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# (De)marketing to Manage Consumer Quality Inferences

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## Abstract

Savvy consumers attribute a product’s market performance to its intrinsic quality as well as the seller’s marketing push. This paper studies how sellers should optimize their marketing decisions in response. The authors find that a seller can benefit from “demarketing” its product, meaning visibly toning down its marketing efforts. Demarketing lowers expected sales *ex ante* but improves product quality image *ex post*, as consumers attribute good sales to superior quality and lackluster sales to insufficient marketing. The authors derive conditions under which demarketing can be a recommendable business strategy. A series of experiments confirm these predictions.

*Key words:* demarketing; observational learning; quality inference; new product adoption; analytical modeling.

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Good marketing contributes to product success. However, the very effectiveness of marketing can be a concern to companies if consumers attribute product success to marketing rather than to product quality. We often hear comments such as “the restaurant is popular because of its convenient location” and “the product sold well because it was heavily promoted.” A Google search of the phrase “it’s just marketing” yields more than one million hits, many of which associate the efficacy of marketing with a product’s lack of substance.

Consumers’ ability to draw savvy attributions has been documented in academic research. For example, Tucker and Zhang (2011) find that consumers are more likely to visit popular vendors, especially those at inconvenient locations. This happens as consumers attribute vendor popularity to location versus quality—in their perception, a popular yet faraway vendor’s quality must be excellent to overcome its locational inconvenience. Zhang and Liu (2012) show evidence of attribution in microloan markets, where individuals borrow and lend money on an open platform. Lenders prefer borrowers who are already well-funded, especially those with obvious shortcomings such as poor credit grades. This is because lenders attribute the unexpected funding success of disadvantaged borrowers to their creditworthiness that is privately observed by other lenders.

How, then, should the supply side respond to consumer attribution? Should vendors settle for inconvenient locations? Should lenders work to lower their credit grades? Counterintuitive as it sounds, there are observations of decision-makers who voluntarily choose adverse conditions to manage how they are perceived by others. For example, Katok and Siemsen (2011) find that agents in laboratory experiments choose more difficult tasks to appear capable. The psychology literature also documents widespread “self-handicapping” behaviors, such as abusing alcohol and setting unrealistic goals, which allow individuals to take credit for success and find excuses for failure (e.g., Jones and Berglas 1978; Kolditz and Arkin 1982; Smith, Snyder and Perkins 1983). However, it is theoretically unclear whether it is an *ex ante* optimal strategy to seek adversity. In the language of Harbaugh (2011), “self-handicapping makes losing more frequent even as it makes losing less painful, so it is unclear why people should prefer to self-handicap.”

The objective of this paper is to formally analyze how companies should optimize their marketing efforts when consumers actively attribute a product’s performance in the marketplace to product quality as well as marketing. We are particularly interested in whether, and under which conditions, a company finds it optimal *ex ante* to adopt a “demarketing”

strategy. We define demarketing as pursuing a marketing activity although another marketing activity that could have improved the product’s market performance is available to the company. Demarketing is thus relative; it does not require companies to actively shun away customers. Demarketing can take many forms, such as choosing inconvenient locations, omitting useful product features, offering limited services, understocking inventory, reducing advertising intensity, or launching a product during the off season.

We analyze the effect of demarketing in the context of new product introduction using a two-period model. A monopolist seller privately knows the quality of its product, which can be either high or low. A buyer’s willingness to pay depends on her perception of the product’s quality. For concreteness, suppose the seller can choose between two levels of marketing efforts: marketing and demarketing, whereby higher marketing efforts increase the expected share of buyers who consider the product. To rule out a simple cost explanation of demarketing, we assume that higher marketing efforts do not impose additional costs.

In the first period, the seller publicly sets the level of marketing efforts and an introductory price. Each first-period consumer (referred to as “early consumer” thereafter) who considers the product conducts a private inspection which imperfectly reveals product quality, and then decides whether to buy. In the second period, first-period sales volume becomes publicly observed. The seller then sets the price for a new generation of “late consumers,” who decide whether to buy based on their observation of first-period marketing efforts, first-period sales, as well as their own inspection outcomes. Late consumers do not observe whether an early consumer considered the product because product consideration, unlike product purchase, is typically a private process (Van den Bulte and Lilien 2004).

Demarketing improves quality image *ex post* in the following way. Suppose an early consumer chose not to buy the product. Late consumers can have two interpretations. It could be that this early consumer simply did not consider the product due to insufficient marketing, or that she considered the product but detected a flaw during her inspection. The second interpretation hurts the seller’s quality image, and demarketing works to shift attention away from it. The downside of demarketing, as discussed earlier, is that it reduces expected sales in the first period.

We find that demarketing can emerge as the *ex ante* optimal strategy under the following conditions. First, the relative mass of late consumers is sufficiently large. Intuitively, demarketing builds a long-run quality image at the cost of current sales, and is thus worthwhile only

when the future market is sufficiently important. Second, buyers' prior quality perception is neither too pessimistic nor too optimistic. If buyers are very pessimistic, the seller in period one should try to achieve stellar sales—sales volumes unattainable by a low-quality seller—to prove its high quality to late consumers. If buyers are very optimistic, there is little room for improvement in quality perception and thus little return to demarketing. The seller's imperative then is to serve as many buyers as possible, who are willing to pay a high price anyway. In both cases, the seller should market intensively in period one.

A series of human subject experiments confirm the main predictions of the model. Buyers' quality beliefs decrease with marketing efforts for a given sales volume. Sellers are more likely to choose demarketing when consumers are uncertain about product quality and when the market is fast growing. In addition, sellers are less likely to choose demarketing when consumers cannot observe either past sales or past marketing efforts. Finally, enhancing the salience of buyer quality inference increases the choice incidence of demarketing, which suggests that subjects do consider demarketing with quality image management in mind.

We extend the model to explore how sellers should adjust their (de)marketing decisions in a rich set of market situations. We find that the demarketing incentive decreases if marketing improves buyers' prior quality beliefs, can be non-monotonic over time if there are more than two periods, and is invariant to heterogeneous buyer willingness to pay for quality. Counter-intuitively, sellers may be more likely to choose demarketing if marketing accelerates buyer arrival, or if consumers are able to directly communicate with their predecessors. Moreover, when sellers are uncertain about their own quality, we uncover a separating equilibrium in which a seller with greater confidence in its quality chooses demarketing to establish a strong quality image, whereas an unconfident seller pursues marketing to grow short-run demand.

New normative insights emerge as we reconsider familiar marketing problems from the demarketing perspective. For example, contrary to recommendations from the advertising scheduling literature, a firm may benefit from conservative advertising during the early phase of its product life cycle. In case of slow takeoff, consumers can attribute it to insufficient advertising instead of inadequate product quality. Similarly, targeting the market with the best taste match does not always help a firm, because lukewarm response in a supposedly friendly market is a particularly worrisome sign of product quality.

In the following sections, we will review the literature, introduce the setup of the main model, present the analysis and results, and report empirical validation of the model's key

predictions. We then extend the main model to accommodate a set of market features, and conclude with a discussion of future research. Proofs and other technical details are relegated to the Web Appendix.

## 1 Relation to Previous Research

### 1.1 Demarketing

The demarketing phenomenon attracted the attention of academic researchers in the 1970's. Kotler and Levy (1971) outline several possible reasons why firms would demarket their products. “General demarketing” aims to shed excess demand; “selective demarketing” helps a seller drop undesirable market segments; “ostensible demarketing” creates a perception of limited supply to actually attract customers. Consistent with the notion of ostensible demarketing, Cialdini (1985) suggests that humans have a psychological tendency to desire things that are less available, Amaldoss and Jain (2005) show that limited availability satisfies consumers’ need for uniqueness, and Stock and Balachander (2005) demonstrate that scarcity can signal high quality.<sup>1</sup> Gerstner, Hess, and Chu (1993) propose the concept of “differentiating demarketing,” whereby a firm introduces a nuisance attribute to differentiate from competition if consumers have heterogenous tolerance for this nuisance attribute.

We study a different market force. First, in our model the seller suppresses marketing today to grow demand tomorrow, rather than to lower demand generally in response to capacity constraints. Second, the purpose of demarketing is not to abandon any unprofitable market segment, but to build a high quality image in the late consumer segment. In fact, we find that the larger this segment, the more likely the seller will pursue demarketing. Third, unlike ostensible demarketing which actually attracts consumers, demarketing in our framework discourages demand (in the short run) by lowering the expected number of consumers who consider the product. Last, we consider a monopolistic seller who is under no competitive pressure to differentiate. By making these assumptions, we focus on the role of demarketing in managing buyers’ attribution process.

In another related study, Zhao (2000) shows that a high-quality-high-cost firm spends less on awareness advertising than a low-quality-low-cost firm (see also Bagwell and Overgaard

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<sup>1</sup>In a related study, Berger and Le Mens (2009) find that first names which enjoy fast initial adoption are less likely to persist because people perceive fads negatively.

2005 for a generalized model). By lowering awareness and reducing market coverage, the high-type firm discourages mimicry from its low-quality-low-cost counterpart who prefers to stay in the volume business. In our model, by contrast, the key intuition behind demarketing is present even in pooling equilibria. Anticipating the mimicry from its low-quality counterpart, a high-quality seller may still choose demarketing to improve its expected profit.

Finally, expectations management may be another reason why firms want to tone down their marketing efforts (e.g., Ho and Zheng 2004; Kopalle and Lehmann 2006; Joshi and Musalem 2011). For example, Kopalle and Lehmann (2006) show that companies deliberately understate quality because customers derive satisfaction from being pleasantly surprised, which in turn drives repeat purchase. In general, expectations management emphasizes buyers' comparison between expectations and experience, highlights the intrapersonal aspect of consumer decision-making, and is more relevant for "experience goods" whereby satisfied customers take further actions such as buying again or referring the product to others. In comparison, our theory focuses on buyers' attribution of sales outcome to various causes, emphasizes the interpersonal aspect of decision-making, and is relevant even in a "search goods" category and even if buyers exit the market right after purchase without making product recommendations (see Nelson 1970 for a discussion of experience goods versus search goods).

## 1.2 Observational Learning

The way buyers infer product quality from product sales is related to the "observational learning" literature. Observational learning means learning the fundamental value of an object (e.g., quality) by observing other decision-makers' actions (e.g., purchase decisions), which reflect their private information about the object. Banerjee (1992), and Bikhchandani, Hirshleifer, and Welch (1992) prove that the mere observation of peer decisions may lead to uniform choices within a society. A few studies expand this literature by exploring supply-side pricing strategies given buyer observational learning. For example, Caminal and Vives (1996) examine a duopoly market where buyers infer product quality from market share, and where sellers secretly cut price to compete for market share. Taylor (1999) derives optimal real estate pricing strategies when a house's long time on the market raises doubts over its quality. Bose et al. (2006) study the long-run dynamic pricing decisions of a monopolistic seller who does not know the quality of its product.<sup>2</sup>

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<sup>2</sup>Empirical evidence of observational learning has been documented in a variety of contexts, such as restaurant ordering (Cai, Chen, and Fang 2009), transplant kidney adoption (Zhang 2010), product purchase on the

Our paper extends the observational learning literature in the following ways. We consider a monopolistic seller who privately knows its quality as in Taylor (1999), but we do not confine ourselves to products such as houses that only serve one buyer and thus can only generate negative observational learning. Furthermore, our analysis goes beyond pricing and explores a broadly defined set of marketing efforts.<sup>3</sup> Last, we allow buyers to fully observe prices and marketing efforts, which distinguishes our model from the signal jamming mechanism that underlies Caminal and Vives (1996). In signal jamming models (see also Fudenberg and Tirole 1986; Holmström 1999; Iyer and Kuksov 2010; Kuksov and Xie 2010), the seller takes a hidden action to influence an observable outcome. In our model, the seller takes conspicuous actions (pricing and marketing effort choices) to influence how buyers interpret an observed outcome.

## 2 Model Setup

### 2.1 Market Environment

We consider a monopolistic seller of a product. The seller privately observes its product quality  $q$ , which could be either high ( $H$ ) or low ( $L$ ). The marginal cost of production is the same for both seller types, which is realistic when quality-related investments are sunk, and can be normalized to zero (see Stock and Balachander 2005 for the same assumption and a detailed discussion).

Buyers fall into two segments: early consumers and late consumers. Segmentation is determined by exogenous factors such as the time a buyer arrives on the market. (We examine endogenous segmentation in the extensions section.) There is a continuum of early consumers whose measure is normalized to 1, and a continuum of late consumers of mass  $\delta > 0$ .<sup>4</sup> Buyers have unit demands for the product, but cannot observe product quality. We make the normalization assumption that a buyer who believes that the product is good with probability  $\mu \in [0, 1]$  is willing to pay  $\mu$  for the product. Buyers share the common prior belief that product quality is high with probability  $\mu_0 \in (0, 1)$ . The seller knows the value of  $\mu_0$ .<sup>5</sup>

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internet (Chen, Wang, and Xie 2011), and lending in microloan markets (Zhang and Liu 2012).

<sup>3</sup>In a related study, Gill and SgROI (2012) show that choosing a tough pre-launch product reviewer can be optimal for a seller of a new product of unknown quality.

<sup>4</sup>For brevity we interpret  $\delta$  as the relative mass of late consumers. However,  $\delta$  also captures the seller's degree of patience for future payoffs. Adding a temporal discounting parameter increases the notational burden in this context without bringing new insights.

<sup>5</sup>We assume a common prior belief to identify how consumers' private information and observations of



We analyze the market dynamics with a two-period model. Figure 1 presents the timing of the game. At the start of the first period, the seller sets the level of marketing efforts  $a$  and an introductory price  $p_1$  that target early consumers. Both decisions are publicly observed. For concreteness, we consider two levels of marketing efforts  $\bar{a} > \underline{a}$ , where  $\underline{a}$  corresponds to demarketing. To identify the strategic forces—rather than mere cost concerns—that lead to demarketing, we deliberately assume that the cost of marketing is the same for both marketing levels, and we normalize it to zero (see Gerstner, Hess, and Chu 1992 for the same assumption).<sup>6</sup>

[Insert Figure 1 about here]

Research on new product adoption often distinguishes two stages that lead to final product choice: the consideration stage and the evaluation stage, with marketing efforts typically affecting consideration (Hauser and Wernerfelt 1990; Urban, Hauser and Roberts 1990; Villas-Boas 1993; Van den Bulte and Lilien 2004). For concreteness, we focus on marketing efforts that raise buyer interest and increase the expected number of consumers who consider the product. Examples of marketing efforts that build consideration include convenient locations that reduce buyers’ transportation costs, devices that lower buyers’ search costs, information campaigns that introduce product features, and advertising that spurs interest among otherwise passive buyers. Nevertheless, the key intuition behind demarketing applies to other types of demand-enhancing marketing efforts (see the Web Appendix).

Let  $x$  denote the share of early consumers who consider buying the product, also referred to as “buyer interest.” The actual level of interest that marketing efforts generate is often influenced by random factors (Mahajan, Muller and Kerin 1984; Urban, Hauser and Roberts 1990). To capture this randomness, we assume that given any level of marketing efforts  $a$ , buyer interest  $x$  follows a conditional probability distribution function  $f(x|a)$ , where  $x \in [\underline{x}, \bar{x}]$

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market outcomes endogenously lead to heterogeneous posterior beliefs. This assumption could hold, for instance, in new product markets where buyers share a similar lack of pre-existing knowledge about the product. Prior beliefs may be category-specific. For example, in a category dominated by technological inventions from established brands, consumers are likely to hold optimistic prior beliefs.

<sup>6</sup>There are situations where this assumption holds. For example, a marketing manager can have a predetermined advertising budget whereby any unspent resources do not carry over; a merchant can choose whether to list its phone number on its website, an action that is readily implementable; a movie studio can decide whether to make an optimistic or pessimistic box office forecast, neither of which is obviously more costly than the other (Goldstein 2009). In a broader context, a company can choose between two marketing plans that are close in budget yet different in efficacy—the cost-effectiveness of marketing campaigns does vary in reality.

and  $0 \leq \underline{x} < \bar{x} \leq 1$ . We further assume that  $f(x|a)$  satisfies the strict monotone likelihood ratio property (MLRP) in  $a$  (Milgrom 1981). Strict MLRP requires that, for any two buyer interest levels, the relative chance of achieving the higher interest level strictly increases with marketing efforts. Formally, for any  $x > x'$ , where  $x, x' \in [\underline{x}, \bar{x}]$ , and any  $a > a'$ :

$$\frac{f(x|a)}{f(x'|a)} > \frac{f(x|a')}{f(x'|a')}. \quad (1)$$

A frequently used assumption in mechanism design theories, the MLRP implies that marketing efforts increase expected buyer interest in the sense of first order stochastic dominance.

We can think of the product as a search good that consumers can inspect and evaluate prior to purchase. Once marketing efforts have spurred interest in the product, every consumer who considers the product conducts a private inspection. Let the quality signal  $s$  represent the consumers' inspection outcome. The value of the quality signal can be either good ( $G$ ) or bad ( $B$ ). We assume that quality signals are identically and independently distributed across consumers conditional on the true quality level:

$$\begin{aligned} \Pr(s = G|q = H) &= 1, \\ \Pr(s = G|q = L) &= b \in (0, 1). \end{aligned} \quad (2)$$

One interpretation of the above distribution is that consumers inspect a product for defects. While a truly high-quality product should be defect free, a low-quality product may still survive scrutiny with probability  $b$ .<sup>7</sup> In this sense, inspection is imperfect—if inspection perfectly reveals quality ( $b = 0$ ), then there is no need for late consumers to engage in observational learning. Each interested early consumer observes her own inspection outcome  $s$ , and all interested early consumers simultaneously decide whether to buy at price  $p_1$ .<sup>8</sup>

In the second period, the seller observes the volume of sales it has achieved among early consumers, denoted by  $m$ , and sets the price  $p_2$  for late consumers. All late consumers observe  $a$ ,  $m$ ,  $p_1$ , and  $p_2$ . However, late consumers do not observe  $x$ , the precise number of

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<sup>7</sup>In an earlier version of the paper, we allow a high-quality product to generate a good signal with probability less than 1 but greater than  $b$ . This specification complicates exposition but leads to the same key results. The analysis is available upon request.

