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The Impact of Consumer Attentiveness and Search Costs on Firm Quality Disclosure: A Competitive Analysis

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Firms can invest to disclose quality information about their products to consumers, but consumers are not always perfectly attentive to these disclosures. Indeed, technologies such as digital video recorders have increased the ease with which disclosures can be avoided by consumers. Although such inattention may result in a consumer missing information from one or more competing firms, consumers who have missed disclosures might decide to search for quality information to become fully informed before making a purchase decision. In this paper we incorporate consumer attentiveness, as well as the related endogenous search decision, into a model of quality disclosure. Our results suggest that firms should disclose less quality information as the share of partially informed consumers (informed about one firm but not the other) increases, or as consumer search costs increase. We also provide insights into the potential impact of consumer trends toward lower attentiveness and lower search costs.

Key words: consumer attentiveness; quality disclosure; search costs; competition
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1. Introduction

Consumers are increasingly inundated with advertising messages, while at the same time their ability to conveniently ignore the information contained in those ads is also increasing. The most familiar example of this is television advertising, where time shifting technologies such as digital video recorders (DVRs) allow consumers to zip through ads.[1] Such a lack of attentiveness to ads is likely to render the communication efforts of a firm ineffective. In the context of ad effectiveness, industry observer David Meerman Scott notes, "I'd like to be bold and boil down thousands of conversations I've had over the past 10 years as well as about 5 years of After Thought columns into one word: *attention*" (Scott 2009, p. 48, italics in original).

A simple car buying example can provide some perspective on the phenomenon modeled in this paper. First, consider the consumer's viewpoint. If this consumer is not currently in the market for a new car, she might be relatively inattentive to communication efforts from car manufacturers (e.g., ignoring magazine ads or skipping television commercials using a DVR).[2] At some point, however, this consumer might decide to purchase a new car. Although the car companies might have invested in disclosing information about the quality[3] of their cars, her inattention means that she might have missed some of these disclosures. In fact, she might not even be aware of whether or not a given company has been investing in quality disclosure. In general, this consumer can be in one of three situations. First, if she has become aware of the quality disclosures of all competing cars (despite her bouts of inattention), then she can make a

[1] Wilbur (2008) notes that a zipped ad may be partially effective because of a combination of factors such as heightened attention during zipping. However, zipping clearly has the potential to leave the consumer incompletely informed about product attributes.

[2] Following the information processing theory of advertising (MacInnis and Jaworski 1989), consumers' attention to brand information depends on their levels of ability, motivation, and opportunity. One may infer that if the consumer is currently not considering purchasing the product, then her motivation to pay attention to firm quality disclosures may be low, leading to inattention. One can also infer a similar inattention using the elaboration likelihood model from psychology. According to Petty and Cacioppo (1986, p. 128), "When conditions foster people's motivation and ability to engage in issue-relevant thinking, the 'elaboration likelihood' is said to be high. This means that people are likely to attend to the appeal…." In our context, a lack of such motivation may lead to inattention.

[3] Quality in our context is defined in broad terms to include items that may not be salient to a consumer if she is not paying attention. It may include, for example, information related to the past performance of the product (Armstrong and Chen 2009).

fully informed purchase decision. Second, her inattention might have resulted in her having no information about the qualities of any of the cars on the market—i.e., she is *uninformed*. As a final possibility, the consumer might have become aware of the information about some cars but not others—i.e., she is *partially informed* (Soberman 2004, Ghosh and Stock 2010).

If, because of her previous lack of attention, a consumer is either uninformed or partially informed, then she might decide to invest some time (or money) in searching for more information before making her decision. From a psychological perspective, a lack of full information implies that the consumer perceives her level of knowledge as being lower, and it has been shown that perceived knowledge has a negative relationship with the propensity to search for additional information (Radecki and Jaccard 1995). For our purposes it is sufficient to note that inattention may lead to search. In these cases, the consumer might visit an aggregator website such as Edmunds.com or KBB.com to find quality information on competing cars.

The above example highlights how quality information revelation and learning about competing cars can happen in two distinct phases. In the first phase, if the consumer is attentive, she observes firm disclosures and obtains all relevant information disclosed by the firms. If the consumer is inattentive in this first phase, there can be an additional phase in which she may engage in costly search to obtain the firm-disclosed information. In the terminology of Peter and Olson (2008, p. 429), information acquisition is "incidental" in the first phase and "intentional" in the second phase. The incidental exposures arising from attentiveness by their very nature involve some randomness, leading to some consumers becoming fully informed, partially informed,[4] or completely uninformed about quality. In a competitive marketplace, the behavior of these initially uninformed or partially informed consumers is critical. This is because the competitive landscape between firms may change depending on how many of these consumers decide to engage in search. It therefore becomes imperative to understand which consumers search and which do not. Of particular relevance is the group of consumers who are partially informed, because the firm to whom these consumers have been attentive enjoys relatively more power over them until (and if) they decide to become better informed via search. Moreover, following the logic of Radecki and Jaccard (1995), a partially informed consumer may have a lower incentive to engage in search than an uninformed consumer, simply because she already has information on one of the products. For this reason, it is more difficult to compete for a consumer in this group, especially for the firm about whose quality the consumer is uninformed.

