Price Discrimination with Demarketing*

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Abstract

We study how demarketing interacts with pricing decisions to explain why and when it can be employed as the seller's optimal strategy. In our model, a monopolistic seller offers different price-quality bundles of the product. A consumer's preference is private information. With demarketing, consumers must make a costly effort to purchase and/or utilize the product, whereas with marketing, the seller instead makes the effort so that the consumer's purchasing decision is independent of the cost of effort. Our result suggests that, for small or large effort costs, it is optimal for the seller to engage in marketing. For intermediate effort costs, however, demarketing can be optimal. With demarketing, the seller induces only the consumers with high-valuation to make transaction effort. By doing so, the seller can price-discriminate more effectively, thus extracting more surplus. We extend our analysis to the case where the seller can offer special deals through exclusive sales channels along with demarketing. Then, demarketing can be optimal even for large costs of effort.

JEL Classification: D82, L11, M21

Key words: Demarketing, Second Degree Price Discrimination.

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I. Introduction

Firms often make it inconvenient for consumers to purchase their products. Coupons, for example, require consumers to bear hassle costs of coupon redemption.[1] Setting up factory outlets is another popular way to price-discriminate. Outlet stores offer significant discounts for consumers who are willing to travel and bear waiting time.[2] In these examples, a common observation is that the consumers with lower valuation incur additional transaction costs — clipping coupons and traveling to factory outlet stores. The low-valuation consumers pay a lower price, but they must incur a transaction cost, which in turn discourages the high-valuation consumers from taking advantage of discounted prices. The underlying assumption behind this price discrimination mechanism is that the low-valuation consumers are assumed to have a lower opportunity cost of time for clipping, waiting and traveling.

Following the previous contributions, this paper also analyzes transaction costs and price discrimination. In our model, however, a costly effort increases the likelihood of transaction, and the seller can make a transaction effort himself, or let the consumers make such an effort. We refer to the former strategy as "marketing" and the latter strategy as "demarketing." We demonstrate that it can be optimal for the seller to engage in demarketing, and in such a case, the seller induces only the high-valuation consumers to exert a transaction effort, thus decreasing the sales opportunity for the low-valuation consumers. This result is in stark contrast to the previous studies mentioned above where only the low-valuation consumers are making a transaction effort.

There are many cases where the seller chooses between marketing and demarketing. For example, a firm can choose whether or not to have sales associates in a showroom. Sales associates foster buyer awareness of the firm's products, help buyers learn about the products, and convince them to consider the products. For skill-based products such as complex consumer electronics and computer software, an expert salesperson often helps consumers to realize how they can utilize a product. Similarly, the firm may operate help-centers to teach product features to consumers or offer free trials of the products. These are the seller's transaction efforts (marketing) to increase the likelihood of a transaction.

When the seller does not make such efforts (demarketing), consumers may have to exert a cognitive effort to be aware of the product, or an information gathering effort to learn the product features and functionalities. Some demarketing also include reducing the number of stores, business hours, and useful features of the product, thus making the buyer incur extra costs for transactions. Again, to alleviate the friction in a transaction, an effort is made by either the seller or the consumer.

We investigate why a seller discourages buyers from purchasing a product/service, by transferring transaction costs to them. We adopt a monopoly framework with second-degree price discrimination. Unlike the traditional setup, in our model, the probability of a transaction rises when a transaction cost is incurred. Under full information, marketing and demarketing give the same optimal outcome

[1] See, for example, Narasimhan [1984] and Gerstner and Holthausen [1986].

[2] See Nocke et al. [2011] for example.

since the seller can adjust the product's price level depending on which party bears the cost of transaction. When the buyers are privately informed about their valuation (type), the answer is not straightforward.

To preview our result, with marketing, the seller must exert a transaction effort independent of the consumer type. With demarketing, however, a transaction effort is made depending on a consumer's type, which involves loss of sales opportunity, but allows the seller to price-discriminate more effectively. As a result, demarketing can dominate marketing. The key trade-off in our paper is "*sales opportunity vs. surplus extraction.*"

The intuition behind our result is as follows. If the seller engages in marketing, the situation becomes the standard screening problem. As usual in models of this type, a high-valuation (high-type) consumer has an incentive to misrepresent her type to reap consumer surplus. To mitigate such incentive, the optimal product quality for the low-type consumer is distorted downward. With demarketing, the seller has to compensate consumers for the transaction cost through the product's price. We show that the seller induces only the high-type consumers to make a transaction effort. Because the low-type consumers are not compensated for transaction efforts, the high-type consumers are discouraged from mimicking the low-type consumers. As a result, a demarketing strategy allows the seller to recover the distortion in the product quality for the low-type consumers.

We show that the seller particularly prefers demarketing to marketing when the transaction cost is intermediate because the high-type consumer's mimicking incentive diminishes substantially. On the other hand, for small and large transaction costs, the seller prefers marketing to demarketing. When the transaction cost is small, the seller's compensation is not attractive enough to significantly mitigate the high-type consumers' mimicking incentive. When the transaction cost is large, the compensation is so large that the reverse incentive problem becomes an issue — the low-type consumers have an incentive to mimic the high-type consumers in such a case.

We extend the analysis in two ways. First, we further study the case where the seller can choose how to allocate a share of transaction cost between himself and consumers, and demonstrate that our main result is robust to this extension. In particular, when the proportion of the high-type consumers is large enough, the seller will not allocate any transaction effort to himself.

Second, we consider the case where the seller can choose a more refined strategy by offering special discounts or deals — the price-quality bundle for the high-type consumers is available only through an exclusive channel, which requires high-type consumers to make a transaction effort for the high quality product. For example, some retailers offer special deals or sales through e-mails only when consumers submit a long survey. As mentioned above, under the demarketing strategy, if the cost of transaction effort is sufficiently large, the price-discount for the high-type consumers must also be large. This induces the low-type consumers to choose the product for the high-type consumers without making a transaction effort. Such incentive, however, is mitigated by exclusive channels that require a transaction effort for the high quality product. We show that demarketing with this exclusive channel strategy dominates marketing for large transaction costs.

Related Literature Following Kotler and Levy [1971] who first discussed demarketing activities, there are several theoretical perspectives to account for demarketing. Narasimhan [1984] and Gerstner and Holthausen [1986] study price discriminating demarketing. Transaction costs, such as an opportunity cost to clip coupons, are deliberately created by firms as a tool for screening consumers.[3] When consumers with a high (low) value for the product also have high (low) transaction costs, offering coupons or making purchasing more difficult can be a profitable price discrimination strategy. This correlation is appropriate when high valuation types have higher incomes, but if instead high valuation types are just more interested in the product then this assumption need not hold. To capture this latter case, in our model we assume a consumer's valuation of the product is independent of her cost of transaction effort. In addition, in these studies a product is not directly differentiated in quality. In our model, the seller offers different price-quality bundles as a screening device. Our point in this paper is that a distortion in quality offered can be lessened when the seller adopts a demarketing strategy.[4]

There are also papers that investigate a signaling effect of demarketing. Feltovich et al. [2002] show that high quality senders choose not to send signals when there exists noisy exogenous information about type. Zhao [2000], Bagwell and Overgaard [2006], Mayzlin and Shin [2011] and Suzuki [2014] show that a high quality producer can distinguish itself from a low quality producer by lowering awareness or spending less on advertising. In particular, Miklós-Thal and Zhang [2013] consider a situation in which sophisticated consumers attribute a product's market performance to product quality and marketing efforts as well. In their model, demarketing can improve quality image *ex post* by highlighting high quality when sales are good and by mitigating quality concerns when sales are bad.[5] In addition, Gerstner et al. [1993] study demarketing as a differentiation from rival firms to avoid a price war. There are also papers providing behavioral explanations. For example, Kopalle and Lehmann [2006] argue that sellers may understate quality deliberately to give a pleasant surprise to consumers.

The current paper employs second degree price discrimination in the monopoly framework pioneered by Mussa and Rosen [1978] and Maskin and Riley [1984]. Using that framework, numerous papers study situations in which marketing or advertising makes price discrimination more profitable to the seller. The literature includes Lewis and Sappington [1994], Ottaviani and Prat [2001], Courty and Li [2001], and more recently, Grubb [2009] and Nocke et al. [2011].[6] Unlike these

[3] There are other papers that study a setting where consumers have to incur some costs. Wernerfelt [1994] compares several different selling formats when buyers incur transaction costs, and Wernerfelt [1996] considers firms being able to increase efficiency by sharing the costs with buyers.

[4] Deneckere and McAfee [1996] provides explanations for "damaged goods" using the downward quality distortion in the second degree price discrimination, which can be interpreted as a type of demarketing. Again, in our paper, demarketing allows the seller to price-discriminate better, which in turn, recovers the downward distortion in quality.

[5] In the signaling explanation of demarketing, most studies deliberately assume costless marketing. Thus, costless marketing makes demarketing costly in the sense that demarketing has to give up the opportunity of using costless marketing activities. This is the reason demarketing incurs a transaction cost which may have a signaling power. However, marketing is costly in our model, and demarketing is the decision to transfer the cost to the consumer.

[6] Bar-Isaac, Caruana, and Cuñat [2010] considers a monopolist who does not price discriminate, but imposes costs

papers, we consider the situation where costly effort can reduce some friction in the sales process. Also, in our paper, the party that directly incurs the effort cost is endogenously determined.

In addition, our paper is connected to studies on "countervailing incentives", which means that consumers may have incentives to overstate their preference in our context. In their seminal work in a principal-agent framework, Lewis and Sappington [1989] show that the presence of countervailing incentives improves the principal's welfare. Jullien [2000] provides a general analysis of type-dependent participation constraints with a continuum of types. The optimal mechanism with countervailing incentives and its benefit is applied in our paper. We show that inducing consumers to incur the effort cost generates countervailing incentives, which helps the seller extract the consumer's information rent.

The rest of the paper is organized as follows. The model is presented in Section 2. In Section 3, we provide a simple example that illustrates our point. In Section 4, the seller's optimal outcome with marketing is discussed, followed by the seller's optimal outcome with demarketing in Section 5. In Section 6, we endogenize the seller's choice between marketing and demarketing. We extend our analysis to the case where the seller and the consumer can share a transaction effort in Section 7. In this section, we also study the case where the seller offers special deals through exclusive channels. We conclude in Section 8. All proofs are in the Appendix.

II. Model

Seller and Buyer We present a monopoly model with second degree price discrimination. The intensity of consumer's preference toward the product is denoted by $i \in \{H, L\}$, where H (L) represents high (low) valuation, and $\Delta \equiv H - L > 0$. With a probability φ_i, the consumer is type-i and $\varphi_H + \varphi_L = 1$. The population of consumers, for simplicity, is normalized to one. The consumer's type is private information, but the probability distribution is common knowledge. The monopolist offers a menu, $(q_i, p_i)_{i\in\{H,L\}}$, where $q_i \in \mathbb{R}_+$ is the product quality and $p_i \in \mathbb{R}_+$ is the lump sum price for a type-i consumer.

A type-i consumer values a product of quality q_i with a concave function $u(q_i, i)$ that satisfies the Inada condition: $u(0, i) = 0$, $u_q(q, i) > 0$, $u_q(0, i) = \infty$, $u_q(\infty, i) = 0$.[7] The value function also satisfies:

$$u^{\Delta}(q_i) \equiv u(q_i, H) - u(q_i, L) > 0 \quad \text{and} \quad u_q^{\Delta}(q_i) \equiv u_q(q_i, H) - u_q(q_i, L) > 0.$$

Manufacturing the product of quality q_i costs cq_i to the seller, where $c > 0$. The seller's profit and the type-i consumer's payoff from a transaction are respectively:

$$\Pi_i = p_i - cq_i \quad \text{and} \quad U_i = u(q_i, i) - p_i.$$

on heterogeneous and imperfectly informed consumers from learning their valuation for the good. An intermediate such cost can be optimal in this environment.

[7]The Inada condition allows us to rule out the case where the seller excludes the type-L consumers.

Marketing and Demarketing The seller engages in "marketing ($\Psi = m$)" to increase the likelihood that a transaction takes place. Marketing is a costly effort for the seller. Instead, the seller can choose "demarketing ($\Psi = d$)" by transferring the cost of transaction to the consumer. In such a case, without the consumer's transaction effort, a purchase might not be made, as discussed below. However, the consumer may want to make a transaction effort — in such case, she utilizes the product at an extra cost.

