, q_M)$ such that $f(\hat{q}_R^*) = 0$. When $\gamma_0 = L(\gamma_1) \leq \gamma_1$, we have $f(1) = 0$, and $f'(q_R) < 0$ for any $q_R \in$

$[1, q_M]$, which implies $\hat{q}_R^* = 1$ and Firm R sells transparent product L. When $\gamma_0 > L(\gamma_1)$, profit $\hat{\pi}_R(q_R)$ on $(1, q_M)$ decreases and Firm R still sells transparent product L.

(2) If $q_H \geq \frac{7}{4}q_M$,

It follows parallel, where $\Gamma_1(\gamma_1) = M(\gamma_1)$.

(3) If $\frac{7}{4} < q_H < \frac{7}{4}q_M$,

We will show by contradiction that when γ_0 goes to infinity, $\hat{q}_R^*$ converges to the endpoint 1 or q_M .

Suppose as $\gamma_0 \rightarrow \infty$, we have $\hat{q}_R^* \rightarrow q \in (1, q_M)$. That is, for $\epsilon \equiv \min\{q_M - q, q - 1\} > 0$, there exists a constant N , as long as $\gamma_0 > N$, $1 \leq q - \epsilon < \hat{q}_R^* < q + \epsilon \leq q_M$. That means $\hat{q}_R^*$ satisfies the FOC $f(q_R) = \varphi(q_R) - \mu(q_R) = 0$. However, as $\gamma_0 \rightarrow \infty$, $\varphi(q_R) \leq 2A^2 \leq 2(q_H - 1)^2$ is bounded, whereas $\mu(q_R) \rightarrow \infty$ (note that $q_R < q_M$). That means, when γ_0 is large enough, $\mu(q_R) > \varphi(q_R)$. This is a contradiction. Therefore, $\hat{q}_R^*(\gamma_0)$ cannot converge to a constant with in $(1, q_M)$. Since $\hat{q}_R^*$ is in a bounded interval, as γ_0 increases the sequence $\hat{q}_R^*(\gamma_0)$ must have a convergent subsequence. Use the same contradiction argument, the convergent subsequence cannot converges to any point within $(1, q_M)$. It must converges to either 1 or q_M . Since the profit at the two endpoints is not affected by γ_0 .

If $q_M \leq \frac{16(q_H-1)q_H}{16q_H-7}$, we have $\hat{\pi}_R(q_M) \geq \hat{\pi}_R(1)$; otherwise we have $\hat{\pi}_R(q_M) < \hat{\pi}_R(1)$. We

assume that Firm R always chooses q_M when $q_M = \frac{16(q_H-1)q_H}{16q_H-7}$. Then we cannot have two

convergent subsequences that one converges to 1 and the other converges to q_M . Therefore, the sequence $\hat{q}_R^*$ is convergent, either to 1 or q_M . Two cases may follow: 1) $\hat{q}_R^*$ never reaches

the endpoint, then $\Gamma_2(\gamma_1) = \infty$; 2) $\hat{q}_R^*$ reaches the endpoint, then $\Gamma_2(\gamma_1) = \min_{\hat{q}_R^*(\gamma_0)=q_M} \gamma_0 <$

∞ . We have shown that $\hat{\pi}_R^*$ is non-increasing in γ_0 . For any $\gamma_0 \geq \Gamma_2(\gamma_1)$, we must have $\hat{\pi}_R^*$ remains the same and $\hat{q}_R^*(\gamma_0)$ remains at the endpoint. From Step 1, we know that if $\gamma_0 < \min\{L(\gamma_1), M(\gamma_1)\}$, then $f(1) > 0$ and $f(q_M) < 0$. Thus, Firm R would sell a random product, implying a lower bound of $\Gamma_2(\gamma_1)$ is $\min\{L(\gamma_1), M(\gamma_1)\}$.

