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Strategic Demarketing

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Abstract

This paper shows that a seller can benefit from strategically "demarketing" its product, meaning visibly suppressing marketing efforts to reduce demand. Demarketing lowers expected sales *ex ante* but improves product quality image *ex post*, as the market attributes good sales to superior quality and lackluster sales to insufficient marketing. We derive conditions for demarketing to be a relevant business strategy.

Key words: demarketing; observational learning; quality inference.

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1 Introduction

Lunch trucks are a regular scene on the campus of an East Coast research university. Essentially mobile kitchens, these trucks can park in any licensed spot. One would expect to see the trucks at locations with high student traffic. However, a good number of trucks choose to operate on quieter side streets where patronage is sparse. To understand the trucks' location choices, we conducted a field study in Spring 2011. Using ethnographic research methods such as participant observation and intensive interviewing (Lofland and Lofland 1995), we tried to elicit truck managers' decision factors within their natural business environment.

As expected, truck managers and customers in the study admit that a high-traffic location has its obvious appeal. More customers would line up in front of the truck, and a longer line signals better food to passersby. Given these observations, it is even more puzzling that some trucks would choose remote locations. Interestingly, this location decision turns out to be a deliberate choice. One benefit is that it helps boost the trucks' quality image. If a truck in a side street attracts a decent number of patrons, passersby tend to think that the food must be good enough to overcome the bad location. Recognizing this fact, the manager of a remotely located truck said:

> "[That we serve a low-traffic area] is precisely the point! Everyone knows that. We have five people in the line, and we look quite good already for this neighborhood."

On the other hand, slow sales are often blamed on the truck's location instead of the food, as one manager argued:

> "It's not the stuff we sell, it's where we are."

Similar examples abound in life where decision-makers visibly choose adverse conditions to influence how they are perceived by others. Some professors of MBA courses intentionally give exams, knowing students' general distaste for exams. Doing so highlights the quality of teaching if students, despite the exams, give favorable course ratings,

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and shifts questioning away from teaching quality if ratings are lackluster.[1] There is also evidence from laboratory experiments that agents choose more difficult tasks to be perceived as being more capable (Katok and Siemsen 2011). Relatedly, the psychology literature has documented 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).

The above examples share the following features. First, a decision-maker's intrinsic value (e.g., a truck's food quality) is uncertain to an external audience (e.g., passersby). Second, the audience draws inference about the intrinsic value from observable performance measures (e.g., the length of the line waiting at the truck). Third, the decision-maker visibly chooses adverse conditions (e.g., a remote location) in the hopes that the audience perceives the intrinsic value more positively.

The way adverse conditions improve value perceptions *ex post* can be explained by the "attribution theory" in social psychology (e.g., Heider 1958). Individuals often attribute observed events to multiple causes—in particular, to external conditions versus intrinsic value. Adverse conditions accentuate high intrinsic value as the driver of success, and alleviate concerns over the intrinsic value in case of failure. However, attribution theory cannot explain why a decision-maker would choose adverse conditions as an *ex ante* optimal strategy. Adversity does increase the probability of failure, and failure does negatively impact how a decision-maker is perceived by others, although adversity mitigates this negative impact. Indeed, Harbaugh (2011) states a similar critique of the self-handicapping literature, that "self-handicapping makes losing more frequent even as it makes losing less painful, so it is unclear why people should prefer to self-handicap."

In this paper we formally analyze whether, and under which conditions, a decision-maker finds it optimal *ex ante* to choose adversity. To cast the decision in a market context, we specifically analyze why a seller would take actions to reduce demand for its product. Kotler and Levy (1971) devised the term "demarketing" in reference to intentional demand-reducing activities. The form of demarketing includes choosing remote locations, setting inconvenient service times, understocking inventory purposely, under-

[1] We thank Duncan Simester for providing this example.

cutting advertising, and introducing nuisance product attributes (Gerstner, Hess, and Chu 1993). We will adopt this definition of demarketing for the paper, and study how a seller can strategically demarket its product to manage buyers' inference of its quality.

To best capture buyers' quality inference dynamics, we focus on the setting of new product introduction using a two-period model, although the intuition behind demarketing can apply to other contexts. A monopolist seller privately knows the quality of its product, which could be either high or low. A buyer's willingness to pay depends on her perceived probability that quality is high. The seller can choose between two levels of marketing efforts: "marketing" and "demarketing." Marketing efforts are demand-enhancing; for concreteness, we assume that marketing efforts increase the expected share of buyers who consider the product. To rule out the 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 for first-period buyers, whom we call "early adopters." Each early adopter who considers the product then conducts a private inspection which imperfectly reveals product quality, and decides whether to buy. In the second period, first-period sales volume becomes publicly observed. The seller then sets the price for "late adopters," 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 adopters do not observe whether an early adopter considered the product because product consideration, unlike product purchase, is often a private process (Van den Bulte and Lilien 2004).

Demarketing improves quality image *ex post* in the following way. Suppose an early adopter chose not to buy the product. Late adopters can have two interpretations—it could be that this early adopter 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 first-period sales *ex ante*.

We find that sellers of both high and low quality can choose demarketing as the *ex ante* optimal strategy under the following conditions. First, the relative mass of late adopters 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 adopters. To do so, the seller should maximize marketing efforts in period one. If buyers are very optimistic about quality, 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. To do so, the seller again should maximize marketing efforts in period one.

We extend the model to explore how a seller's marketing decisions change in richer market contexts. We find that the seller is less likely to demarket when marketing improves buyers' prior quality beliefs, but may be even more likely to demarket if marketing accelerates buyer arrival to the market—the seller may strategically delay business until buyers form a higher valuation of its product. Moreover, we uncover a separating equilibrium in which a seller with greater confidence in its quality demarkets to establish a strong quality image, whereas an unconfident seller markets its product intensively 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 next section we summarize possible explanations of demarketing and discuss how our approach differs. We also survey the literature on "observational learning," the mechanism underlying buyers' attribution process in our theory. Section 3 presents the main analysis and derives the conditions for demarketing to be the optimal strategy. Section 4 extends the analysis to incorporate other roles of marketing, and to investigate the possibility of separating equilibria. Section 5 concludes the paper and presents a list of empirically testable hypotheses.

2 Relation to Previous Research

2.1 Reasons to Demarket

The demarketing phenomenon first attracted the attention of academic researchers in the 1970's. It is intriguing why marketers would intentionally reduce demand. Kotler and Levy (1971) outline several possible reasons. "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 want 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.[2] Gerstner, Hess, and Chu (1993) further propose the notion 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 adopter segment. In fact, we find that the faster this segment grows, the more likely the seller will pursue demarketing. Third, unlike ostensible demarketing which actually attracts consumers, demarketing in our framework indeed 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 isolate a new role of demarketing in managing buyers' quality inference.

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.[3] By lowering awareness and reducing market coverage, the high-type firm discourages mimicry from its low-

[2]In a related study, Berger and Mens (2009) find that first-names which enjoy fast initial adoption are less likely to persist because people perceive fads negatively.

[3]Bagwell and Overgaard (2005) generalize the result of Zhao (2000).

quality-low-cost counterpart who instead 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. Our separating equilibrium is also built on a different mechanism; it does not rely on the cost gap between sellers, but reflects sellers' different tradeoffs between short-run sales and long-run quality image.

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). For example, Kopalle and Lehmann (2006) show that companies deliberately understate quality because customers derive satisfaction if their actual product experience exceeds their expectations, which in turn drives repeat purchase. Our perspective differs from expectations management in three ways. (1) Expectations management emphasizes buyers' comparison between expectations and experience, whereas our theory focuses on buyers' attribution of sales outcome to various causes. (2) Expectations management highlights the intrapersonal aspect of consumer decision-making, meaning how one's internal comparison of hopes and reality affects her utility. Our approach emphasizes the interpersonal aspect of decision-making, meaning how one's external observation of others' purchase decisions influences her quality perception. (3) Expectations management is more relevant for "experience goods," and it helps the firm when satisfied customers take further actions such as buying again or recommending the product to others. In our model, demarketing can benefit the seller even in a pure "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).