We denote by $e \in \{0, 1\}$ the effort level of either party, depending on $\Psi \in \{m, d\}$. The probability of purchase is given by:

$$\gamma(e) = e + (1 - e)\beta, \quad \beta \in (0, 1).$$

With no effort, the probability of transaction is $\gamma(e = 0) = \beta$. When either the seller or the consumer makes the effort, a transaction can take place with probability $\gamma(e = 1) = 1$. We note that $\beta > 0$, which reflects a possibility of random purchases, is required for demarketing to be optimal. If $\beta = 0$, a market transaction never takes place without an effort. As will be shown later, the optimal demarketing strategy induces only the type-H consumer to exert a transaction effort, and it becomes equivalent to excluding the type-L consumer. And if $\beta = 0$, i.e., the seller excludes the type-L consumer with demarketing, marketing can always implement the same outcome from demarketing.

The cost of transaction effort is given by $\tau(e) = \alpha e$ for all parties, where $\alpha > 0$. Although both the seller's and the consumer's transaction effort play the same role, their transaction costs may not be the same. Adopting symmetric cost, however, allows us to isolate the strategic effect of demarketing. Our result holds as long as the type-H consumer's cost of effort is not significantly larger than the type-L consumer's.

The situations that we have in mind for our model, in particular, are illustrated in the following bullet points — purchases are probabilistic without a transaction effort, and the type-H and type-L consumer's cost of transaction effort are similar (in our model they are the same for simplicity).

- When consumers are boundedly rational, they may not be aware of what products are feasible for purchase even when they know of the existence of products.[8] When the seller does not make an effort to make consumers aware of the products, consumers may have to exert a costly (cognitive) effort for her awareness.

- For a skill-based product, a costly effort is required to understand product features and functionalities for utilizing the product — either the seller must incur an instruction cost, or the consumer must incur a learning cost.

In both examples above, if the consumer decides not to exert a transaction effort (under demarketing), a transaction may still take place. For example, awareness can come from a third party

[8] This notion of awareness has been well established in the marketing literature. Consumers in many cases are considering a small set of feasible alternatives at an earlier stage of the purchasing decision process. The marketing literature has termed this the "consideration set".

by chance. Likewise, the consumer may happen to know someone who is well informed of product features and functionalities. Also, in these examples, when the type-H consumer is more knowledgeable or aware of the product, it is likely that she has equal or even lower cost of transaction effort, compared to the type-L consumer.

Timing of the Game We summarize the timing of the game, depending on the seller's choice between marketing and demarketing:

1. The seller chooses $\Psi \in \{m, d\}$.

- Marketing ($\Psi = m$)

2. The seller makes a transaction effort, and makes it publicly observable.[9]
3. The seller commits to a menu of offers contingent on the consumer's type, $(q_i, p_i)_{i \in \{H,L\}}$.
4. A transaction takes place.

- Demarketing ($\Psi = d$)

2. The seller commits to a menu of offers contingent on the consumer's type, $(q_i, p_i)_{i \in \{H,L\}}$.
3. The consumer decides whether or not to make a transaction effort, $e \in \{0, 1\}$.
4. A transaction takes place depending on $\gamma(e)$.

Full Information Benchmark The optimal product quality under full information is the first-best. We introduce the following notation.

Definition 1 *The first-best outcome is denoted by q_i^*, characterized by:*

$$u_q(q_i^*, i) = c, \quad i \in \{H, L\}.$$

Under full information, the seller can implement perfect price discrimination:

$$p_i^* = u(q_i^*, i),$$

and leaves no surplus to the consumer of either type.

In the subsequent sections, we show that, when the consumer's type is her private information, demarketing allows the seller to price-discriminate more effectively, and hence can dominate marketing.

[9] As will be clear later, we assume that the cost of transaction effort is not prohibitively large that the seller always wants to exert an effort under marketing.

III. Illustrative Example

We provide a simple example that illustrates our point. Suppose the consumer's value schedule with the product of quality level q is as follows:

	High-type	Low-type
$q = 2:$	$u(2,H) = 4$	$u(2,L) = 2.5$
$q = 1:$	$u(1,H) = 3$	$u(1,L) = 2$
$q = 0:$	$u(0,H) = 0$	$u(0,L) = 0$

The consumer's payoff is $u - p$, where p is the price. The seller's profit is $p - q$, where the cost is given by q. The consumer's type is her private information. The probability that the consumer is high-type is $\varphi_H = 1/4$ (thus $\varphi_L = 3/4$), which is common knowledge. The cost of transaction effort is $\alpha = 1/2$. If a transaction effort is made, then the transaction takes place with certainty. If a transaction effort is not made, then the transaction takes place with probability of $\beta = 1/2$.

Under full information, the optimal outcome is the first best and: $q_H^* = 2$ with $p_H^* = 4$ (for the high-type consumer, the product quality level is 2 and the price is 4) and $q_L^* = 1$ with $p_L^* = 2$ (for the low-type consumer, the product quality level is 1 and the price is 2). Therefore, the consumer surplus of either type is zero, and the seller's expected profit is: $\pi^* = \frac{1}{4}(4-2) + \frac{3}{4}(2-1) = \frac{5}{4}$. When the consumer's type is private information the high type consumer has an incentive to mimic the low type consumer to command a strictly positive consumer surplus of $u(1,H) - 2 = 1$.

Below we present the seller's optimal offers and expected profits with the marketing and the demarketing strategy when the consumer's type is her private information.

- Marketing (the seller exerts an effort): In this case, a surplus of $u = 1$ must be provided to the high-type consumer to keep her from mimicking the low-type. In this simple setting, pooling and separating strategy yield the same profit. The seller's pooling strategy is $q_H = q_L = 1$ with $p_H = p_L = 2$, and his expected profit is:
$$\Pi^m = \frac{1}{4}[2-1] + \frac{3}{4}[2-1] - \frac{1}{2} = \frac{1}{2}.$$
- Demarketing (the seller exerts no effort): With demarketing, inducing both types to exert a transaction effort gives the same profit as the case with marketing. Suppose the seller induces only the high-type consumer to exert a transaction effort to separate the consumer's types. To induce the high-type consumer to exert a transaction effort, the seller's offer must satisfy: $u(2,H) - p_H - 1/2 = \frac{1}{2}[u(2,H) - p_H]$. The LHS of the equation is the high-type consumer's payoff when she decides to exert a transaction effort by incurring the cost 1/2. The RHS is her expected payoff if she decides to exert no effort — the payoff is realized with probability 1/2. From the equation, since $u(2,H) = 4$, the seller charges $p_H = 3$ for $q_H = 2$. For the low-type consumer, $q_L = 1$ with $p_L = 2$. The low-type consumer will not exert an effort since she is not compensated for the transaction cost. The high-type consumer's surplus is: $4 - 3 - 1/2 = 1/2$ (< 1), and she has no incentive to mimic the low-type consumer with or without a transaction

effort since: $\frac{1}{2}[u(1,H)-2]=1/2$ without a transaction effort, and $u(1,H)-2-1/2=1/2$. The seller's expected profit is:

$$\Pi^d = \frac{1}{4}[3-2]+\frac{3}{4}\left[\frac{1}{2}(2-1)\right]=\frac{5}{8}.$$

The example above illustrates the central trade-off between marketing and demarketing: sales opportunity vs. surplus extraction. The game tree in Figure 1 represents the example.

Place Figure 1 here

IV. Marketing: The Seller Makes a Transaction Effort

In this section, we analyze more generally the seller's optimal offers when he engages in marketing ($\Psi=m$). In what follows, we denote by e^m the seller's transaction effort. Since the seller does not know the consumer's type when deciding whether or not to exert a transaction effort, the seller's choice of effort level is:

$$e^m \in \arg\max_{\widehat{e}^m}\left\{\gamma(\widehat{e}^m)\left[\sum\nolimits_i \varphi_i\left(p_i-cq_i\right)\right]-\alpha\widehat{e}^m\right\}$$

The expression above implies that if the following inequality,

(1) $$\alpha<(1-\beta)\left[\varphi_H\left(u(q_H^*,H)-u^{\Delta}(q_L^m)-cq_H^*\right)+\varphi_L\left(u(q_L^m,L)-cq_L^m\right)\right],$$

holds, where q_L^m is defined by $u_q(q_L^m,L)=c+\frac{\varphi_H}{\varphi_L}u_q^{\Delta}(q_L^m)$, then the seller exerts full effort, i.e., $e^m=1$. Throughout this paper, we assume that the transaction cost is not too large so that (1) is always satisfied.

Provided that (1) holds, the seller's problem is the standard non-linear pricing that screens the consumer's type. With $\Psi=m$, the seller solves the following problem:

(2) $$\underset{q,p}{Max}\;\Pi^m=\sum\nolimits_i \varphi_i\left(p_i-cq_i\right)-\alpha,\ \text{s.t.}$$

(3) $$u(q_i,i)-p_i\geq 0,\quad i\in\{H,L\},$$

(4) $$u(q_i,i)-p_i\geq u(q_j,i)-p_j,\quad i,j\in\{H,L\}.$$

The first constraints, (3), are the participation constraints for the consumer, and the second constraints, (4), assures that the consumer's payoff is higher when she truthfully represents her type.

The following proposition presents the seller's optimal offer when the seller makes a transaction effort.

Proposition 1 *With marketing, the seller's optimal offers are characterized as follows:*

$$q_H^m = q_H^* \quad and \quad q_L^m < q_L^*,$$

$$p_H^m < p_H^* \quad and \quad p_L^m < p_L^*.$$

The result above is standard. The product quality for a type-H consumer is at the first best level, known as "efficiency at the top" in the literature, but the product quality for a type-L consumer is distorted downwards. In models of this type, the type-H consumer has an incentive to mimic the type-L consumer to reap an information rent of $u^{\Delta}(q_L)$. The seller discourages such a mimicry by distorting the product quality for the type-L consumer downwards. As a result, the seller must reduce both p_H and p_L from the first best levels ($p_H < p_H^*$ and $p_L < p_L^*$), resulting in imperfect price discrimination.

V. Demarketing: The Consumer Makes a Transaction Effort

We now proceed to the case where the seller engages in demarketing. In this case, the seller's choice of price and quality can affect the consumer's incentive to make a transaction effort. The key difference from the case in the previous section is the fact that, when the demarketing strategy is chosen, the seller can induce only a particular type of consumer to make a transaction effort. In other words, the seller can manipulate offers in a way that one type of consumer purchases the product by making a transaction effort, while the other type may purchase the product only by chance without a transaction effort.

Before we proceed, we first establish the following lemma.

Lemma 1 *If the seller prefers demarketing to marketing, then the seller induces only the type-H consumer to make a transaction effort.*

It is not difficult to see that inducing both the type-H and the type-L consumer to make a transaction effort simply makes it more costly to the seller, compared to the case in which the seller makes a transaction effort. Since the type-L consumer gets zero consumer surplus from a purchase, she has no incentive to make a transaction effort. Therefore, to incentivize the type-L consumer, the seller must provide her with a strictly positive consumer surplus. Such a surplus to the type-L consumer, however, makes the type-H consumer misrepresent her type. As a result, the seller must provide the additional surplus to both the type-H and the type-L consumer.

Similarly, it is suboptimal for the seller to induce only the type-L consumer to make a transaction effort. To do so, the seller must compensate the type-L consumer's effort by decreasing p_L, which encourages the type-H consumer to misrepresent her type as the type-L consumer. Again, the seller will simply end up providing more consumer surplus under this arrangement.

Another possibility is that the seller induces neither type to make a transaction effort. This case, however, is no different from when the seller chooses the marketing strategy without making an effort. This is the case when β is so large that (1) does not hold — marketing and demarketing become effectively the same. To differentiate the two strategies, we assume that β is not too large.

In what follows, we denote by e_i^d a type-i consumer's transaction effort. The type-i consumer's problem when deciding whether to make a transaction effort is:

$$e_i^d \in \arg\max_{\widehat{e_i}^d} \gamma(\widehat{e_i}^d)\left[u(q_i, i) - p_i\right] - \alpha\widehat{e_i}^d, \quad i \in \{H, L\}. \tag{5}$$

To induce $e_H^d = 1$, the seller's optimal offer for the type-H consumer must satisfy:

$$u(q_H, H) - p_H \geq \frac{\alpha}{1-\beta}. \tag{6}$$

On the other hand, the seller wants to ensure that the type-L consumer prefers not to make a transaction effort, i.e., $e_L^d = 0$:

$$u(q_L, L) - p_L \leq \frac{\alpha}{1-\beta} \tag{7}$$

Since consumer surplus must be non-negative, the seller's maximization problem must satisfy the following participation constraints for the consumer:

$$u(q_H, H) - p_H - \alpha \geq 0, \tag{8}$$

$$\beta\left[u(q_L, L) - p_L\right] \geq 0. \tag{9}$$

Finally, as the revelation principle applies in our model, the seller's offer must satisfy the incentive constraints for the consumer's truthful behavior:

$$u(q_H, H) - p_H - \alpha \geq \max\left\{ \begin{array}{c} u(q_L, H) - p_L - \alpha, \\ \beta\left[u(q_L, H) - p_L\right] \end{array} \right\}, \tag{10}$$

$$\beta\left[u(q_L, L) - p_L\right] \geq \max\left\{ \begin{array}{c} u(q_H, L) - p_H - \alpha, \\ \beta\left[u(q_H, L) - p_H\right] \end{array} \right\}. \tag{11}$$

The constraints above assure that the consumer's payoff from truthfully representing her type (the left hand sides) is higher than her payoff from misrepresentation (the right hand sides). The right hand sides of (10) and (11) exhibit the consumer's choice of whether or not to make a transaction effort if she decides to misrepresent her type.