Next, consider the firm's disclosure decision. For the firm, a critical consideration is the fact that disclosure of quality information is often costly (Guo and Zhao 2009). The question then becomes, given the inattentiveness described above (and the resulting categories of consumers), should a firm invest in disclosing the quality of its products? Whether or not this disclosure investment is justified depends on two distinct outcomes of consumer inattentiveness—the direct effect of consumers possibly missing the disclosure and the indirect effect of inattentive consumers deciding whether or not to engage in costly search for quality information that they missed. In this paper we develop and analyze a duopoly model that simultaneously considers both of these factors, along with firm disclosure costs, to provide insights into firm quality disclosure decisions. That is, we address the question of how firm disclosure strategies should change given consumer attentiveness and the possibility of subsequent costly searching, which is endogenous to our model. This question is of particular relevance given consumer trends toward lower attentiveness to firm disclosures (mentioned above) and easier information acquisition via (online) search.

Our analysis yields the following main insights regarding firm disclosure decisions, pricing, and profits. In terms of quality disclosure, we find that firms should disclose *less* when there are relatively more consumers who are partially informed (informed about only one of the two products) prior to deciding whether to engage in costly search for additional quality information. This market structure, where more consumers are partially informed, arises when the degree of consumer inattentiveness is intermediate. Intermediate attentiveness leads to price compression, as firms charge lower prices to dissuade partially informed consumers from searching and becoming fully informed. Since lower prices make consumers less likely to search before buying, firms' incentives to disclose quality information are reduced. This price compression is contrary to the extant literature on informative ads, where the presence of more partially informed consumers has been shown to be associated with higher equilibrium prices (Soberman 2004, Ghosh and Stock 2010). In terms of profit implications, our results suggest that changes in ex ante

[4] One may suggest that if a consumer is not in the market for a particular product category, she may be inclined to avoid the quality disclosures of *all* competing products within that category, calling into question the plausibility of a segment of partially informed consumers. However, selective avoidance of ads (i.e., random skipping of ads) enjoys support from both the extant literature and common experience. Our conceptualization of this behavior is identical to that of Ghosh and Stock (2010).

equilibrium profits depend critically on both consumer attentiveness and firm disclosure costs. Profits are *U shaped* in attentiveness when disclosure costs are low but follow an *inverted U shape* when disclosure costs are high. In addition, we show that the trend toward lower consumer search costs will lead to *higher* profits if quality disclosure costs are low but will result in *lower* profits if disclosure costs are high.

2. Literature

This paper lies at the intersection of three research streams—firm quality disclosure, consumer attentiveness, and consumer search—which we review in turn below.

Several papers in both marketing and economics have examined the question of costly disclosure of quality information. In a pioneering paper, Jovanovic (1982) shows that a monopolist truthfully discloses quality information only when it is above a threshold. Two more recent papers in the disclosure literature are central to our analysis. First, Guo and Zhao (2009) analyze quality disclosure in a competitive setting where competing firms simultaneously or sequentially disclose quality information. Their results suggest that, compared with a monopoly context, simultaneous disclosure by competing firms leads to less information being revealed. In a market in which firms sequentially disclose information, the disclosure leader discloses less than in the simultaneous disclosure case. The decision of the disclosure follower, however, depends on disclosure cost. Levin et al. (2009) analyze a competitive model of simultaneous quality disclosure with vertically and horizontally differentiated firms. Their objective is to examine the social welfare implications of firm disclosure decisions, examining both a traditional competitive context and a market where two firms form a cartel and maximize joint profits. This paper contributes to the quality disclosure literature by considering consumer attentiveness. Attentiveness adds two important facets to firm decisions that previous models of quality disclosure are unable to capture. First, since quality disclosure is costly, the disclosure decision should be affected by the likelihood that consumers will pay attention to it. The second effect of inattentiveness is indirect. If consumers are inattentive, those who miss firm disclosures might decide to search for the information that they missed. This endogenous search process impacts the distribution of consumers across the fully informed, partially informed, and uninformed segments, in turn affecting equilibrium firm disclosure strategies. Our analysis enables us to provide insights into how two timely topics in consumer behavior, inattentiveness and the resultant costly search, affect firm disclosure behavior and profits. The net effect of these consumer phenomena on firm decisions is not intuitively obvious, and it has not been addressed in the past literature on quality disclosure. We find that changes in attentiveness or search costs can make a firm either more or less likely to disclose quality information, depending on market conditions. Our results are driven by the link between inattentiveness and the share of consumers who are ex ante partially informed prior to the search decision—a link that is moderated by the endogenous search decision.

Although distinct from traditional models of costly quality disclosure, the literature on endogenous quality choice and revelation in competitive markets with consumer uncertainty is also relevant. In a recent paper, Kuksov and Lin (2010) document that, although a higher-quality firm should always provide information to help consumers resolve quality uncertainty, there are cases in which a low-quality firm will have a higher incentive to do so. In another paper, Bhardwaj et al. (2008) analyze the problem of the format of quality information revelation. In particular, they consider buyer-initiated versus seller-initiated information revelation. In a buyer-initiated revelation, the buyer decides the information to which she wants to be exposed. They find that, in a monopoly context, buyer-initiated revelation is associated with high-quality products. A similar association also emerges in a duopoly market as the cost of buyer-initiated revelation declines. This literature on quality choice and revelation, although related, is distinct from our focus on how consumer uncertainty *due to a lack of attention to disclosures* may lead to costly search by some consumers, as well as how this can affect firm disclosure decisions and profits.