<sup>8</sup>We make the conservative assumption that early consumers who do not consider the product exit the market at the end of the first period. Alternatively, if these early consumers remain in the market as potential buyers in the second period, the high-quality seller could have even stronger incentives to pursue demarketing because demarketing improves the quality beliefs of a larger segment of late consumers. In the extensions section we formally model the endogenous segmentation of buyers across the two periods.

early consumers who considered the product. This is because product consideration is not an overt buyer behavior, unlike product adoption which tends to leave a paper trail (Van den Bulte and Lilien 2004). Similarly, late consumers do not directly access the inspection outcomes of early consumers. As a result, late consumers can have two interpretations of why some early consumers did not buy—it could be that early consumers did not consider the product due to insufficient marketing, or considered it but were discouraged by unfavorable inspection outcomes. As we shall see, this ambiguity in interpretation allows marketing efforts to affect late consumers’ attribution process.

The seller should in principle also determine the level of marketing efforts in the second period. However, because there is no need to influence quality beliefs beyond late consumers in a two-period model, the seller would always want to maximize costless marketing efforts in period two. We therefore assume that all late consumers consider the product in order to simplify presentation without weakening the main message. Correspondingly, unless otherwise indicated, by marketing efforts we specifically refer to those that target early consumers.<sup>9</sup>

Finally, late consumers also inspect the product before deciding whether to buy at price  $p_2$ . (If first-period market outcome fully reveals quality, it is irrelevant whether late consumers inspect the product because inspection does not provide additional information about quality.) A late consumer’s inspection outcome again follows the distribution specified in Equation 2. Table 1 summarizes the key notations.

[Insert Table 1 about here]

## 2.2 Equilibrium Concept

We derive the Perfect Bayesian Equilibria (PBE) of this multi-period game of incomplete information. There are two important observations. First, a seller that is identified as being low quality ( $\mu = 0$ ) earns zero profit. Second, marketing efforts and production are costless. Therefore, a low-quality seller always weakly prefers to mimic a high-quality seller (but not vice versa) by choosing the same marketing efforts and charging the same price. The only separating PBEs in this setting are degenerate equilibria in which a high-quality seller earns

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<sup>9</sup>The implicit assumption is that marketing efforts are adjustable over time. Some marketing decisions (such as store location choices) might be harder to change in a timely fashion. We analyze this issue in the Web Appendix. The key intuition of demarketing continues to hold, although the parameter range for demarketing to be optimal is smaller when the level of marketing is fixed than when it is adjustable.

zero profit by charging a prohibitively high price or offering the product for free, so that the low-quality seller has no incentives for mimicry.

There exist multiple pooling PBEs, in which high-quality and low-quality sellers make the same decisions. In particular, any decisions can be sustained as a pooling equilibrium if buyers attribute any deviation from the equilibrium decisions to a low-quality seller. We approach the equilibrium selection issue by focusing on the equilibria in which the high-quality seller chooses optimal decisions. This allows us to derive a unique pooling PBE outcome by solving the high-quality seller's profit maximization problem. Since it is the low-quality seller who wishes to mimic the high-quality seller but not the reverse, this equilibrium refinement, which allows the high-quality seller to follow its sequentially optimal course of action, is intuitively appealing. This equilibrium outcome coincides with the unique strongly undefeated PBE outcome (see Mezzetti and Tsoulouhas 2000 for a development of this equilibrium concept, which is a variant of the undefeated PBE of Mailath, Okuno-Fujiwara and Postlewaite 1993; see Gill and SgROI 2012 for an application).

A few remarks on our assumption about the cost of marketing efforts are in order. We deliberately assume that (incremental) marketing is costless. Whenever pooling on demarketing is an equilibrium outcome for costless marketing, it remains an equilibrium outcome if marketing is costly. Moreover, as the cost of marketing increases, we obtain a (weakly) larger range of parameters in which the demarketing pooling equilibrium is the most profitable of all pooling equilibria for the high-quality seller. These forces are in favor of demarketing emerging in equilibrium. However, for sufficiently high marketing costs, there may also exist separating equilibria in which marketing effort signals high quality to buyers. While undoubtedly important, this quality signaling role of marketing has been analyzed extensively elsewhere in the literature,<sup>10</sup> and is therefore not the focus of this study. We focus instead on the following question: how can a high-quality seller choose the right level of marketing to communicate its quality to consumers when this choice itself can be freely mimicked by a low-quality seller? To answer this question, we turn to the analysis of the model in the next section.

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<sup>10</sup>See for example, Milgrom and Roberts (1986); Wernerfelt (1988); Bagwell and Riordan (1991); Desai and Srinivasan (1995); Moorthy and Srinivasan (1995); Simester (1995); Erdem, Keane and Sun (2008). Also see Bagwell (2007) for a survey.

### 3 Analysis

#### 3.1 Evolution of Buyer Beliefs

Buyers' beliefs about product quality evolve as new information arrives. An interested early consumer's information includes the observation of seller strategies (marketing efforts and prices) and her private inspection outcome. However, in a pooling equilibrium where high-quality and low-quality sellers choose the same strategies, the exact strategy does not affect early consumers' quality beliefs. Therefore, an early consumer can only update her quality belief through inspection. Her posterior quality belief follows from Bayes' rule:

$$\mu_1(s) = \begin{cases} \frac{\mu_0}{\mu_0 + b(1-\mu_0)} & \text{if } s = G, \\ 0 & \text{if } s = B. \end{cases} \quad (3)$$

Since inspection is imperfect, although a defect reveals low quality, the failure to detect a flaw only partially indicates high quality, so that  $\mu_0 < \mu_1(G) < 1$ .

An interested early consumer's willingness to pay can be either  $\mu_1(G)$  or  $\mu_1(B) = 0$ , depending on her inspection outcome. The most profitable introductory price for a high-quality seller is therefore:

$$p_1^* = \mu_1(G). \quad (4)$$

The low-quality seller will charge this same price in equilibrium. In practice, the seller can set the price one cent below  $p_1^*$  to ensure purchase. At this introductory price, only interested early consumers who observe a favorable inspection outcome will buy. As a result, first-period sales contain useful information about product quality for late consumers.

Specifically, recall that a fraction  $x$  of early consumers are interested in the product. By the law of large numbers, the measure of early consumers who receive a good inspection outcome and purchase the product is  $x$  if quality is high, and  $bx$  if quality is low. Since  $x$  itself varies stochastically between  $\underline{x}$  and  $\bar{x}$ , the highest possible level of first-period sales for a low-quality product is  $b\bar{x}$ , while the lowest possible level of first-period sales for a high-quality product is  $\underline{x}$ . If  $b\bar{x} < \underline{x}$ , then any level of first-period sales perfectly indicates quality. For the rest of the paper, we focus on the more interesting case where:

$$\underline{x} \leq b\bar{x}. \quad (5)$$

Under this assumption, there exist three ranges of first-period sales: “stellar” sales ( $m > b\bar{x}$ ) perfectly reveal high quality to late consumers, “poor” sales ( $m < \underline{x}$ ) unambiguously indicate low quality, and “mediocre” sales ( $m \in [\underline{x}, b\bar{x}]$ ) leave late consumers uncertain. After observing mediocre first-period sales  $m$ , late consumers know that the interest level among early consumers must have been  $x = m$  if quality is high and  $x = m/b$  if quality is low. However, late consumers do not directly observe the realized interest level, but understand that interest varies stochastically with marketing efforts. To be concrete, suppose  $f(x|a)$  is continuous. (The intuition behind demarketing remains valid if  $f(x|a)$  is discrete, as we show with an example later.) Given marketing effort  $a$ , late consumers know that the probability density function of first-period sales  $m$  is  $f(m|a)$  if quality is high, and  $f(\frac{m}{b}|a)\frac{1}{b}$  if quality is low, following the Jacobian transformation (Casella and Berger 1990). In this way, marketing efforts influence late consumers’ quality beliefs although they do not directly convey quality in a pooling equilibrium.

A last factor that further updates a late consumer’s quality belief, if first-period sales are mediocre, is her own inspection outcome. A bad inspection outcome again reveals low quality, whereas a good inspection outcome updates quality beliefs in the following way: if quality is high, the probability of observing mediocre first-period sales  $m$  and a good inspection outcome should be  $f(m|a)$ ; if quality is low, this probability becomes  $f(\frac{m}{b}|a)\frac{1}{b}b = f(\frac{m}{b}|a)$ . The late consumer can then form her posterior quality beliefs using Bayes’ rule.

In summary, after observing marketing efforts  $a$ , first-period sales  $m$ , and her inspection outcome  $s$ , a late consumer’s posterior quality belief is:

$$\mu_2(a, m, s) = \begin{cases} 1 & \text{if } m > b\bar{x}, \\ \frac{f(m|a)\mu_0}{f(m|a)\mu_0 + f(\frac{m}{b}|a)(1-\mu_0)} & \text{if } \underline{x} \leq m \leq b\bar{x} \text{ and } s = G, \\ 0 & \text{otherwise.} \end{cases} \quad (6)$$

One key observation is that, keeping  $m$  constant, the quality belief term  $\frac{f(m|a)\mu_0}{f(m|a)\mu_0 + f(\frac{m}{b}|a)(1-\mu_0)}$  decreases with marketing effort  $a$  if and only if the following condition holds:

$$\frac{f(\frac{m}{b}|\bar{a})}{f(m|\bar{a})} > \frac{f(\frac{m}{b}|\underline{a})}{f(m|\underline{a})}. \quad (7)$$

Since  $b < 1$ , Condition 7 always holds if  $f(x|a)$  satisfies the strict MLRP in  $a$  as defined in Condition 1. Intuitively, since marketing efforts raise expected product consideration by

the MLRP, intensive marketing competes with product quality in explaining good sales and exacerbates buyers' concerns over quality when sales are lackluster. We summarize these results with the following proposition. The proof holds by construction.

**Proposition 1.** *If buyers' interest in a product satisfies the strict monotone likelihood ratio property in marketing efforts, then for any level of first-period sales late consumers' quality beliefs (weakly) decrease with marketing efforts.*

The analysis thus far shows how demarketing can improve buyers' quality beliefs *ex post*. However, late consumers' quality beliefs as specified in Equation 6 are conditional on a realized first-period sales volume  $m$ . It is unclear yet how marketing efforts affect seller profits *ex ante* since demarketing also lowers first-period sales in expectation. We next analyze seller profits and derive the conditions for demarketing to emerge as the equilibrium strategy.

### 3.2 Seller Profits and Equilibrium (De)marketing Strategies

In this section, we explore sellers' equilibrium choice between marketing ( $\bar{a}$ ) and demarketing ( $\underline{a}$ ). As discussed previously, we focus on a high-quality seller's profits associated with different marketing efforts. A low-quality seller will always mimic the high-quality seller in the pooling equilibrium; any deviation would reveal its bad quality and reduce its profit to zero.

Note that in the second period it is optimal for the high-quality seller to set the price  $p_2$  equal to  $\mu_2(a, m, s)$  as specified in Equation 6. This price extracts the full surplus of all late consumers who have a positive willingness to pay for the product. Since a high-quality product will always pass an inspection and will always achieve at least mediocre first-period sales ( $m \geq \underline{x}$ ), its optimal second-period price is:

$$p_2^*(a, m) = \begin{cases} 1 & \text{if } m > b\bar{x}, \\ \frac{f(m|a)\mu_0}{f(m|a)\mu_0 + f(\frac{m}{b}|a)(1-\mu_0)} & \text{if } \underline{x} \leq m \leq b\bar{x}. \end{cases} \quad (8)$$

The low-quality seller will imitate the high-quality seller's second-period price unless its first-period sales are poor ( $m < \underline{x}$ ), in which case it will not be able to sell anything at a positive price.

For subsequent analysis, it will be useful to formulate late consumers' *expected* quality belief about a high-quality seller, integrated over all possible levels of first-period sales. A high-quality seller's first-period sales is stellar with probability  $1 - F(b\bar{x}|a)$  and mediocre

otherwise. Its expected quality belief among late consumers is therefore:

$$E[\mu_2(a, m, s)|H] = E[\mu_2(a, x, G)] = [1 - F(b\bar{x}|a)] + \int_{\underline{x}}^{b\bar{x}} \mu_2(a, x, G)f(x|a)dx. \quad (9)$$

It follows that a high-quality seller's expected profit ultimately depends on its marketing effort choice:

$$E\Pi(a|H) = E(x|a)\mu_1(G) + \delta [1 - F(b\bar{x}|a)] + \delta \int_{\underline{x}}^{b\bar{x}} \mu_2(a, x, G)f(x|a)dx. \quad (10)$$

Equation 10 shows that marketing efforts affect a high-quality seller's expected profit in several ways. The first term on the right-hand side,  $E(x|a)\mu_1(G)$ , is the high-quality seller's expected profit in period one. This term reflects the demand-enhancing effect of marketing efforts, as expected consideration among early consumers  $E(x|a)$  increases with  $a$  by the MLRP. The second term  $\delta [1 - F(b\bar{x}|a)]$  represents the profit from selling to late consumers when first-period sales are stellar so that  $p_2^* = 1$ . This term increases with  $a$  as well by definition of the MLRP. The last term is the profit derived from late consumers when first-period sales turn out mediocre. We have shown that  $\mu_2(a, x, G)$  decreases with  $a$  by the MLRP. However,  $a$  also affects the probabilities for different levels of mediocre sales to arise, as captured by the distribution function  $f(x|a)$  in the last term of Equation 10.

We are interested in whether demarketing arises in equilibrium. We first note a necessary condition for demarketing to be optimal, that the relative mass of late consumers  $\delta$  should be sufficiently large. If  $\delta$  is too close to 0, the seller will maximize marketing efforts to serve as many early consumers as possible. However, even when  $\delta$  is sufficiently large, demarketing is worthwhile only if it improves second-period profits. We note two boundary conditions below.

If buyers' prior quality beliefs are very pessimistic ( $\mu_0$  being close to 0), demarketing will never be optimal. For very pessimistic prior beliefs, buyers continue to hold minimal confidence in quality whenever in doubt. This can be seen from Equation 3, where early consumers' quality beliefs are close to 0 regardless of the private signal received; and Equation 6, where late consumers' quality beliefs are also close to 0 unless first-period sales are stellar ( $m > b\bar{x}$ ). As a result, unless first-period sales are stellar, the profits that can be earned from consumers in either period are close to zero. Hence, the high-quality seller's imperative is to maximize the probability of stellar sales in period one to provide absolute proof of high quality



to late consumers. To achieve this goal, the seller should maximize its marketing efforts in the first period.

On the other hand, if buyers' prior quality beliefs are very optimistic ( $\mu_0$  being close to 1), demarketing will not be optimal either. As Equation 3 shows, if early consumers have firm faith in product quality to start with, their quality belief will be close to 1 unless their inspection detects a flaw, which will not happen for the high-quality product. Similarly, as Equation 6 shows, late consumers' quality beliefs also remain close to 1 as long as first-period sales are at least mediocre ( $m \geq \underline{x}$ ), a level that a high-quality seller will achieve for certain. Therefore, for a high-quality seller, consumers will have high willingness to pay anyway, and so the imperative is to maximize expected sales volume through full marketing efforts.

Taken together, the prior belief  $\mu_0$  must fall in an intermediate range for demarketing to arise in equilibrium. Intuitively, the purpose of demarketing lies in belief manipulation, which is effective only if buyers face significant quality uncertainty. The following proposition summarizes the necessary conditions for a demarketing equilibrium (see the Web Appendix for proof).

**Proposition 2.** *A pooling equilibrium with demarketing ( $a = \underline{a}$ ) being the optimal strategy can only exist if*

- (i) the relative mass of late consumers  $\delta$  is sufficiently large, and*
- (ii) the prior quality belief  $\mu_0$  is neither too pessimistic (i.e., close to 0) nor too optimistic (i.e., close to 1).*

Since beliefs following mediocre sales, as well as the probabilities by which different mediocre sales levels occur, depend on the buyer interest distribution function  $f(x|a)$ , it is difficult to derive sufficient conditions for the demarketing equilibrium without putting additional structure on this function. To demonstrate the existence of the demarketing equilibrium, we turn to an example that assumes a specific functional form for  $f(x|a)$ .

### 3.3 An Example

Suppose that marketing efforts generate purchase interest among either all early consumers ( $x = 1$ ) or a fraction of them ( $x = b < 1$ ). The conditional distribution of interest given

marketing efforts is

$$\begin{aligned}
 f(x|\bar{a}) &= \begin{cases} \bar{\theta} & \text{if } x = 1, \\ 1 - \bar{\theta} & \text{if } x = b, \end{cases} \\
 f(x|\underline{a}) &= \begin{cases} \underline{\theta} & \text{if } x = 1, \\ 1 - \underline{\theta} & \text{if } x = b, \end{cases}
 \end{aligned} \tag{11}$$

with  $0 < \underline{\theta} < \bar{\theta} < 1$ . It follows that  $f(x|a)$  satisfies the strict MLRP in  $a$ .

When the seller charges the optimal first-period price  $p_1^* = \mu_1(G)$ , first-period sales are either 1 or  $b$  if quality is high, and either  $b$  or  $b^2$  if quality is low. Late consumers thus remain uncertain about quality after observing the mediocre sales level  $b$ , which makes the example interesting in spite of its simplicity. Indeed, there exists an equilibrium in which demarketing emerges as the optimal strategy (see the Web Appendix for proof):

**Proposition 3.** *Let buyer interest  $(x)$  generated by marketing effort  $(a)$  follow the conditional distribution function  $f(x|a)$  as defined in Equation 11. There exists a pooling equilibrium in which demarketing is the optimal strategy when the relative mass of late consumers  $\delta$  is sufficiently large and the prior quality belief  $\mu_0$  is neither too pessimistic nor too optimistic.*

Figure 2 shows sellers' equilibrium (de)marketing choice as a function of buyers' prior quality belief  $\mu_0$  and the relative mass of late consumers  $\delta$ . For illustration we fix the remaining parameters as  $\bar{\theta} = 0.6$ ,  $\underline{\theta} = 0.1$ , and  $b = 2/3$ . Demarketing arises as the equilibrium strategy for reasonable parameter values. Consistent with Propositions 2 and 3, demarketing is optimal when the relative mass of late consumers is sufficiently large, and when buyers face significant prior uncertainty about quality.