When inducing only the type-H consumer to make a transaction effort, the seller's problem is as follows:

$$\underset{q,p}{Max}\, \Pi^d = \varphi_H\left(p_H - cq_H\right) + \beta\varphi_L\left(p_L - cq_L\right), \tag{12}$$

subject to (6), (7), (8), (9), (10) and (11). Notice that (6) implies (8).

We distinguish three regimes for the optimal outcome when the seller engages in demarketing and only the type-H consumer makes a transaction effort. To characterize the optimal outcomes in each regime, we first present the following cutoff levels of the transaction cost.

Definition 2 *Let* $\underline{\alpha} \equiv (1-\beta)u^{\Delta}(q_L^*)$ *and* $\overline{\alpha} \equiv (1-\beta)u^{\Delta}(q_H^*)$.

The following proposition characterizes the seller's optimal offers with a demarketing strategy in which only the type-H consumer is induced to make a transaction effort.

Proposition 2 *With demarketing, the seller's optimal offers with* $e_H = 1$ *and* $e_L = 0$ *are characterized as follows:*

- *When* $\alpha < \underline{\alpha}$*:* $q_H^d = q_H^m$. *For* α *close enough to zero,* $q_L^d < q_L^m$, $p_H^d > p_H^m$ *and* $p_L^d < p_L^m$. *For* α *close enough to* $\underline{\alpha}$, $q_L^d > q_L^m$, $p_H^d < p_H^m$ *and* $p_L^d > p$.
- *When* $\alpha \in [\underline{\alpha}, \overline{\alpha}]$*:* $q_i^d = q_i^* \ \forall i$, $p_H^d = p_H^* - \frac{\alpha}{1-\beta}$, *and* $p_L^d = p_L^*$.
- *When* $\alpha > \overline{\alpha}$*:* $q_H^d > q_H^m$, $q_L^d = q_L^*$, $p_H^d < p_H^m$, *and* $p_L^d < p_L^m$.

When the transaction cost is sufficiently small, i.e., $\alpha < \underline{\alpha}$, the type-$H$ consumer's information rent $u^{\Delta}(q_L)$ is large enough that the seller does not need to compensate her for a transaction effort, and consequently, $p_H^d > p_H^m$. Yet, the type-L consumer's lack of transaction effort leads to a larger quality distortion compared to the one with $\Psi = m$ ($q_L^d < q_L^m$). As a result, the price for the type-L consumer also becomes lower ($p_L^d < p_L^m$). As the transaction cost increases, the seller must incentivize the type-H consumer to make an effort by providing a discount ($p_H^d < p_H^m$). This extra consumer surplus is provided only when the type-H consumer truthfully represents her type as H, which allows the seller to recover some of the distortion in the optimal product quality for the type-L consumer ($q_L^d > q_L^m$). As a result, the price for the type-L consumer becomes higher than when the seller chooses the marketing strategy ($p_L^d > p_L^m$). In this regime ($\alpha < \underline{\alpha}$), as the transaction cost α increases, although demarketing allows the seller to recover the distortion in q_L by extracting the type-H consumer's information, the seller still cannot completely restore the first-best quality level.

As the transaction cost increases further, i.e., $\alpha \in [\underline{\alpha}, \overline{\alpha}]$, while it becomes more costly to induce the type-H consumer to make a transaction effort, her private information becomes less of a problem. Within this intermediate range, the seller's extra discount for the type-H consumer to induce her effort is large enough that the type-H consumer no longer has an incentive to misrepresent her type as type-L. In other words, "countervailing incentives" arise in this range of the transaction cost — the type-H consumer's incentive to acquire information rent is mitigated by her incentive to be compensated for her transaction effort. Consequently, the seller does not need to distort the product qualities in his optimal offer to extract the consumer's surplus linked to her private information ($q_i^d = q_i^*$, $\forall i$). In this range of the transaction cost, although the seller must give the type-H consumer a discount for her effort, the seller's price discrimination is efficient.

As the transaction cost becomes yet larger, i.e., $\alpha > \overline{\alpha}$, the discount to the type-H consumer leads to the "reverse incentive" problem. In this regime, the type-H consumer has no misrepresenting incentive, but the type-L consumer has such an incentive when she purchases the product by chance. To discourage the type-L consumer from mimicking type-H consumer, the seller must increase p_H, but this will discourage the type-H consumer's transaction effort. As a result, the seller must increase the product quality for the type-H consumer from the first-best level ($q_H^d > q_H^*$).[10] In addition to increasing p_H, the seller also gives the type-L consumer a discount to prevent mimicry. As a result, the price for the type-L consumer becomes lower compared to the case with $\Psi = m$ ($p_L^d < p_L^m$).

In summary, unlike the marketing strategy, the demarketing strategy brings about different incentive problems according to the size of the transaction cost. In the next section, we examine pros and cons of each strategy, and endogenize the seller's choice of $\Psi \in \{m, d\}$.

VI. Choice between Marketing and Demarketing

By incurring the transaction cost directly ($\Psi = m$), the seller can sell his product with certainty — the transaction will always take place. However, the seller then makes an effort regardless of the consumer's type. Moreover, with the marketing strategy, the seller must always provide type-H consumer with strictly positive information rent.

The demarketing strategy ($\Psi = d$) brings more flexibility, allowing the seller to induce the consumer's transaction effort depending on the consumer's type (only the type-H consumer in the optimum). Such flexibility allows the seller to partially save the transaction cost, but more importantly, it has a strategic benefit. In particular, when the effort cost is neither too small nor too large, the demarketing strategy creates the consumer's "countervailing incentives" — the type-H consumer's incentive to mimic the type-L consumer in order to command information rent is alleviated since she is compensated for her transaction effort only when she chooses the bundle of $\{q_H, p_H\}$. That is, the demarketing strategy enables the seller to extract the consumer's information rent more effectively.

From Proposition 1, we obtain the seller's expected profit $\Pi^m(\alpha)$, whereas Proposition 2 characterizes $\Pi^d(\alpha)$. With marketing, the seller himself exerts a transaction effort and hence the effort cost directly affects the seller's objective function, and $\Pi^m(\alpha)$ is linearly decreasing. With demarketing, however, the type-H consumer's effort must be induced and therefore the cost of effort affects the seller indirectly, and $\Pi^d(\alpha)$ is concavely decreasing in α. This leads to our main result — we characterize the seller's optimal strategy depending on the transaction cost in the following proposition.

Proposition 3 *Suppose $\Delta \equiv H - L$ is large enough. Then, there exist α_l and α_h $(> \alpha_l)$ such that $\Pi^m(\alpha) > \Pi^d(\alpha)$ for $\alpha < \alpha_l$ and $\alpha > \alpha_h$, while $\Pi^m(\alpha) < \Pi^d(\alpha)$ for $\alpha \in (\alpha_l, \alpha_h)$.*

- *When $\alpha < \alpha_l$, the seller chooses marketing.*
- *When $\alpha \in [\alpha_l, \alpha_h]$, the seller chooses demarketing.*

[10] The outcome under the reverse incentive problem may explain the excessive qualities of some products and services — e.g., there are exceptionally fine restaurants that limit the number of seats. See Kotler and Levy [1971] for more examples.

- *When $\alpha > \alpha_h$, the seller chooses marketing.*

For a small transaction cost, the compensation to the type-H consumer for making a transaction effort with demarketing is also small — the compensation for the type-H consumer's effort is not attractive enough for her to give up taking advantage of her private information. The seller with the demarketing strategy, therefore, still has to provide significant information rent to induce the consumer's truthful behavior. With the marketing strategy, although information rent needs to be provided to the type-H consumer, the seller can have a higher probability of transaction at a low cost. When the transaction cost is small, the benefit from marketing outweighs the benefit from demarketing.

When the transaction cost is not so small, the marketing strategy becomes less attractive to the seller, while the demarketing strategy becomes more attractive. Despite the lower chance of transaction, demarketing enables the seller to extract the consumer's information rent when the transaction cost is intermediate, leading to more efficient price discrimination. This effect dominates when the difference in the consumer's valuations is large enough, and consequently, the seller prefers the demarketing strategy.

When the transaction cost is large, however, the strategic merit in the demarketing strategy vanishes since it brings about the reverse incentive problem. Under the reverse incentive problem, the same compensation for transaction effort given to the type-H consumer must also be provided to the type-L consumer. It becomes too costly to induce the consumer's transaction effort, and the seller again prefers the marketing strategy.

An interesting question is how a change in β affects the seller's optimal strategy. Recall that an increase in β implies that the transaction effort becomes less important. We find that as β rises, the parameter range for demarketing to be optimal becomes greater. The seller's expected profit with marketing Π^m remains the same, whereas that with demarketing Π^d is increasing in β. Applying the envelope theorem to (12), we obtain:

$$\left.\frac{\partial \Pi^d}{\partial \beta}\right|_{q_i = q_i^d} = \varphi_L \left(p_L^d - c q_L^d\right) > 0,$$

which leads to the following Corollary immediately.

Corollary 1 $\frac{\partial \alpha_l(\beta)}{\partial \beta} < 0$ *and* $\frac{\partial \alpha_h(\beta)}{\partial \beta} > 0$.

The intuition is straightforward. Demarketing reduces a market transaction with the type-L consumers by probability $1 - \beta$. This cost of demarketing becomes smaller in β. This result, however, has to be carefully understood. When β is sufficiently large and, for example, close to 1, the seller may decide neither to make an effort himself nor to induce it from the consumer. That is, when (1) does not hold, marketing is no different than demarketing. Thus, the result that demarketing becomes more attractive as β rises is valid under the assumption that (1) holds, i.e., when β is not prohibitively large.

As mentioned before, the transaction costs may not be the same for the two types. Suppose $\alpha(H) > \alpha(L)$, i.e., the type-H consumer's cost is higher than the type-L consumer's, as in models of price discrimination through coupons. If the gap between $\alpha(H)$ and $\alpha(L)$ is small enough, then demarketing by inducing only the type-H consumer to exerts a transaction effort is still optimal. If $\alpha(H) < \alpha(L)$, then it reinforces our result since it is relatively cheaper to induce the type-H consumer to exert an effort. In general, as $\alpha(H)$ becomes smaller relative to $\alpha(L)$, demarketing becomes more attractive to the seller. While some previous studies, such as those with price discrimination using coupons, show that it is optimal to induce only the type-L consumer to incur the transaction cost for $\alpha(H) > \alpha(L)$, our study suggests that if the gap is not significant, or $\alpha(H) \leq \alpha(L)$, it can be optimal to induce only the type-H consumer to induce the transaction cost.

VII. Extensions

In this section, we extend our analysis in two directions. First, we allow the possibility of joint transaction effort made both by the seller and the consumer. Second, we look at a case in which the seller offers the menu for a type-H consumer only through an exclusive sales channel for which the consumer's transaction effort is required.

VII(i). Possibility of Sharing a Transaction Effort

Thus far, we have considered that the transaction cost is incurred by either the seller or the consumer. We now investigate the case where the seller can share the transaction cost with the consumer. The seller chooses three effort levels, $e^m, e^d_H, e^d_L \in [0,1]$, where e^m is the seller's transaction effort, and e^d_H and e^d_L are the type-H and the type-L consumer's transaction effort respectively (the seller chooses e^d_H and e^d_L respecting the consumer's incentives).

Our base framework, and what we have shown in the previous sections implies the following points. First, $e^m + e^d_i \leq 1$, $i \in \{H, L\}$ in the optimum. Otherwise, there will be a wasted effort. In our framework, therefore, the likelihood of transaction, $\gamma(e)$, becomes:

$$\gamma(e^m + e^d_i) = e^m + e^d_i + \left[1 - (e^m + e^d_i)\right]\beta, \quad i \in \{H, L\}.$$

Second, $e^m + e^d_i < 1$ for $\forall i$ is suboptimal. If $e^m + e^d_i < 1$ for $\forall i$, then (1) implies that increasing e^m until $e^m + e^d_i = 1$ dominates such cases. Third, similar to Lemma 1, inducing $e^m + e^d_H < 1$ and $e^m + e^d_L = 1$ is suboptimal. To induce type-L consumer to make an effort higher than the type-H consumer, the seller's compensation to the type-L consumer encourages the type-H consumer to misrepresent her type as type-L. As a result, the seller must provide the additional rent to the type-H consumer as well as the type-L consumer.