2.2 Observational Learning

The way buyers infer product quality from others' purchase decisions is related to the observational learning literature. Banerjee (1992), Bikhchandani, Hirshleifer, and Welch (1992) analytically prove that merely observing peer decisions without knowing their private signals may lead to uniform choices within a society. A few studies expand this literature by looking at 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) explores optimal real estate property 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.

Our paper extends the observational learning literature in several ways. We consider a monopolistic seller who has private information about its quality as in Taylor (1999), but we do not confine ourselves to products such as houses that only serve one buyer and thus only generate negative observational learning. Furthermore, our analysis goes beyond pricing and explores the role of a broadly defined set of marketing efforts. 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; 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.

3 Main Analysis

3.1 Model Setup

We consider a monopolistic seller of a product. The seller privately observes its product quality q. 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).

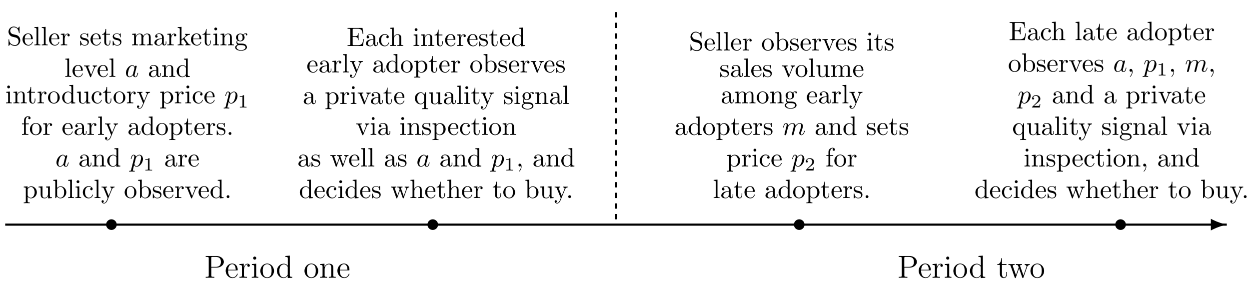
Potential buyers fall into two segments: early adopters and late adopters. Segmentation is determined by exogenous factors such as the time a buyer arrives on the market. (We examine endogenous segmentation in Section 4.2.) There is a continuum of early adopters whose measure is normalized to 1, and a continuum of late adopters of mass $\delta > 0$.[4] Buyers have unit demands for the product, but cannot observe product quality.

[4]For brevity we interpret δ as the relative mass of late adopters. However, δ also captures the seller's

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 μ for the product.

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 adopters. 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, which we normalize to zero (see Gerstner, Hess, and Chu 1992 for the same assumption).

Figure 1: Timing of the Game



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). Therefore, we focus on marketing efforts that raise buyer interest and increase the expected number of consumers who consider buying 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

degree of patience for future payoffs. Adding a temporal discounting parameter increases the notational burden in this context without bringing new insights.

Section 4.4).

Let x denote the share of early adopters 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 $x \in [\underline{x}, \overline{x}]$ and $0 \leq \underline{x} < \overline{x} \leq 1$. We further assume that $f(x|a)$ satisfies the monotone likelihood ratio property (MLRP) in a (Milgrom 1981). 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 (but not vice versa). Furthermore, the MLRP requires that, for any two interest levels, the relative chance of achieving the higher interest level increases with marketing efforts.

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:

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

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.[5] In this sense, inspection is imperfect—if inspection perfectly reveals quality ($b = 0$), then there is no need for late adopters to engage in observational learning. Each interested early adopter observes her own inspection outcome s, and all interested early adopters simultaneously decide whether to buy at price p_1.[6]

[5] 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 complicates exposition but leads to the same key results. The analysis is available upon request.

[6] We make the conservative assumption that early adopters who do not consider the product exit the market at the end of the first period. Alternatively, if these early adopters remain in the market

In the second period, the seller observes the volume of sales it has achieved among early adopters, denoted by m, and sets the price p_2 for late adopters. All late adopters observe a, m, p_1, and p_2. However, late adopters do not observe x, the precise number of early adopters 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 adopters do not directly access the inspection outcomes of early adopters.[7] As a result, late adopters can have two interpretations why some early adopters did not buy—it could be that they simply 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 adopters' 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 adopters in a two-period model, the seller would always want to maximize costless marketing efforts in period two. We therefore assume that all late adopters consider the product in order to simplify presentation without weakening the main message.[8] Correspondingly, unless otherwise indicated, by marketing efforts we specifically refer to those that target early adopters.

Finally, late adopters 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 adopters inspect the product because inspection does not provide additional information about quality.) A late adopter's inspection outcome again follows the distribution specified in Equation (1). Table 1 summarizes the key notations.

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 adopters. In Section 4 we formally model the endogenous segmentation of buyers as early versus late adopters.

[7]For parsimony, we focus on the case in which late adopters do not observe any first-period signals, although the intuition of this paper still holds if we allow late adopters to observe a finite number of first-period signals, for example, through word-of-mouth communications (Godes and Mayzlin 2004).

[8]Alternatively, a fraction $E(x|\bar{a})$ of late adopters will consider the product if their interest follows the same function as that of early adopters. Since this fraction $E(x|\bar{a})$ cannot be separately identified from the relative mass of late adopters δ, we assume the degree of consideration among late adopters is 1 for notation simplicity.

Table 1: Summary of Key Notations

Notation	Definition
Main Analysis	
a	The level of marketing efforts, $a \in \{\underline{a}, \bar{a}\}$
b	The probability that a buyer receives a good signal when product quality is low
δ	The relative mass of late adopters
$f(x\|a)$	The conditional p.d.f. of buyer interest x given marketing efforts a
m	The share of early adopters who buy the product
μ_t	Buyer's belief (i.e., perceived probability) in period t that quality is good, where $t \in \{0, 1, 2\}$ and μ_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)
s	The private quality signal a buyer receives, which can be either good (G) or bad (B); private signals are i.i.d. across consumers given quality
θ	The conditional probability of achieving full buyer interest in the example of Section 3.5, $\theta \in \{\bar{\theta}, \underline{\theta}\}$
x	The share of early adopters interested in the product, $x \in [\underline{x}, \bar{x}]$
Extensions	
e	The effectiveness of marketing in accelerating buyers' arrival on the market
r	The precision of seller's private quality signal, $r \in (1/2, 1)$
v	Seller's private signal about its quality, $v \in \{H, L\}$
w	The persuasiveness of marketing in improving buyers' prior quality belief

3.2 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 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. (We extend the model to look at the possibility of separating equilibria in Section 4.3.)

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 2010 for an application).[9]

A few remarks on our assumption about the cost of marketing efforts are in order. Our analysis deliberately assumes costless marketing. 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,[10] and is therefore not the focus of this study. Interestingly, nevertheless, we find in Section 4.3 that for costless marketing there exists a separating equilibrium, in which demarketing signals a seller's confidence in its quality.

[9] A pooling equilibrium that the high-quality seller does not prefer over all other pooling PBE cannot be strongly undefeated because a deviation consistent with a high-quality seller's preferred pooling equilibrium would weakly increase the belief that the deviator's product is of high quality, so that the high-quality seller would have an incentive to deviate. A high-quality seller's preferred pooling equilibrium is undefeated, on the other hand, as the most pessimistic off-equilibrium beliefs are consistent with the strongly undefeated PBE concept.