[Insert Figure 2 about here]

### 3.4 Discussion

#### 3.4.1 Pooling in Actions, Separating in Payoffs

A further reflection on the pooling equilibrium analyzed thus far is in order. It is worth noting that although the two types of sellers pool in actions, they diverge in payoffs. A low-quality seller only passes inspections with probability  $b$  in either period. Therefore, the

*expected* quality belief a low-quality seller can achieve among early consumers is  $b\mu_1(G)$ ; in expectation, a fraction  $b$  of early consumers hold belief  $\mu_1(G)$  whereas the remaining fraction  $1 - b$  hold belief 0. Moreover, a low-quality seller cannot achieve stellar sales in period one but faces the risk of poor sales. Therefore, the low-quality seller's expected quality belief among late consumers is:

$$E[\mu_2(a, m, s)|L] = bE[\mu_2(a, bx, G)] = b \int_{\frac{x}{b}}^{\bar{x}} \mu_2(a, bx, G) f(x|a) dx, \quad (12)$$

which is different from a high-quality seller's expected quality belief among late consumers as specified in Equation 9. It can be shown that buyers' expected quality beliefs for a high-quality seller are more optimistic than their expected quality beliefs for a low-quality seller in both periods (see the Web Appendix for proof).

In other words, although product quality is not immediately revealed through seller actions, it is partially revealed through market data (inspection outcomes, first-period sales). Divergent quality beliefs generate divergent profits. Indeed, since a seller's expected profit equals its expected quality belief in each period, in a pooling equilibrium, a high-quality seller earns a higher expected profit than a low-quality seller in both periods.

Finally, it is interesting to see how the level of marketing efforts further affects the payoff divergence between the two seller types. Early consumers' quality beliefs depend on the prior belief and inspection outcomes. However, late consumers' quality beliefs are influenced by marketing efforts in the following way.

**Proposition 4.** *Demarketing improves late consumers' expected quality belief about a high-quality seller if and only if it worsens late consumers' expected quality belief about a low-quality seller.*

Proof: By the law of iterated expectations, we obtain:

$$\mu_0 = \mu_0 E[\mu_2(a, m, s)|H] + (1 - \mu_0) E[\mu_2(a, m, s)|L], \quad (13)$$

hence  $E[\mu_2(a, m, s)|H] > E[\mu_2(\bar{a}, m, s)|H] \iff E[\mu_2(a, m, s)|L] < E[\mu_2(\bar{a}, m, s)|L]$ .  $\square$

The law of iterated expectations implies that buyers' expected posterior quality beliefs for the two seller types must straddle their prior belief. Intuitively, since buyers rationally use available data (inspection outcomes, first-period sales) to update their beliefs, learning

brings their perception closer to truth in expectation. In this sense, if demarketing (relative to marketing) helps a high-type seller better unveil its high quality, it also forces a low-type seller who mimics the same demarketing choice to further reveal its low quality, although the low-type seller still prefers mimicry to deviation. Therefore, demarketing can not only improve a high-quality seller's profit, but also provide better information to the marketplace by helping late consumers better discern quality from available data. In fact, when the relative mass of late consumers is sufficiently large, demarketing maximizes a high-quality seller's expected profit if and only if it maximizes the expected amount of information in the marketplace, and if and only if it minimizes a low-quality seller's expected profit from mimicry.

### **3.4.2 What Do Buyers Need to Observe for Demarketing to Work?**

The analysis thus far highlights two fundamental requirements on buyers' information set that allow demarketing to work as an optimal seller strategy. Buyers must (1) at least partially observe past product sales, and (2) at least partially observe the level of marketing efforts. We discuss these requirements below.

First, if buyers have no information on past sales, they cannot infer product quality by observing previous buyers' purchase decisions. The seller in turn has no incentive to manipulate buyer observational learning through demarketing. In our model, the seller would maximize costless marketing efforts to maximize expected buyer interest. In reality, however, buyers can often obtain informative signals of a product's market performance. For example, they can observe the length of the line waiting outside a store, track how many units of the iPad have been sold since launch, and more generally, form an impression of whether a new product is a hit or a flop.

Second, the credibility of demarketing in influencing buyers' quality perception depends on its visibility to buyers. If the level of marketing is unobservable, the seller in our model will lose its incentive to demarket—buyers will dismiss any demarketing claims by the seller as untrustworthy cheap talk, and so the seller might as well exhaust its free marketing resources. Consistent with this visibility requirement of demarketing, the psychology literature finds that humans exhibit self-handicapping more often when others can observe their handicap. For instance, Kolditz and Arkin (1982) show that experiment subjects are far more likely to take a debilitating drug in an IQ test if the drug choice is public than if it is private. The implications are twofold. Normatively, demarketing, if it is to be used, should be used

conspicuously. Positively, we expect more adoption of demarketing when it is observable, for example, when passersby can (trivially) observe business locations, when stores can publicize inconvenient service terms, and when consumers can witness how often a company advertises.

Additionally, there is a technical condition for demarketing to work, that the precise level of buyer interest (or other direct outputs of marketing efforts) should be unobservable to subsequent buyers, who would otherwise be able to fully infer quality from the conversion rate between buyer interest and sales. A general condition for demarketing to arise is that late consumers cannot completely “parse out” the effect of marketing on sales so as to perfectly infer quality. If demarketing loses its influence on beliefs, the seller will again maximize marketing efforts. This technical condition should hold in many circumstances due to the personal and often idiosyncratic nature of buyer interest.

## 4 Empirical Validation

The analysis thus far identifies a set of conditions for demarketing to be an optimal seller strategy. First, the *ex post* effect of demarketing, as described by Proposition 1, relies on the (implicit) assumption that consumers are able to draw savvy inference about product quality taking marketing efforts into account. Second, Proposition 2 specifies the necessary market conditions for demarketing to be optimal. Third, we have discussed what buyers must observe for demarketing to achieve its purpose.

We conduct a series of human subject experiments to validate these conditions. These experiments test whether individuals, when taking the role of buyers or sellers, behave consistently with the model’s implications. We proceed with five studies. Study 1 tests whether buyers’ quality beliefs decrease with marketing efforts for a given level of past sales (Proposition 1). Study 2 tests the main prediction of the model, that demarketing is relevant when buyers are uncertain about product quality and the market is fast growing (Proposition 2). Study 3 replicates Study 2 using business students as subjects. Study 4 evaluates the condition that demarketing is recommendable only if buyers can observe past sales and past marketing effort. Study 5 further investigates whether it is quality image management that motivates sellers to choose demarketing.

### *Study 1*

We begin with a  $1 \times 2$  design to test whether buyers’ quality beliefs decrease with marketing

efforts *ex post*. Condition 1 presents information about past sales, describes marketing efforts as “intensive,” and elicits buyers’ quality perception. We ask the following question.

“An e-book reader was introduced into the market a year ago. The company that produces and sells the e-book reader put in intensive marketing efforts. The e-book reader sold 5 million units globally within 12 months.

Based on the information, how good do you think the quality of the e-book reader is? Please indicate your answer on a 1-to-5 scale, with 1 being the poorest quality and 5 being the best quality.”

We choose e-book readers because this is a category of new products where quality uncertainty is likely to be high. We set the sales volume of 5 million units based on the 2011 sales of the Apple iPad (60 million), Kindle (19 million), and Nook (12 million) to evoke a perception of mediocre sales. Condition 2 asks the same question except that the seller is described as putting in “moderate marketing efforts.” We adopt the wording “intensive” versus “moderate” marketing because, as defined earlier, the concept of demarketing is relative. We hypothesize that perceived quality is greater in Condition 2 than in Condition 1.

We recruit human subjects from Amazon Mechanical Turk (MTurk), a leading Internet-based labor market that has been widely adopted for behavioral experimental research (e.g., Paolacci et al. 2010).<sup>11</sup> We randomly assign 50 subjects into Condition 1 and 50 subjects into Condition 2. Each subject is given up to 15 minutes to complete the experiment. Subjects earn an effective hourly rate of around \$6.

The top panel of Table 2 reports the experiment results. The mean perceived quality is 3.68 in Condition 1, which is significantly lower than its counterpart of 4.12 in Condition 2 ( $p = 0.008$ ).<sup>12</sup> This finding supports the hypothesis of savvy consumer attribution—for a given sales volume, lower marketing intensity does increase buyers’ perceived quality.

[Insert Table 2 about here]

## ***Study 2***

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<sup>11</sup>As a quality screening measure, we require that a participating subject receive a task approval rate greater than 95% and have more than 500 tasks approved.

<sup>12</sup>Throughout this section we report  $p$ -values based on one-tailed tests because the hypotheses of interest are uni-directional.

Having validated the *ex post* effect of demarketing on buyer quality inference, we proceed to study 2 to test the main prediction of the model, that higher prior quality uncertainty and a higher market growth rate increase the relevance of demarketing. We ask subjects to choose whether to market a new e-book reader “intensively” or “moderately” during its first year of launch. The decision task aims to capture the key elements of the theory: marketing builds buyer consideration yet the purchase decision also depends on evaluation; second-year consumers observe first-year marketing intensity and sales volume; the cost of marketing is not a concern, and the goal of a subject is to maximize profit over a two-year span. (See the Web Appendix for a copy of the question asked.)

We adopt a  $1 \times 3$  design.<sup>13</sup> Condition 3 evokes a high-uncertainty, high-growth environment by stating that “consumers are fairly uncertain about the quality of your e-book reader at the time of launch,” and that “it is forecast that the potential customer base for e-book readers will significantly grow over the two years.” Condition 4 asks the same question as Condition 3 except that consumers are described as being “fairly certain” about the quality of the e-book reader at launch. Condition 5 differs from Condition 3 by stating that the potential customer base will “stay stable” over the two-year span. We randomly assign 50 MTurk subjects into each of the three conditions.<sup>14</sup>

The second panel of Table 2 reports the results. The share of subjects who choose moderate marketing over intensive marketing is 32.7% in Condition 3 (high uncertainty, high growth), which is higher than 16% in Condition 4 (low uncertainty, high growth) with a  $p$ -value of 0.03. This percentage is also higher than 14% in Condition 5 (high uncertainty, low growth) at the  $p = 0.01$  level. These results support our central hypothesis that demarketing is more relevant when buyers’ prior quality uncertainty is high and when the market grows fast.

### ***Study 3***

Although MTurk subjects are found to perform comparably to laboratory subjects (e.g., Paolacci et al. 2010), we want to evaluate explicitly whether our key results are robust with respect to alternative subject types. It is common to use students to test theories of firm strategies (Holt 1995). Indeed, a number of studies that compare students and managers document little difference in their decisions (Plott 1987; Ball and Cech 1996). Therefore,

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<sup>13</sup>We do not pursue a  $2 \times 2$  design because our theory makes no prediction about the interaction effect of prior quality uncertainty and market growth rate.

<sup>14</sup>One subject in Condition 3, as well one subject in Condition 12 of Study 5, did not submit an answer.

we replicate Study 2 using students as subjects. A total of 99 business students at a major university in the United States participate in the experiment. The three conditions in Study 2, which we relabel as Conditions 6, 7, and 8 for Study 3, receive 34, 31, and 34 subjects respectively. Participation is voluntary and unpaid.

The third panel of Table 2 displays the results. The percentage of subjects who choose moderate marketing is 38.2% in Condition 6 (high uncertainty, high growth), which is higher than 19.4% in Condition 7 (low uncertainty, high growth) at the  $p = 0.05$  level, and higher than 17.6% in Condition 8 (high uncertainty, low growth) at the  $p = 0.03$  level. These patterns are consistent with those of Study 2, although student subjects seem more prone to choose demarketing.

#### ***Study 4***

We extend our analysis to evaluate the observability requirements of demarketing, that demarketing is recommendable only if buyers can observe past sales and past marketing intensity. We create two new conditions. Condition 9 is identical to Condition 3 except by telling subjects that “in your second year of launch, consumers cannot observe how many units your company actually sold during the first year.” Condition 10 is identical to Condition 3 except by stating that “consumers cannot observe how intensively you have marketed your product during the first year.” We randomly assign 50 MTurk subjects into each condition. We run Conditions 9 and 10 (as well as Conditions 11 and 12 of Study 5) simultaneously with the benchmark Condition 3 to minimize confounding time effects and maximize comparability.

The fourth panel of Table 2 reports the results. The percentage of subjects who choose moderate marketing declines to 14% in Condition 9 (unobservable sales) and 18% in Condition 10 (unobservable marketing), both of which are significantly lower than their counterpart in Condition 3 ( $p = 0.01$  and  $0.05$  respectively). These results confirm the observability requirements of demarketing.

#### ***Study 5***

Finally, we want to know whether subjects have chosen demarketing with buyer quality inference being a consideration. To do so, we exogenously vary the salience of buyer quality inference by asking a subject to infer product quality from a buyer perspective before choosing marketing intensity as a seller. Specifically, we create two new conditions. In Condition 11, each subject first answers the question of Condition 1 (inferring product quality observing



intensive marketing), and then answers the question of Condition 3. In Condition 12, each subject answers the question of Condition 2 (inferring product quality observing moderate marketing) and then the question of Condition 3. We randomly assign 50 MTurk subjects into each condition.

The fifth panel of Table 2 highlights three results. First, mean perceived quality is 3.89 in Condition 11, which is lower than 4.27 in Condition 12 at the  $p = 0.006$  level, replicating the finding of Study 1. Second, the percentages of subjects choosing moderate marketing are 48% and 51% in Conditions 11 and 12 respectively, both significantly higher than the level in Condition 3 ( $p$ -value being 0.06 and 0.03 respectively). In other words, when subjects are primed to consciously think about quality inference from the buyer perspective, they are indeed more prone to choose demarketing. Last, the percentage of subjects choosing moderate marketing does not significantly differ between Conditions 11 and 12 ( $p = 0.38$ ). This result rules out the possibility that it is the mention of moderate marketing *per se* in Condition 12 that has anchored subjects to choose demarketing.

In summary, the lab experiments provide reassuring evidence that real-world decision-makers can intuit the key ideas of the model: buyers are able to make savvy inference of product quality based on marketing efforts, and sellers are able to understand this fact and adjust their marketing efforts in response. In the following section, we build on the main model to explore how firms should adjust their (de)marketing strategies in response to a rich set of market conditions.

## 5 Extensions

This section explores a set of real-world situations that may affect sellers' (de)marketing incentives. We will focus on presenting the results and discussing the intuition. All technical details, including derivations and proofs, are collected in the Web Appendix.

### 5.1 Marketing that Improves Prior Quality Beliefs

The main analysis focuses on the role of marketing in raising buyer interest. In addition, marketing can also directly improve buyers' prior quality beliefs. For example, persuasive advertising can boost buyers' confidence in quality. To capture this effect, we allow buyers' prior beliefs to be  $\mu_0(a)$  where  $\mu'_0(a) \geq 0$ . It follows that marketing improves early consumers'

quality belief unless their inspection outcome is unfavorable. The effect of marketing on late consumers’ quality beliefs, however, is ambiguous: although intensive marketing hurts quality perceptions *ex post*, as shown in the main analysis, it also “anchors” late consumers with more optimistic prior quality beliefs. We find that sellers have less incentive to demarket if marketing is more effective at improving buyers’ prior quality beliefs. Naturally, demarketing should be used with greater caution if buyers’ prior perception of product quality is susceptible to marketing efforts.

## 5.2 Marketing that Accelerates Buyer Arrival

Marketing activities such as awareness advertising campaigns may also help accelerate the arrival of buyers. We model this effect of marketing by allowing the mass of early consumers to be  $\lambda(a)$  and the mass of late consumers to be  $\delta + 1 - \lambda(a)$ , where  $0 \leq \lambda(\underline{a}) \leq \lambda(\bar{a}) \leq 1 + \delta$ . Interestingly, we find that greater effectiveness of marketing efforts in accelerating buyer arrival may increase the parameter range for demarketing to be optimal. The intuition is as follows. With endogenous buyer arrival, marketing has two effects on seller profits (besides raising interest among early consumers). It shifts the distribution of buyers across time, and it influences the expected equilibrium price in period two by affecting late consumers’ quality beliefs. With this latter effect, the seller does not always want to accelerate buyer arrival and expedite sales. In fact, if the expected equilibrium price in period two exceeds the equilibrium price in period one as market data reveal product quality over time, the high-quality seller has the incentive to shift greater sales volume to period two. Demarketing helps to serve this purpose.<sup>15</sup>

## 5.3 More than Two Time Periods

Sellers have no incentive to choose demarketing, a future-oriented strategy, in the final period of the game. The two-period structure of the main model thus implies that marketing levels weakly increase over time. Would this monotonicity property always hold when there are more than two periods? The answer is no. As a counterexample, we consider a three-period model.

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<sup>15</sup>This finding raises another question: what happens if consumers can strategically postpone their purchases to gain more information about product quality? Strategic waiting does not occur in our model for the following reason. Consumers who receive a bad inspection outcome will not buy and will earn their outside utility of zero. Consumers who receive a good inspection outcome will receive zero net utility as well, because the equilibrium prices in both periods equal buyers’ quality beliefs unless first-period sales are poor, in which case the consumer will again receive her outside utility of zero. Therefore, even though buyers can choose when to buy, they have no incentive to wait.

There exist pooling equilibria in which sellers choose high marketing in the first and third periods, and demarketing in the second period if and only if first-period sales are mediocre.