The discussion above implies that, in the optimum:

$$e^d_H = 1 - e^m \quad \text{and} \quad e^d_L < 1 - e^m. \tag{13}$$

The constraints the seller faces for the consumer's effort is:

$$e_i^d \in \arg\max_{\widehat{e}_i^d} \left\{\gamma(e^m + \widehat{e}_i^d)\left[u(q_i, i) - p_i\right] - \alpha\widehat{e}_i^d\right\}, \quad i \in \{H, L\}. \tag{14}$$

Since $e_H^d = 1 - e^m$ from (13) and the consumer's problem is linear in e_i^d, a type-i consumer chooses $e_i^d = 1 - e_m$ if she makes an effort and $e_i^d = 0$ otherwise. Then, by (13), $e_L^d = 1 - e_m$ and $e_L^d = 0$ for demarketing to be optimal. That is, (14) and (13) imply:

$$u(q_H, H) - p_H - \alpha(1 - e^m) \geq \left[e^m + (1 - e^m)\,\beta\right]\left[u(q_H, H) - p_H\right], \tag{15}$$

$$\left[e^m + (1 - e^m)\,\beta\right]\left[u(q_L, L) - p_L\right] \geq u(q_L, L) - p_L - \alpha(1 - e^m). \tag{16}$$

Notice that, with $e_m = 1$, then (15) and (16) become identities — if only the seller exerts a transaction effort, then the consumer's incentive for an effort becomes irrelevant.

Proposition 4 *With demarketing, suppose the seller can share a fraction of the consumer's transaction effort. If φ_L is small enough, the seller will not exert any transaction effort.*

As in Proposition 3, demarketing is optimal when $\Delta \equiv H - L$ is large enough, but even if the seller can share the consumer's transaction effort, he would not do so if the consumer is unlikely to be type-L. Recall that demarketing allows the seller to save the cost of transaction effort, depending on the consumer's type. When there is no need to let the consumer exert the entire transaction effort with demarketing, the seller may also exert some effort — because $e_L^d = 0$ in the demarketing strategy, if the consumer is likely to be type-L, exerting $e^m > 0$ allows the seller to recover some potential sales loss from type-L consumer. If the consumer is unlikely to be type-L, however, the seller will exert no effort to save the cost of transaction effort.

VII(ii). Possibility of Exclusive Channel Strategy

So far, we have assumed that the seller always offers the full menu, $\{q_H, p_H : q_L, p_L\}$. Offering the full menu is optimal when the seller employs the marketing strategy ($\Psi = m$). When employing the demarketing strategy ($\Psi = d$), however, the seller may have more room to manipulate the availability of the menu, depending on the consumer's transaction effort. In this section, we distinguish two different strategies under demarketing. The first one is the demarketing strategy which has already been discussed — offering full menu, $\{q_H, p_H : q_L, p_L\}$, regardless of the consumer's transaction effort.

The second one is the strategy that makes $\{q_H, p_H\}$ available only for the consumer who makes a transaction effort ($e^d = 1$), while making $\{q_L, p_L\}$ available for the consumer regardless of the consumer's effort. For example, the seller can set up different purchasing channels for the consumer: the "exclusive channel" through which $\{q_H, p_H\}$ is offered only for the consumer who makes an effort to access the exclusive channel. This can be thought of as special discounts or deals for which consumers must incur a transaction effort. For example, some companies offer certain products for sale only online and do not make them available in their retail stores, and vice versa. Some fast food and coffee franchises, such as In-N-Out, McDonald's and Starbucks, offer fancier menus through less known channels.[11] These "exclusive sales channels" are available only to the consumers who make an effort to acquire information. Another example is when some retailers offer special deals or sales through e-mails only when consumers incur a "hassle" cost, such as submitting a long survey.[12] We refer this to "the exclusive channel strategy ($\Psi = \widetilde{d}$)."

We assume that, with the exclusive channel strategy, the full menu $\{q_H, p_H : q_L, p_L\}$ is available only through an exclusive sales channel so that without making a transaction effort, the consumer cannot have an access to $\{q_H,\ p_H\}$ — only $\{q_L,\ p_L\}$ is available to the consumer if she makes no transaction effort. Figure 2 illustrates the difference among marketing ($\Psi = m$), demarketing ($\Psi = d$) and exclusive channel strategy ($\Psi = \widetilde{d}$).

Place Figure 2 here

The difference between the two strategies is clear from the figure. Unlike the demarketing strategy, the exclusive channel strategy does not physically allow the type-L consumer to mimic the type-H consumer without making a transaction effort. This leads to two changes. First, if the type-H consumer decides not to make a transaction effort, only the low-quality product is available for her (as before, the chance that she finds the product is β in such a case). Therefore, the condition for the type-H consumer's transaction effort becomes:

$$u(q_H, H) - p_H - \alpha \geq \beta \left[u(q_L, H) - p_L\right]. \tag{17}$$

Second, the type-L consumer must incur the transaction cost if she decides to mimic type-H. Therefore, instead of (11) in the demarketing strategy, the seller must satisfy the following incentive constraint for the type-L consumer's truthful behavior:

$$\beta \left[u(q_L, L) - p_L\right] \geq u(q_H, L) - p_H - \alpha. \tag{18}$$

The seller maximizes his expected payoff in (12), subject to (8), (9), (17), (10) and (18). To characterize the optimal outcomes in each regime, we first present the following cutoff levels of the transaction cost.

Definition 3 *Let* $\widetilde{\alpha} \equiv (1-\beta)u^{\Delta}(q_L^m)$.

The seller's optimal offers with the exclusive channel strategy are presented in the next proposition.

[11] See, for example, Bryant [2014].

[12] See The Wall Street Journal, "Why pay full price?", May 5. 2011.

Proposition 5 *With $\Psi = \widetilde{d}$, the seller's optimal offers with the exclusive channel strategy are characterized as follows:*

- *When $\alpha < \widetilde{\alpha}$: $\widetilde{q}_H^d = q_H^m$ and $\widetilde{q}_L^d < q_L^m$, $\widetilde{p}_H^d < p_H^m$ and $\widetilde{p}_L^d < p_L^m$.*
- *When $\alpha \geq \widetilde{\alpha}$: $\widetilde{q}_H^d = q_H^m$ and $\widetilde{q}_L^d = q_L^m$, $\widetilde{p}_H^d \geq p_H^m$, and $\widetilde{p}_L^d = p_L^m$.*

When α is small enough, the effect is similar to the demarketing strategy. The type-H consumer's information rent is large enough relative to α that the seller does not need to compensate her for her transaction effort, which leads to $\widetilde{p}_H^d > p_H^m$. The fact that the type-L consumer does not make a transaction effort leads to a larger quality distortion in the product compared to the case with marketing ($\widetilde{q}_L^d < q_L^m$). As a result, the price for the type-L consumer becomes lower ($\widetilde{p}_L^d < p_L^m$) as well.

As α becomes larger, the seller must incentivize the type-H consumer to make a transaction effort by providing a discount. However, the effect of the exclusive channel strategy becomes different from that of the demarketing strategy. First, under the demarketing strategy, the type-H consumer can truthfully reveal her type regardless of her transaction effort. Under the exclusive channel strategy, however, if the type-H consumer decides not to make a transaction effort, she cannot reveal her true type (only the price-quality bundle for the type-L consumer is offered through the regular channel). Second, recall that, under the demarketing strategy when α is large, the type-L consumer has an incentive to mimic the type-H consumer (without making a transaction effort). This, however, is not the case under the exclusive channel strategy. The type-L consumer must incur the transaction cost to mimic type-H. These two effects together, when $\alpha \geq \widetilde{\alpha}$, make the product quality levels identical to those in the case of marketing ($\widetilde{q}_H^d = q_H^m$ and $\widetilde{q}_L^d = q_L^m$). The only difference from the marketing strategy is that p_H is higher ($\widetilde{p}_H^d > p_H^m$ for $\alpha > \widetilde{\alpha}$) since the seller must compensate the consumer for her transaction effort.

We now compare the three strategies that we have discussed to demonstrate the robustness of the demarketing strategy. As shown below, demarketing strategy blended with special deals through exclusive channels can dominate the marketing strategy. The next proposition presents the seller's optimal choice when the exclusive channel strategy is available.

Proposition 6 *Suppose $\Delta \equiv H - L$ is large enough. Then, there exists $\widetilde{\alpha}_h < \alpha_h$ such that $\widetilde{\Pi}^d(\alpha) > \max\{\Pi^m(\alpha), \Pi^d(\alpha)\}$ for $\alpha > \widetilde{\alpha}_h$.*

- *When $\alpha < \alpha_l$, the seller chooses marketing.*
- *When $\alpha \in [\alpha_l, \widetilde{\alpha}_h]$, the seller chooses demarketing.*
- *When $\alpha > \widetilde{\alpha}_h$, the seller chooses demarketing with exclusive channels.*

With the exclusive channel strategy, the type-L consumer's incentive to mimic type-H is not an issue since the high-quality product is available only through the exclusive channel. This has both a negative and a positive effect. The negative effect is that the consumer's "countervailing incentives" under the demarketing strategy vanishes under the exclusive channel strategy. As mentioned above, the exclusive channel strategy does not allow the type-H consumer to reveal her true type without making a transaction effort. As a result, with the exclusive channel strategy, the seller cannot achieve the first-best product qualities for both types when the transaction cost is intermediate. The positive side is that the exclusive channel strategy eliminates the "reverse incentive" when the transaction cost is large. For large transaction costs, therefore, the exclusive channel strategy allows the seller to avoid giving a discount to the type-L consumer without an upward distortion in q_H.

In summary, for intermediate transaction costs, the demarketing strategy generates countervailing incentives, which enables the seller to price-discriminate more effectively by extracting the consumer's information rent. For large transaction costs, the exclusive channel strategy dominates the demarketing strategy because the seller effectively price-discriminates with respect to the consumer's transaction effort, which cannot be implemented with the full menu strategy. Finally, the exclusive channel strategy dominates the marketing strategy because the seller can save the effort cost for the type-L consumer without having the reverse incentive problem. The result is illustrated in Figure 3.

Place Figure 3 here

Before we close this section, we discuss the possibility of different types of strategies. For example, one may ask if it can be optimal to offer $\{q_L, p_L\}$ only in the exclusive channel, while offering $\{q_H, p_H : q_L, p_L\}$ in the regular channel. That is, the seller has to induce the type-L consumer to make an effort for purchase $\{q_L, p_L\}$. In this case, the seller can induce a transaction effort either from both types, or only from the type-L consumer. However, as shown in Lemma 1, this case cannot dominate the marketing strategy.

VIII. Conclusion

In this paper, we have shown that a seller can employ demarketing as an instrument for price discrimination. We have defined marketing as the seller making an effort to increase the likelihood of a transaction, and demarketing as the seller not making such effort. Our result suggests that, when a consumer's preference is private information, demarketing can dominate marketing. We have shown that in the optimal demarketing strategy, the seller induces the high-valuation consumers to exert an effort for transaction, without inducing the low-valuation consumers to do so. This strategy allows the seller to be able to extract the consumer's surplus more effectively. According to our results, when the transaction cost is small or large, it is optimal for the seller to engage in marketing. For intermediate transaction costs, by contrast, the seller may prefer demarketing. We have also shown that, with exclusive sales channels, demarketing can be the optimal strategy even for large transaction costs.

Appendix

Proof of Proposition 1.

Since α does not play any role, only (4) for the type-H consumer and (3) for the type-L consumer are binding as in a standard screening problem:

$$p_H = u(q_H, H) - u^{\Delta}(q_L) \quad \text{and} \quad p_L = u(q_L, L). \tag{19}$$

Substituting for p_H and p_L in the objective function in (2), we solve:

$$\underset{q_H, q_L}{Max}\, \varphi_H \left[u(q_H, H) - u^{\Delta}(q_L) - cq_H\right] + \varphi_L \left[u(q_L, L) - cq_L\right] - \alpha. \tag{20}$$

The first-order conditions give:

$$u_q(q_H^m, H) = c \quad \text{and} \quad u_q(q_L^m, L) = c + \frac{\varphi_H}{\varphi_L} u_q^{\Delta}(q_L^m),$$

implying that $q_H^m = q_H^*$ and $q_L^m < q_L^*$. From (19), $p_H^m < p_H^*$ and $p_L^m < p_L^*$.■

Proof of Lemma 1.