There is a burgeoning literature on consumer (in)attentiveness to firm communications and its resulting impact on strategy. In the context of combative advertising by firms, Chen et al. (2009) explicitly model the responsiveness of consumers to advertising. They show that if consumers are responsive, overall price competition decreases and profits are enhanced. In the context of DVRs, Wilbur (2008) documents that consumers have a strong aversion to television advertising. Thus, Wilbur (2008) speculates that increased penetration of DVRs, which aid consumers in skipping television ads, will affect market equilibria. However, in an extensive field study on consumer packaged goods, Bronnenberg et al. (2010) find no appreciable long-term effect of DVRs on firm sales. Using a model of informative advertising (as opposed to our model of quality disclosure), Ghosh and Stock (2010) analytically demonstrate the competitive effect of DVR penetration. In particular, they show that an increase in consumer inattentiveness emanating from higher levels of DVR penetration has a direct negative effect of demand contraction. However, by increasing the share of partially informed consumers relative to fully informed consumers, DVRs can have an indirect positive effect. The net impact of DVRs depends on the magnitude of these two effects. Interestingly, Ghosh and Stock (2010) find that DVRs and ad avoidance benefit competing firms at high levels of DVR penetration. Their analysis does not, however, consider the possibility that a consumer who is ex ante incompletely informed may engage in search and become fully informed. The incorporation of such a possibility in our paper yields additional insights. Specifically, while confirming that increases in consumer inattention may help firms when the level of inattention is above a threshold, we identify market conditions when exactly the opposite result may hold. Our insights contribute to the literature on consumer attentiveness by showing how the impact of attentiveness changes when firm quality disclosure costs and endogenous consumer searching are considered.

Finally, this paper also relates to the search-theoretic literature. There is an extensive game theory literature on endogenous search for product information. We refer the reader to Stigler (1961) and Diamond (1971) for some pioneering work in this area. Broadly speaking, the search-theoretic literature considers two types of search: sequential and nonsequential. With sequential search, consumers sample one product at a time before making a purchase decision (Stahl 1989, Kuksov 2006). Kuksov and Villas-Boas (2010) examine how sequential search costs affect the number of alternatives being offered by firms. Branco et al. (2012) derive optimal stopping rules for consumers whose sequential searching reveals information on product attributes of varying informativeness. In this paper, however, we consider simultaneous search. With simultaneous (also called "fixed sample") search, consumers simultaneously sample a group of competing products prior to making a purchase decision (Baye and Morgan 2001, Villas-Boas 2009). For example, Baye and Morgan (2001) describe how consumers can obtain price-related information on multiple products from "information gatekeepers." In line with Baye and Morgan (2001), we consider simultaneous search in this paper. Finally, there is also an evolving stream of research examining the potential for television advertising to encourage consumers to engage in costly search (Mayzlin and Shin 2011, Joo et al. 2013).

3. Model

We consider two firms $i = A, B$, each selling a product to a continuum of consumers located along a Hotelling line of unit length. Firm A is located at 0, and firm B is located at 1. In other words, the products are horizontally differentiated. Moreover, the products are vertically differentiated along a quality dimension, with the same base valuation v. Similar to Guo and Zhao (2009) and Levin et al. (2009), quality q_i is exogenous, and consumers have a prior belief that each firm's quality is a random observation from identically and independently distributed uniform distributions with support over $[0, 1]$. Firms, in turn, have the same prior belief about the quality of the competing firm's product. The price of product is given by p_i. Thus, a consumer located at $x \in [0, 1]$ on the unit line derives a utility of $v + q_A - p_A - x$ if she buys from firm A and $v + q_B - p_B - (1 - x)$ if she buys from firm B. To ensure complete market coverage, we assume that consumers have a high preference for the product and will buy it as long as its total valuation (base valuation v plus the lowest perceived quality realization, as defined in §4) is greater than $\frac{3}{2}$. The assumption of complete market coverage in equilibrium is consistent with the larger literature in marketing and economics (see, e.g., Levin et al. 2009). Moreover, our focus on the case of full market coverage enables us to examine our question of interest—the effect of consumer attentiveness and search costs on firm disclosure decisions and profits—as opposed to digressions into the overall "extent of demand" that may occur under various scenarios when product valuations are relatively low.

3.1. Consumers

The consumer market is segmented on the basis of how well informed the consumers are about the products. A consumer is attentive to quality information from one of the firms with probability $\alpha \in [0, 1]$ and misses or avoids quality information with probability $1 - \alpha$. In the ensuing analysis, we use the terms "viewership" and "attentiveness" interchangeably to describe the parameter α. A lack of attentiveness to quality information implies that the consumer does not know a firm's quality and, in fact, is not even aware of whether or not the firm has incurred costs to disclose quality.[5]

With two products, the consumer market is divided into four distinct segments based on consumers' attentiveness to firms' quality disclosures and the resulting level of awareness of quality information *prior to any consumer searching*. First, a proportion α^2 are attentive to quality information from both firms and hence are fully informed. In addition, two groups of consumers, each of size $\alpha(1 - \alpha)$, are attentive to quality information from one firm but not the other, and they are therefore partially informed prior to

[5] In reality, the nature of the disclosure technology itself may cause consumers to be inattentive. For simplicity, in this paper we do not consider the disclosure technology decision but instead model consumer attentiveness α as a purely exogenous variable.

search. Finally, a proportion $(1-\alpha)^2$ of consumers are inattentive to both firms, and thus they do not have information on either product's quality prior to search. Below, we outline the search behavior of consumers who are partially informed or uninformed about quality.