This result reflects a high-quality seller's tradeoff in setting its first-period marketing level. On the one hand, demarketing protects the seller's quality image in the case of mediocre sales. Since there are more future periods to benefit from a good quality image, there is *caeteris paribus* greater return to demarketing early on. On the other hand, there is also better reason to market intensively in the first period. If the seller can achieve stellar sales in period one, all future periods benefit from this flawless quality image. If early sales are mediocre, the seller ends period one with a worse quality image than if it had chosen demarketing, but it has another chance to improve quality beliefs in period two, possibly through demarketing. This second effect may break the monotonicity of marketing effort dynamics. Managerially, it suggests that the timing of demarketing requires careful analysis when the seller has a planning horizon longer than two periods.

#### 5.4 Heterogeneous Willingness to Pay

The main model assumes that consumers hold homogeneous willingness to pay for quality. We can relax this assumption by allowing a consumer's willingness to pay to equal her quality belief multiplied by her intrinsic valuation for quality, which follows a generic, commonly known distribution across consumers. This modification generates a downward-sloping demand curve even if consumers hold the same quality belief.

We find that accommodating heterogeneous willingness to pay does not affect sellers' (de)marketing incentives. The key reason is that the introductory price does not change late consumers' quality beliefs. For example, although a low introductory price boosts first-period sales, a late consumer is aware of this fact. The seller in turn must achieve a greater sales volume to prove its high quality. In fact, we find that a high-quality seller would choose a price in each period to maximize its static profit of that period. A low-quality seller mimics this choice. Furthermore, we show that the high-quality seller's expected profit given these prices are identical to its expected profit in the main model up to a scaling factor, which comes from optimal pricing on a downward-sloping demand curve. Therefore, the parameter range for (de)marketing to be optimal stays the same as in the main model.

One reason why the introductory price does not affect subsequent beliefs is that the demand curve is deterministic and is known by consumers. Based on our earlier discussion, this

fact rules out introductory price as a form of demarketing since late consumers can fully parse out the effect of price on sales. However, if we built randomness into the demand curve, much as how we incorporate randomness in the buyer interest function, then sellers could demarket *through* pricing. For instance, if we allowed demand to satisfy the MLRP in the negative of price, then sellers could demarket by charging an introductory price that is higher than its static optimal level. Intuitively, this excessively high price would help alleviate quality concerns if sales were lackluster and highlight good quality if sales were satisfactory (see also Taylor 1999).<sup>16</sup>

## 5.5 Word-of-Mouth Communication

Besides observational learning, word-of-mouth communication could also facilitate social learning among consumers (e.g., Godes and Mayzlin 2004; Kuksov and Shachar 2010; Chen, Wang, and Xie 2011). In our model, besides observing past sales, late consumers could also update their quality beliefs by communicating with past consumers. To investigate how this additional channel of social learning affects sellers’ (de)marketing decisions, we extend the main model in the following way: we allow each late consumer to communicate with one randomly selected consumer from the first period. The message transmitted through this communication could be a good signal this predecessor obtained through her private inspection, a bad signal, or the fact that this predecessor did not consider the product (referred to as a “null” signal thereafter).

Interestingly, we find that a null word-of-mouth message is more diagnostic of high quality than a good word-of-mouth message. The reason is as follows. Regardless of actual product quality, all early consumers with a good signal would purchase the product in equilibrium. For a given period-one sales level  $m$ , the fraction of early consumers with a good, bad, or null signal is  $m$ , 0, and  $1 - m$  respectively if quality is high, and  $m$ ,  $m(1 - b)/b$ , and  $1 - m/b$  respectively if quality is low. In other words, since late consumers already observe past sales, knowing the reason behind purchase (good word-of-mouth message) does not bring additional information about quality. It is the reason behind the no-purchase decisions that provides new information—the reason would be the lack of consideration if quality is high; it would be the

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<sup>16</sup>This result complements the literature of quality signaling through high price. The standard rationale focuses on separating equilibria, in which high-quality sellers raise price to deter mimicry of low-quality sellers. The demarketing account of pricing could generate the same high-price outcome in a pooling equilibrium—high-quality sellers raise price not to separate from their low-quality counterparts, but to manage buyers’ quality inference taking mimicry as a fact. We thank a referee for pointing out this connection.

lack of consideration *or* a bad signal if quality is low. Therefore, knowing that her predecessor did not consider the product suggests high quality disproportionately, which serves to increase a late consumer's quality belief.

This result affects a high-quality seller's (de)marketing incentives in two ways. First, demarketing lowers expected consideration *ex ante*, which makes it more likely that a late consumer receives a null message through word-of-mouth. Second, demarketing could also dilute the quality implication of a null signal *ex post*. At one extreme, if no one considered the product in the first period, a late consumer will receive a null signal regardless of product quality, which makes the null signal uninformative. At the other extreme, if first-period sales equal  $b$ , the highest level of mediocre sales, a null signal is perfectly indicative of high quality because a low-quality seller would have required 100% consideration to achieve this sales level. The second effect dominates if buyers' prior quality belief  $\mu_0$  is sufficiently high. When late consumers are already optimistic, a null signal does not improve their quality belief much beyond a good signal. Instead, the high-quality seller has more to gain from increasing first-period sales and making a null signal an almost-sure sign of high quality.

When buyers' prior quality belief is not too optimistic, word-of-mouth communication can actually increase the parameter range for demarketing to be the optimal seller strategy (see for example Figure W6 of the Web Appendix). This result might appear surprising because word-of-mouth enriches the amount of information available to late consumers, which might weaken the need for a high-quality seller to prove its quality through demarketing. Indeed, allowing word-of-mouth does increase a high-quality seller's expected profit. However, unless buyers' prior beliefs are too optimistic, a high-quality seller could convey its quality through null signals, and demarketing makes null signals more prevalent in the marketplace. We summarize these results with the following proposition (see the Web Appendix for proof).

**Proposition 5.** *When buyers' prior quality belief  $\mu_0$  is not too optimistic, word-of-mouth communication can increase the range of (other) parameters for demarketing to be the optimal seller strategy.*

## 5.6 Seller Uncertainty about Quality

Finally, sellers might not know their own quality with absolute certainty (Bose et al. 2006). When sellers are uncertain about quality, separating equilibria may emerge because a seller who is revealed to hold low confidence in quality can still earn a positive margin. By contrast,

in the main model a low-quality seller would always want to mimic its high-quality counterpart because a seller who is identified as low quality posts zero profits.

To investigate whether seller uncertainty about quality leads to separating equilibria,<sup>17</sup> we assume that a seller only observes a private signal  $v \in \{H, L\}$  about its quality. The precision of the signal is  $r$ , as defined by:

$$\Pr(v = q) = r, \tag{14}$$

where  $r \in (1/2, 1)$  such that the signal is informative but imperfect. A seller who receives an  $H$  signal has greater confidence in its quality than a seller who receives an  $L$  signal.

In a pure-strategy separating equilibrium of interest, a seller's marketing decision affects consumer beliefs in two ways. First, by signaling higher (lower) confidence in quality, the seller anchors consumers with more optimistic (pessimistic) prior quality beliefs than in a pooling equilibrium. Second, when first-period sales are mediocre, demarketing improves late consumers' quality beliefs *ex post*, for the same intuition behind the pooling equilibrium analyzed earlier. As Figure W7 of the Web Appendix shows, there does exist a separating equilibrium in which demarketing signals a seller's greater confidence in quality. Below we formally state the necessary conditions for such an equilibrium to exist (see the Web Appendix for proof):

**Proposition 6.** *A separating equilibrium in which demarketing signals a seller's higher confidence in quality can only exist if*

- (i) *the relative mass of late consumers  $\delta$  is sufficiently large,*
- (ii) *the prior quality belief  $\mu_0$  is not too optimistic,*
- (iii) *the seller's private information is neither too precise (i.e.,  $r$  close to 1) nor too noisy (i.e.,  $r$  close to 1/2), and*
- (iv) *demarketing hurts short-run profits even if it anchors early consumers with a more optimistic prior quality belief.*

To understand Condition (i), suppose  $\delta$  is small enough that the seller only cares about its first-period profits. However, both types of sellers face the same tradeoff in period one—demarketing signals greater confidence in quality whereas marketing raises buyer interest,

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<sup>17</sup>A demarketing pooling equilibrium can continue to exist when the seller only observes a noisy signal of its quality. Detailed results are available upon request.

regardless of the seller’s actual level of confidence. In other words, first-period incentives alone cannot achieve separation between the two seller types; the ability for demarketing to signal seller confidence relies on its long-run impact on quality image.

To understand Condition (ii), suppose the prior belief  $\mu_0$  is close to 1. It follows that buyers’ willingness to pay approaches the highest level, unless they witness sure signs of low quality (bad inspection outcomes and poor first-period sales). However, with a very optimistic prior belief, both types of sellers are confident that they will not generate these signs of low quality, and will therefore both maximize marketing to grow sales volume, for the same intuition behind the high-marketing pooling equilibrium discussed earlier.<sup>18</sup>

Condition (iii) can be interpreted as follows. If the seller’s private information about its quality is very precise, the situation is similar to the main model, whereby revealing seller type amounts to revealing product quality. A low-type seller will thus prefer to mimic its high-type counterpart. If the seller’s private information about its quality is too noisy, intuitively, the two types of sellers have almost aligned incentives, thus nullifying the need for separation.

Condition (iv) states that, for demarketing to signal seller confidence, it must truly hurt profits in the short run; the demand reduction effect of demarketing must dominate its belief anchoring effect among early consumers. Separation is then achieved as a confident seller enjoys its better quality image whereas an unconfident seller focuses on immediate profitability. The result reinforces the message from the pooling equilibrium analysis, that the credibility of demarketing comes from its costly nature (in terms of sacrificed short-run sales).

Finally, there is an important observation—no separating equilibrium exists in which demarketing signals lower seller confidence. Otherwise, a low-type seller would want to deviate to marketing; doing so improves both the sales volume and price in period one, and anchors consumers with a more optimistic prior belief in period two. The total benefit of marketing more than offsets any *ex post* decrease in quality beliefs. We formally state this result below (see the Web Appendix for proof).

**Proposition 7.** *A separating equilibrium in which demarketing signals the seller’s lower confidence in quality does not exist.*

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<sup>18</sup>When the prior belief  $\mu_0$  approaches 0, both types of sellers expect no business unless they can prove their high quality by achieving stellar sales in period one. This again parallels the result of the pooling equilibrium. However, a seller with a very pessimistic prior belief expects no chance at achieving stellar sales. Therefore, the expected profits of both types of sellers approach zero. The separating equilibrium passively exists as neither type can profitably deviate by mimicking the other type.

## 6 Concluding Remarks

Savvy consumers attribute a product's performance in the marketplace to product quality versus marketing efforts. This paper finds that a seller's best response could be to demarket its product. Demarketing hurts demand directly, but exactly because of this fact, demarketing highlights great quality when sales are satisfactory and mitigates quality concerns when sales are disappointing. We confirm the main predictions of the demarketing theory through a series of experiments, and extend the model to accommodate a rich set of market conditions.

We have presented a theory in which marketing serves to increase buyer consideration. The same intuition behind demarketing could be extended to other marketing decisions. One important decision is inter-temporal advertising scheduling (e.g., Little and Lodish 1969; Horsky and Simon 1983; Mahajan and Muller 1986), for which a classic recommendation is to front-load advertising. Another frequent decision is market selection, for which the conventional wisdom is to target the market that offers good match potential. From the demarketing perspective, however, modest initial advertising and less precise targeting might benefit companies in the long run, if consumers are able to draw savvy inference of product quality from marketing decisions and their market achievements (see the Web Appendix for models that demonstrate this result). It will be interesting for future research to study the implications of demarketing in various business contexts.



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Table 1: Summary of Key Notations

Notation	Definition
$a$	Level of marketing efforts, $a \in \{\underline{a}, \bar{a}\}$
$b$	Probability that inspection generates a good signal when product quality is low
$\delta$	Relative mass of late consumers
$f(x a)$	Probability distribution function of buyer interest $x$ conditional on marketing efforts $a$
$m$	Share of early consumers who buy the product
$\mu_t$	Buyer's belief (i.e., perceived probability) in period $t$ that quality is good, where $t \in \{0, 1, 2\}$ and $\mu_0$ is the prior belief
$p_t$	Price in period $t$ , $t \in \{1, 2\}$
$q$	Product quality, which can be either high ( $H$ ) or low ( $L$ )
$r$	Precision of seller's private quality signal, $r \in (1/2, 1)$
$s$	Private quality signal a consumers receives through inspection, which can be either good ( $G$ ) or bad ( $B$ ); private signals are i.i.d. across consumers given quality
$\theta$	Conditional probability of achieving full buyer interest in the example of Equation 11
$x$	Share of early consumers interested in the product, $x \in [\underline{x}, \bar{x}]$

Table 2: Experiment Results

Condition		# Subjects	Perceived Quality		Demarketing (Dummy)	
			Mean	Std Dev	Mean	Std Dev
<i>Study 1</i>						
1	Quality Inference Observing Marketing	50	3.680	0.819	—	—
2	Quality Inference Observing Demarketing	50	4.120	0.961	—	—
<i>Study 2</i>						
3	High Uncertainty, High Growth	49	—	—	0.327	0.474
4	Low Uncertainty, High Growth	50	—	—	0.160	0.370
5	High Uncertainty, Low Growth	50	—	—	0.140	0.351
<i>Study 3</i>						
6	High Uncertainty, High Growth; Business Students	34	—	—	0.382	0.493
7	Low Uncertainty, High Growth; Business Students	31	—	—	0.194	0.402
8	High Uncertainty, Low Growth; Business Students	34	—	—	0.176	0.387
<i>Study 4</i>						
9	High Uncertainty, High Growth; Unobservable Sales	50	—	—	0.140	0.351
10	High Uncertainty, High Growth; Unobservable Marketing	50	—	—	0.180	0.388
<i>Study 5</i>						
11	Quality Inference Observing Marketing + High Uncertainty, High Growth	50	3.886	0.876	0.480	0.505
12	Quality Inference Observing Demarketing + High Uncertainty, High Growth	49	4.265	0.569	0.510	0.505

Note. The dummy variable “demarketing” equals 1 if the subject chooses moderate marketing and 0 if the subject chooses intensive marketing.

Figure 1: Timing of the Game

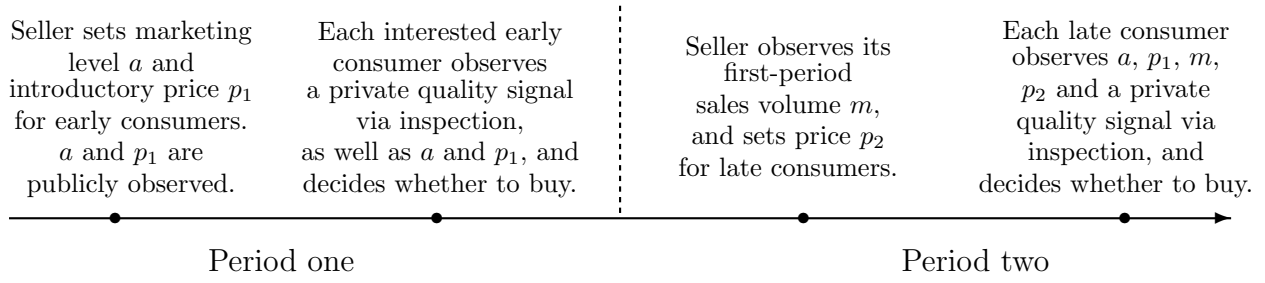
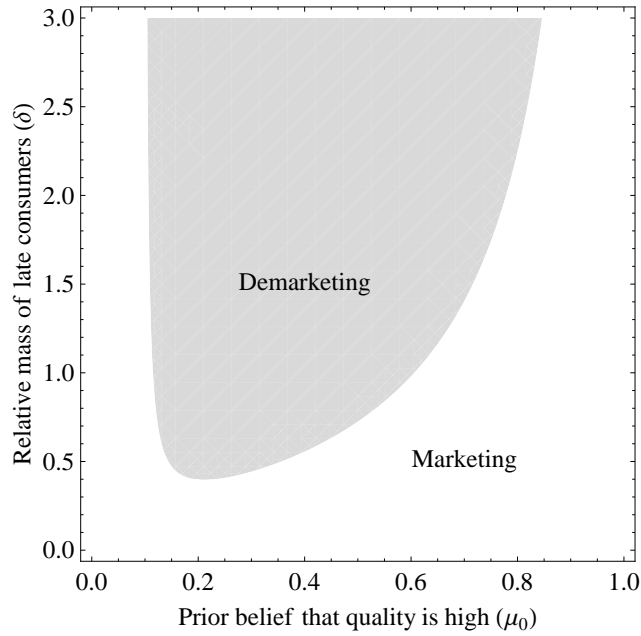


Figure 2: Equilibrium Marketing Level



Note. This figure is based on the functional form specification of Equation 11 where  $\bar{\theta} = 0.6$ ,  $\underline{\theta} = 0.1$ , and  $b = 2/3$ .

# (De)marketing to Manage Consumer Quality Inferences

## Web Appendix

Jeanine Miklós-Thal, Juanjuan Zhang

### W.1 Proof of Proposition 2

(i) As  $\delta$  goes to zero, a high-quality seller's expected profit goes to the following limit:

$$\lim_{\delta \rightarrow 0} E\Pi(a|H) = E(x|a)\mu_1(G).$$

Since  $E(x|a)$  increases with  $a$ , the expected profit in the limit case is always maximized for  $a = \bar{a}$ . The continuity of  $E\Pi(a|H)$  in  $\delta$  then implies that  $a < \bar{a}$  can only arise in equilibrium if  $\delta$  is sufficiently different from 0.