We show that, with $\Psi = d$, (i) the case in which the seller induces a transaction effort from the consumer regardless of her type and (ii) the case in which the seller only induces the type-L consumer's transaction effort are both dominated by the seller's optimal outcome with $\Psi = m$. First, suppose, with $\Psi = d$, the seller induces a transaction effort from both types. Then, the following constraint must be satisfied:

$$u(q_i, i) - p_i - \alpha \geq \beta \left[u(q_i, i) - p_i\right], \quad i \in \{H, L\},$$

which can be rewritten as:

$$u(q_i, i) - p_i \geq \frac{\alpha}{1 - \beta}, \quad i \in \{H, L\}. \tag{21}$$

The consumer's participation constraint $u(q_i, i) - p_i - \alpha \geq 0$ is implied by (21) regardless of her type. The constraints that induce the consumer's truthful representation of her type are:

$$u(q_i, i) - p_i - \alpha \geq \max \left\{ \begin{array}{c} u(q_j, i) - p_j - \alpha, \\ \beta \left[u(q_j, i) - p_j\right] \end{array} \right\}, \quad i, j \in \{H, L\}. \tag{22}$$

The RHS of (22) exhibits the consumer's choice of whether or not to exert a transaction effort if she decides to misrepresent her type (off the equilibrium path). To simplify (22), we first make the following claim.

Claim 4 *Suppose* (21) *holds. Then, the inequality below must hold if* (22) *for a type-i consumer is binding:*

$$u(q_j, i) - p_j \geq \frac{\alpha}{1-\beta}, \quad i, j \in \{H, L\}.$$

Proof. Suppose $u(q_j, i) - p_j < \frac{\alpha}{1-\beta}$, which implies that $u(q_j, i) - p_j - \alpha < \beta [u(q_j, i) - p_j]$ in the RHS of (22). Then, binding (22) for a type-i consumer can be rewritten as:

$$u(q_i, i) - p_i - \frac{\alpha}{1-\beta} = \beta \left[u(q_j, i) - p_j - \frac{\alpha}{1-\beta} \right],$$

which is a contradiction since the LHS of the equation is positive by (21), but the RHS is negative. ■

Claim 1 implies that RHS of (22) is $u(q_j, i) - p_j - \alpha$. Therefore, (22) becomes the same as (4) in the case with $\Psi = m$, since α cancels out with each other in both sides of (22). The seller's problem then is written as:

$$\underset{q_i, p_i}{Max} \sum\nolimits_i \varphi_i (p_i - cq_i),$$

subject to

$$u(q_i, i) - p_i \geq \frac{\alpha}{1-\beta}, \quad i \in \{H, L\}, \tag{23}$$

$$u(q_i, i) - p_i \geq u(q_j, i) - p_j, \quad i, j \in \{H, L\}. \tag{24}$$

Compared to the case with $\Psi = m$, there are two differences. First, the transaction cost α is transferred to the consumer, and second, the consumer's reservation payoff is $\frac{\alpha}{1-\beta}$. As usual, (23) for type-L and (24) for the type-H consumer are binding at the optimum, and we have expression for p_i, $i \in \{H, L\}$, from these binding constraints. After substituting for the prices in the seller's objective function, the optimization problem becomes:

$$\underset{q_H, q_L}{Max} \quad \varphi_H \left[u(q_H, H) - u^{\Delta}(q_L) - cq_H \right] + \varphi_L \left[u(q_L, L) - cq_L \right] - \frac{\alpha}{1-\beta}. \tag{25}$$

Directly comparing (25) to (20) shows that the seller's profit with $\Psi = d$ is strictly lower than his profit with $\Psi = m$.

Next, suppose, with $\Psi = d$, the seller induces a transaction effort only from the type-L consumer. Then, the following constraint must be satisfied:

$$u(q_L, L) - p_L \geq \frac{\alpha}{1-\beta}. \tag{26}$$

The constraints that induce the consumer's truthful representation of her type are:

$$\beta [u(q_H, H) - p_H] \geq \max \left\{ \begin{array}{c} u(q_L, H) - p_L - \alpha, \\ \beta [u(q_L, H) - p_L] \end{array} \right\}, \tag{27}$$

$$u(q_L, L) - p_L - \alpha \geq \max \left\{ \begin{array}{c} u(q_H, L) - p_L - \alpha, \\ \beta [u(q_H, L) - p_H] \end{array} \right\}. \tag{28}$$

Claim 5 *Suppose* $u(q_H, H) - p_H < \frac{\alpha}{1-\beta}$. *Then, the inequality below must hold:*

$$u(q_L, H) - p_L < \frac{\alpha}{1-\beta}.$$

Proof. Suppose $u(q_L, H) - p_L \geq \frac{\alpha}{1-\beta}$, which implies that $u(q_L, H) - p_L - \alpha \geq \beta\left[u(q_L, H) - p_L\right]$ in the RHS of (27). Then, (27) with a simple manipulation gives:

$$\beta\left[u(q_H, H) - p_H - \frac{\alpha}{1-\beta}\right] \geq u(q_L, H) - p_L - \frac{\alpha}{1-\beta},$$

which is a contradiction since the LHS is negative, but the RHS is positive. ■

Claim 2 implies that the RHS of (27) is $\beta\left[u(q_L, H) - p_L\right]$. Also by Claim 1, RHS of (28) is $u(q_H, L) - p_L - \alpha$. Therefore, (27) and (28) become the same as (4) in the case with $\Psi = m$. For type-L consumer, (26) implies that the constraint for her participation, $u(q_L, L) - p_L - \alpha \geq 0$, is automatically satisfied. By Claim 2, (27) is written as $u(q_H, H) - p_H \geq u(q_L, H) - p_L$, which implies that the participation constraint for the type-H consumer $u(q_H, H) - p_H \geq 0$ is automatically satisfied. Therefore, the seller's problem is written as:

$$\underset{q,p}{Max}\ \beta\varphi_H\left(p_H - cq_H\right) + \varphi_L\left(p_L - cq_L\right),$$

subject to

$$u(q_L, L) - p_L \geq \frac{\alpha}{1-\beta}, \tag{29}$$

$$u(q_i, i) - p_i \geq u(q_j, i) - p_j, \quad i, j \in \{H, L\}. \tag{30}$$

Again, by Claim 1 and 2, (27) and (28) become the constraints in (30). It can be easily shown that (29) and (30) for the type-H are binding, and (30) for the type-L consumer is slack. By substituting for p_L and p_H in the objective function, the seller's problem becomes:

$$\underset{q_H, q_L}{Max}\quad \beta\varphi_H\left[u(q_H, H) - u^{\Delta}(q_L) - cq_H - \frac{\alpha}{1-\beta}\right] + \varphi_L\left[u(q_L, L) - cq_L - \frac{\alpha}{1-\beta}\right]. \tag{31}$$

Clearly, the seller's profit in (31) is even smaller than it's profit in (25). ■

Proof of Proposition 2.

We first establish the following two claims.

Claim 6 *Suppose* (6) *holds. Then, the inequality below must hold if* (10) *is binding:*

$$u(q_L, H) - p_L \geq \frac{\alpha}{1-\beta}.$$

Proof. Suppose $u(q_L, H) - p_L < \frac{\alpha}{1-\beta}$, which implies that $u(q_L, H) - p_L - \alpha < \beta\left[u(q_L, H) - p_L\right]$ in the RHS of (10) Then, binding (10) can be rewritten as:

$$u(q_H, H) - p_H - \frac{\alpha}{1-\beta} = \beta\left[u(q_L, H) - p_L - \frac{\alpha}{1-\beta}\right],$$

which is a contradiction since the LHS is positive by (6), but the RHS is negative. ■

The Claim above implies that RHS of (10) is $u(q_L, H) - p_L - \alpha$. Therefore, (10) can be rewritten as $u(q_H, H) - p_H \geq u(q_L, H) - p_L$.

Claim 7 *Suppose* $u(q_L, L) - p_L < \frac{\alpha}{1-\beta}$. *Then, the inequality below must hold:*

$$u(q_H, L) - p_H < \frac{\alpha}{1-\beta}.$$

Proof. Suppose $u(q_H, L) - p_H \geq \frac{\alpha}{1-\beta}$, which implies that $u(q_H, L) - p_H - \alpha \geq \beta\left[u(q_H, L) - p_H\right]$ in the RHS of (11). Then, (11) with a simple manipulation gives:

$$\beta\left[u(q_L, L) - p_L - \frac{\alpha}{1-\beta}\right] \geq u(q_H, L) - p_H - \frac{\alpha}{1-\beta},$$

which is a contradiction since the LHS is negative, but the RHS is positive. ■

The Claim above implies that RHS of (11) is $\beta\left[u(q_L, H) - p_L\right]$. Therefore, (11) can be rewritten as $u(q_L, L) - p_L \geq u(q_H, L) - p_H$.

It can be easily shown that (7) is automatically satisfied by the solution without it in our problem. Also, (6) implies (8), and by Claims 3 and 4, the incentive compatibility constraints (10) and (11) can be rewritten respectively as:

$$u(q_H, H) - p_H \geq u(q_L, H) - p_L \text{ and}$$
$$u(q_L, L) - p_L \geq u(q_H, L) - p_H.$$

Thus, the Lagrangian of the seller's problem can be written as:

$$\begin{aligned}
\mathcal{L} = {} & \varphi_H\left(p_H - cq_H\right) + \beta\varphi_L\left(p_L - cq_L\right) \\
& + \lambda_1\left[u(q_H, H) - p_H - \frac{\alpha}{1-\beta}\right] \\
& + \lambda_2[u(q_L, L) - p_L] \\
& + \lambda_3\left[u(q_H, H) - p_H - u(q_L, H) + p_L\right] \\
& + \lambda_4\left[u(q_L, L) - p_L - u(q_H, L) + p_H\right].
\end{aligned}$$

In the optimum:

$$\frac{\partial \mathcal{L}}{\partial p_H} = \varphi_H - \lambda_1 - \lambda_3 + \lambda_4 = 0, \tag{32}$$

$$\frac{\partial \mathcal{L}}{\partial p_L} = \beta\varphi_L - \lambda_2 + \lambda_3 - \lambda_4 = 0, \tag{33}$$

$$\frac{\partial \mathcal{L}}{\partial q_H} = -\varphi_H c + (\lambda_1 + \lambda_3)u_q(q_H, H) - \lambda_4 u_q(q_H, L) = 0, \tag{34}$$

$$\frac{\partial \mathcal{L}}{\partial q_L} = -\beta\varphi_L c + (\lambda_2 + \lambda_4)u_q(q_L, L) - \lambda_3 u_q(q_L, H) = 0, \tag{35}$$

$$\frac{\partial \mathcal{L}}{\partial \lambda_1} = u(q_H, H) - p_H - \frac{\alpha}{1-\beta} \geq 0, \quad \lambda_1 \frac{\partial \mathcal{L}}{\partial \lambda_1} = 0, \tag{36}$$

$$\frac{\partial \mathcal{L}}{\partial \lambda_2} = u(q_L, L) - p_L \geq 0, \quad \lambda_2 \frac{\partial \mathcal{L}}{\partial \lambda_2} = 0, \tag{37}$$

$$\frac{\partial \mathcal{L}}{\partial \lambda_3} = u(q_H, H) - p_H - u(q_L, H) + p_L \geq 0, \ \lambda_3 \frac{\partial \mathcal{L}}{\partial \lambda_3} = 0, \tag{38}$$

$$\frac{\partial \mathcal{L}}{\partial \lambda_4} = u(q_L, L) - p_L - u(q_H, L) + p_H \geq 0, \ \lambda_4 \frac{\partial \mathcal{L}}{\partial \lambda_4} = 0. \tag{39}$$

As will be shown below, the first regime, $\alpha < \underline{\alpha}$ is divided into two sub-regimes, $\alpha < \underline{\underline{\alpha}}$ and $\alpha \in [\underline{\underline{\alpha}}, \underline{\alpha})$, and $\alpha > \overline{\alpha}$ is also divided into two sub-regimes, $\alpha \in (\overline{\alpha}, \overline{\overline{\alpha}}]$ and $\alpha > \overline{\overline{\alpha}}$. The following two Claims establish the binding constraints in each case.