Consider consumers who are partially informed. Following our assumptions, such a consumer may decide, before making a purchase decision, to search for information on the quality of the product whose quality disclosure she did not observe. The cost of search is denoted by $s \in (0, \frac{1}{\sqrt{2}})$.[6] Overall, a consumer who is aware of the quality information provided by firm A but not firm B has three choices: (i) she can purchase from firm A without engaging in search; (ii) she can purchase from firm B without engaging in search (based solely on a strong horizontal preference—see the next section for details); or (iii) she can spend $s > 0$, become informed about the quality information provided by both firms A and B, and make her decision accordingly. Thus, in case (iii), after search she will have full information about both products (note that the "information" she has about each product might simply be the fact that the firm chose not to disclose its quality). The ultimate demand from partially informed consumers depends on how many decide to engage in search and how many decide to make a purchase based on partial information.

Next, there are consumers who are inattentive to quality disclosures by both firms and are thus completely uninformed about the quality of either product (in fact, they do not even know if either firm has invested in quality disclosure). These consumers might find it rational to purchase without quality information (based solely on horizontal preferences). Alternatively, they can invest s once to engage in nonsequential search (e.g., using an information gatekeeper) and become fully informed about both firms' quality disclosures. Our assumption of simultaneous search can be viewed as a limitation since, in reality, the search cost for an ex ante uninformed consumer may be higher than for a partially informed consumer, suggesting that a sequential search framework may be appropriate. However, our assumption is appropriate in some contexts—for example, the case where any imperfectly informed consumer will go to an aggregator website and obtain pertinent information on all products in her consideration set.

[6] We focus our analysis on the interesting case where s is not so high that no consumer in the partially informed segment finds it optimal to engage in search and thus become fully informed about the competing product. The specifics on the interval become apparent in the following section.

3.2. Game Sequence

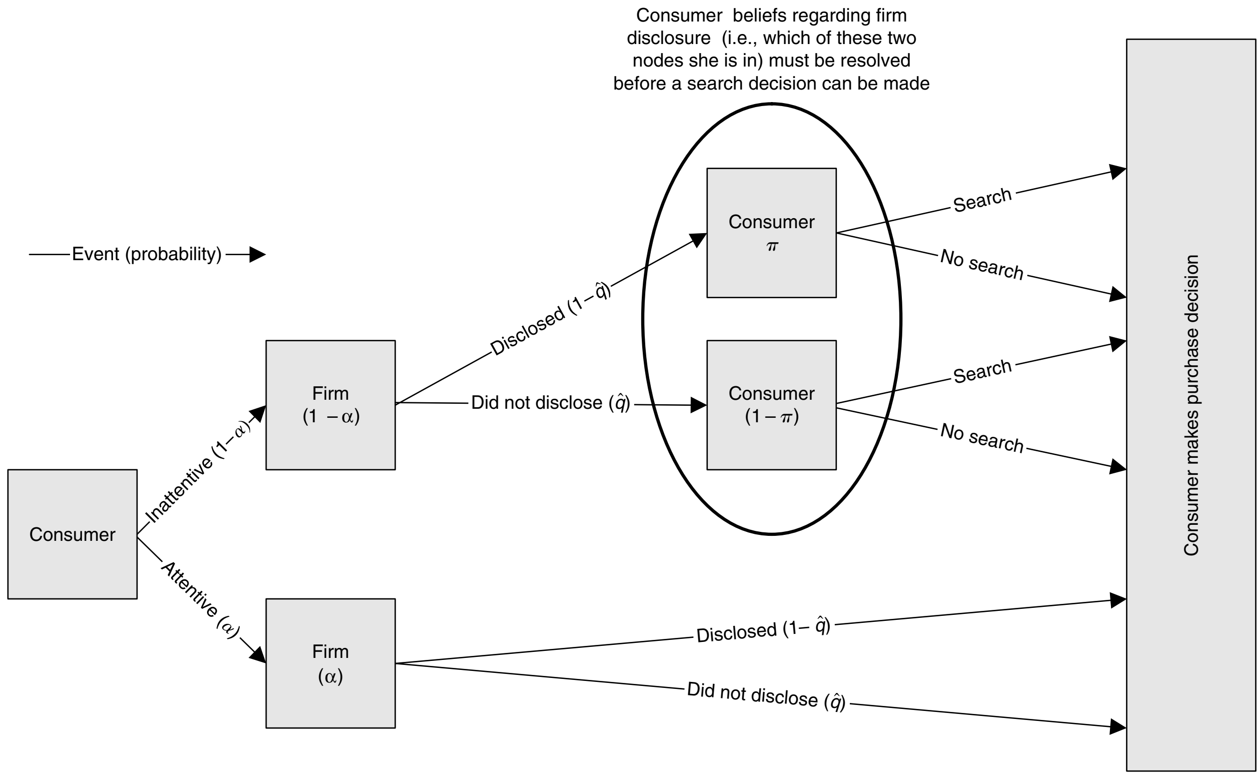
We consider a three-stage game. In stage 1, firms make their quality disclosure decisions given by the indicator function I_i, where $I_i = 1$ if firm i decides to disclose the quality information and $I_i = 0$ otherwise. Quality can be disclosed at a cost c and is credible and truthful (Jovanovic 1982, Guo 2009). In reality, the cost of disclosure may be different depending on the media chosen. However, following the larger literature and for model parsimony, we assume a single disclosure cost. Consumer inattention will result in some consumers being unaware of the quality disclosures of one or both firms after this stage. In stage 2, firms choose prices. Finally, in stage 3, consumers who have missed the quality disclosures of one or both firms will decide whether or not to engage in such costly search, and then purchase decisions are made by all consumers. Consumers who are informed about a product's quality disclosure (as a result of either attentiveness to disclosures or of searching) base their decisions on the product's perceived quality $\tilde{q}_i$ (Levin et al. 2009), which is equal to the true quality q_i when $I_i = 1$ and to an expected quality when $I_i = 0$. Since the equilibrium defined below is conditional on the consumers' expectation about quality, the solution concept we use is a perfect Bayesian equilibrium. Next, we analyze and present results on how firms' disclosure policies and equilibrium profits change with market conditions.