Next we show the monotonicity of $\Gamma_2(\gamma_1)$. Given γ_1 , if $\Gamma_2(\gamma_1) < \infty$, when $\gamma_0 = \Gamma_2(\gamma_1)$ there are two possible cases: 1) the derivative $\frac{d\hat{\pi}_R}{dq_R}$ at one endpoint is 0; 2) the FOC point in the middle gives the same profit as the higher end point. Then for any $\bar{\gamma}_1 > \gamma_1$, in case 1), if $f(1) = \frac{1}{4} \cdot \left[13 - \frac{4 \cdot (1 + \gamma_0)}{1 + \gamma_1} - 18q_H + 8q_H^2 - \frac{9}{1 + 2q_H} \right] = 0$, at $\bar{\gamma}_1$, $f(1) > 0$; if $f(q_M) = -\frac{1 + \gamma_1}{1 + \gamma_0} + \frac{(q_H - q_M)^2(4q_H + q_M)}{q_M^2(2q_H + q_M)} = 0$, at $\bar{\gamma}_1$, $f(q_M) < 0$. Therefore the endpoints 1 or q_M is no longer the maximum point, and Firm R chooses to offer random product, implying $\Gamma_2(\bar{\gamma}_1) > \Gamma_2(\gamma_1)$. In case 2), since $\frac{\partial \hat{\pi}_R}{\partial \gamma_1} > 0$ for $q_R \in (1, q_M)$, we have the optimum profit is larger than the endpoints, and Firm R chooses to offer random product, implying $\Gamma_2(\bar{\gamma}_1) > \Gamma_2(\gamma_1)$.

(Profit Comparison) First, we show that $\hat{\pi}_R^* = \pi_R^*$ when $\gamma_0 = \gamma_1$. When $\gamma_0 = \gamma_1 = \gamma$, $f(q_R) \propto 4q_H \cdot (q_M - 1) + \gamma \cdot q_M \cdot (4q_H - 7q_M) - [7(q_M - 1) + \gamma \cdot (4q_H - 7)] \cdot q_R$.

When $q_H \leq \frac{7}{4} L(\gamma_1) \leq \gamma_1 = \gamma_0 \leq M(\gamma_1)$. We have $f(1) \leq 0$, and we must have $f(q_R) < 0$ for any $q_R \in [1, q_M]$, which implies $q_R^* = 1$. This yields a profit the same as that in Proposition 1, as shown in Table A.1. The case for $q_H \geq \frac{7}{4} q_M$ follows parallel.

When $\frac{7}{4} < q_H < \frac{7}{4} q_M$, $\gamma_1 = \gamma_0 < \min\{L(\gamma_1), M(\gamma_1)\}$, we have $f(1) > 0$ and $f(q_M) < 0$.

Thus, we must have a unique $q_R^* \in (1, q_M)$ such that $f'(q_R^*) = 0$. That is, $q_R^* =$

$\frac{4q_H \cdot (q_M - 1) + \gamma \cdot q_M \cdot (4q_H - 7q_M)}{7(q_M - 1) + \gamma \cdot (4q_H - 7)}$, which yields $\hat{\pi}_R^* = \frac{q_H}{48}$, the same as that in Proposition 1, as shown in

Table A.1.

Table A.1. The Profit Comparison

Cases	$\gamma_1 = \gamma_0$ (no regret)	$\gamma_1 > \gamma_0$	$\gamma_1 < \gamma_0$
$q_H \leq \frac{7}{4}$	$\frac{q_H(q_H - 1)}{(4q_H - 1)^2}$	$\begin{cases} > \frac{q_H(q_H - 1)}{(4q_H - 1)^2}, \text{ if } \gamma_0 < \Gamma_1(\gamma_1) \\ \frac{q_H(q_H - 1)}{(4q_H - 1)^2}, & \text{ otherwise} \end{cases}$	$\frac{q_H(q_H - 1)}{(4q_H - 1)^2}$
$\frac{7}{4} < q_H < \frac{7}{4}q_M$	$\frac{q_H}{48}$	$> \frac{q_H}{48}$	$< \frac{q_H}{48}$
$q_H \geq \frac{7}{4}q_M$	$\frac{q_H(q_H - q_M)q_M}{(4q_H - q_M)^2}$	$\begin{cases} > \frac{q_H(q_H - q_M)q_M}{(4q_H - q_M)^2}, \text{ if } \gamma_0 < \Gamma_1(\gamma_1) \\ \frac{q_H(q_H - q_M)q_M}{(4q_H - q_M)^2}, & \text{ otherwise} \end{cases}$	$\frac{q_H(q_H - q_M)q_M}{(4q_H - q_M)^2}$

Consequently, we have $\hat{\pi}_R^* = \pi_R^*$ when $\gamma_0 = \gamma_1$. Then by applying $\frac{\partial \hat{\pi}_R^*}{\partial \gamma_0} \leq 0$, and $\frac{\partial \hat{\pi}_R^*}{\partial \gamma_1} \geq 0$,

this part follows. ■

Proof of Corollary 2.