Claim 8 $\lambda_3 \lambda_4 = 0$, *i.e.,* (10) *and* (11) *cannot be simultaneously binding.*

Proof. Suppose $\lambda_3 > 0$ and $\lambda_4 > 0$. Then, from (32) and (33), $\lambda_3 = \varphi_H - \lambda_1 + \lambda_4$ and $\lambda_4 = \beta\varphi_L - \lambda_2 + \lambda_3$. Also, from (34) and (35), $\lambda_3 = \frac{\varphi_H c}{u_q(q_H,H)} - \lambda_1 + \frac{u_q(q_H,L)}{u_q(q_H,H)}\lambda_4$ and $\lambda_4 = \frac{\beta\varphi_L c}{u_q(q_L,L)} - \lambda_2 + \frac{u_q(q_L,H)}{u_q(q_L,L)}\lambda_3$. These equations imply that $u_q(q_H, H) = u_q(q_L, L) = u_q(q_H, L) = u_q(q_L, H)$, which is not possible. ■

Claim 9 *If* $\lambda_4 = 0$ $(\lambda_3 = 0)$*, then* $\lambda_2 > 0$ $(\lambda_1 > 0)$ *and* $q_H^d = q_H^*$ $(q_L^d = q_L^*)$*. In other words,* (*i*) *if* (*10*) *is non-binding, then* (*6*) *is binding and* $q_H^d = q_H^*$*, and* (*ii*) *if* (*11*) *is non-binding, then* (*8*) *is binding and* $q_L^d = q_L^*$*.*

Proof. Suppose $\lambda_4 = \lambda_2 = 0$. (35) gives $\lambda_3 < 0$, which is a contradiction. From (32) and (34) with $\lambda_4 = 0$, we obtain $u_q(q_H, H) = c$, and thus $q_H^d = q_H^*$. Similarly, $\lambda_3 = \lambda_1 = 0$ yields $\lambda_4 < 0$ in (34), which is a contradiction. Also, (33) and (35) with $\lambda_3 = 0$, we obtain $u_q(q_L, L) = c$, and thus $q_L^d = q_L^*$. ■

By Claim 5 and 6, we can confine our attention to the five cases below. Case I, in which $\lambda_1 = 0$, $\lambda_2 > 0$, $\lambda_3 > 0$ and $\lambda_4 = 0$ ((9) and (10) are binding), Case II, in which $\lambda_1 > 0$, $\lambda_2 > 0$, $\lambda_3 > 0$ and $\lambda_4 = 0$ ((6), (9) and (10) are binding), Case III, in which $\lambda_1 > 0$, $\lambda_2 > 0$, $\lambda_3 = 0$ and $\lambda_4 = 0$ ((6) and (9) are binding), Case IV, in which $\lambda_1 > 0$, $\lambda_2 > 0$, $\lambda_3 = 0$ and $\lambda_4 > 0$ ((6), (9) and (11) are binding), and Case V, in which $\lambda_1 > 0$, $\lambda_2 = 0$, $\lambda_3 = 0$ and $\lambda_4 > 0$ ((6) and (11) are binding). We show that Case I and II belong to the regime of $\alpha < \underline{\alpha}$, Case III to the regime of $\alpha \in [\underline{\underline{\alpha}}, \underline{\alpha})$, and Case IV and V to the regime of $\alpha > \overline{\alpha}$. We denote

$$\underline{\underline{q_L}} \text{ by } u_q(\underline{\underline{q_L}}, L) = c + \frac{\varphi_H}{\beta\varphi_L} u_q^{\Delta}(\underline{\underline{q_L}}), \tag{40}$$

$$\underline{q_L} \text{ by } u^{\Delta}(\underline{q_L}) = \frac{\alpha}{1-\beta}, \tag{41}$$

$$\overline{q_H} \text{ by } u^{\Delta}(\overline{q_H}) = \frac{\alpha}{1-\beta}, \text{ and} \tag{42}$$

$$\overline{\overline{q_H}} \text{ by } u_q(\overline{\overline{q_H}}, H) = c - \frac{\beta\varphi_L}{\varphi_H} u_q^{\Delta}(\overline{\overline{q_H}}). \tag{43}$$

Case I: $\lambda_1 = 0$, $\lambda_2 > 0$, $\lambda_3 > 0$ and $\lambda_4 = 0$. Suppose α is close to zero. Then, the problem becomes a standard screening problem in which only (10) and (9) are binding. From (32) and (34) with $\lambda_4 = 0$, we have $u_q(q_H, H) = c$, and thus $q_H^d = q_H^m$ $(= q_H^*)$. To find q_L^d, we insert $\lambda_2 = \varphi_H + \beta\varphi_L$ into (35). We have:

$$u_q(q_L, L) = c + \frac{\varphi_H}{\beta\varphi_L} u_q^{\Delta}(q_L),$$

which implies $q_L^d = \underline{\underline{q_L}} < q_L^m$. Accordingly, $p_H^d = u(q_H^*, H) - u^{\Delta}(\underline{\underline{q_L}}) > p_H^m$ and $p_L^d = u(\underline{\underline{q_L}}, L) < p_L^m$. The non-binding constraint associated with λ_1 is written as:

$$u^{\Delta}(\underline{\underline{q_L}}) - \frac{\alpha}{1-\beta} > 0.$$

As α increases, the constraint will eventually be binding at $\alpha = \underline{\underline{\alpha}}$, where $\underline{\underline{\alpha}} = (1-\beta)u^{\Delta}(\underline{\underline{q_L}})$.

Case II: $\lambda_1 > 0$, $\lambda_2 > 0$, $\lambda_3 > 0$ and $\lambda_4 = 0$. As α becomes $\underline{\underline{\alpha}}$, the constraint linked to λ_1, (6), begins to bind as well. In this case, the binding (36), (37), and (38) give:

$$u^{\Delta}(q_L) = \frac{\alpha}{1-\beta},$$

which implies $q_L^d = \underline{q_L} \lesseqgtr q_L^F$, depending on the size of α. From (32) and (34) with $\lambda_4 = 0$, we have $q_H^d = q_H^m$ $(= q_H^*)$. From the binding constraints, we have $p_H^d = u(q_H^*, H) - \frac{\alpha}{1-\beta} \gtreqless p_H^m$ and $p_L^d = u(\underline{q_L}, L) \lesseqgtr p_L^m$. Case II is now valid when $\alpha \in [\underline{\underline{\alpha}}, \underline{\alpha})$, where $\underline{\alpha} = (1-\beta)u^{\Delta}(q_L^*)$. If α becomes greater than $\underline{\alpha}$, the constraint linked to λ_3, (10), becomes no longer binding.

Case III: $\lambda_1 > 0$, $\lambda_2 > 0$, $\lambda_3 = 0$ and $\lambda_4 = 0$. Only (6) and (9) are binding in this sub-regime. As in the above two cases, $\lambda_4 = 0$ implies that $q_H^d = q_H^*$. From (33) and (35) with $\lambda_3 = 0$ we have $q_L^d = q_L^*$. From the binding constraints, we have $p_H^d = u(q_H^*, H) - \frac{\alpha}{1-\beta} \left(= p_H^* - \frac{\alpha}{1-\beta}\right)$ and $p_L^d = u(q_L^*, L) = p_L^*$. The non-binding constraint related with λ_4, (11), is written as:

$$u^{\Delta}(q_H^*) > \frac{\alpha}{1-\beta}.$$

As α becomes larger, this constraint will bind at $\alpha = \overline{\alpha}$, where $\overline{\alpha} = (1-\beta)u^{\Delta}(q_H^*)$.

Case IV: $\lambda_1 > 0$, $\lambda_2 > 0$, $\lambda_3 = 0$ and $\lambda_4 > 0$. As $\alpha > \overline{\alpha}$, we consider the case where the constraint linked to λ_4, (11), begins to bind. Note that q_H^d is no longer q_H^* because of $\lambda_4 > 0$. Binding (36), (37), and (39) give:

$$u^{\Delta}(q_H) = \frac{\alpha}{(1-\beta)},$$

which implies $q_H^d = \overline{q_H} > q_H^*$. As in Case III, $\lambda_3 = 0$ implies that $q_L^d = q_L^*$. From the binding constraints, $p_H^d = u(\overline{q_H}, H) - \frac{\alpha}{1-\beta}$ $(< p_H^m)$ and $p_L^d = u(q_L^*, H) - \frac{\alpha}{1-\beta}$ $(< p_L^m)$. As α increases, p_L^d decreases and eventually the constraint linked to λ_2 becomes no longer binding at $\alpha = \overline{\overline{\alpha}}$, where $\overline{\overline{\alpha}}$ $= (1-\beta)u^{\Delta}(\overline{\overline{q_H}})$.

Case V: $\lambda_1 > 0$, $\lambda_2 = 0$, $\lambda_3 = 0$ and $\lambda_4 > 0$. Solving (32) and (33) together with $\lambda_2 = \lambda_3 = 0$, we obtain $\lambda_1 = \varphi_H + \beta\varphi_L$ and $\lambda_4 = \beta\varphi_L$. Thus, (34) is rewritten as:

$$u_q(q_H, H) = c - \frac{\beta\varphi_L}{\varphi_H} u_q^{\Delta}(q_H),$$

which implies $q_H^d = \overline{\overline{q_H}} > q_H^m = q_H^*$. As in Case III and IV, $\lambda_3 = 0$ implies that $q_L^d = q_L^*$. From the binding constraints, we have $p_H^d = u(\overline{\overline{q_H}}, H) - \frac{\alpha}{1-\beta}$ $(< p_H^m)$ and $p_L^d = u(q_L^*, L) - u_q^{\Delta}(\overline{\overline{q_H}}) - \frac{\alpha}{1-\beta}$ $(< p_L^m)$.

It follows that Case I and II belong to the regime of $\alpha < \underline{\alpha}$, Case III to the regime of $\alpha \in [\underline{\underline{\alpha}}, \underline{\alpha})$, and Case IV and V to the regime of $\alpha > \overline{\alpha}$. ■

Proof of Proposition 3.

By Proposition 1, the seller's expected profit with $\Psi = m$ is:

$$\Pi^m = \varphi_H \left[u(q_H^*, H) - cq_H^* - u^{\Delta}(q_L^m)\right] + \varphi_L \left[u(q_L^m, L) - cq_L^m\right] - \alpha.$$

Also, by Proposition 2, the seller's expected profit with $\Psi = C$ is:

$$\Pi^d = \begin{cases} \varphi_H \left[u(q_H^*, H) - cq_H^* - u^{\Delta}(\underline{\underline{q_L}})\right] + \beta\varphi_L \left[u(\underline{\underline{q_L}}, L) - c\underline{\underline{q_L}}\right] & \text{for } \alpha < \underline{\underline{\alpha}}, \\ \varphi_H \left[u(q_H^*, H) - cq_H^* - \frac{\alpha}{1-\beta}\right] + \beta\varphi_L \left[u(\underline{q_L}, L) - c\underline{q_L}\right] & \text{for } \alpha \in [\underline{\underline{\alpha}}, \underline{\alpha}), \\ \varphi_H \left[u(q_H^*, H) - cq_H^* - \frac{\alpha}{1-\beta}\right] + \beta\varphi_L \left[u(q_L^*, L) - cq_L^*\right] & \text{for } \alpha \in [\underline{\alpha}, \overline{\alpha}], \\ \varphi_H \left[u(\overline{q_H}, H) - c\overline{q_H} - \frac{\alpha}{1-\beta}\right] + \beta\varphi_L \left[u(q_L^*, L) - cq_L^* - \frac{\alpha}{1-\beta}\right] & \text{for } \alpha \in (\overline{\alpha}, \overline{\overline{\alpha}}], \\ \varphi_H \left[u(\overline{\overline{q_H}}, H) - c\overline{\overline{q_H}} - \frac{\alpha}{1-\beta}\right] + \beta\varphi_L \left[u(q_L^*, L) - cq_L^* - u_q^{\Delta}(\overline{\overline{q_H}}) - \frac{\alpha}{1-\beta}\right] & \text{for } \alpha > \overline{\overline{\alpha}}. \end{cases}$$

Claim 10 Π^C *is non-increasing and weakly concave in* α.