[10] See for example, Milgrom and Roberts (1986); Wernerfelt (1988); Bagwell and Riordan (1991); Desai and Srinivasan (1995); Moorthy and Srinivasan (1995); Simester (1995). Also see Bagwell (2007) for a survey.

3.3 Buyers' Beliefs

At the start of the game, buyers share the common prior belief that product quality is high with probability $\mu_0 \in (0,1)$. The seller knows the value of μ_0. Buyers' beliefs about quality evolve as new information arrives. An interested early adopter'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 always choose the same strategies, the exact strategy does not affect early adopters' quality beliefs. Therefore, an early adopter can only update her quality belief through inspection. Her posterior quality belief follows from Bayes' rule:

$$\mu_1(s) = \begin{cases} \frac{\mu_0}{\mu_0 + b(1-\mu_0)} & \text{if } s = G, \\ 0 & \text{if } s = B. \end{cases} \tag{2}$$

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

$$p_1^* = \mu_1(G) = \frac{\mu_0}{\mu_0 + b(1-\mu_0)}. \tag{3}$$

The low-quality seller will charge this same price in equilibrium. In practice, the seller can set the price one cent below $\mu_1(G)$ to ensure purchase. At this introductory price, only interested early adopters who observe a favorable inspection outcome will buy. As a result, first-period sales contain useful information about product quality for late adopters.

Specifically, suppose a fraction x of early adopters become interested in the product. By the law of large numbers, the measure of early adopters 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 $b\overline{x}$, 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

$$\underline{x} \leq b\overline{x}. \tag{4}$$

Under this assumption, there exist three ranges of first-period sales: "stellar" sales ($m > b\overline{x}$) perfectly reveal high quality to late adopters, "poor" sales ($m < \underline{x}$) unambiguously indicate low quality, and "mediocre" sales ($m \in [\underline{x}, b\overline{x}]$) leave late adopters uncertain. After observing mediocre first-period sales m, late adopters know that the interest level among early adopters must have been $x = m$ if quality is high and $x = m/b$ if quality is low. However, late adopters do not directly observe the realized interest level, but understand that interest varies stochastically with marketing efforts. To be specific, suppose $f(x|a)$ is continuous. (The intuition behind demarketing remains valid if $f(x|a)$ is discrete, as we show with an example in Section 3.5.) Given marketing effort a, late adopters 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 Berger1990). In this way, marketing efforts affect late adopters' quality beliefs.

A last factor that further updates a late adopter'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 adopter 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 adopter's posterior quality belief is:

$$\mu_2(a, m, s) = \begin{cases} 1 & \text{if } m > b\overline{x}, \\ \frac{f(m|a)\mu_0}{f(m|a)\mu_0 + f(\frac{m}{b}|a)(1-\mu_0)} & \text{if } \underline{x} \leq m \leq b\overline{x} \text{ and } s = G, \\ 0 & \text{otherwise.} \end{cases} \tag{5}$$

One key observation is that 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:

$$\frac{f(\frac{m}{b}|\bar{a})}{f(m|\bar{a})} > \frac{f(\frac{m}{b}|\underline{a})}{f(m|\underline{a})}. \tag{6}$$

Note that Condition (6) always holds if $f\left(x|a\right)$ satisfies the monotone likelihood ratio property (MLRP) in a, which stipulates that $\frac{f(x|\bar{a})}{f(x|\underline{a})}$ increases with x.[11] Indeed, the MLRP parallels the intuition underlying the attribution theory: since marketing raises product consideration, it competes with product quality in explaining good sales and casts doubts 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 monotone likelihood ratio property in marketing efforts, then late adopters' quality beliefs (weakly) decrease with marketing efforts.*

The analysis thus far shows how a seller can adopt demarketing to improve buyers' quality beliefs *ex post*. However, late adopters' quality beliefs as specified in Equation (5) 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.

3.4 Seller Profits and Equilibrium (De)marketing Strategies

In this section, we explore equilibrium (de)marketing strategies. In doing so, we focus on a high-quality seller's profits associated with different marketing efforts. As discussed, the high-quality seller's profit maximizing strategy forms the PBE. 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 described in Equation (5). This price extracts the full surplus

[11]Proof: $\frac{f(m/b|\bar{a})}{f(m|\bar{a})} > \frac{f(m/b|\underline{a})}{f(m|\underline{a})}$ if and only if $\frac{f(m/b|\bar{a})}{f(m/b|\underline{a})} > \frac{f(m|\bar{a})}{f(m|\underline{a})}$. Since $b < 1$, the MLRP implies that the latter condition is satisfied.

of all late adopters who have a positive willingness to pay for the product. Since a high-quality product will never fail an inspection and will always achieve at least mediocre first-period sales ($m \geq \underline{x}$), its optimal second-period price is:

$$p_2^*(a,m) = \mu_2(a,m,G) = \begin{cases} 1 & \text{if } m > b\overline{x}, \\ \frac{f(m|a)\mu_0}{f(m|a)\mu_0 + f(\frac{m}{b}|a)(1-\mu_0)} & \text{if } \underline{x} \leq m \leq b\overline{x}. \end{cases} \tag{7}$$

The low-quality seller will imitate the high-quality seller's second-period price unless its first-period sales are poor mediocre ($m < \underline{x}$), 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 adopters' *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. Therefore,

$$E[\mu_2(a,x,G)|H] \;=\; [1 - F(b\overline{x}|a)] + \int_{\underline{x}}^{b\overline{x}} \mu_2(a,x,G) f(x|a)dx. \tag{8}$$

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

$$E\Pi(a|H) \;=\; E(x|a)\mu_1(G) + \delta\,[1 - F(b\overline{x}|a)] + \delta \int_{\underline{x}}^{b\overline{x}} \mu_2(a,x,G) f(x|a)dx. \tag{9}$$

Equation (9) 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 adopters $E(x|a)$ increases with a by the MLRP. The second term $\delta\,[1 - F(b\overline{x}|a)]$ represents the profit from selling to late adopters 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 adopters when first-period sales turn out mediocre. We know from Proposition 1 that $\mu_2(a,x,G)$ decreases with a since high marketing efforts adversely affect quality beliefs following mediocre sales. However, marketing efforts also affect the probabilities for different levels of mediocre sales to arise, as captured by the probability weights $f(x|a)$ attached to different prices in the last term of Equation (9). We will adopt a particular functional form for $f(x|a)$ in Section 3.5 to demonstrate that demarketing can indeed improve profits.

We are interested in whether demarketing arises in equilibrium, where the seller chooses $a = \underline{a}$ although marketing is costless. We first note a necessary condition for demarketing to be optimal, that the relative mass of late adopters δ should be sufficiently large. If δ is too close to 0, the seller will maximize marketing efforts to serve as many early adopters as possible. However, even when δ 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 (μ_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 (2), where early adopters' quality beliefs are close to 0 regardless of the private signal received; and Equation (5), where late adopters' 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 either early or late adopters 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 adopters. 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 (μ_0 being close to 1), demarketing will not be optimal either. As can be seen from Equation (2), if early adopters have firm faith in product quality, 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 (5) shows, late adopters' 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 sufficiently optimistic prior beliefs, consumers will have high willingness to pay anyway, and the high-quality seller's imperative is to maximize expected first-period sales volume through full marketing efforts.

Altogether, the prior belief μ_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 Appendix for proof).

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

(i) the relative mass of late adopters δ is sufficiently large, and

(ii) the prior quality belief μ_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 further evaluate the net impact of demarketing on second-period profits without putting additional structure on this function. To demonstrate the existence of demarketing equilibria and to gain further insights, we will assume a specific functional form for $f(x|a)$ in the next section.