4. Analysis

Consistent with the larger literature on quality disclosure, we assume that when firms choose not to disclose quality, consumers observe this decision and update their beliefs accordingly. Specifically, consumers take the lack of quality disclosure as indicative of an upper bound on the quality of a product, thus expecting that the quality is below some threshold $\hat{q}$. In this case, we define the expected quality to be $\bar{q}$, where $\bar{q} = E[q_i \mid q \le \hat{q}] = \hat{q}/2$. Given that disclosure is costly, we assume that $\hat{q} > 0$. In other words, a firm discloses the true quality of the product if and only if it is strictly positive.

Next, we examine the demand that firms face. Demand depends on the search behavior of ex ante inattentive consumers. Consumer search behavior is endogenous and depends on consumer beliefs about firms disclosure decision. In the following, we therefore first outline consumer beliefs given the above game sequence, consumers' probability of being attentive α, and the probability of disclosure. Before doing so, it is useful to outline the extensive form of the game. We provide this outline in Figure 1. (For simplicity, the figure is created from the perspective of a single firm.)

Figure 1 Game Tree from the Perspective of a Single Firm



In the game tree in Figure 1, the only nontrivial consumer posterior belief corresponds to the one following the case where the consumer is inattentive. The posterior belief relates to the probability of being in one of the two nodes in the information set (circled in Figure 1). Denote the probability of being in the top node (the firm did in fact disclose) as π and the probability of being in the bottom node as $(1-\pi)$. For consistency, the posterior beliefs π and $(1-\pi)$ are constructed using Bayes law so that, given the priors, a consumer can compute the probability of being in either the top or bottom node given $\hat{q}$.[7] In other words,

$$\pi \equiv \frac{(1-\alpha)(1-\hat{q})}{(1-\alpha)(1-\hat{q})+(1-\alpha)\hat{q}} = 1-\hat{q}. \tag{1}$$

In essence, the consumer's beliefs are characterized by firm disclosure decisions. Given this belief structure, we must ensure that (i) consumers make the search decision rationally, and (ii) firms make disclosure and pricing decisions optimally given consumer behavior. Next, we outline the demand that firms derive.

For expositional clarity, we focus on the demand function for firm A. Firm A derives demand from three distinct groups of consumers: fully informed consumers (with mass α^2), partially informed consumers (two segments each with mass $\alpha(1-\alpha)$), and uninformed consumers (with mass $(1-\alpha)^2$).

4.1. Fully Informed Market

Consumers in the fully informed market will buy from firm A if buying from A delivers higher surplus than buying from B, which is true for all consumers located to the left of x_f, where $x_f = (p_B - p_A + \tilde{q}_A - \tilde{q}_B + 1)/2$. Thus, the demand that firm A faces from the fully informed market is Q_f^A, where

$$Q_f^A = \alpha^2 x_f. \tag{2}$$

Demands from the other two consumer groups, partially informed and uninformed, are more involved and are treated separately in the following subsections.

4.2. Partially Informed Market

Define $Q^A_{\text{partial } B}$ as the demand for A's product from consumers who are informed of the quality information disclosed by firm B only. Since these consumers

[7] Since the consumer beliefs are constructed using Bayes law, they are consistent (at least weakly) with sequential rationality (Myerson 1997). Beliefs consistent with sequential rationality are, by definition, also consistent with a perfect Bayesian equilibrium, which is the solution concept employed in this paper. Moreover, if $\hat{q}$ is strictly between 0 and 1 such that all move probabilities in the extensive-form game occur with strictly positive probabilities, then the consumer's beliefs are fully consistent with sequential rationality (Kreps and Wilson 1982).

have information about B's quality but not A's, we refer to $Q^A_{\text{partial }B}$ as firm A's demand from "firm B's turf." Conversely, consumers who are informed about the quality of the product from firm A only are "firm A's turf," and the demand that firm A faces from this group is given by $Q^A_{\text{partial }A}$. To find $Q^A_{\text{partial }A}$ and $Q^A_{\text{partial }B}$, we need to resolve the mass of consumers in this market who engage in search (and who do not).