Proof. Applying the envelope theorem to the Lagrangian, we have $\frac{\partial \Pi^C}{\partial \alpha} = -\frac{\lambda_1(\alpha)}{1-\beta} \leq 0$. Now, we need to show

$$sign\left(\frac{\partial^2 \Pi^C}{\partial \alpha^2}\right) = sign\left(-\frac{\partial \lambda_1(\alpha)}{\partial \alpha}\right) \leq 0.$$

Let us find $\lambda_1(\alpha)$. From (32), $\lambda_1 = \varphi_H - \lambda_3 + \lambda_4$. Solving (33) and (35), we obtain $\lambda_3 = \beta\varphi_L \frac{u_q(q_L, L) - c}{u_q^{\Delta}(q_L)}$. Similarly, solving (32) and (34), we obtain $\lambda_4 = \max\left\{\varphi_H \frac{c - u_q(q_H, H)}{u_q^{\Delta}(q_H)}, 0\right\}$. As a result,

$$\lambda_1(\alpha) = \varphi_H - \beta\varphi_L \frac{u_q(q_L, L) - c}{u_q^{\Delta}(q_L)} + \max\left\{\varphi_H \frac{c - u_q(q_H, H)}{u_q^{\Delta}(q_H)}, 0\right\}.$$

It is immediate that $\frac{\partial \lambda_1(\alpha)}{\partial \alpha} = 0$ when $\alpha < \underline{\underline{\alpha}}$, $\alpha \in [\underline{\alpha}, \overline{\alpha}]$, and $\alpha > \overline{\overline{\alpha}}$, because q_H^*, $\overline{\overline{q_H}}$, q_L^*, and $\overline{\overline{q_L}}$ is independent of α. In other words, in these three regimes, Π^C is linearly decreasing. However, when $\alpha \in [\underline{\underline{\alpha}}, \underline{\alpha})$ or $\alpha \in (\overline{\alpha}, \overline{\overline{\alpha}}]$, we have to investigate the sign of $\frac{\partial \lambda_1(\alpha)}{\partial \alpha}$. First, when $\alpha \in [\underline{\underline{\alpha}}, \underline{\alpha})$, $\lambda_1(\alpha) = -\beta\varphi_L \frac{u_q(\underline{q_L}, L) - c}{u_q^{\Delta}(\underline{q_L})}$. Thus, a simple calculation gives

$$\frac{\partial \lambda_1(\alpha)}{\partial \alpha} = -\beta\varphi_L \frac{\left[u_{qq}(\underline{q_L}, L)u_q^{\Delta}(\underline{q_L}) - u_{qq}^{\Delta}(\underline{q_L})(u_q(\underline{q_L}, L) - c)\right]}{u_q^{\Delta}(\underline{q_L})^2} \frac{\partial \underline{q_L}}{\partial \alpha} > 0.$$

The terms in the bracket are negative under $\frac{u_{qq}(q,L)}{u_q(q,L)} \leq \frac{u_{qq}(q,H)}{u_q(q,H)}$. By applying the implicit function theorem to $u^{\Delta}(\underline{q_L}) = \frac{\alpha}{1-\beta}$, we have $\frac{\partial q_L}{\partial \alpha} = \frac{1}{(1-\beta)u_q^{\Delta}(\underline{q_L})} > 0$. Likewise, it can be easily checked that for $\alpha \in (\overline{\alpha}, \overline{\overline{\alpha}}]$, $\lambda_1(\alpha) = \varphi_H \frac{c-u_q(q_H,H)}{u_q^{\Delta}(q_H)}$ is decreasing in α. ■

Π^m is linearly decreasing, while Π^d is concavely decreasing in α. Also, note that $\Pi^m(\alpha = 0) > \Pi^d(\alpha = 0)$, while $\Pi^m(\alpha = \overline{\overline{\alpha}}) > \Pi^d(\alpha = \overline{\overline{\alpha}})$. Thus, if we find any α such that $\Pi^m(\alpha) < \Pi^d(\alpha)$, there should exist α_l and α_h so that $\Pi^m(\alpha) \geq \Pi^d(\alpha)$ for $\alpha \leq \alpha_l$ and $\alpha \geq \alpha_h$, but $\Pi^m(\alpha) < \Pi^d(\alpha)$ for $\alpha \in (\alpha_l, \alpha_h)$. Next, consider $\underline{\alpha} \equiv (1-\beta)u^{\Delta}(q_L^*)$. Then, we have:

$$\begin{aligned}\Pi^d\left(\alpha = \underline{\alpha}\right) - \Pi^m\left(\alpha = \underline{\alpha}\right) &= (1-\beta)u^{\Delta}(q_L^*) + \beta\varphi_L\left[u(q_L^*, L) - cq_L^*\right] \\ &\quad - \varphi_H\left[u^{\Delta}(q_L^*) - u^{\Delta}(q_L^m)\right] - \varphi_L\left[u(q_L^F, L) - cq_L^m\right]\end{aligned}$$

The first two terms are positive, whereas the last two terms are negative. Given L, as H increases (hence Δ increases), both $u^{\Delta}(q_L^*)$ and $u^{\Delta}(q_L^F)$ increase. On the other hand, $u(q_L^m, L) - cq_L^m$ become smaller due to a greater downward distortion in q_L^m. Therefore:

$$\lim_{H \to \infty} \Pi^d\left(\alpha = \underline{\alpha}\right) - \Pi^m\left(\alpha = \underline{\alpha}\right) > 0,$$

which implies that $\Pi^m(\alpha) < \Pi^d(\alpha)$ for $\alpha \in (\alpha_l, \alpha_h)$, where $\alpha_l < \underline{\alpha} < \alpha_h$. ■

Proof of Proposition 4.

With the possibility of sharing the transaction effort with the consumer, the participation constraints and incentive constraints are written accordingly as:

$$u(q_H, H) - p_H - \alpha(1 - e^m) \geq 0, \tag{44}$$

$$\left[e^m + (1 - e^m)\beta\right]\left[u(q_L, L) - p_L\right] \geq 0. \tag{45}$$

$$\begin{aligned}&u(q_H, H) - p_H - \alpha(1 - e^m) \\ &\geq \max\left\{\begin{array}{c} u(q_L, H) - p_L - \alpha(1 - e^m), \\ \left[e^m + (1 - e^m)\beta\right]\left[u(q_L, H) - p_L\right] \end{array}\right\},\end{aligned} \tag{46}$$

$$\begin{aligned}&\left[e^m + (1 - e^m)\beta\right]\left[u(q_L, L) - p_L\right] \\ &\geq \max\left\{\begin{array}{c} u(q_H, L) - p_H - \alpha(1 - e^m), \\ \left[e^m + (1 - e^m)\beta\right]\left[u(q_H, L) - p_H\right] \end{array}\right\}.\end{aligned} \tag{47}$$

Thus, the seller solves the following problem:

$$\underset{q,p,e}{Max}\, \Pi^s = \varphi_H\left(p_H - cq_H\right) + \varphi_L\gamma(e^m)\left[p_L - cq_L\right] - \alpha e^m,$$

subject to (15), (16), (44), (45), (46) and (47).

The structure of the problem is the same as the seller's problem with $\Psi = d$ where the type-H consumer exerts an effort of $e = 1$ (Proof of Proposition 2). As in Proof of Proposition 2, there are multiple cases here, depending on the parameters. We focus on the case where α is large enough that (15) and (45) are the binding constraints, instead of (46) and (45) — Case III in Proof of Proposition 2. We will first obtain the solution within this regime with only (15) and (45) to show that these constraints are in fact binding. Then, we characterize the cutoff value of α for this regime. It can be easily shown that the other constraints are satisfied in this regime. With (15) and (45), the Lagrangian of the seller's problem can be written as:

$$\begin{aligned}\mathcal{L} = {} & \varphi_H (p_H - cq_H) + [e^m + (1-e^m)\beta]\,\varphi_L (p_L - cq_L) - \alpha e^m \\ & + \delta_1 \{u(q_H, H) - p_H - \alpha(1-e^m) - [e^m + (1-e^m)\beta]\,[u(q_H,H) - p_H]\} \\ & + \delta_2 \{[e^m + (1-e^m)\beta]\,[u(q_L, L) - p_L]\}\end{aligned}$$

The first order conditions are:

$$\frac{\partial \mathcal{L}}{\partial p_H} = \varphi_H - \delta_1 \{1 - [e^m + (1-e^m)\beta]\} = 0, \tag{48}$$

$$\frac{\partial \mathcal{L}}{\partial p_L} = [e^m + (1-e^m)\beta]\,(\varphi_L - \delta_2) = 0, \tag{49}$$

$$\begin{aligned}\frac{\partial \mathcal{L}}{\partial e^m} = {} & (1-\beta)\varphi_L (p_L - cq_L) - \alpha \\ & + \delta_1 \{\alpha - (1-\beta)\,[u(q_H, H) - p_H]\} + \delta_2 (1-\beta)\,[u(q_L, L) - p_L] \le 0.\end{aligned} \tag{50}$$

Notice first that, if $e^m = 1$, then we have a contradiction in (48) — with the marketing strategy (only the seller exerts the transaction effort), as shown in Proposition 1, (15) becomes irrelevant since no effort from the consumer needs to be induced. That is, α is large enough that $\partial \mathcal{L}/\partial e^m$ cannot be strictly positive in this regime, and $e^m < 1$. Then, $e^m + (1-e^m)\beta \in (0,1)$, and it is implied from (48) that $\delta_1 > 0$. Therefore, (15) is binding and:

$$u(q_H, H) - p_H - \alpha(1-e^m) = [e^m + (1-e^m)\beta]\,[u(q_H, H) - p_H]\,. \tag{51}$$

If $e^m = 1$, then this, after a simple manipulation, becomes:

$$u(q_H, H) - p_H = \frac{\alpha}{1-\beta}. \tag{52}$$

Also, from (49), $\delta_2 = \varphi_L > 0$, and therefore (45) is binding and:

$$u(q_L, L) - p_L = 0. \tag{53}$$

Replacing p_H and p_L with their values in the objective function and optimizing in q_H and q_L, we have:

$$u_q(q_H^s, H) = c \quad \text{and} \quad u_q(q_L^s, L) = c,$$

implying that $q_H^s = q_H^*$ and $q_L^s = q_L^*$. Using (52) and (53), we can replace the consumer surplus with their values in (50). We then have:

$$u(q_L^s, L) - cq_L^s \leq \frac{\alpha}{\varphi_L(1-\beta)}. \tag{54}$$

Again, in this regime, α is large enough that the week inequality in (54) holds. Therefore, if φ_L is small enough, the inequality in (54) is strictly satisfied and $e_m = 0$.

When $e_m = 0$ (φ_L is small enough), the optimal outcome is exactly the same as the one in Case III in Proof of Proposition 2, and so is the cutoff α, i.e., the outcome here is optimal for $\alpha \in [\underline{\alpha}, \overline{\alpha}]$, where $\underline{\alpha} = (1-\beta)u^{\Delta}(q_L^*)$ and $\overline{\alpha} = (1-\beta)u^{\Delta}(q_H^*)$. Showing that demarketing is optimal is the same as in Proposition 3. ■

Proof of Proposition 5.

First, (8) is implied by (17) and (9):

$$\begin{aligned} u(q_H, H) - p_H - s &\geq \beta\left[u(q_L, H) - p_L\right] \\ &\geq \beta\left[u(q_L, L) - p_L\right] \geq 0. \end{aligned}$$

Thus, (8) is not binding. Next we show that (18) is non-binding. After rearranging (17), we have: $\alpha \geq u(q_H, H) - p_H - \beta\left(u(q_L, H) - p_L\right)$. Similarly, (18) is written as $\alpha \geq u(q_H, L) - p_H - \beta\left[u(q_L, L) - p_L\right]$. These two inequalities imply that the latter is always satisfied because $u^{\Delta}(q_H) > \beta u^{\Delta}(q_L)$ regardless of (17). Since (8) and (18) are non-binding, the Lagrangian of the seller's problem can be written as:

$$\begin{aligned} \mathcal{L} = {} & \varphi_H\left(p_H - cq_H\right) + \beta\varphi_L\left(p_L - cq_L\right) \\ & + \mu_1\left[u(q_H, H) - p_H - \alpha - \beta\left(u(q_L, H) - p_L\right)\right] \\ & + \mu_2[u(q_L, L) - p_L] \\ & + \mu_3\left[u(q_H, H) - p_H - u(q_L, H) + p_L\right] \end{aligned}$$

The first order conditions are:

$$\frac{\partial \mathcal{L}}{\partial p_H} = \varphi_H - \mu_1 - \mu_3 = 0, \tag{55}$$

$$\frac{\partial \mathcal{L}}{\partial p_L} = \beta\varphi_L + \beta\mu_1 - \mu_2 + \mu_3 = 0, \tag{56}$$

$$\frac{\partial \mathcal{L}}{\partial q_H} = -\varphi_H c + \left(\mu_1 + \mu_3\right) u_q(q_H, H) = 0, \tag{57}$$

$$\frac{\partial \mathcal{L}}{\partial q_L} = -\beta\varphi_L c + \mu_2 u_q(q_L, L) - \left(\mu_1\beta + \mu_3\right) u_q(q_L, H) = 0, \tag{58}$$

$$\frac{\partial \mathcal{L}}{\partial \mu_1} = u(q_H, H) - p_H - \alpha - \beta\left(u(q_L, H) - p_L\right) \geq 0, \quad \mu_1 \frac{\partial \mathcal{L}}{\partial \mu_1} = 0, \tag{59}$$

$$\frac{\partial \mathcal{L}}{\partial \mu_2} = u(q_L, L) - p_L \geq 0, \quad \mu_2 \frac{\partial \mathcal{L}}{\partial \mu_2} = 0, \tag{60}$$

$$\frac{\partial \mathcal{L}}{\partial \mu_3} = u(q_H, H) - p_H - u(q_L, H) + p_L \geq 0, \ \mu_3 \frac{\partial \mathcal{L}}{\partial \mu_3} = 0, \tag{61}$$

As will be shown below, the first regime, $\alpha < \widetilde{\alpha}$, is divided into two sub-regimes: $\alpha < \underline{\underline{\alpha}}$ and $\alpha \in [\underline{\underline{\alpha}}, \widetilde{\alpha})$.