3.5 An Example

The goal of this section is to illustrate how demarketing may improve profits with a parsimonious example. Marketing efforts can generate purchase interest among either all early adopters ($x = 1$) or a fraction of them ($x = b < 1$). The conditional distribution of interest given marketing efforts is

$$\begin{aligned} f(x|\overline{a}) &= \begin{cases} \overline{\theta} & \text{if } x = 1, \\ 1 - \overline{\theta} & \text{if } x = b, \end{cases} \\ f(x|\underline{a}) &= \begin{cases} \underline{\theta} & \text{if } x = 1, \\ 1 - \underline{\theta} & \text{if } x = b, \end{cases} \end{aligned} \tag{10}$$

with $0 < \underline{\theta} < \bar{\theta} < 1$. It follows that $f(x|a)$ satisfies the 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 adopters thus remain uncertain about quality after observing the mediocre sales level b, which makes the example interesting in spite of its simplicity.[12]

After observing marketing efforts a, first-period sales m, and the outcome of her inspection s, a late adopter's quality belief is:[13]

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

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

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

The above result illustrates Proposition 1. Demarketing to early adopters leads to more favorable quality beliefs among late adopters when first-period sales are mediocre ($m = b$). Late adopters are uncertain whether the mediocre sales result from a marketing campaign by a low-quality seller that raised full interest, or from a marketing campaign by a high-quality seller that only generated partial interest. Since demarketing decreases the chance for a campaign to achieve full interest, it induces late adopters to believe that mediocre sales likely result from insufficient marketing and that the product may not necessarily be bad.

As discussed, the optimal second-period price is given by Equation (7) as:

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

[12]To demonstrate the emergence of demarketing in equilibrium with the simplest model possible, we assume that the fraction of interested early adopters in the "partial interest" case, b, equals the probability that a buyer receives a good signal when product quality is low.

[13]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 Berger1990).

Finally, the expected profits under different marketing levels follow from Equation (9):

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

Whether the seller should choose demarketing depends on the comparison between these expected profits. We first compare expected second-period profits (see Appendix for proof).

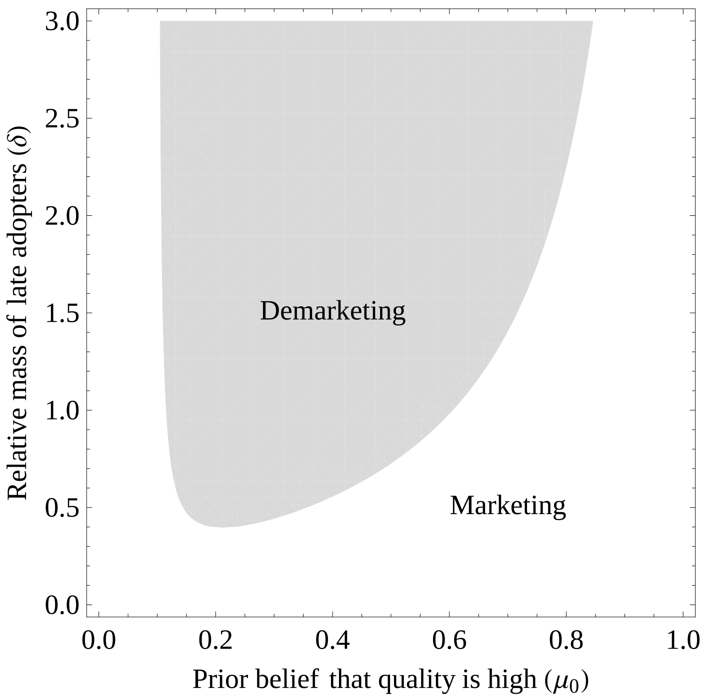
Proposition 3. *Let buyer interest x generated by marketing effort* a *follow the conditional distribution function $f(x|a)$ as defined in Equation (10). Demarketing strictly maximizes the expected second-period profit of a high-quality seller if and only if buyers' prior quality belief is sufficiently optimistic ($\mu_0 > \widehat{\mu}$, where $\widehat{\mu} = \frac{\underline{\theta}\overline{\theta}b}{1-\underline{\theta}-\overline{\theta}+(1+b)\underline{\theta}\overline{\theta}} \in (0,1)$).*

If the relative mass of late adopters is sufficiently high, the equilibrium marketing strategy will be the one that maximizes a high-quality seller's second-period profits. A low-quality seller will duplicate this strategy. Proposition 3 therefore directly implies the following result.

Corollary 1. *Let buyer interest x generated by marketing efforts* a *follow the conditional distribution function $f(x|a)$ as defined in Equation (10). For any sufficiently optimistic prior quality belief $\mu_0 > \widehat{\mu}$, where $\widehat{\mu} = \frac{\underline{\theta}\overline{\theta}b}{1-\underline{\theta}-\overline{\theta}+(1+b)\underline{\theta}\overline{\theta}} \in (0,1)$, there exists a threshold for the relative mass of late adopters $\widehat{\delta}$, such that the seller chooses demarketing in equilibrium if $\delta > \widehat{\delta}$.*

Figure 2 shows the seller's equilibrium (de)marketing decision as a function of buyers' prior quality belief μ_0 and the relative mass of late adopters δ. For illustration we fix the remaining parameters as $\overline{\theta} = 0.6$, $\underline{\theta} = 0.1$, and $b = 2/3$. Demarketing arises as the equilibrium strategy for reasonable parameter values. In particular, there are three observations. First, if the relative mass of late adopters is small, then high marketing efforts are always optimal. Intuitively, if the first-period market is more important, the seller's priority should be to maximize sales among early adopters. Second, given any δ, if the prior belief is very pessimistic (μ_0 close to 0), high marketing efforts are optimal. This is because, as discussed in the previous section, the seller's imperative now is to maximize the likelihood of stellar sales ($m = 1$) to convince pessimistic late adopters that quality

Figure 2: Equilibrium Marketing Level



Note. The figure sets $\overline{\theta} = 0.6$, $\underline{\theta} = 0.1$, and $b = 2/3$.

is high. Third, if the prior belief is very optimistic (μ_0 close to 1), it is again optimal for the seller to market heavily in the first period.[14] When buyers have firm confidence in product quality, marketing efforts have negligible impact on the profit margin, and the high-quality seller should maximize marketing efforts to expand sales volume among early adopters. These observations illustrate the predictions of Proposition 2 that demarketing can only arise as an optimal strategy when there is a sufficient mass of late adopters and when buyers face significant uncertainty about quality.

[14]This result does not contradict Corollary 1. For any finite δ, there exists a cutoff value of μ_0 such that high marketing is optimal for prior beliefs above this cutoff value. At the same time, for any $\mu_0 > \widehat{\mu}$, there exists a cutoff value of δ such that demarketing is optimal for δ above this cutoff (see Figure 2).

3.6 Discussion

3.6.1 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, cannot achieve stellar sales in period one but could experience poor sales. Specifically, the *expected* quality belief a low-quality seller can achieve among early adopters is $b\mu_1(G)$, because in expectation a fraction b of early adopters hold belief $\mu_1(G)$ whereas the remaining fraction $1-b$ hold belief 0. Similarly, the low-quality seller's expected quality belief among late adopters is

$$E[\mu_2(a, bx, s)|L] = bE[\mu_2(a, bx, G)|L] = b\int_{\frac{\underline{x}}{b}}^{\overline{x}} \mu_2(a, bx, G)f(x|a)dx, \tag{11}$$

which is different from a high-quality seller's expected quality belief among late adopters as specified in Equation (8). We establish the following result (see Appendix for proof).