First, consider $Q^A_{\text{partial }A}$. These consumers know the following information: $(p_A, p_B, \tilde{q}_A)$. There is a mass of consumers within $Q^A_{\text{partial }A}$ who do not engage in search for information about product B because they know that, irrespective of the disclosure decision of firm B, they will purchase product B. These consumers realize that they will derive higher surplus from buying B under the worst possible outcome of their quality search—a nondisclosure of quality by B, which implies a perceived quality for B of $\bar{q}$—than they would from buying A with its known quality of $\tilde{q}_A$. Thus, the rational decision for these consumers is to purchase product B without search. Such consumers are located to the right of $\hat{x}_N$, where

$$\hat{x}_N = \frac{p_B - p_A + \tilde{q}_A - \bar{q} + 1}{2}. \tag{3}$$

Technically, $\hat{x}_N$ defines the marginal consumer who is indifferent between buying A and buying B without search (derived by equating $(v - x - p_A + \tilde{q}_A)$ and $(v - (1-x) - p_B + \bar{q})$). In our context, which includes the endogenous search decision, consumers to the left of $\hat{x}_N$ might engage in search before making a purchase decision. The decision to search depends on the net benefit of search, which we denote by $\Delta_B(x)$. In effect, $\hat{x}_N$ denotes the consumer who is indifferent between buying B without search and engaging in search to become fully informed. We evaluate the net benefit from search using the search methodology outlined in Gabszewicz and Garella (1986).[8] Define $\Delta_i(x)$ as the benefit of search for a partially informed consumer located at $x \in [0,1]$. A consumer in firm A's turf will search for quality information of firm B's product (as opposed to simply purchasing A without search) if the net benefit from search $\Delta_B(x) > 0$, where

$$\Delta_B(x) = \underbrace{\left(\int_0^{q_B^*} (v - s - x - p_A + \tilde{q}_A)\, dq_B + \int_{q_B^*}^1 (v - s - (1-x) - p_B + q_B)\, dq_B\right)}_{\text{Benefit of search}} - \underbrace{(v - x - p_A + \tilde{q}_A)}_{\text{Opportunity cost of search}}, \tag{4}$$

$$q_B^* = 1 - p_A + p_B + \tilde{q}_A - 2x \quad \text{for all } x \in [0, \hat{x}_N] \text{ and } q_B \in [\hat{q}, 1]. \tag{5}$$

A consumer engages in search knowing that her investment of s will reveal either firm B's true quality, q_B (if firm B has disclosed its quality), or the expected quality, $\bar{q}$ (if firm B chose not to disclose). This post-search quality information may or may not justify purchasing firm B's product, depending on the threshold value q_B^*, which is derived by simply equating the post-search surplus of buying from A $(v - s - x - p_A + \tilde{q}_A)$ with that of buying from B $(v - s - (1-x) - p_B + q_B)$. If search reveals the quality of product B to be below the threshold, the consumer will buy product A. Otherwise, if quality is above the threshold, she will buy product B. In either case, now her surplus from buying will be net of the search cost incurred. Of course, the consumer also has the option of not searching and simply buying the product from firm A. The surplus generated from not searching and buying directly from A defines the opportunity cost of search.

The marginal consumer $\hat{x}_B$ who is indifferent between searching and not searching for quality information on product B has $\Delta_B(\hat{x}_B) \equiv 0$, where

$$\hat{x}_B = \frac{p_B - p_A + \tilde{q}_A + \sqrt{2s}}{2}. \tag{6}$$

All partially informed consumers in the interval $[0, \hat{x}_B]$ do not have any incentive to search for quality information from firm B, so they simply buy from A. Similarly, all partially informed consumers in the interval $[\hat{x}_N, 1]$ simply buy from B without search. Consumers in the intermediate interval $[\hat{x}_B, \hat{x}_N]$ will incur the search cost s, become fully informed, and make purchase decisions accordingly. Hence, both firms compete for consumers in this interval. Of these consumers, all who are located to the left of x_f will buy from firm A after search, where $x_f = (p_B - p_A + \tilde{q}_A - \tilde{q}_B + 1)/2$.

The ultimate distribution of consumers in the partially informed market between firms A and B depends on the relative magnitude of x_f, $\hat{x}_B$, and $\hat{x}_N$. At the candidate equilibrium, $\hat{x}_B < \hat{x}_N$.[9] Moreover, one sees that $x_f \le \hat{x}_N$ since $\tilde{q}_B \ge \bar{q}$. Therefore there are two possibilities: (1) $x_f \in [0, \hat{x}_B)$ and (2) $x_f \in [\hat{x}_B, \hat{x}_N]$. Figure 2 summarizes the demand distribution in these two cases. In both cases, as noted above, consumers in $[0, \hat{x}_B]$ buy from firm A without search and consumers in $[\hat{x}_N, 1]$ buy from B without engaging in

[8] Whereas Gabszewicz and Garella (1986) model search for prices, we take pricing as common knowledge and use their methodology to model search for quality information.

[9] This condition requires that $1 - \bar{q} \ge \sqrt{2s} \equiv \delta$, which always holds since, in the candidate equilibrium, we have $\delta < 1/2$, and $\bar{q} < 1/2$ trivially holds. A proof of the existence of the candidate equilibrium we consider is provided in the appendix.

search. However, in the first case, the consumers in $[\hat{x}_B, \hat{x}_N]$ buy from firm B after engaging in search. In the second case, where $x_f \in [\hat{x}_B, \hat{x}_N]$, all consumers in the interval $[0, x_f]$ buy from firm A—consumers in $[0, \hat{x}_B)$ buy from A without searching and consumers in the interval $[\hat{x}_B, x_f]$ buy from A after search—and consumers in the interval $[x_f, \hat{x}_N]$ buy from firm B after search.