(ii) Note that  $\mu_1(G)$  is continuous in  $\mu_0$ , and  $\mu_2(a, m, G)$  is continuous in  $\mu_0$  if  $m \in [\underline{x}, b\bar{x}]$ . Therefore:

$$\begin{aligned} \lim_{\mu_0 \rightarrow 0} \mu_1(G) &= 0, \\ \lim_{\mu_0 \rightarrow 0} \mu_2(a, m, s) &= \begin{cases} 1 & \text{if } m > b\bar{x}, \\ 0 & \text{otherwise.} \end{cases} \end{aligned}$$

A high-quality seller's expected profit approaches the following limit:

$$\lim_{\mu_0 \rightarrow 0} E\Pi(a|H) = \delta [1 - F(b\bar{x}|a)].$$

By continuity, the above result implies that, for  $\mu_0$  sufficiently close to 0, profit maximization calls for  $a = \bar{a}$  so as to maximize  $1 - F(b\bar{x}|a)$ , the likelihood of first-period sales  $m$  being above  $b\bar{x}$ . Hence, demarketing can arise in equilibrium only if  $\mu_0$  is sufficiently positive.

On the other hand, as  $\mu_0$  goes to 1, beliefs approach the following limits:

$$\begin{aligned} \lim_{\mu_0 \rightarrow 1} \mu_1(G) &= 1, \\ \lim_{\mu_0 \rightarrow 1} \mu_2(a, m, s) &= \begin{cases} 0 & \text{if } m < \underline{x}, \text{ or if } m \in [\underline{x}, b\bar{x}] \text{ and } s = B, \\ 1 & \text{otherwise.} \end{cases} \end{aligned}$$

Since a high-quality seller will achieve first-period sales of  $m \geq \underline{x}$  and will generate an inspection outcome  $s = G$  for certain, its expected profit approaches the following limit:

$$\lim_{\mu_0 \rightarrow 1} E\Pi(a|H) = E(x|a) + \delta.$$

The seller's optimal strategy in this limit case is hence to set  $a = \bar{a}$  to maximize  $E(x|a)$ . By continuity, the same result is true for  $\mu_0$  close to 1, and hence demarketing can only be optimal if  $\mu_0$  lies sufficiently below 1.

## W.2 Proof of Proposition 3

After observing marketing efforts  $a$ , first-period sales  $m$ , and the outcome of her inspection  $s$ , a late consumer's quality belief is:<sup>W1</sup>

$$\mu_2(a, m, s) = \begin{cases} 1 & \text{if } m = 1, \\ \frac{(1-\bar{\theta})\mu_0}{(1-\bar{\theta})\mu_0 + \bar{\theta}b(1-\mu_0)} & \text{if } m = b, s = G, \text{ and } a = \bar{a}, \\ \frac{(1-\underline{\theta})\mu_0}{(1-\underline{\theta})\mu_0 + \underline{\theta}b(1-\mu_0)} & \text{if } m = b, s = G, \text{ and } a = \underline{a}, \\ 0 & \text{otherwise.} \end{cases}$$

Since  $\bar{\theta} > \underline{\theta}$ , we have:

$$\mu_2(\bar{a}, b, G) < \mu_2(\underline{a}, b, G).$$

As discussed, the optimal second-period price is given by Equation 8 as:

$$p_2^*(a, m) = \begin{cases} 1 & \text{if } m = 1, \\ \mu_2(a, b, G) & \text{if } m = b. \end{cases}$$

Finally, the expected profits under different marketing levels follow from Equation 10:

$$\begin{aligned} E\Pi(\bar{a}|H) &= [\bar{\theta} + (1 - \bar{\theta})b] \mu_1(G) + \delta [\bar{\theta} + (1 - \bar{\theta}) \mu_2(\bar{a}, b, G)], \\ E\Pi(\underline{a}|H) &= [\underline{\theta} + (1 - \underline{\theta})b] \mu_1(G) + \delta [\underline{\theta} + (1 - \underline{\theta}) \mu_2(\underline{a}, b, G)]. \end{aligned}$$

Demarketing ( $a = \underline{a}$ ) leads to higher second-period profits than marketing ( $a = \bar{a}$ ) if and only

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<sup>W1</sup>Note that since  $f(x|a)$  is discrete in this example, the probability mass function of first-period sales  $m$  in the case of low quality is  $f(\frac{m}{b}|a)$  (Casella and Berger 1990).



if:

$$(1 - \underline{\theta}) \mu_2(\underline{a}, b, G) - (1 - \bar{\theta}) \mu_2(\bar{a}, b, G) > \bar{\theta} - \underline{\theta},$$

which is equivalent to:

$$\frac{(1 - \underline{\theta})^2 \mu_0}{(1 - \underline{\theta}) \mu_0 + \underline{\theta} b (1 - \mu_0)} - \frac{(1 - \bar{\theta})^2 \mu_0}{(1 - \bar{\theta}) \mu_0 + \bar{\theta} b (1 - \mu_0)} > \bar{\theta} - \underline{\theta}.$$

Straightforward calculation shows that this last condition can be rewritten as:

$$\mu_0 > \hat{\mu} = \frac{\underline{\theta} \bar{\theta} b}{1 - \underline{\theta} - \bar{\theta} + (1 + b) \underline{\theta} \bar{\theta}}. \quad (\text{W1})$$

Since  $\underline{\theta}, \bar{\theta} \in (0, 1)$ , we have  $\hat{\mu} \in (0, 1)$ . For any sufficiently optimistic prior quality belief  $\mu_0 > \hat{\mu}$ , there exists a threshold for the relative mass of late consumers  $\hat{\delta}$  such that the seller chooses demarketing in equilibrium if  $\delta > \hat{\delta}$ . This establishes the existence result of Proposition 3.

### W.3 Pooling in Actions, Separating in Payoffs

We want to show that, in a pooling equilibrium, buyers' expected quality belief for a high-quality seller is more optimistic than their expected quality belief for a low-quality seller in both periods.

In the first period, buyers' expected quality belief is  $\mu_1(G)$  if the seller is high quality, and is  $b\mu_1(G) < \mu_1(G)$  if the seller is low quality.

For the second period, we want to show that:

$$1 - F(b\bar{x}|a) + \int_{\underline{x}}^{b\bar{x}} \mu_2(a, x, G) f(x|a) dx > b \int_{\frac{\underline{x}}{b}}^{\bar{x}} \mu_2(a, bx, G) f(x|a) dx. \quad (\text{W2})$$

Using the change of variables  $y = bx$ , RHSW2 becomes:

$$\int_{\underline{x}}^{b\bar{x}} \mu_2(a, y, G) f\left(\frac{y}{b}|a\right) dy = \int_{\underline{x}}^{b\bar{x}} \mu_2(a, x, G) f\left(\frac{x}{b}|a\right) dx.$$

Therefore, Inequality W2 is equivalent to:

$$\begin{aligned}
1 &> F(b\bar{x}|a) - \int_{\underline{x}}^{b\bar{x}} \mu_2(a, x, G) f(x|a) dx + \int_{\underline{x}}^{b\bar{x}} \mu_2(a, x, G) f(\frac{x}{b}|a) dx \\
&= \int_{\underline{x}}^{b\bar{x}} [f(x|a) - \mu_2(a, x, G) f(x|a) + \mu_2(a, x, G) f(\frac{x}{b}|a)] dx \\
&= \int_{\underline{x}}^{b\bar{x}} \{[1 - \mu_2(a, x, G)] f(x|a) + \mu_2(a, x, G) f(\frac{x}{b}|a)\} dx.
\end{aligned} \tag{W3}$$

Plugging in  $\mu_2(a, x, G)$  from Equation 6, the last integrand becomes:

$$\frac{f(\frac{x}{b}|a)(1 - \mu_0)}{f(x|a)\mu_0 + f(\frac{x}{b}|a)(1 - \mu_0)} f(x|a) + \frac{f(x|a)\mu_0}{f(x|a)\mu_0 + f(\frac{x}{b}|a)(1 - \mu_0)} f(\frac{x}{b}|a),$$

which in turn equals:

$$\frac{f(\frac{x}{b}|a)f(x|a)}{f(x|a)\mu_0 + f(\frac{x}{b}|a)(1 - \mu_0)}. \tag{W4}$$

Next, we want to show that:

$$W4 \leq f(\frac{x}{b}|a)\mu_0 + f(x|a)(1 - \mu_0), \tag{W5}$$

which is equivalent to:

$$f(\frac{x}{b}|a)f(x|a) \leq [f(x|a)\mu_0 + f(\frac{x}{b}|a)(1 - \mu_0)] [f(\frac{x}{b}|a)\mu_0 + f(x|a)(1 - \mu_0)]. \tag{W6}$$

But

$$\begin{aligned}
\text{RHS(W6)} &= f(x|a)f(\frac{x}{b}|a)\mu_0^2 + f(x|a)f(\frac{x}{b}|a)(1 - \mu_0)^2 + [f(x|a)^2 + f(\frac{x}{b}|a)^2]\mu_0(1 - \mu_0) \\
&\geq f(x|a)f(\frac{x}{b}|a)\mu_0^2 + f(x|a)f(\frac{x}{b}|a)(1 - \mu_0)^2 + 2f(x|a)f(\frac{x}{b}|a)\mu_0(1 - \mu_0) \\
&= f(x|a)f(\frac{x}{b}|a)[\mu_0^2 + (1 - \mu_0)^2 + 2\mu_0(1 - \mu_0)] \\
&= f(x|a)f(\frac{x}{b}|a).
\end{aligned}$$

Therefore, Inequality W5 holds. It follows that:

$$\begin{aligned}
\text{RHS(W3)} &\leq \int_{\underline{x}}^{b\bar{x}} [f(\frac{x}{b}|a)\mu_0 + f(x|a)(1 - \mu_0)] dx \\
&= \mu_0 \int_{\underline{x}}^{b\bar{x}} f(\frac{x}{b}|a) dx + (1 - \mu_0) \int_{\underline{x}}^{b\bar{x}} f(x|a) dx \\
&< \mu_0 + (1 - \mu_0) \\
&= 1.
\end{aligned} \tag{W7}$$

Hence Inequality W3 holds.

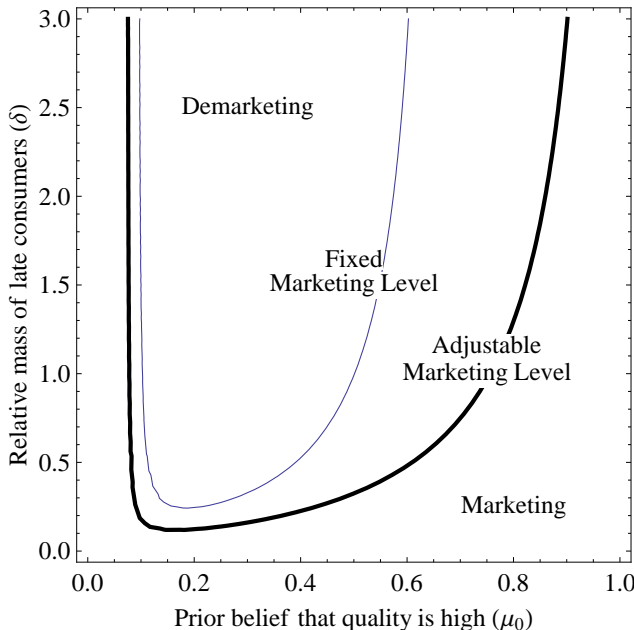
### W.4 Adjustable versus Fixed Marketing Level

The main model assumes that a seller can adjust its level of marketing across time. As a result, even if the seller chooses demarketing in period one, it can still engage in full marketing in period two. In a broader context, marketing decisions (such as store location choices) might be fixed over a long horizon. Correspondingly, a high-quality seller’s expected profit will be modified as:

$$E\Pi(a|H) = E(x|a) \left( \mu_1(G) + \delta [1 - F(b\bar{x}|a)] + \delta \int_x^{b\bar{x}} \mu_2(a, x, G) f(x|a) dx \right).$$

This modification highlights a new market force against the use of demarketing—demarketing lowers the expected level of consideration in period two although it might improve the quality beliefs of late consumers who do consider the product. This effect reduces the parameter range for demarketing to be optimal. We illustrate this result using the example of Equation 11. As Figure W1 shows, the parameter range for demarketing to be optimal is smaller when marketing level is fixed than when it is adjustable.<sup>W2</sup>

Figure W1: Equilibrium Marketing Level When Marketing is Adjustable versus Fixed



Note. This figure is based on the functional specification of Equation 11 where  $\bar{\theta} = 0.3$ ,  $\underline{\theta} = 0.2$ , and  $b = 3/4$ .

<sup>W2</sup>For simplicity we have assumed that expected buyer interest in the second period is 1 when marketing is adjustable. However, we obtain the same qualitative conclusion if we replace this value with  $E(x|\bar{a})$ .

## W.5 Sample Question for the Experiment

Figure W2: Sample Question for the Experiment

Suppose your company produces and sells a new e-book reader. You are to determine whether to intensively market the e-book reader during its first year of launch. You have the following information:

- Marketing helps you attract consumers to consider your product. However, whether a consumer eventually buys also depends on his/her evaluation of your product quality.
- In your second year of launch, consumers can observe how many units your company actually sold during the first year.
- Consumers can also observe how intensively you have marketed your product during the first year.
- Consumers are fairly **uncertain** about the quality of your e-book reader at the time of launch.
- It is forecast that the potential customer base for e-book readers will **significantly grow** over the two years.

The cost of marketing is taken care of and should not be your concern. Your goal is to maximize the profit your company could earn from selling the e-book reader over a two-year span. Keep in mind that the quality image of your e-book reader affects your profit.

How would you market your e-book reader during the first year of launch?

**Market it intensively**

**Market it moderately**

Note. This is an excerpt of the question used for the “High Uncertainty, High Growth” Condition (Condition #3). The complete set of questions and instructions for the experiments is available from the authors upon request.

## W.6 Extensions: Technical Details

### W.6.1 Marketing that Improves Prior Quality Beliefs

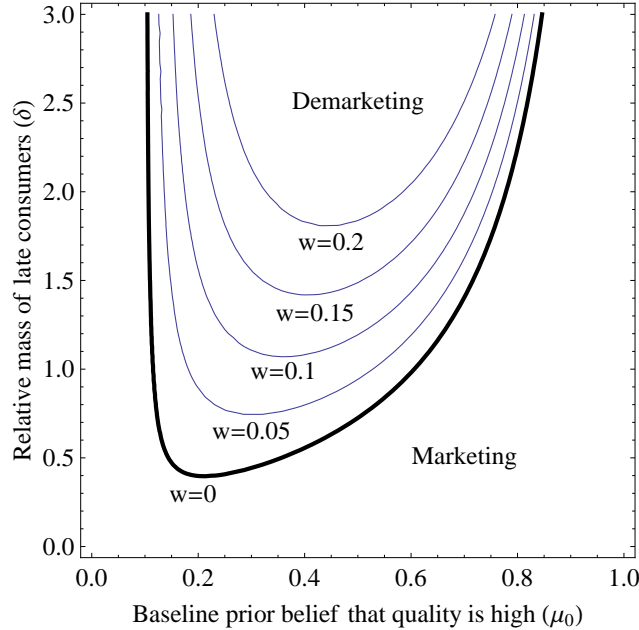
We allow buyers' prior beliefs to be  $\mu_0(a)$  where  $\mu_0'(a) \geq 0$ . We keep the rest of the main model unchanged to isolate the effect of endogenizing prior beliefs. An interested early consumer's posterior belief  $\mu_1$  varies with the marketing level through its effect on the prior beliefs:

$$\mu_1(a, s) = \begin{cases} \frac{\mu_0(a)}{\mu_0(a) + b[1 - \mu_0(a)]} & \text{if } s = G, \\ 0 & \text{if } s = B. \end{cases}$$

Similarly, a late consumer's quality belief varies with marketing efforts as follows:

$$\mu_2(a, m, s) = \begin{cases} 1 & \text{if } m > b\bar{x}, \\ \frac{f(m|a)\mu_0(a)}{f(m|a)\mu_0(a) + f(\frac{m}{b}|a)[1 - \mu_0(a)]} & \text{if } \underline{x} \leq m \leq b\bar{x} \text{ and } s = G, \\ 0 & \text{otherwise.} \end{cases}$$

Figure W3: Equilibrium Marketing Level When Marketing Improves Prior Quality Beliefs



Note. This figure is based on the functional specification of Equation 11 where  $\bar{\theta} = 0.6$ ,  $\underline{\theta} = 0.1$ , and  $b = 2/3$ . We normalize  $\mu_0(\underline{a})$  as  $\mu_0$ , the exogenous baseline prior quality belief, and parameterize  $\mu_0(\bar{a})$  as  $w + (1 - w)\mu_0$ , where  $w \in [0, 1]$  increases with the persuasiveness of marketing efforts.

The directional effect of  $a$  on the term  $\frac{f(m|a)\mu_0(a)}{f(m|a)\mu_0(a)+f(\frac{m}{b}|a)(1-\mu_0(a))}$  is ambiguous.

For comparability, we continue to use the example specified by Equation 11 to illustrate the effect of endogenizing prior beliefs on the seller's equilibrium marketing level. We normalize  $\mu_0(\underline{a})$  as  $\mu_0$ , the exogenous baseline prior quality belief in the main model. We then parameterize  $\mu_0(\bar{a})$  as  $w + (1 - w)\mu_0$ , where  $w \in [0, 1]$  increases with the persuasiveness of marketing efforts in improving prior beliefs. Figure W3 presents the equilibrium (de)marketing decision as a function of  $\mu_0$ ,  $\delta$ , and  $w$ , where along each curve the seller is indifferent between marketing and demarketing. When  $w = 0$ , the marketing level decision reduces to that of the main model as illustrated in Figure 2. When  $w$  increases, there is a smaller parameter range for demarketing to be optimal, as expected.