Lemma 1. *In a pooling equilibrium, both early adopters' and late adopters' expected quality beliefs for a high-quality seller are more optimistic than their expected quality beliefs for a low-quality seller.*

In other words, although a seller's quality is not immediately revealed through actions, it is partially revealed through market data (inspection outcomes, first-period sales). Divergent quality beliefs generate divergent profits. In contrast to $E\Pi(a|H)$ as specified in Equation (9), a low-quality seller's expected profit given marketing effort a is

$$E\Pi(a|L) \;=\; b\left[E(x|a)\mu_1(G) + \delta\int_{\frac{\underline{x}}{b}}^{\overline{x}} \mu_2(a, bx, G)f(x|a)dx\right]. \tag{12}$$

Since a seller's expected profit is equal to its expected quality beliefs in each period, Lemma 1 directly leads to the following corollary.

Corollary 2. *In a pooling equilibrium, a high-quality seller earns a higher expected profit than a low-quality seller.*

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

Proposition 4. *In a pooling equilibrium, demarketing improves late adopters' expected quality beliefs about a high-quality seller if and only if it worsens late adopters' expected quality beliefs about a low-quality seller.*

Proof: By the law of iterated expectations,

$$\mu_0 = \mu_0 E[\mu_2(a, x, G)|H] + (1 - \mu_0)E[\mu_2(a, bx, s)|L], \tag{13}$$

hence $E[\mu_2(\underline{a}, x, G)|H] > E[\mu_2(\overline{a}, x, G)|H] \iff E[\mu_2(\underline{a}, bx, s)|L] < E[\mu_2(\overline{a}, bx, s)|L]$. $\square$

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 mimic the same demarketing choice to better 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 adopters better discern quality from available data. In fact, when the relative mass of late adopters 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.

3.6.2 What Buyers Need to Know for Demarketing to Work

The analysis thus far highlights three 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, (2) at least partially observe the level of marketing efforts, and (3) know that demarketing does reduce short-run sales. 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 receive informative signals of how a product has been received by the market. For example, they can observe the length of the line waiting outside a lunch truck, track how many units of iPad 2 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. Therefore, the seller might as well exhaust its free marketing resources.[15] 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 frequent incidences of demarketing when it is observable, for example, when passersby can (trivially) observe lunch truck locations, when stores can publicly set inconvenient service times, and when consumers can witness how frequently a company advertises.

Third, for demarketing to serve as an effective excuse, buyers must believe that demarketing does hurt sales in the short run. For instance, customers must believe that a lunch truck attracts less business in a remote location, with other things being equal. In practice, companies might seek ad hoc excuses, such as bad weather, for disappointing sales. This strategy is less costly than demarketing, but also less convincing. Morgenson (2004) vividly describes this disbelief:

> "A prime excuse for bad news, especially among retailers, is weather—handy because it works rain or shine. If it was too sunny during the quarter, everyone

[15] This is true except when the support of the buyer interest distribution $f(x|a)$ varies with marketing efforts in highly contrived manners such that demarketing produces a buyer interest level and sales volume which unambiguously indicates high quality.

was at the beach and nobody shopped. If it was too rainy, too cold or too hot, nobody left home."

Weather and other ad hoc excuses fail to achieve their purpose here because buyers, in attribution theory terms, do not readily evoke a causal schema between these excuses and sales (Kelley 1973).[16] In this sense, demarketing can credibly influence buyers' causal attribution exactly because it is known to damage sales.

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. Clearly, a general condition for demarketing to arise is that late adopters 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.

When these aforementioned conditions are satisfied, demarketing might be a relevant strategy to consider. In the following section, we extend the main analysis to explore how a richer set of market conditions further affect sellers' incentives to demarket.

4 Extensions

4.1 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 $\mu_0'(a) \geq 0$. We keep the rest of the main model unchanged to isolate the effect of endogenizing prior beliefs.

[16] Buyers may also discount the weather excuse if they cannot observe or recall how bad weather was in the focal market during the past quarter—consistent with the visibility requirement for demarketing to work.

An interested early adopter's posterior quality belief μ_1 is now a function of the marketing level through its effect on the prior beliefs:

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

Naturally, marketing improves early adopters' quality confidence by endowing them with a more positive prior belief, unless their inspection outcome is unfavorable. Therefore, the optimal first-period price $p_1^*(a) = \mu_1(a, G)$ increases with marketing efforts.

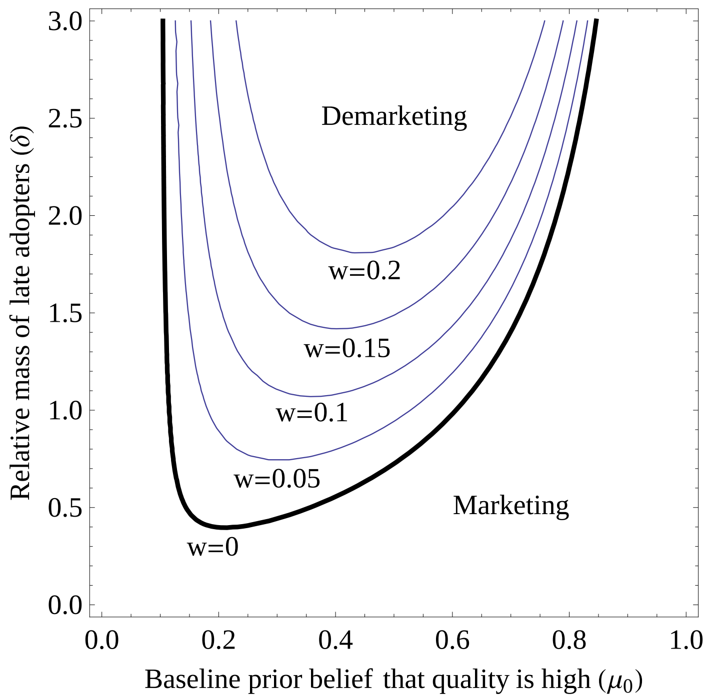
Similarly, a late adopter's quality belief depends on marketing efforts as follows:

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

Notably, 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. This ambiguity reflects two countervailing effects of marketing on late adopters' quality beliefs: although intensive marketing hurts quality perceptions *ex post*, as suggested in the main analysis, it also "anchors" late adopters with more optimistic prior quality beliefs.

Intuitively, the high-quality seller would have less incentive to demarket if marketing is more effective at improving buyers' prior quality beliefs. For comparability, we continue using the model specification in Section 3.5 to illustrate the effect of endogenizing prior beliefs on the seller's equilibrium marketing choice. We normalize $\mu_0(\underline{a})$ as μ_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 3 presents the equilibrium (de)marketing decision as a function of μ_0, δ, and w, where along each curve the seller is indifferent between marketing and demarketing. When $w = 0$, the marketing decision reduces to that of the main model as illustrated in Figure 2. When w increases, as expected, there is a smaller parameter range for demarketing to be optimal. This result suggests that demarketing should be used with greater caution if buyers' prior perception of product quality is susceptible to marketing efforts.

Figure 3: Equilibrium Marketing Level when Marketing Improves Prior Quality Beliefs



Note. We normalize $\mu_0(\underline{a})$ as μ_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 figure sets $\bar{\theta} = 0.6$, $\underline{\theta} = 0.1$, and $b = 2/3$.

4.2 Marketing that Accelerates Buyer Arrival

The main analysis fixes the mass of potential buyers as 1 and δ for the two periods respectively. However, marketing activities such as awareness advertising campaigns may also help accelerate the arrival of buyers. To capture this effect of marketing, in this subsection we allow the mass of early adopters to be $\lambda(a)$ and the mass of late adopters 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 decisions.[17]

An interested early adopter'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

[17]In this formulation δ 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.

the first period is again $p_1^* = \mu_1(G)$, so that an interested early adopter 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 $bx\lambda(a)$ if quality is low. Following the main analysis, we focus on the more interesting case of $\underline{x} \leq b\overline{x}$ such that there exists a mediocre sales range $m \in [\underline{x}\lambda(a), b\overline{x}\lambda(a)]$, where late adopters remain uncertain about product quality. After observing marketing effort a, first-period sales m, and her inspection outcome s, a late adopter's quality belief is:

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

When first-period sales are mediocre while her private inspection is good, a late adopter's quality belief decreases with marketing efforts. This result echoes Proposition 1: mediocre sales are a rather satisfactory result given insufficient marketing, but signify low quality if there has been a marketing extravaganza.