One can readily see that $x_f \in [\hat{x}_B, \hat{x}_N]$ for $\tilde{q}_B \le 1 - \sqrt{2s}$ and $x_f \in [0, \hat{x}_B)$ for $\tilde{q}_B > 1 - \sqrt{2s}$. The probabilities that $\tilde{q}_B \le 1 - \sqrt{2s}$ or $\tilde{q}_B > 1 - \sqrt{2s}$ are $1 - \sqrt{2s}$ and $\sqrt{2s}$, respectively. As indicated earlier, in our analysis we focus on the more interesting case corresponding to $\tilde{q}_B \in (0, 1)$, $s \in (0, \frac{1}{\sqrt{2}})$. Finally, to make the following analysis more parsimonious, and without any loss of generality, we define δ as a simple transform of search cost, $\delta = \sqrt{2s}$. Thus, we examine changes in search cost in terms of changes in δ.

Aggregating the above information, the demand that firm A faces from consumers in its turf is

$$Q^A_{\text{partial } A} = \alpha(1-\alpha)[\delta\hat{x}_B + (1-\delta)x_f]. \tag{7}$$

Similar logic can be used to determine $Q^A_{\text{partial } B}$, which is the demand for firm A's product from consumers in firm B's turf:

$$Q^A_{\text{partial } B} = \alpha(1-\alpha)[\delta\hat{x}_A + (1-\delta)x_f], \tag{8}$$

$$\hat{x}_A = \frac{2 + p_B - p_A - \tilde{q}_B - \delta}{2}. \tag{9}$$

Finally, we outline demand from the ex ante uninformed consumer market.

4.3. Uninformed Market

Uninformed consumers know only (p_A, p_B); they are unaware of the qualities and disclosure decisions of both firms. We reiterate that if consumers in this market search, they will engage in nonsequential search (Baye and Morgan 2001) and become fully informed about the quality of both products. As in the ex ante partially informed market, we first find consumers who will buy either product A or product B without search since their horizontal preference for the product is so strong that they would prefer it regardless of what searching would reveal about qualities. It can readily be seen that consumers to the left of $\hat{x}_{u_1} = (p_B - p_A + \bar{q})/2$ will buy A without search, since these consumers prefer buying product A with a perceived quality $\bar{q}$ over product B with quality 1. In other words, these consumers do not need to engage in search to make a buying decision. At the other extreme, consumers to the right of $\hat{x}_{u_2} = 1 + (p_B - p_A - \bar{q})/2$ will buy product B without search. Consumers on $[\hat{x}_{u_1}, \hat{x}_{u_2}]$ may or may not engage in search, depending on the net benefit of searching. Given high base valuations, these consumers (whose horizontal preferences are less strong) will still buy a product at $\bar{q}$, even if they decide not to search. If they decide not to search, all consumers in the interval $[\hat{x}_{u_1}, \hat{x}_u]$, $\hat{x}_u = (p_B - p_A + 1)/2$ will buy product A, and all consumers in the interval $(\hat{x}_u, \hat{x}_{u_2}]$ will buy B. Notice that the location of $\hat{x}_u$ does not depend on the uninformed consumer's beliefs about quality as long as her beliefs about A and B are the same.

The net benefit from searching, Ω_U, for this mass of consumers on $[\hat{x}_{u_1}, \hat{x}_u]$ is therefore given by

$$\Omega_U = \hat{q}\Omega_U(\bar{q}) + \int_{\hat{q}}^{1} \Omega_U(q_A)\,dq_A - \max[v - p_A - x + \bar{q},\; v - p_B - (1-x) + \bar{q}], \tag{10}$$

$$\Omega_U(\tilde{q}_A) \equiv \left(\int_0^{q_B^*} (v - s - x - p_A + \tilde{q}_A)\,d\tilde{q}_B + \int_{q_B^*}^{1} (v - s - (1-x) - p_B + \tilde{q}_B)\,d\tilde{q}_B\right), \tag{11}$$

$$q_B^* = 1 - p_A + p_B + \tilde{q}_A - 2x, \quad x \in [\hat{x}_{u_1}, \hat{x}_{u_2}], \quad \text{and} \tag{12}$$

$$\forall \tilde{q}_A = \{\bar{q}, q_A\}, \quad q_A \in [\hat{q}, 1]. \tag{13}$$

The net benefit from search given in (10) is computed as follows. For simplicity, we start with a given quality realization, $\tilde{q}_A$. An uninformed consumer, however, is unaware of the quality of both firms. Therefore, we need to integrate over all possible values of $\tilde{q}_A$, which is $[\hat{q}, 1]$ if firm A discloses or $\bar{q}$ if firm A does not disclose. This explains the first two terms in (10). The same approach applies if we start with a given quality realization $\tilde{q}_B$. Finally, to compute the net benefit, we need to subtract the opportunity cost of search, which is the surplus from buying A or B without search. This is given by the third term in (10). Notice that uninformed consumers are willing to buy at $\bar{q}$ without search. Thus, in computing (10) we assume that uninformed consumers assess the opportunity cost of search at $\bar{q}$.[10]