### W.6.2 Marketing that Accelerates Buyer Arrival

We allow the mass of early consumers to be  $\lambda(a)$  and the mass of late consumers to be  $\delta + 1 - \lambda(a)$ , where  $0 \leq \lambda(\underline{a}) \leq \lambda(\bar{a}) \leq 1 + \delta$ . We retain the rest of the model to identify how endogenizing buyer arrival changes equilibrium marketing level decisions.<sup>W3</sup>

An interested early consumer's quality belief depends on the prior belief and her private inspection outcome, as characterized in the main analysis. The seller's optimal price in the first period is again  $p_1^* = \mu_1(G)$ , so that an interested early consumer buys if and only if she receives a good inspection outcome. It follows that, for any interest level  $x$ , first-period sales volume  $m$  equals  $x\lambda(a)$  if product quality is high, and  $b\bar{x}\lambda(a)$  if quality is low. Following the main analysis, we focus on the more interesting case of  $\underline{x} \leq b\bar{x}$  such that there exists a mediocre sales range  $m \in [\underline{x}\lambda(a), b\bar{x}\lambda(a)]$ , where late consumers remain uncertain about product quality. After observing marketing effort  $a$ , first-period sales  $m$ , and her inspection outcome  $s$ , a late consumer's quality belief is:

$$\mu_2(a, m, s) = \begin{cases} 1 & \text{if } m > b\bar{x}\lambda(a), \\ \frac{f[\frac{m}{\lambda(a)}|a]\mu_0}{f[\frac{m}{\lambda(a)}|a]\mu_0 + f[\frac{m}{b\bar{x}\lambda(a)}|a](1-\mu_0)} & \text{if } \underline{x}\lambda(a) \leq m \leq b\bar{x}\lambda(a) \text{ and } s = G, \\ 0 & \text{otherwise.} \end{cases}$$

When first-period sales are mediocre while her private inspection is good, a late consumer's quality belief decreases with marketing efforts. This result echoes Proposition 1: mediocre

<sup>W3</sup>In this formulation  $\delta$  no longer captures seller patience. However, a discount factor can be easily added to the model. Intuitively, demarketing can not be an equilibrium outcome if the seller is myopic.

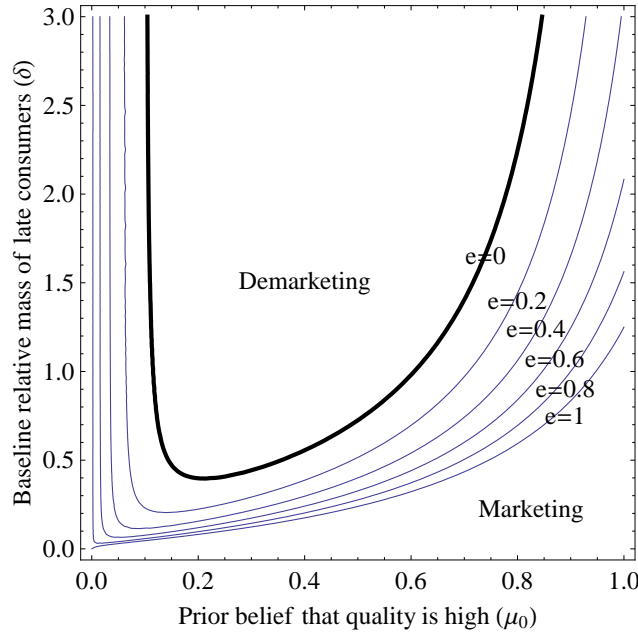
sales are a rather satisfactory result given insufficient marketing, but signify low quality if there has been a marketing extravaganza.

The equilibrium price in the second period is  $p_2^*(a, m) = \mu_2(a, m, G)$ . A high-quality seller chooses its marketing effort level to maximize its expected profit:

$$E\Pi(a|H) = \lambda(a)E(x|a)\mu_1(G) + [\delta + 1 - \lambda(a)] \left[ 1 - F(b\bar{x}|a) + \int_{\underline{x}}^{b\bar{x}} \mu_2(a, x\lambda(a), G)f(x|a)dx \right].$$

Greater effectiveness of marketing efforts in accelerating buyer arrival may increase the parameter range for demarketing to be optimal. We illustrate this result using the specification from Equation 11. We normalize  $\lambda(\underline{a})$  as 1, and parameterize  $\lambda(\bar{a})$  as  $1 + e\delta$ , where the parameter  $e \in [0, 1]$  measures the effectiveness of marketing efforts in accelerating buyer arrival. Figure W4 presents the seller's equilibrium marketing level as a function of  $\mu_0$ ,  $\delta$ , and  $e$ , where on each curve the seller is indifferent between marketing and demarketing. When  $e = 0$ , the equilibrium marketing level is identical to that of the main model as illustrated in Figure 2. When  $e$  increases, so does the parameter range for demarketing to be optimal.

Figure W4: Equilibrium Marketing Level When Marketing Accelerates Buyer Arrival



Note. This figure is based on the functional specification of Equation 11 where  $\bar{\theta} = 0.6$ ,  $\underline{\theta} = 0.1$ , and  $b = 2/3$ . The mass of early consumers is  $\lambda(a)$  and the mass of late consumers is  $\delta + 1 - \lambda(a)$ . We normalize  $\lambda(\underline{a})$  as 1, and parameterize  $\lambda(\bar{a})$  as  $1 + e\delta$ , where  $e \in [0, 1]$  measures the effectiveness of marketing efforts in accelerating buyer arrival.

### W.6.3 More than Two Time Periods

Equilibrium marketing efforts are weakly increasing over time in our baseline model. We now show that marketing dynamics can be non-monotonic when there are more than two time periods. While the seller always chooses high marketing in the final period, the (expected) marketing effort may be decreasing over time in earlier periods.

For illustration, we consider a three-period model. In each period  $t = 1, 2, 3$ , the high-quality seller sets its marketing effort  $a_t \in \{\underline{a}, \bar{a}\}$  to maximize its total expected profits from period  $t$  until the end of the game. The seller rationally anticipates that its current marketing effort may affect its own future marketing efforts. As before, marketing generates buyer interest.

There are three buyer generations  $t = 1, 2, 3$ . The mass of period  $t$  consumers relative to period  $t - 1$  consumers is  $\delta > 0$ .<sup>W4</sup> Each potential buyer in generation  $t$  observes the entire history of marketing efforts and sales volumes up to period  $t$ , denoted by  $H_t = (a_1, \dots, a_{t-1}, m_1, \dots, m_{t-1})$ , where  $H_1 = \emptyset$ .<sup>W5</sup> For example, generation 3 observes  $H_3 = (a_1, a_2, m_1, m_2)$ . In addition, each interested buyer observes a quality signal  $s$ .

We denote by  $\tilde{\mu}_t(H_t)$  the quality belief of a potential buyer in generation  $t$  *prior* to any private quality inspection:

$$\tilde{\mu}_t(H_t) = \begin{cases} \mu_0 & \text{if } H_t = \emptyset, \\ \frac{f(m_{t-1}|a_{t-1})\tilde{\mu}_{t-1}(H_{t-1})}{f(m_{t-1}|a_{t-1})\tilde{\mu}_{t-1}(H_{t-1}) + f(\frac{m_{t-1}}{b}|a_{t-1})\frac{1}{b}[1 - \tilde{\mu}_{t-1}(H_{t-1})]} & \text{otherwise.} \end{cases}$$

The belief of an interested consumer in generation  $t$  whose private inspection reveals  $s = G$  is:

$$\mu_t(H_t, G) = \frac{\tilde{\mu}_t(H_t)}{\tilde{\mu}_t(H_t) + b[1 - \tilde{\mu}_t(H_t)]}.$$

Note that  $\tilde{\mu}_t(H_t) = 1$  always implies  $\tilde{\mu}_{t+1}(H_{t+1}) = 1$ . Once stellar sales have revealed high quality, the seller enjoys a high quality reputation in all future periods.

In period 3, it is evidently optimal for a high-quality seller to set  $a_3 = \bar{a}$  so as to maximize the expected level of buyer interest. There is no benefit from demarketing. The profit analysis in period 2 proceeds as in our main model except that the initial belief is  $\tilde{\mu}_2(a_1, m_1)$  instead of  $\mu_0$ . As in the main model, if  $\tilde{\mu}_2(a_1, m_1)$  is intermediate and  $\delta$  is high enough, there are

<sup>W4</sup>As before,  $\delta$  incorporates both changes in the mass of potential buyers over time and the discount factor. The  $t$ -period model could be extended to allow for other patterns of growth in the mass of consumers.

<sup>W5</sup>A consumer in generation  $t$  could also observe  $a_t$ . However, as discussed with the main model, observing  $a_t$  *per se* does not update this consumer's quality belief in a pooling equilibrium.

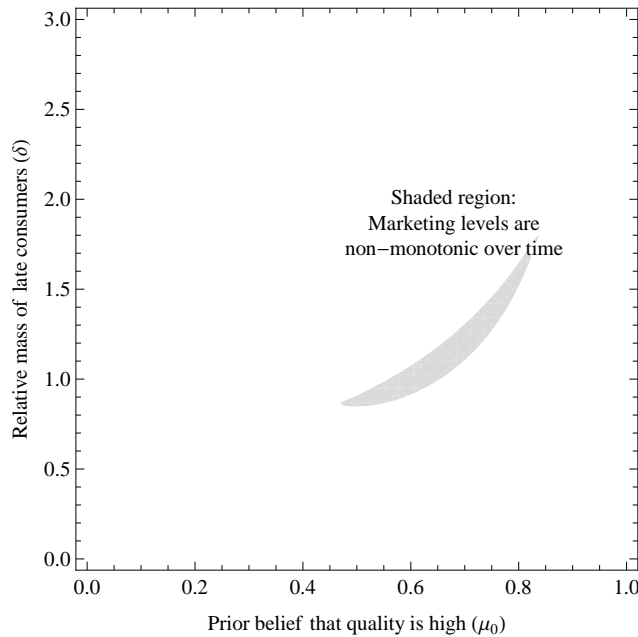


distribution functions  $f(m|a)$  such that  $a_2 = \underline{a}$  in a pooling equilibrium of the subgame starting at  $t = 2$  (see Proposition 3).

Several factors explain why the first-period marketing effort can differ from the second-period marketing effort in equilibrium. First, the future horizon is longer, which by itself would suggest that there may be a greater benefit to demarketing. Second, the initial belief is  $\mu_0$  instead of  $\tilde{\mu}_2(a_1, m_1)$ . The impact of this difference on the optimal marketing decision is ambiguous. Third, the first-period marketing effort affects the distribution of  $\tilde{\mu}_2(a_1, m_1)$  both directly and indirectly via its expected impact on  $m_1$ , which, in turn, means that the first-period decision  $a_1$  affects the second-period decision  $a_2$ .

Taken together, these effects imply that there can exist pooling equilibria in which the seller always chooses marketing in the first and the third period, but chooses demarketing in the second period after some realizations of  $m_1$ . The expected marketing effort is thus lowest in the second period. For illustration, we use a numerical example based on the functional specification of Equation 11. The shaded area in Figure W5 illustrates the range of  $\mu_0$  and  $\delta$  for which there is a pooling equilibrium with the following marketing dynamics:  $a_1 = \bar{a}$ ;  $a_2 = \bar{a}$  if  $m_1 = 1$ , but  $a_2 = \underline{a}$  if  $m_1 = b$ ;  $a_3 = \bar{a}$ .

Figure W5: Parameter Range for Marketing Levels to be Non-monotonic Over Time



Note. This figure is based on the functional specification of Equation 11 where  $\bar{\theta} = 0.7$ ,  $\underline{\theta} = 0.1$ , and  $b = 2/3$ .

#### W.6.4 Heterogeneous Willingness to Pay

We extend the main model to capture consumers' heterogeneous tastes. We allow a consumer's willingness to pay for a product to equal her quality belief about this product multiplied by her intrinsic valuation for quality,  $\nu$ , which is distributed over  $[0, 1]$  following a generic cumulative distribution function  $U$  and probability distribution function  $u$ . A consumer's valuation  $\nu$  is her private information. However, its distribution is common knowledge.

##### The *Ex Post* Effect of Demarketing is Robust

An interested early consumer's quality belief follows Equation 3 of the main model. For any positive introductory price  $p_1$ , an early consumer who receives a bad signal will not buy regardless of her quality valuation; an early consumer who receives a good signal will buy if and only if  $\mu_1(G)\nu \geq p_1$ . It follows that, for any consideration level  $x$ , a high-quality seller's first-period sales volume equals  $x D_1(p_1)$  where  $D_1(p_1) = 1 - U\left[\frac{p_1}{\mu_1(G)}\right]$ . A low-quality seller's first-period sales volume equals  $b x D_1(p_1)$ . Therefore, after observing marketing efforts  $a$ , introductory price  $p_1$ , first-period sales  $m$ , and her inspection outcome  $s$ , a late consumer's posterior quality belief is:

$$\mu_2(a, p_1, m, s) = \begin{cases} 1 & \text{if } m > b\bar{x}D_1(p_1), \\ \frac{f\left[\frac{m}{D_1(p_1)}|a\right]\mu_0}{f\left[\frac{m}{D_1(p_1)}|a\right]\mu_0 + f\left[\frac{m}{bD_1(p_1)}|a\right](1-\mu_0)} & \text{if } \underline{x}D_1(p_1) \leq m \leq b\bar{x}D_1(p_1) \text{ and } s = G, \\ 0 & \text{otherwise.} \end{cases}$$

Keeping  $m$  constant, the quality belief term  $\frac{f\left[\frac{m}{D_1(p_1)}|a\right]\mu_0}{f\left[\frac{m}{D_1(p_1)}|a\right]\mu_0 + f\left[\frac{m}{bD_1(p_1)}|a\right](1-\mu_0)}$  decreases with marketing effort  $a$  since  $f(x|a)$  satisfies the MLRP in  $a$ . This *ex post* effect of demarketing echoes Proposition 1 of the main model.

##### The *Ex Ante* Effect of Demarketing is Robust

In the second period, the high-quality seller will choose a price  $p_2$  to maximize its second-period profit, given late consumers' quality belief and taste distribution. The low-quality seller will imitate the high-quality seller's second-period price unless its first-period sales are poor ( $m < \underline{x}D_1(p_1)$ ), in which case it will not be able to sell anything at a positive price.

It follows that a high-quality seller's expected profit ultimately depends on its first-period

marketing effort and price choices in the following way:

$$\begin{aligned} E\Pi(a, p_1|H) &= E(x|a)p_1 \left\{ 1 - U \left[ \frac{p_1}{\mu_1(G)} \right] \right\} + \delta [1 - F(b\bar{x}|a)] \max_{p_2} p_2 [1 - U(p_2)] \\ &\quad + \delta \int_{\underline{x}}^{\bar{x}} \max_{p_2} p_2 \left\{ 1 - U \left[ \frac{p_2}{\mu_2(a, p_1, xD_1(p_1), G)} \right] \right\} f(x|a) dx. \end{aligned}$$

However, in the case of mediocre sales we have:

$$\mu_2(a, p_1, xD_1(p_1), G) = \frac{f \left[ \frac{x D_1(p_1)}{D_1(p_1)} | a \right] \mu_0}{f \left[ \frac{x D_1(p_1)}{D_1(p_1)} | a \right] \mu_0 + f \left[ \frac{x D_1(p_1)}{b D_1(p_1)} | a \right] (1 - \mu_0)} = \frac{f(x|a) \mu_0}{f(x|a) \mu_0 + f\left(\frac{x}{b}|a\right) (1 - \mu_0)}$$

which is identical to  $\mu_2(a, x, G)$  of the main model in the case of mediocre sales. That is, the introductory price does not affect late consumers' quality belief. The high-quality seller will thus set its introductory price to maximize its static profit in the first period. The low-quality seller will charge the same price.

To aid subsequent analysis, we define a "static optimal price"  $p_t^S$  for any buyer belief  $\mu_t > 0$ :

$$p_t^S = \arg \max_{p_t} \pi(p_t) = p_t \left[ 1 - U \left( \frac{p_t}{\mu_t} \right) \right].$$

Below we prove a general result that  $\pi(p_t^S)$  is linear in  $\mu_t$ . The first-order condition of the profit maximization problem leads to:

$$1 - U(\psi) = \psi u(\psi), \text{ where } \psi = \frac{p_t^S}{\mu_t}.$$

For a given distribution  $U$ ,  $\psi$  is a constant. For instance, if  $U$  is the c.d.f. of the uniform distribution, then  $\psi = \frac{1}{2}$ . By the envelope theorem we have:

$$\frac{\partial \pi(p_t^S)}{\partial \mu_t} = \left( \frac{p_t^S}{\mu_t} \right)^2 u \left( \frac{p_t^S}{\mu_t} \right) = \psi^2 u(\psi).$$

Therefore,  $\pi(p_t^S)$  is linear in  $\mu_t$  with constant coefficient  $\psi^2 u(\psi)$ .

As discussed before, the high-quality seller will choose  $p_1^S$  and  $p_2^S$  in equilibrium over the two

periods, respectively. It follows that its expected profit can be rewritten as:

$$E\Pi(a|H) = \psi^2 u(\psi) \left\{ E(x|a)\mu_1(G) + \delta[1 - F(b\bar{x}|a)] + \delta \int_x^{b\bar{x}} \mu_2(a, x, G) f(x|a) dx \right\}.$$

But this is identical to the profit function in the main model as given by Equation 10 except for the scaling factor  $\psi^2 u(\psi)$ . Therefore, the high-quality seller's (de)marketing incentives are the same as in the main model. The parameter range for demarketing to be optimal does not change.

### W.6.5 Word-of-Mouth Communication

We extend the main model by allowing each late consumer to communicate with one randomly chosen consumer from the first period. Through communication, the late consumer learns whether her predecessor considered the product, and if so, this predecessor's private signal.

Let  $s_1$  denote the information from the predecessor, which could be a good signal ( $G$ ), a bad signal ( $B$ ), or the lack of consideration ( $\emptyset$ ). Let  $s_2$  denote the late consumer's private signal. If first-period sales ( $m$ ) are stellar, the late consumer knows that quality is high. If first-period sales are poor or if there is a bad signal, the late consumer knows that quality is low. Below we derive the late consumer's quality belief in the remaining cases, in which first-period sales are mediocre,  $s_1$  equals  $G$  or  $\emptyset$ , and  $s_2$  equals  $G$ .