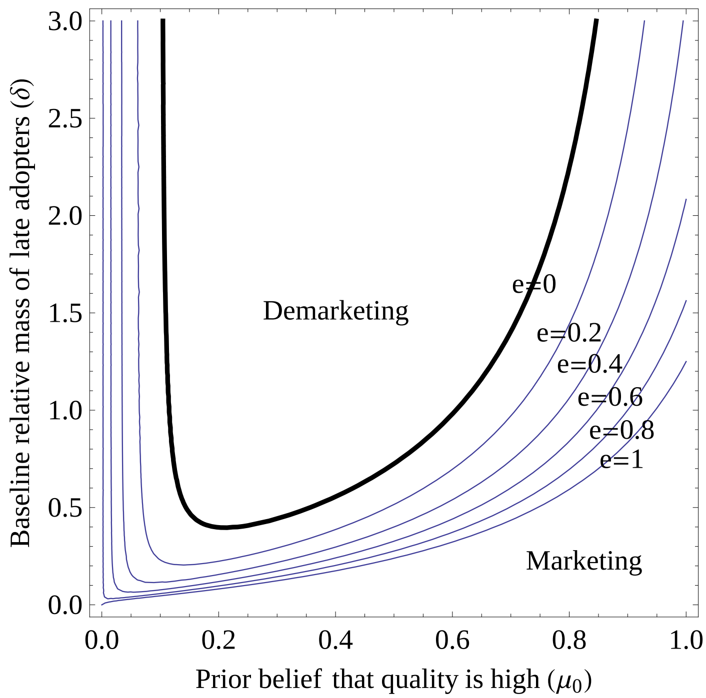
The equilibrium price in the second period is $p_2^*(a, m) = \mu_2(a, m, G)$. A high-quality seller chooses its marketing effort level to maximize its expected profit:

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

Interestingly, 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 Section 3.5. 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 4 presents the seller's equilibrium (de)marketing decision as a function of μ_0, δ, 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.

The intuition is as follows. With endogenous buyer arrival, marketing has two separate effects on seller profits (besides raising interest among early adopters). It shifts the

Figure 4: Equilibrium Marketing Level when Marketing Accelerates Buyer Arrival



Note. The mass of early adopters is $\lambda(a)$ and the mass of late adopters 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. The figure sets $\overline{\theta} = 0.6$, $\underline{\theta} = 0.1$, and $b = 2/3$.

distribution of buyers across time, and it influences the expected equilibrium price in period two by affecting late adopters' quality beliefs. With this latter effect, the seller does not always want to accelerate buyer arrival. In fact, if the expected equilibrium price in period two exceeds the equilibrium price in period one (which can be shown to be true for the current example), the high-quality seller has the incentive to shift greater sales volume to period two. It does so by reducing marketing; the more effective marketing is in accelerating buyer arrival, the more the high-quality seller wants to cut marketing. This counterintuitive result suggests that companies may not always want to expedite sales, especially if delaying business results in higher customer valuation.[18]

[18]This finding raises another question: what happens if buyers can strategically postpone their purchases to gain more information about product quality? Buyer strategic waiting does not occur in our model for the following reason. Buyers who receive a bad inspection outcome will not buy and will earn their outside utility of zero. Buyers 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

4.3 Separating Equilibrium

We are also interested in whether there exists a separating equilibrium in which demarketing serves as a signal of high seller type. As discussed in Section 3.2, such a separating equilibrium does not exist for the main model, because a low-quality seller would always want to mimic its high-quality counterpart. A key assumption underlying this result is that the seller knows its quality, so that seller type revelation in a separating equilibrium amounts to quality revelation, and buyers have no demand for a low-quality product. In reality, however, sellers rarely know their quality with absolute certainty (Bose et al. 2006). To investigate whether accommodating this fact would restore the separating equilibrium, in this subsection we will 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. We will refer to a seller who receives an H signal as a high-type seller, and one who receives a L signal as a low-type seller.

The 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 the seller's signal is informative, $\mu_0^H > \mu_0 > \mu_0^L$; 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 $\mu_0(a) \in \{\mu_0^H, \mu_0^L\}$.[19]

A bad inspection outcome again reveals low product quality for certain. A good

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. Nevertheless, buyer strategic waiting is an interesting issue in general. We leave its full analysis to future research.

[19] As discussed before, in a pooling equilibrium $\mu_0(a) = \mu_0$ for all a. 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.

inspection outcome updates an interested early adopter'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:

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

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

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

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

When first-period sales are mediocre, the late adopter's quality belief reflects two effects of demarketing. First, for the same intuition behind the pooling equilibrium analyzed earlier, demarketing improves quality beliefs *ex post*. Second, by signaling greater seller confidence in a separating equilibrium, demarketing anchors buyers with more optimistic prior quality beliefs than in a pooling equilibrium (i.e., $\mu_0^H > \mu_0$). Below we investigate whether and when such a separating equilibrium exists.

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

$$E\Pi (\underline{a}|H) - E\Pi (\overline{a}|H) \geq 0 \geq E\Pi (\underline{a}|L) - E\Pi (\overline{a}|L). \tag{15}$$

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

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

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

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

We can similarly specify $E\Pi\left(\bar{a}|L\right)$ and $E\Pi\left(\underline{a}|L\right)$. Condition (15) 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. Below we first state the necessary conditions for such a separating equilibrium to exist, and then discuss the intuition. A formal proof is presented in the Appendix.

Proposition 5. *A separating equilibrium in which demarketing signals a seller's higher confidence in quality can only exist if*

(i) the relative mass of late adopters δ is sufficiently large,

(ii) the prior quality belief μ_0 is not too optimistic (i.e., close to 1),

(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 adopters with a more optimistic prior quality belief (i.e., $E(x|\underline{a})\mu_1^H < E(x|\bar{a})\mu_1^L$).

To understand Condition (i), suppose δ 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, 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 μ_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.[20]

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 defeating the purpose of separation.

Finally, Condition (iv) states that, for demarketing to signal seller confidence in quality, it must be truly costly in the short run; the demand reduction effect of demarketing must dominate its belief anchoring effect among early adopters. Separation is 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).

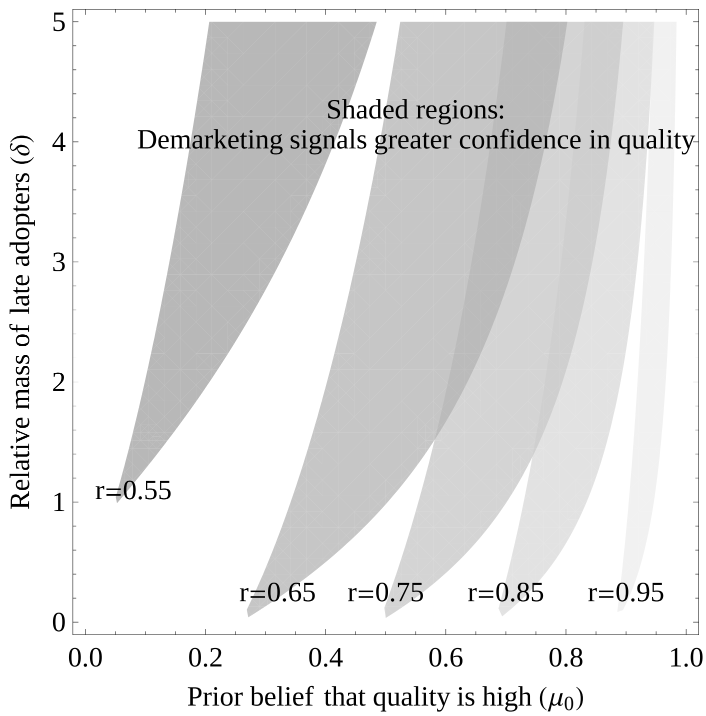
Condition (iv) leads to an important observation—there is no separating equilibrium in which demarketing signals lower seller confidence. Otherwise, a low-type seller would want to deviate to marketing; doing so improves both the sales volume and price in period one, and anchors late adopters with a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

Proposition 6. *A separating equilibrium in which demarketing signals the seller's lower confidence in quality does not exist.*

[20] When the prior belief μ_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.