Case I: $\mu_1 = 0, \mu_2 > 0$, and $\mu_3 > 0$. Suppose α is small enough. Then, the problem is reduced to a standard problem. We obtain $\widetilde{q}_H^d = q_H^*$ and $\widetilde{q}_L^d = \underline{\underline{q_L}}$ as in Case I in the full menu case. The non-binding constraint associated with μ_1 is written as:

$$u^{\Delta}(\underline{\underline{q_L}}) - \frac{\alpha}{(1-\beta)} > 0.$$

Accordingly, $\widetilde{p}_H^d = u(q_H^*, H) - u^{\Delta}(\underline{\underline{q_L}}) > p_H^m$ and $\widetilde{p}_L^d = u(\underline{\underline{q_L}}, L) < p_L^m$. As α becomes large, the constraint will be binding at $\alpha = \underline{\underline{\alpha}}$, where $\underline{\underline{\alpha}} \equiv (1-\beta)u^{\Delta}(\underline{\underline{q_L}})$.

Case II: $\mu_1 > 0, \mu_2 > 0$, and $\mu_3 > 0$. As α becomes $\underline{\underline{\alpha}}$, the three constraints, (59), (60), and (61), simultaneously bind. Thus, in this case, $\widetilde{q}_H^d = q_H^*$, and $\widetilde{q}_L^d$ is characterized as:

$$u^{\Delta}(\widetilde{q}_L^d) = \frac{\alpha}{(1-\beta)}.$$

This case is valid when $\alpha \in [\underline{\underline{\alpha}}, \widetilde{\alpha})$, where $\widetilde{\alpha} = (1-\beta)u^{\Delta}(q_L^F)$ and $\underline{\underline{\alpha}}$ is defined in the Proof of Proposition 2. From the binding constraints, we have $\widetilde{p}_H^d = u(q_H^*, H) - \beta u^{\Delta}(\underline{q_L}) - \alpha$ and $\widetilde{p}_L^d = u(\widetilde{q}_L^d, L)$. If α becomes larger than $\widetilde{\alpha}$, then (10) becomes no longer binding.

Case III: $\mu_1 > 0, \mu_2 > 0$, and $\mu_3 = 0$. Next, when $\alpha > \widetilde{\alpha}$, only (17) and (9) are binding. Substituting (17) and (9) into the seller's objective function, we obtain

$$\varphi_H\left(u(q_H, H) - \alpha - \beta u^{\Delta}(q_L) - cq_H\right) + \beta\varphi_L\left(u(q_L, L) - cq_L\right).$$

The first order conditions give $\widetilde{q}_H^d = q_H^*$ and $\widetilde{q}_L^d = q_L^F$. Note that β does not affect the choice of $\widetilde{q}_L^d$, which is characterized by $u_q(\widetilde{q}_L^d, L) = c + \frac{\varphi_H}{\varphi_L} u_q^{\Delta}(\widetilde{q}_L^d)$. From the binding constraints, $\widetilde{p}_H^d = u(q_H^*, H) - \beta u^{\Delta}(q_L^m) - \alpha$ and $\widetilde{p}_L^d = u(q_L^m, L)$.■

Proof of Proposition 6.

By proposition 4, the seller's expected profit with $\Psi = \widetilde{d}$ is:

$$\widetilde{\Pi}^d = \begin{cases} \varphi_H\left[u(q_H^*, H) - cq_H^* - u^{\Delta}(\underline{\underline{q_L}})\right] + \beta\varphi_L\left[u(\underline{\underline{q_L}}, L) - c\underline{\underline{q_L}}\right] & \text{for } \alpha < \underline{\underline{\alpha}}, \\ \varphi_H\left[u(q_H^*, H) - cq_H^* - \frac{\alpha}{1-\beta}\right] + \beta\varphi_L\left[u(\underline{q_L}, L) - c\underline{q_L}\right] & \text{for } \alpha \in [\underline{\underline{\alpha}}, \widetilde{\alpha}), \\ \varphi_H\left[u(q_H^*, H) - cq_H^* - \beta u^{\Delta}(q_L^m) - \alpha\right] + \beta\varphi_L\left[u(q_L^m, L) - cq_L^m\right] & \text{for } \alpha \geq \widetilde{\alpha}. \end{cases}$$

Like $\Pi^d(\alpha)$, it can be shown that $\widetilde{\Pi}^d(\alpha)$ is non-increasing and weakly concave in α. It is clear that $\Pi^d(\alpha) = \widetilde{\Pi}^d(\alpha)$ for $\alpha \leq \widetilde{\alpha}$.

Note that $\widetilde{\Pi}^d(\alpha)$ is decreasing in α more slowly than $\Pi^d(\alpha)$ and $\Pi^m(\alpha)$ for $\alpha > \underline{\alpha}$, where $\underline{\alpha}$ is defined in Definition 1. Thus, if we find $\widetilde{\Pi}^d(\alpha) < \Pi^d(\alpha)$ at a certain α, then there must exist $\widetilde{\alpha}_h < \alpha_h$ such that $\widetilde{\Pi}^d(\alpha) > \max\{\Pi^d(\alpha), \Pi^m(\alpha)\}$ for $\alpha > \widetilde{\alpha}_h$. Below we provide a sufficient condition for it. We compare $\widetilde{\Pi}^d(\alpha)$ and $\Pi^d(\alpha)$ at $\alpha = \underline{\alpha}$ to find:

$$\widetilde{\Pi}^d(\alpha = \underline{\alpha}) - \Pi^d(\alpha = \underline{\alpha}) < 0 \Leftrightarrow \frac{\varphi_H}{\varphi_L} < \frac{[(u(q_L^*, L) - cq_L^*) - (u(q_L^m, L) - cq_L^m)]}{\left[u^{\Delta}(q_L^*) - u^{\Delta}(q_L^F)\right]}.$$

Thus, the seller's choice of $\Psi = \widetilde{d}$ generates a higher profit when α is sufficiently large. ■

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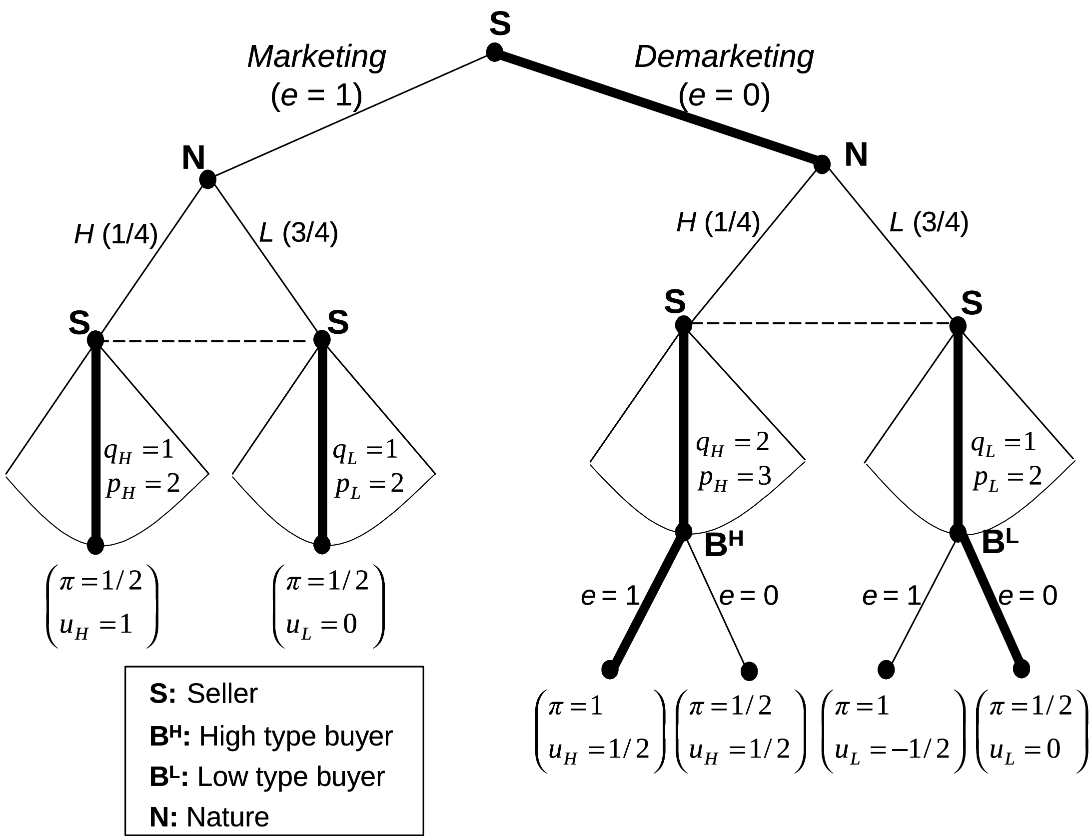

Figure 1 Game Tree of the Illustrative Example

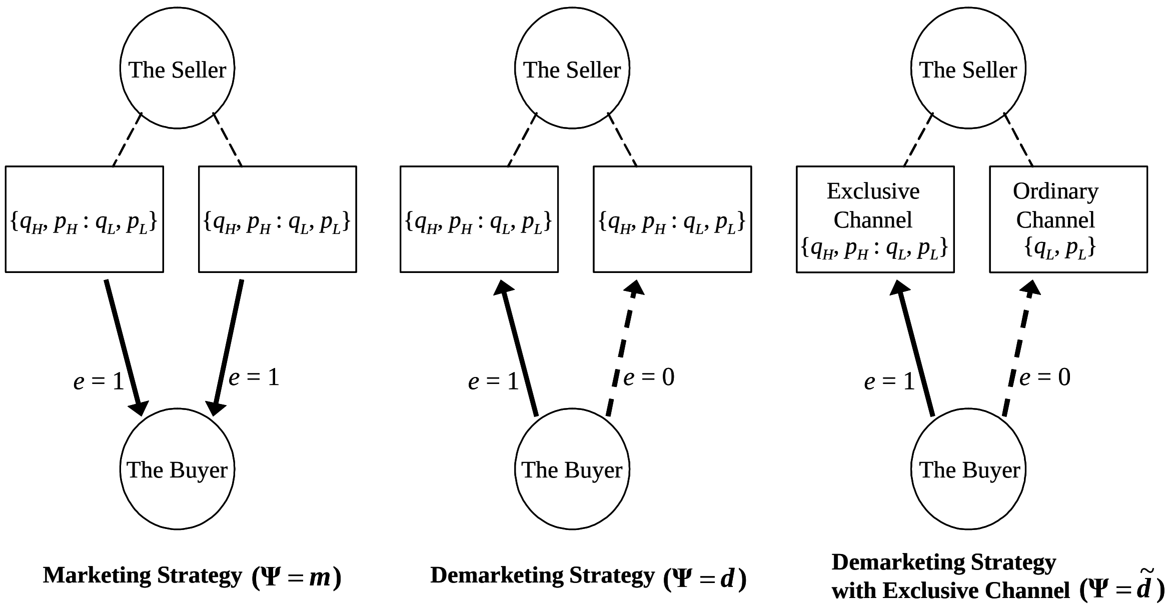

Figure 2 Marketing, Demarketing and Exclusive Channel

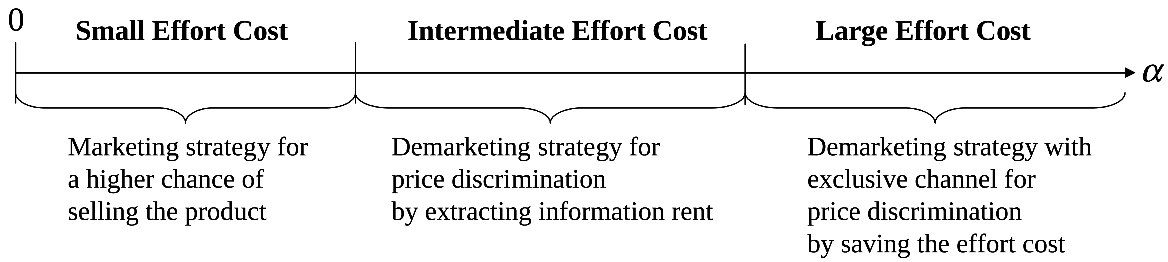

Figure 3 The Effort Cost and the Seller's Optimal Strategy