Observing past sales volume  $m$ , the late consumer knows that the fraction of consumers who considered the product in period one is  $m$  if product quality is high and  $m/b$  if quality is low. Her probability of obtaining a good signal from a random predecessor is thus  $m$  if quality is high and  $b \times m/b = m$  if quality is low. Her quality belief in this case is hence the same as if she does not communicate with her predecessor. On the other hand, her probability of obtaining a  $\emptyset$  signal from a random predecessor is  $1 - m$  if quality is high and  $1 - m/b$  if quality is low. Since  $0 < b < 1$ , unless  $m = 0$ , a  $\emptyset$  word-of-mouth signal is more diagnostic of high quality than a good word-of-mouth signal.

In summary, a late consumer's quality belief is:

$$\mu_2(a, m, s_1, s_2) = \begin{cases} 1 & \text{if } m > b\bar{x}, \\ \frac{f(m|a)\mu_0}{f(m|a)\mu_0 + f(\frac{m}{b}|a)(1-\mu_0)} & \text{if } \underline{x} \leq m \leq b\bar{x}, s_1 = G \text{ and } s_2 = G, \\ \frac{(1-m)f(m|a)\mu_0}{(1-m)f(m|a)\mu_0 + (1-\frac{m}{b})f(\frac{m}{b}|a)(1-\mu_0)} & \text{if } \underline{x} \leq m \leq b\bar{x}, s_1 = \emptyset \text{ and } s_2 = G, \\ 0 & \text{otherwise.} \end{cases}$$

The *ex post* effect of demarketing on buyer quality inference continues to hold. Analogous to Proposition 1, when first-period sales are mediocre while neither of the signals is bad, a late consumer’s quality belief decreases with marketing efforts for a given sales volume. Moreover, the late consumer’s quality belief is more positive when the past consumer she communicates with did not consider the product than when the past consumer received a good signal:

$$\mu_2(a, m, \emptyset, G) > \mu_2(a, m, G, G), \quad \forall m > 0 \text{ and } m \in [\underline{x}, \bar{x}]. \quad (\text{W8})$$

If first-period sales are stellar, the high-quality seller will charge a price equal to 1 in the second period. If first-period sales are mediocre, the high-quality seller knows the following facts: a fraction  $x = m$  of late consumer are communicating with a past consumer who has considered the product (and received a good signal), and thus hold a quality belief of  $\mu_2(a, m, G, G)$ ; a fraction  $1 - m$  of late consumers are communicating with a past consumer who has not considered the product, and thus hold a quality belief of  $\mu_2(a, m, \emptyset, G)$ . It follows that a high-quality seller’s expected profit (where  $c$  denotes the case of communication) is as follows:<sup>W6</sup>

$$\begin{aligned} E\Pi^c(a|H) &= E(x|a)\mu_1(G) + \delta[1 - F(\bar{x}|a)] + \\ &\quad \delta \int_{\underline{x}}^{\bar{x}} [x\mu_2(a, x, G, G) + (1 - x)\mu_2(a, x, \emptyset, G)] f(x|a)dx. \end{aligned}$$

This profit function is the same as its counterpart in the main model,  $E\Pi(a|H)$ , except for the expected second-period profit component in the case of mediocre sales. Since  $\mu_2(a, x, G, G)$  equals  $\mu_2(a, x, G)$  of the main model, Inequality W8 then implies that:

$$E\Pi^c(a|H) > E\Pi(a|H).$$

Naturally, word-of-mouth communication increases the amount of information available to

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<sup>W6</sup>For simplicity, this profit formulation assumes that the seller observes whether a late consumer communicates with an early consumer who considered the product or one who did not. This assumption is plausible with today’s consumer tracking technologies. For instance, if the seller limits its marketing activities in certain geographic areas and if consumers mainly communicate with their neighbors, then the seller could infer from address information whether a late consumer obtains a  $\emptyset$  signal or a good signal via communication. Alternatively, if a high-quality seller does not have any information about the likely content of word-of-mouth communication, when first-period sales are mediocre, it must choose between (1) charging a high price  $\mu_2(a, m, \emptyset, G)$  and selling to a fraction  $1 - m$  of late consumers, and (2) charging a low price  $\mu_2(a, m, G, G)$  and selling to all late consumers. This complicates exposition without changing the basic insight behind Result W8—the message that an early consumer did not consider the product is more indicative of high quality than positive word-of-mouth.

late consumers, which helps a high-quality firm further differentiate itself from its low-quality counterpart.

We extend our investigation by asking whether word-of-mouth communication would ever increase the parameter range for demarketing to be optimal. Recall that:

$$\begin{aligned} E\Pi(\underline{a}|H) - E\Pi(\bar{a}|H) &= [E(x|\underline{a}) - E(x|\bar{a})]\mu_1(G) + \delta [F(b\bar{x}|\bar{a}) - F(b\bar{x}|\underline{a})] + \\ &\delta \int_{\underline{x}}^{b\bar{x}} [\mu_2(\underline{a}, x, G)f(x|\underline{a}) - \mu_2(\bar{a}, x, G)f(x|\bar{a})]dx. \end{aligned}$$

It follows that:

$$\begin{aligned} E\Pi^c(\underline{a}|H) - E\Pi^c(\bar{a}|H) &= E\Pi(\underline{a}|H) - E\Pi(\bar{a}|H) + \\ &\delta \int_{\underline{x}}^{b\bar{x}} (1-x)\{[\mu_2(\underline{a}, x, \emptyset, G) - \mu_2(\underline{a}, x, G, G)]f(x|\underline{a}) \\ &- [\mu_2(\bar{a}, x, \emptyset, G) - \mu_2(\bar{a}, x, G, G)]f(x|\bar{a})\}dx. \end{aligned}$$

For any  $\delta > 0$ , word-of-mouth communication increases the parameter range for demarketing to be optimal if and only if:

$$\begin{aligned} \int_{\underline{x}}^{b\bar{x}} (1-x)[\mu_2(\underline{a}, x, \emptyset, G) - \mu_2(\underline{a}, x, G, G)]f(x|\underline{a})dx > \\ \int_{\underline{x}}^{b\bar{x}} (1-x)[\mu_2(\bar{a}, x, \emptyset, G) - \mu_2(\bar{a}, x, G, G)]f(x|\bar{a})dx. \end{aligned} \quad (\text{W9})$$

Whether Condition W9 holds depends on parameter values and the functional form of  $f(x|a)$ . However, we can gain some intuition into what market forces make this condition more likely to hold. First, demarketing lowers expected consideration *ex ante*, which makes it more likely that a late consumer receives a  $\emptyset$  signal from word-of-mouth communication. Mathematically, demarketing shifts greater weight to lower values of  $x$  and higher values of  $1-x$ , which is in favor of Condition W9. Indeed, since  $f(x|a)$  satisfies the MLRP in  $a$ , it is easy to show that:

$$\int_{\underline{x}}^{b\bar{x}} (1-x)f(x|\underline{a})dx > \int_{\underline{x}}^{b\bar{x}} (1-x)f(x|\bar{a})dx.$$

However, there is a countervailing effect of demarketing; it could dilute the quality implication of a  $\emptyset$  signal *ex post*. To see the intuition, consider the following two extreme cases. If first-

period sales are zero, it must be that none of the early consumers considered the product. It follows that a late consumer will receive a  $\emptyset$  signal regardless of product quality, which makes the  $\emptyset$  signal uninformative. If first-period sales equal  $b$  (which is the highest level of mediocre sales), the degree of consideration among early consumers must be  $b$  if quality is high and 1 if quality is low. It follows that a  $\emptyset$  signal is perfectly indicative of high quality. Mathematically, the level of marketing will vary the term  $\mu_2(a, x, \emptyset, G) - \mu_2(a, x, G, G)$ .

Whether Inequality W9 holds depends on both effects. Below we derive a necessary condition for it to hold. For notational convenience, let  $z(x, a) = \frac{1-\mu_0}{\mu_0} \frac{f(\frac{x}{b}|a)}{f(x|a)}$  and  $\gamma(x) = \frac{b-x}{b(1-x)}$ . Rearranging terms, we have:

$$\begin{aligned} \mu_2(a, x, \emptyset, G) - \mu_2(a, x, G, G) &= \frac{1}{1 + \gamma(x)z(x, a)} - \frac{1}{1 + z(x, a)} \\ &= \frac{[1 - \gamma(x)]z(x, a)}{[1 + \gamma(x)z(x, a)][1 + z(x, a)]}. \end{aligned}$$

Inequality W9 can then be rewritten as:

$$\int_{\underline{x}}^{b\bar{x}} \frac{xf(\frac{x}{b}|\underline{a})}{[1 + \gamma(x)z(x, \underline{a})][1 + z(x, \underline{a})]} dx > \int_{\underline{x}}^{b\bar{x}} \frac{xf(\frac{x}{b}|\bar{a})}{[1 + \gamma(x)z(x, \bar{a})][1 + z(x, \bar{a})]} dx. \quad (\text{W10})$$

Note that:

$$\lim_{\mu_0 \rightarrow 1} \text{LHS(W10)} = \int_{\underline{x}}^{b\bar{x}} xf(\frac{x}{b}|\underline{a})dx, \quad \text{and} \quad \lim_{\mu_0 \rightarrow 1} \text{RHS(W10)} = \int_{\underline{x}}^{b\bar{x}} xf(\frac{x}{b}|\bar{a})dx.$$

Using the change of variables  $y = \frac{x}{b}$ , we have:

$$\lim_{\mu_0 \rightarrow 1} \text{LHS(W10)} = b^2 \int_{\underline{x}/b}^{\bar{x}} yf(y|\underline{a})dy, \quad \text{and} \quad \lim_{\mu_0 \rightarrow 1} \text{RHS(W10)} = b^2 \int_{\underline{x}/b}^{\bar{x}} yf(y|\bar{a})dy.$$

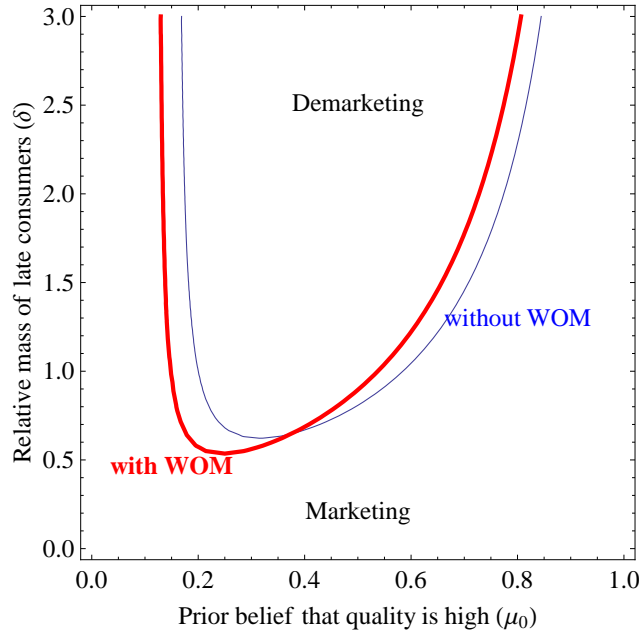
However, since  $f(\cdot|a)$  follows the MLRP in  $a$ , we get  $\int_{\underline{x}/b}^{\bar{x}} yf(y|\underline{a})dy < \int_{\underline{x}/b}^{\bar{x}} yf(y|\bar{a})dy$ , which violates Inequality W10. Because both sides of Condition W9 are continuous in  $\mu_0$ , a necessary condition for Condition W9 to hold is that  $\mu_0$  be sufficiently bounded below 1.

We use an example to illustrate this result. Suppose:

$$\begin{aligned}
 f(x|\bar{a}) &= \begin{cases} \bar{\theta} & \text{if } x = b, \\ 1 - \bar{\theta} & \text{if } x = b^2, \end{cases} \\
 f(x|\underline{a}) &= \begin{cases} \underline{\theta} & \text{if } x = b, \\ 1 - \underline{\theta} & \text{if } x = b^2, \end{cases}
 \end{aligned} \tag{W11}$$

with  $0 < \underline{\theta} < \bar{\theta} < 1$ . Figure W6 presents the seller's equilibrium (de)marketing decision as a function of  $\mu_0$  and  $\delta$ , where on each curve the seller is indifferent between marketing and demarketing. Word-of-mouth communication increases the parameter range for demarketing to be optimal when  $\mu_0$  is small, and decreases the parameter range when  $\mu_0$  is large.

Figure W6: Word-of-Mouth Communication and Equilibrium Marketing Level



Note. This figure is based on the functional specification of Equation W11 where  $\bar{\theta} = 0.6$ ,  $\underline{\theta} = 0.2$ , and  $b = 1/2$ .

### W.6.6 Seller Uncertainty about Quality

A seller's quality belief after observing signal  $v$  is:

$$\mu_0^v = \begin{cases} \frac{r\mu_0}{r\mu_0 + (1-r)(1-\mu_0)} & \text{if } v = H, \\ \frac{(1-r)\mu_0}{(1-r)\mu_0 + r(1-\mu_0)} & \text{if } v = L. \end{cases}$$



Since  $r > 1/2$ , we have  $\mu_0^H > \mu_0 > \mu_0^L$ ; a high-type seller has greater confidence in its quality than a low-type seller. We denote by  $\mu_0(a)$  a buyer's quality belief after observing marketing effort  $a$ . In the pure-strategy separating equilibrium of interest, the seller's choice of marketing effort reveals its type, so that  $\mu_0(a) \in \{\mu_0^H, \mu_0^L\}$ .

A bad inspection outcome again reveals low product quality for certain. A good inspection outcome updates an interested early consumer's quality belief to:

$$\mu_1(G, \mu_0(a)) = \frac{\mu_0(a)}{\mu_0(a) + b[1 - \mu_0(a)]}.$$

To simplify presentation, we will later on use the following notations:

$$\mu_1^H = \mu_1(G, \mu_0^H), \quad \mu_1^L = \mu_1(G, \mu_0^L).$$

These simplified notations recognize the fact that the level of marketing does not further affect early consumers' quality beliefs beyond signaling the seller's confidence in its quality.

After observing first-period sales  $m$  and a good inspection outcome, a late consumer's quality belief is updated as follows (we suppress the argument  $G$  for notational simplicity):

$$\mu_2(a, m, \mu_0(a)) = \begin{cases} 1 & \text{if } m > b\bar{x}, \\ \frac{f(m|a)\mu_0(a)}{f(m|a)\mu_0(a) + f(\frac{m}{b}|a)[1 - \mu_0(a)]} & \text{if } \underline{x} \leq m \leq b\bar{x}, \\ 0 & \text{otherwise.} \end{cases}$$

Let  $E\Pi(a|v)$  denote the expected profit of a seller who receives quality signal  $v$  and who chooses marketing level  $a$ . For demarketing to signal high type in a separating equilibrium, we need:

$$E\Pi(\underline{a}|H) - E\Pi(\bar{a}|H) \geq 0 \geq E\Pi(\underline{a}|L) - E\Pi(\bar{a}|L). \quad (\text{W12})$$

More specifically, we look for an equilibrium in which the high-type seller sets  $a = \underline{a}$ ,  $p_1 = \mu_1^H$ , and  $p_2 = \mu_2(\underline{a}, m, \mu_0^H)$ , and the low type chooses  $a = \bar{a}$ ,  $p_1 = \mu_1^L$ , and  $p_2 = \mu_2(\bar{a}, m, \mu_0^L)$ . Since its type is revealed in the separating equilibrium, in each period the seller optimally charges a price equal to the quality belief of consumers who receive a good inspection outcome. It follows that, by signaling its confidence through demarketing, a high-type seller earns an expected profit of:

$$E\Pi(\underline{a}|H) = \mu_0^H \{E(x|\underline{a})\mu_1^H + \delta E[\mu_2(\underline{a}, m, \mu_0^H)|H]\} + (1 - \mu_0^H) b \{E(x|\underline{a})\mu_1^H + \delta E[\mu_2(\underline{a}, m, \mu_0^H)|L]\}.$$

The former (latter) half of the above profit function captures the expected profit if the seller is high quality (low quality), weighted by a confident seller's perceived probability that quality is indeed high (low). By deviating to marketing, this confident seller earns:

$$E\Pi(\bar{a}|H) = \mu_0^H \{E(x|\bar{a})\mu_1^L + \delta E[\mu_2(\bar{a}, m, \mu_0^L)|H]\} + (1 - \mu_0^H) b \{E(x|\bar{a})\mu_1^L + \delta E[\mu_2(\bar{a}, m, \mu_0^L)|L]\}.$$

We can similarly specify  $E\Pi(\bar{a}|L)$  and  $E\Pi(\underline{a}|L)$ . Condition W12 states that demarketing should overall benefit the high-type seller (compared with marketing) but hurt the low-type seller. In addition to the pros and cons of demarketing identified in the main analysis, demarketing in the separating equilibrium of interest also signals the seller's greater confidence in quality, which anchors buyers with more optimistic prior quality beliefs.

### Proof of Proposition 6

(i) As  $\delta$  approaches 0, the differences of a seller's expected profits between demarketing and marketing approach the following limits:

$$\begin{aligned} \lim_{\delta \rightarrow 0} [E\Pi(\underline{a}|H) - E\Pi(\bar{a}|H)] &= [\mu_0^H + (1 - \mu_0^H) b] [E(x|\underline{a})\mu_1^H - E(x|\bar{a})\mu_1^L], \\ \lim_{\delta \rightarrow 0} [E\Pi(\underline{a}|L) - E\Pi(\bar{a}|L)] &= [\mu_0^L + (1 - \mu_0^L) b] [E(x|\underline{a})\mu_1^H - E(x|\bar{a})\mu_1^L], \end{aligned}$$

which are either both positive or both negative, violating Condition W12.