We close this subsection by illustrating the demarketing separating equilibrium using the specification of Section 3.5. Figure 5 presents the parameter ranges for this separating equilibrium to arise. The results are consistent with the conditions of Proposition 5—the parameter ranges grow with the relative mass of late adopters, are bounded away from $\mu_0 = 1$, and are larger with intermediate levels of seller information precision.

Figure 5: 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: $r \in \{0.55, 0.65, 0.75, 0.85, 0.95\}$. The figure sets $\overline{\theta} = 0.6$, $\underline{\theta} = 0.1$, and $b = 1/3$.

4.4 Other Marketing Decisions

The extensions suggest that the key mechanism underlying demarketing is robust when marketing has additional effects besides growing buyer interest, and when the seller's imperfect information about its quality gives rise to a separating equilibrium. We expect the demarketing argument to be relevant in other domains of marketing decisions. Below we briefly describe the implications to two classic marketing problems: advertising scheduling and market selection. Sections A.6 and A.7 of the Appendix present the related analyses in greater detail.

Advertising scheduling has attracted significant attention both in practice and in academia (e.g., Little and Lodish 1969; Horsky and Simon 1983; Mahajan and Muller 1986; Villas-Boas 1993). How should a company allocate its advertising budget over time? The literature has extensively studied how to schedule advertising to maximize its effectiveness and to accelerate product adoption. For example, Horsky and Simon (1983) suggest that a firm advertise heavily in the early stage of the product life cycle to inform all innovators of the existence of the product. However, the consumer quality inference perspective has not been emphasized in the literature. If sales and advertising intensity are at least partially observable, they may influence consumers' quality beliefs (if quality is uncertain). In the spirit of demarketing, relatively light advertising early on in the product life cycle may improve long-run profits, as late adopters attribute slow takeoff of sales to conservative advertising, and immediate success to superior product quality.

Firms also frequently face a market selection problem. Conventional wisdom would recommend targeting the market where the product has good match potential. However, if sales and market match potential are both publicly observable, such targeting strategies may come with a hidden cost. If sales in the target market fail to excel, which could happen due to uncontrollable random factors, the firm may suffer more than if it had targeted markets of worse match. For instance, Daimler's Smart mini-car is believed to perfectly match urban drivers as a new-age convenient city car (Landler 2006). Suppose consumers subsequently fail to see enough Smart cars in urban traffic. The car's desirability might be more seriously questioned than if the company had, counterintuitively, chosen to start with rural drivers. In the (likely) event of slow rural sales, the company can credibly cite unwise targeting as an excuse, while saving the quality image of its brand. This demarketing perspective can be particularly relevant when firms are selecting test markets for new products. Besides gathering market information, test marketing itself may also influence sales at national launch if the general public draws quality inferences from the test outcome. Due to the importance of national launch, firms might want to consider "tougher" cities for test marketing.

5 Concluding Remarks

This paper finds that sellers can benefit from "demarketing," where they visibly suppress marketing efforts even if these efforts do not impose additional costs. Buyers infer product quality from its sales volume, and marketing intensity moderates this inference process. Demarketing hurts demand directly, but exactly because of this, demarketing highlights great quality when sales are satisfactory and takes the blame when sales are disappointing. Table 2 summarizes the market conditions under which demarketing is likely to be a relevant business strategy to consider.

Table 2: Market Conditions for Demarketing to be A Relevant Strategy

- The product's long-run quality image is important to the seller
- Buyers face sufficient uncertainty about product quality
- Buyers at least partially observe past product sales
- Buyers at least partially observe the level of marketing efforts
- Buyers know that demarketing does reduce short-run sales
- Demarketing does not hurt buyers' prior quality belief too much
- Marketing accelerates buyers' arrival on the market
- The seller, if it is uncertain, is confident about its quality

Besides its normative value, Table 2 leads to a set of counterintuitive yet empirically testable predictions. Future research can investigate how cross-sectional and longitudinal variations in the aforementioned market conditions affect the incidence of demarketing. For example, we can test whether, *ceteris paribus*, companies do less marketing (1) in categories with faster natural rates of growth, (2) in newer industries, (3) where consumption is conspicuous, (4) when marketing is public (e.g., public relations) rather than private (e.g., pharmaceutical detailing), (5) when the focal marketing tactics are known to draw business (e.g., good business locations), (6) when marketing entails awareness advertising rather than persuasive advertising, (7) when marketing targets next-generation buyers (e.g, e-reader-for-high-school campaigns), and (8) when an established brand launches a new technology.

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Appendix

A.1 Proof of Proposition 2

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

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

Since $E(x|a)$ is increasing in a, expected profits in the limit case are always maximized for $a = \overline{a}$. The continuity of $E\Pi\left(a|H\right)$ in δ then directly implies that $a < \overline{a}$ can only arise in equilibrium if δ is sufficiently different from 0.

(ii) Note first that, if $m \in [\underline{x}, b\overline{x}]$, both $\mu_1\left(G\right)$ and $\mu_2\left(a, m, G\right)$ are continuous in μ_0, and that expected profits are continuous in beliefs. As μ_0 approaches 0, beliefs go to the following limits:

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

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

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

By continuity, the above result implies that for μ_0 sufficiently close to 0 profit maximization calls for $a = \overline{a}$ so as to maximize the likelihood of first-period sales m being above $b\overline{x}$. Hence, demarketing can arise in equilibrium only if μ_0 is sufficiently positive.

On the other hand, as μ_0 goes to 1, beliefs approach the following limits:

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

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:

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

The seller's optimal strategy in the limit case is hence to set $a = \overline{a}$ to maximize $E(x|a)$. By continuity, the same is true for μ_0 close to 1, and hence demarketing can only be optimal if μ_0 lies sufficiently below 1.

A.2 Proof of Proposition 3

We compare the expected second-period profits of a high-quality seller after different choices of a. Demarketing ($a = \underline{a}$) leads to higher second-period profits than marketing ($a = \overline{a}$) if and only if

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

which is equivalent to

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

Straightforward calculation shows that this last condition can be rewritten as

$$\mu_0 > \widehat{\mu} = \frac{\underline{\theta}\overline{\theta}b}{1-\underline{\theta}-\overline{\theta}+(1+b)\underline{\theta}\overline{\theta}}. \tag{A1}$$

Since $\underline{\theta}, \overline{\theta} \in (0,1)$, $\widehat{\mu} \in (0,1)$.