The limiting property on γ_0 is proven in Proof of Proposition 2. Here we prove the the limiting property on γ_1 .

Given γ_0 , as γ_1 increases to infinity, both $L(\gamma_1)$ and $M(\gamma_1)$ increase to infinity, therefore, both $\Gamma(\gamma_1)$ increases to infinity and larger than γ_0 , and Firm R sells random product. When $\gamma_1 \geq \gamma_0$, $f'(q_R) < 0$. Therefore, $\hat{q}_R^*$ satisfies the FOC $f(q_R) = 0$. That is

$$\frac{A^2 \cdot (4A + 5B)}{B^2 \cdot (2A + 3B)} = \frac{1 + \gamma_1}{1 + \gamma_0} \cdot \frac{[q_M - 1 + \gamma_0 \cdot (q_M - q_R)]^2}{[q_M - 1 + \gamma_1 \cdot (q_M - q_R)]^2}.$$

As $\gamma_1 \rightarrow \infty$, $A \rightarrow q_H - 1$. B is a positive constant. The left-hand-side converges to a constant. If $\hat{q}_R^*(\gamma_1)$ has a subsequence converging to $q \in [1, q_M)$, then the right-hand-side goes to 0. To equalize the two sides, we must $\hat{q}_R^* \rightarrow q_M$. More specifically, we need $q_M - \hat{q}_R^* = O\left(\gamma_1^{-\frac{1}{2}}\right)$. ■

Proof of Lemma 3.

From Proof of Proposition 2, in equilibrium, we have

$$p_R = \frac{A \cdot B}{4A + 3B}, p_H = \frac{2A \cdot (A + B)}{4A + 3B}.$$

$$D_R = \frac{A + B}{4A + 3B}, D_H = \frac{2(A + B)}{4A + 3B}.$$

$$\hat{\pi}_R = \frac{A \cdot B \cdot (A + B)}{(4A + 3B)^2}, \hat{\pi}_H = \frac{4A \cdot (A + B)^2}{(4A + 3B)^2}.$$

We can verify that

$$\frac{dp_R}{d\gamma_0} < 0, \frac{dp_H}{d\gamma_0} < 0, \frac{dD_R}{d\gamma_0} < 0, \frac{dD_H}{d\gamma_0} < 0, \frac{d\hat{\pi}_R}{d\gamma_0} < 0, \frac{d\hat{\pi}_H}{d\gamma_0} < 0.$$

■

¹ Source: Fox Business, <http://www.foxbusiness.com/personal-finance/2012/05/24/five-keys-to-unlocking-hidden-hotel-deals/>

² The “no return” policy is common in probabilistic selling, see more details at <https://www.hotwire.com/helpcenter/hotels/after-booking/reservation-changes-cancellations/can-i-cancel-or-make-changes.jsp>. This policy can prevent consumers from arbitrage (e.g. repeatedly returning undesirable purchase until obtaining the favorable one), especially when quality differences exist in probabilistic selling.

³ According to a consumer relationship manager at Hotwire, many consumer complaints are about feeling regret buying products sold through probabilistic selling when consumers get an inferior product. Also, see more complaints on TripAdvisor: http://www.tripadvisor.com/ShowUserReviews-g154998-d281720-r138268528-Advantage_Inn-Niagara_Falls_Ontario.html

⁴ This result also provides a potential interpretation for the strict “no return” policy. Specifically, our findings suggest that, if this “no return” policy aggravates consumer regret, this actually benefits the probabilistic selling and encourages the use of this selling strategy.

⁵ Bell (1982, 1983, 1985) and Loomes and Sugden (1982, 1986, 1987) incorporate anticipation emotions into a theory of choice. Inman et al. (1997) consider a generalized utility model of regret and showed that they have significant effects on post-choice valuation.

⁶ The infrastructure/fixed investments costs across vertical products/services (e.g. a suite room versus an ordinary room) are significant in the travel industry but they are often sunk. The maintenance costs are relatively less salient compared to the infrastructure/fixed investments costs.

⁷ Such a sweet spot $\frac{4}{7}q_H$ is found in Choi and Shin (1992), where two firms freely choose any quality levels. In ours, Firm R can only choose quality between 1 and q_M , implying possible corner solutions.