(ii) As  $\mu_0$  approaches 1, quality beliefs approach the following limits:

$$\begin{aligned} \lim_{\mu_0 \rightarrow 1} \mu_0^H &= \lim_{\mu_0 \rightarrow 1} \mu_0^L = 1, \\ \lim_{\mu_0 \rightarrow 1} \mu_1^H &= \lim_{\mu_0 \rightarrow 1} \mu_1^L = 1, \\ \lim_{\mu_0 \rightarrow 1} \mu_2(a, m, \mu_0^H) &= \begin{cases} 1 & \text{if } m \geq \underline{x} \\ 0 & \text{otherwise.} \end{cases} \end{aligned}$$

It follows that:

$$\begin{aligned} \lim_{\mu_0 \rightarrow 1} E\Pi(\underline{a}|H) &= E(x|\underline{a}) + \delta, \\ \lim_{\mu_0 \rightarrow 1} E\Pi(\bar{a}|H) &= E(x|\bar{a}) + \delta, \end{aligned}$$

which violates Condition W12.

(iii) As  $r$  approaches 1, quality beliefs approach the following limits:

$$\begin{aligned}\lim_{r \rightarrow 1} \mu_0^H &= \lim_{r \rightarrow 1} \mu_1^H = 1, \\ \lim_{r \rightarrow 1} \mu_0^L &= \lim_{r \rightarrow 1} \mu_1^L = 0, \\ \lim_{r \rightarrow 1} \mu_2(a, m, \mu_0^H) &= \begin{cases} 1 & \text{if } m > \underline{x} \\ 0 & \text{otherwise,} \end{cases} \\ \lim_{r \rightarrow 1} \mu_2(a, m, \mu_0^L) &= \begin{cases} 1 & \text{if } m > b\bar{x} \\ 0 & \text{otherwise.} \end{cases}\end{aligned}$$

It follows that:

$$\begin{aligned}\lim_{r \rightarrow 1} E\Pi(\underline{a}|L) &= bE(x|\underline{a}), \\ \lim_{r \rightarrow 1} E\Pi(\bar{a}|L) &= 0,\end{aligned}$$

which violates Condition W12.

As  $r$  approaches  $1/2$ , quality beliefs approach the following limits:

$$\begin{aligned}\lim_{r \rightarrow \frac{1}{2}} \mu_0^H &= \lim_{r \rightarrow \frac{1}{2}} \mu_0^L = \mu_0, \\ \lim_{r \rightarrow \frac{1}{2}} \mu_1^H &= \lim_{r \rightarrow \frac{1}{2}} \mu_1^L.\end{aligned}$$

It follows that:

$$\lim_{r \rightarrow \frac{1}{2}} [E\Pi(\underline{a}|H) - E\Pi(\bar{a}|H)] = \lim_{r \rightarrow \frac{1}{2}} [E\Pi(\underline{a}|L) - E\Pi(\bar{a}|L)],$$

which violates Condition W12 except in the measure-zero event that both sides of the above equation equal 0 in the limit.

(iv) By the law of iterated expectations, we obtain:

$$\begin{aligned}\mu_0^H &= \mu_0^H E[\mu_2(\underline{a}, m, \mu_0^H)|H] + (1 - \mu_0^H)bE[\mu_2(\underline{a}, m, \mu_0^H)|L], \\ \mu_0^L &= \mu_0^L E[\mu_2(\bar{a}, m, \mu_0^L)|H] + (1 - \mu_0^L)bE[\mu_2(\bar{a}, m, \mu_0^L)|L].\end{aligned}$$

Rearranging terms yields:

$$E\Pi(\underline{a}|L) - E\Pi(\bar{a}|L) = [\mu_0^L + (1 - \mu_0^L)b][E(x|\underline{a})\mu_1^H - E(x|\bar{a})\mu_1^L] + \delta \left(1 - \frac{\mu_0^L}{\mu_0^H}\right) bE[\mu_2(\underline{a}, m, \mu_0^H)|L].$$

If  $E(x|\underline{a})\mu_1^H \geq E(x|\bar{a})\mu_1^L$ , the right-hand side of the above equation will be strictly positive, violating Condition W12.

### Proof of Proposition 7

For demarketing to signal low type in a separating equilibrium, we need:

$$E\Pi(\bar{a}|H) - E\Pi(\underline{a}|H) \geq 0 \geq E\Pi(\bar{a}|L) - E\Pi(\underline{a}|L), \quad (\text{W13})$$

where

$$\begin{aligned} E\Pi(\bar{a}|L) &= [\mu_0^L + (1 - \mu_0^L)b]E(x|\bar{a})\mu_1^H + \delta\{\mu_0^L E[\mu_2(\bar{a}, m, \mu_0^H)|H] + (1 - \mu_0^L)bE[\mu_2(\bar{a}, m, \mu_0^H)|L]\}, \\ E\Pi(\underline{a}|L) &= [\mu_0^L + (1 - \mu_0^L)b]E(x|\underline{a})\mu_1^L + \delta\{\mu_0^L E[\mu_2(\underline{a}, m, \mu_0^L)|H] + (1 - \mu_0^L)bE[\mu_2(\underline{a}, m, \mu_0^L)|L]\}. \end{aligned}$$

By the law of iterated expectations, we obtain:

$$\begin{aligned} \mu_0^H &= \mu_0^H E[\mu_2(\bar{a}, m, \mu_0^H)|H] + (1 - \mu_0^H)bE[\mu_2(\bar{a}, m, \mu_0^H)|L], \\ \mu_0^L &= \mu_0^L E[\mu_2(\underline{a}, m, \mu_0^L)|H] + (1 - \mu_0^L)bE[\mu_2(\underline{a}, m, \mu_0^L)|L]. \end{aligned}$$

Rearranging terms yields:

$$E\Pi(\bar{a}|L) - E\Pi(\underline{a}|L) = [\mu_0^L + (1 - \mu_0^L)b][E(x|\bar{a})\mu_1^H - E(x|\underline{a})\mu_1^L] + \delta \left(1 - \frac{\mu_0^L}{\mu_0^H}\right) bE[\mu_2(\bar{a}, m, \mu_0^H)|L].$$

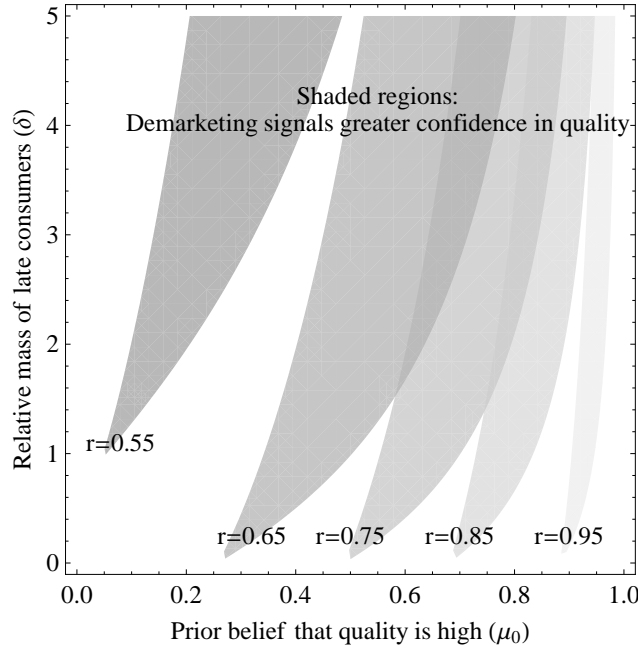
The right-hand side of the above equation is strictly positive, violating Condition W13.

We close this section by illustrating the demarketing separating equilibrium using the specification of Equation 11. Figure W7 presents the parameter ranges for this separating equilibrium to arise. The results are consistent with the conditions of Proposition 6—the parameter ranges grow with the relative mass of late consumers, are bounded away from  $\mu_0 = 1$ , and are larger with intermediate levels of seller information precision.

## W.7 Other Forms of Demarketing

In this section, we analyze two other classic marketing problems: advertising scheduling and market selection. In doing so, we show the robustness of the demarketing idea and explore its applications in these alternative marketing decision contexts.

Figure W7: Parameter Ranges for a Separating Equilibrium to Exist in Which Demarketing Signals Seller's Greater Confidence in Quality



Note. We present a set of five regions for demarketing to signal seller's greater confidence in quality, corresponding to five precision levels of the seller's private information about its quality:  $r \in \{0.55, 0.65, 0.75, 0.85, 0.95\}$ . This figure is based on the functional form specification of Equation 11 where  $\bar{\theta} = 0.6$ ,  $\underline{\theta} = 0.1$ , and  $b = 1/3$ .

### W.7.1 An Advertising Scheduling Model

Suppose the seller has a fixed advertising budget  $K > 0$  that provides an upper bound on the sum of advertising expenditures  $a_1 + a_2$  over the two periods. The level of interest among early consumers, denoted by  $x_1$ , follows a conditional p.d.f.  $f_1(x_1|a_1)$ , whereas the level of interest among late consumers,  $x_2$ , follows a conditional p.d.f.  $f_2(x_2|a_2 + \phi a_1)$ . The conditional distribution functions  $f_1$  and  $f_2$  need not be identical. However, we make a similar assumption as in the main model that  $f_1$  satisfies the MLRP in advertising. The parameter  $\phi$  captures the prolonged effect of advertising (e.g., Horsky and Simon 1983). The case of  $\phi = 0$  represents the highest level of advertising decay, whereby the impact of advertising is confined to its current period. The case of  $\phi = 1$  represents the highest level of advertising carry-over, whereby buyer interest depends on the cumulative advertising stock to date.

In our two-period model, it is always optimal for the seller to fully exhaust the advertising budget in the second period; the seller will want to maximize interest among late consumers for any given level of first-period advertising. Therefore,  $a_2 = K - a_1$ . It follows that the

expected fraction of interested buyers in the two periods are  $E(x_1|a_1)$  and  $E(x_2|K - a_1 + \phi a_1)$  respectively. Let  $\tilde{\delta}$  denote the relative mass of late consumers (we will discuss how  $\tilde{\delta}$  relates to  $\delta$  in the main model). The high-quality seller’s expected profit over the two periods is:

$$E\Pi(a_1|H) = E(x_1|a_1)p_1 + \tilde{\delta}E(x_2|K - a_1 + \phi a_1)p_2. \quad (\text{W14})$$

We first consider the benchmark case in which late consumers do not engage in observational learning, a case often examined in traditional advertising scheduling models. Interested buyers in both periods make their purchase decisions based on their inspection outcomes. Therefore, the optimal prices to charge in both periods are  $p_1^* = p_2^* = \mu_1(G)$  as defined in Equation 4. The seller should then schedule its advertising to maximize  $E(x_1|a_1) + \tilde{\delta}E(x_2|K - a_1 + \phi a_1)$ . Other things being equal, the higher the value of  $\phi$ —that is, the stronger the prolonged effect of advertising—the greater the seller’s incentive to engage in heavy advertising at product launch. In particular, for  $\phi = 1$ , the seller would want to exhaust its advertising budget in period one. Intuitively, when the benefit of advertising fully carries over to future periods, the seller should “front-load” advertising to take the most advantage of its long-run market expansion effect.

With observational learning, however, less front-loaded advertising can increase the seller’s profit. The profit-maximizing prices are determined in the same way as in the main model (Equations 4 and 8). A high-quality seller’s expected profit across the two periods becomes:

$$E\Pi(a_1|H) = E(x_1|a_1)\mu_1(G) + \tilde{\delta}E(x_2|K - a_1 + \phi a_1) \int_{\underline{x}}^{\bar{x}} \mu_2(a_1, x, G) f_1(x_1|a_1) dx_1. \quad (\text{W15})$$

By Proposition 1, late consumers’ quality belief  $\mu_2(a_1, x, G)$  is weakly decreasing in  $a_1$  since  $f_1(x_1|a_1)$  satisfies the MLRP in  $a_1$ . For  $\phi = 1$ , the measure of interested late consumers is independent of  $a_1$  and equal to  $\tilde{\delta}E(x_2|K)$ . In this case, the analysis of the advertising scheduling model is equivalent to that of the main model where  $\delta$  is set equal to  $\tilde{\delta}E(x_2|K)$  and where  $f = f_1$ . In particular,  $a_1 < K$  can be the equilibrium first-period advertising level for intermediate values of prior quality belief  $\mu_0$  if the measure of interested late consumers  $\tilde{\delta}E(x_2|K)$  is sufficiently large (Figure 2).

### W.7.2 A Market Selection Model

Suppose a firm can select one of multiple identically sized markets to serve. Each consumer derives the following consumption utility from the firm’s product:

$$U = x + \beta\mu_1 + \epsilon.$$

This utility function is often adopted in the literature (e.g., Guadagni and Little 1983). The term  $x$  can be interpreted as the “match value” between the consumer and the brand which reflects, for example, how the product caters to a consumer’s personal tastes independent of the quality it offers. The term  $\mu_1$  is the consumer’s perceived probability that product quality is high, which corresponds to early consumers’ quality belief  $\mu_1$  in the main model. The coefficient  $\beta > 0$  denotes the utility weight the consumer attaches to quality beliefs.<sup>W7</sup> Finally,  $\epsilon$  denotes consumers’ idiosyncratic utility shocks.

The match value a product eventually delivers often depends on both the characteristics of the target market and random factors. To capture this idea, we let  $a$  denote the intrinsic “match potential” of the product in a given market, which relies on the characteristics of the target market. Meanwhile, let  $f(x|a)$  denote the conditional p.d.f. of delivering a specific match value  $x$  to consumers in a market that has match potential  $a$ . We assume that  $f(x|a)$  satisfies the MLRP in  $a$ . For instance, by selecting the urban market which exhibits greater match potential, Daimler’s Smart mini-car improves the relative chance of fulfilling higher match values to consumers in this market. We assume that a market’s match potential  $a$  is commonly observable but the exact match value  $x$  is not; it is commonly known that Smart cars have greater match potential in the urban market but the exact match value is susceptible to randomness.

We abstract from specifying the micro-process (such as a private signal structure) by which true quality affects quality beliefs. Instead, we make a mild non-parametric assumption that all consumers in the target market hold a more favorable quality belief if true quality is high (denoted as  $\mu_1^H$ ) than if true quality is low (denoted as  $\mu_1^L$ ):

$$\mu_1^H > \mu_1^L. \tag{W16}$$

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<sup>W7</sup>Consumption utility can also depend on other product attributes. However, the key intuition of the model continues to hold as long as these attributes are commonly observable. Therefore, we exclude these attributes from the utility function for notational simplicity.

We normalize consumers' no-purchase utility to be zero. Depending on the functional form of the utility shocks, we can then specify the product's share of the target market. We denote this market share as  $m$ , which echoes first-period sales  $m$  in the main model. For concreteness, suppose utility shocks follow an i.i.d. double exponential distribution across markets. The firm's market share follows the logit specification:

$$m = \frac{\exp(x + \beta\mu_1)}{1 + \exp(x + \beta\mu_1)}.$$

To maximize its expected market share, the firm should select the market with the greatest match potential  $a$ .

Now suppose the firm's objective is to maintain the quality beliefs of the general public beyond the target market. Consider the general public's posterior quality belief after observing the firm's match potential choice  $a$  and the resulting market share  $m$ :  $\mu_2(a, m)$ .<sup>W8</sup> This term corresponds to late consumers' quality beliefs in the main model. Given the logit specification, the general public knows that the match value  $x$  must be  $\log \frac{m}{1-m} - \beta\mu_1^H$  if quality is high, and  $\log \frac{m}{1-m} - \beta\mu_1^L$  if quality is low, hence:

$$\mu_2(a, m) = \frac{f(\log \frac{m}{1-m} - \beta\mu_1^H | a) \mu_0}{f(\log \frac{m}{1-m} - \beta\mu_1^H | a) \mu_0 + f(\log \frac{m}{1-m} - \beta\mu_1^L | a) (1 - \mu_0)} = \frac{1}{1 + \frac{f(\log \frac{m}{1-m} - \beta\mu_1^L | a) (1 - \mu_0)}{f(\log \frac{m}{1-m} - \beta\mu_1^H | a) \mu_0}}.$$

Since  $\mu_1^H > \mu_1^L$ ,  $\beta > 0$  and  $f(x|a)$  satisfies the MLRP in  $a$ , for any given market share  $m$ , the choice of greater match potential hurts the general public's quality beliefs:

$$\frac{\partial \mu_2(a, m)}{\partial a} < 0. \tag{W17}$$

It remains to be checked whether the firm would ever prefer markets with worse match potential *ex ante* given their lower probabilities of achieving high market share.

Absent cost considerations, the high-quality firm will choose the market with match potential  $a$  to maximize the expected quality belief of the general public  $E[\mu_2(a, m)|H]$ . The low-quality firm will mimic its high-quality counterpart's market selection in a pooling equilibrium. Recall that for any match value  $x$ , the high-quality firm's market share is  $m = \exp(x + \beta\mu_1^H) / [1 +$

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<sup>W8</sup>The same conclusion holds qualitatively if the general public also receives quality signals.



$\exp(x + \beta\mu_1^H)$ ]. Therefore:

$$E[\mu_2(a, m)|H] = \int \mu_2(a, m)f(x|a)dx = \int \frac{1}{1 + \frac{f(x+\beta\mu_1^H - \beta\mu_1^L|a)}{f(x|a)} \frac{1-\mu_0}{\mu_0}} f(x|a)dx.$$

The greatest match potential does not always maximize the above term. For example, suppose  $f(x|a) = -a \exp(ax)$  where  $x \geq 0$  and  $a < 0$  such that  $f(x|a)$  satisfies the MLRP in  $a$ . The above expression becomes:

$$E[\mu_2(a, m)|H] = \int_0^\infty \frac{-a \exp(ax)}{1 + \exp[a\beta(\mu_1^H - \mu_1^L)] \frac{1-\mu_0}{\mu_0}} dx = \frac{1}{1 + \exp[a\beta(\mu_1^H - \mu_1^L)] \frac{1-\mu_0}{\mu_0}}.$$

It follows that:

$$\frac{\partial E[\mu_2(a, m)|H]}{\partial a} < 0. \tag{W18}$$

That is, given the functional form assumptions, if a firm is sufficiently concerned about the quality beliefs of the general public, it should select the least viable target market.

## References

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