A.3 Proof of Lemma 1

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

$$1 - F\left(b\overline{x}|a\right) + \int_{\underline{x}}^{b\overline{x}} \mu_2(a, x, G) f(x|a) dx > b \int_{\frac{\underline{x}}{b}}^{\overline{x}} \mu_2(a, bx, G) f(x|a) dx. \qquad \text{(A2)}$$

Using the change of variables $y = bx$, RHS(A2) becomes

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

Therefore, (A2) is equivalent to

$$\begin{aligned} 1 &> F\left(b\overline{x}|a\right) - \textstyle\int_{\underline{x}}^{b\overline{x}} \mu_2(a, x, G) f(x|a) dx + \int_{\underline{x}}^{b\overline{x}} \mu_2(a, x, G) f(\frac{x}{b}|a) dx \\ &= \textstyle\int_{\underline{x}}^{b\overline{x}} [f(x|a) - \mu_2(a, x, G) f(x|a) + \mu_2(a, x, G) f(\frac{x}{b}|a)] dx \qquad \text{(A3)} \\ &= \textstyle\int_{\underline{x}}^{b\overline{x}} \{[1 - \mu_2(a, x, G)] f(x|a) + \mu_2(a, x, G) f(\frac{x}{b}|a)\} dx. \end{aligned}$$

Plugging in $\mu_2(a, x, G)$ from Equation (5), the term $[1 - \mu_2(a, x, G)] f(x|a) + \mu_2(a, x, G) f(\frac{x}{b}|a)$ 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

$$\frac{f(\frac{x}{b}|a) f(x|a)}{f(x|a)\mu_0 + f(\frac{x}{b}|a)(1-\mu_0)}. \qquad \text{(A4)}$$

Next, we show that

$$\text{(A4)} \leq f(\frac{x}{b}|a)\mu_0 + f(x|a)(1-\mu_0), \qquad \text{(A5)}$$

which is equivalent to

$$f(x|a) f(\frac{x}{b}|a) \leq [f(x|a)\mu_0 + f(\frac{x}{b}|a)(1-\mu_0)][f(\frac{x}{b}|a)\mu_0 + f(x|a)(1-\mu_0)]. \qquad \text{(A6)}$$

But

$$\begin{aligned}
\text{RHS(A6)} &= f(x|a)f(\tfrac{x}{b}|a)\mu_0^2 + f(x|a)f(\tfrac{x}{b}|a)(1-\mu_0)^2 + [f(x|a)^2 + f(\tfrac{x}{b}|a)^2]\mu_0(1-\mu_0) \\
&\geq f(x|a)f(\tfrac{x}{b}|a)\mu_0^2 + f(x|a)f(\tfrac{x}{b}|a)(1-\mu_0)^2 + 2f(x|a)f(\tfrac{x}{b}|a)\mu_0(1-\mu_0) \\
&= f(x|a)f(\tfrac{x}{b}|a)[\mu_0^2 + (1-\mu_0)^2 + 2\mu_0(1-\mu_0)] \\
&= f(x|a)f(\tfrac{x}{b}|a)[\mu_0 + (1-\mu_0)]^2 \\
&= f(x|a)f(\tfrac{x}{b}|a).
\end{aligned}$$

Therefore, (A5) holds. It follows that

$$\begin{aligned}
\text{RHS(A3)} &\leq \int_{\underline{x}}^{b\overline{x}} [f(\tfrac{x}{b}|a)\mu_0 + f(x|a)(1-\mu_0)]dx \\
&= \mu_0 \int_{\underline{x}}^{b\overline{x}} f(\tfrac{x}{b}|a)dx + (1-\mu_0)\int_{\underline{x}}^{b\overline{x}} f(x|a)dx \\
&< \mu_0 + (1-\mu_0) \\
&= 1.
\end{aligned} \tag{A7}$$

Hence (A3) holds.

A.4 Proof of Proposition 5

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

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

which are either both positive or both negative, violating Condition (15).

(ii) As μ_0 approaches 1, quality beliefs approach the following limits:

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

It follows that

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

which violates Condition (15).

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

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

It follows that

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

which violates Condition (15).

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

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

It follows that

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

which violates Condition (15) except in the measure-zero event that both sides of the above equation equals 0 in the limit.

(iv) By the law of iterated expectations,

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

Rearranging terms:

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

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 (15).

A.5 Proof of Proposition 6

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

$$E\Pi(\overline{a}|H) - E\Pi(\underline{a}|H) \geq 0 \geq E\Pi(\overline{a}|L) - E\Pi(\underline{a}|L), \quad \text{(A8)}$$

where

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

By the law of iterated expectations,

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

Rearranging terms:

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

The right-hand side of the above equation is strictly positive, violating Condition (A8).

A.6 An Advertising Scheduling Model

We extend the main model of Section 3. 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 adopters, denoted by x_1, follows a conditional p.d.f. $f_1(x_1|a_1)$, whereas the level of interest among late adopters, 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 ϕ captures the prolonged effect of advertising (e.g., Horsky and Simon 1983). The case of $\phi = 0$ represents the most advertising decay, whereby the impact of advertising is confined to its current period. The case of $\phi = 1$ represents the most 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 adopters 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 $\widetilde{\delta}$ denote the relative mass of late adopters (we will discuss how $\widetilde{\delta}$ relates to δ in the main model). The high-quality seller's expected profit over the two periods is

$$E\Pi(a_1|H) = E(x_1|a_1)\, p_1 + \widetilde{\delta} E(x_2|K - a_1 + \phi a_1)\, p_2. \tag{A9}$$

We first consider the benchmark case in which late adopters 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 (3). The seller should then schedule its advertising to maximize $E(x_1|a_1) + \widetilde{\delta} E(x_2|K - a_1 + \phi a_1)$. Other things being equal, the higher the value of ϕ—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 fully 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 (3) and (7)). A high-quality seller's profit across the two periods becomes

$$E\Pi(a_1|H) = E\left(x_1|a_1\right)\mu_1\left(G\right) + \widetilde{\delta}E\left(x_2|K - a_1 + \phi a_1\right)\int_{\underline{x}}^{\overline{x}} \mu_2\left(a_1, x, G\right) f_1\left(x_1|a_1\right) dx_1. \tag{A10}$$

By Proposition 1, late adopters' quality belief $\mu_2\left(a_1, x, G\right)$ is weakly decreasing in a_1 since $f_1\left(x_1|a_1\right)$ satisfies the MLRP in a_1. For $\phi = 1$, the measure of interested late adopters is independent of a_1 and equal to $\widetilde{\delta}E\left(x_2|K\right)$. In this case, the analysis of the advertising scheduling model is equivalent to that of the main model where δ is set equal to $\widetilde{\delta}E\left(x_2|K\right)$ 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 μ_0 if the measure of interested late adopters $\widetilde{\delta}E\left(x_2|K\right)$ is sufficiently large (Figure 2).

A.7 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 specification 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 μ_1 is the consumer's perceived probability that product quality is high, which corresponds to early adopters' quality belief μ_1 in the main model. The coefficient $\beta > 0$ denotes the utility weight the consumer attaches to quality beliefs.[21] Finally, ϵ denotes consumers' idiosyncratic utility shocks.

The match value a product eventually delivers often depends on both the characteristics of

[21]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 notation simplicity.

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 (μ_1^H) than if true quality is low (μ_1^L):

$$\mu_1^H > \mu_1^L. \tag{A11}$$

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: $\mu_2(a, m)$.[22] This term corresponds to late adopters' 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

[22]The same conclusion holds qualitatively if the general public also receives quality signals.

quality is high, and $\log \frac{m}{1-m} - \beta\mu_1^L$ if quality is low. It follows that

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

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:

$$\frac{\partial \mu_2(a,m)}{\partial a} < 0. \tag{A12}$$

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 PBE. Recall that for any match value x, the high-quality firm's market share is $m = \exp(x + \beta\mu_1^H)/[1 + \exp(x + \beta\mu_1^H)]$. 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

$$\frac{\partial E[\mu_2(a,m)|H]}{\partial a} < 0. \tag{A13}$$

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.