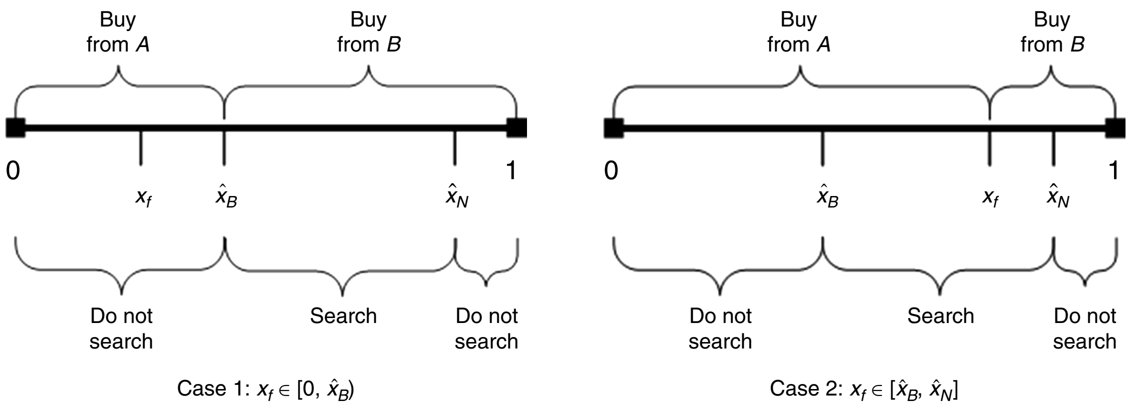
The following lemma reports an important result for this intermediate interval of the uninformed segment of the market.

LEMMA 1. *All ex ante uninformed consumers on the interval $[\hat{x}_{u_1}, \hat{x}_{u_2}]$ will engage in search if $\delta \le \bar{\delta} = \sqrt{2(\frac{13}{24} - \frac{1}{3}\bar{q}(3 + \bar{q}^2))}$.*

Given Lemma 1, we can summarize the behavior of the ex ante uninformed consumers, given δ

[10] The analysis does not qualitatively change because $\hat{x}_u$ and $\hat{x}_{u_i}$, $i = A, B$ are independent of $E_{\text{No\_Search}}(\tilde{q}_i)$ as long as $E_{\text{No\_Search}}(\tilde{q}_A) = E_{\text{No\_Search}}(\tilde{q}_B)$ for all $\tilde{q}_A$, $\tilde{q}_B \in [0, 1]$. For instance, an alternate reasonable assumption about quality assessment without search is $E_{\text{No\_Search}}(\tilde{q}_i) = \frac{1}{2}$, $i = A$, B. However, with that alternate assumption, all the main results remain the same. The only change relates to the expression of $\bar{\delta}$, which we outline in Lemma 1.

Figure 2 Consumer Search and Purchase Behavior



below the threshold, as follows. Uninformed consumers on $[0, \hat{x}_{u_1})$ do not engage in search and buy product A, consumers on $[\hat{x}_{u_1}, \hat{x}_{u_2}]$ engage in search and purchase the product that delivers the higher surplus, and consumers on $(\hat{x}_{u_2}, 1]$ do not engage in search and buy product B. The demand that firm A faces from this segment, similar to the case of partially informed consumers, depends on the value of x_f relative to $\hat{x}_{u_1}$ and $\hat{x}_{u_2}$. There are three possibilities: (i) $x_f < \hat{x}_{u_1}$, in which case demand for firm A is $\hat{x}_{u_1}$; (ii) $x_f \in [\hat{x}_{u_1}, \hat{x}_{u_2}]$, in which case demand for firm A is x_f; and finally, (iii) $x_f > \hat{x}_{u_2}$, in which case demand for firm A is $\hat{x}_{u_2}$. Notice, however, that $x_f \in [\hat{x}_{u_1}, \hat{x}_{u_2}]$ for $|\tilde{q}_A - \tilde{q}_B| \le 1 - \bar{q}$, which always holds since $\tilde{q}_i$ has a maximum value of 1 and a minimum of $\bar{q}$. In other words, scenario (ii) is realized with probability 1, and thus firm A sells to a mass of x_f consumers from the uninformed segment. Formally, let Q_U^A be the demand that firm A derives from this segment:

$$Q_U^A = (1-\alpha)^2 x_f. \tag{14}$$

Combining the above analysis for fully informed, partially informed, and uninformed consumers, the demand and profit functions are as follows:

$$\begin{gathered} Q^A = Q_f^A + Q^A_{\text{partial } A} + Q^A_{\text{partial } B} + Q_U^A, \\ Q^B = 1 - Q^A; \end{gathered} \tag{15}$$

$$\Pi^i = Q^i \cdot p_i, \quad i = A, B. \tag{16}$$

Simple profit maximization with respect to prices yields the following equilibrium prices and profit:[11]

$$p_i^* = \tfrac{1}{3}(3 + (\tilde{q}_i - \tilde{q}_j)(1 - \delta\alpha(1-\alpha))), \tag{17}$$

$$\Pi_i^* = \tfrac{1}{18}(3 + (\tilde{q}_i - \tilde{q}_j)(1 - \delta\alpha(1-\alpha)))^2, \quad i = A, B. \tag{18}$$

Because there are multiple segments of consumers, to establish the existence of equilibrium, we must check whether firms have any incentive to unilaterally deviate from the equilibrium defined in Equations (17) and (18). The condition for existence of the equilibrium is $\delta \in (0, \min[\bar{\delta}, \frac{1}{2}])$, a proof of which is provided in the appendix.

4.4. Quality Disclosure Decisions

Having outlined the equilibrium in terms of pricing, we now turn our attention to the firms' disclosure decisions. In line with Guo and Zhao (2009), we focus on symmetric disclosure decisions. Recall that the firm discloses quality information only when its quality q_i is greater than a threshold $\hat{q}$, which is formally defined in the following lemma.

Lemma 2. *In equilibrium, a firm discloses the true quality of its product when $q_i > \hat{q}$, where*

$$\hat{q} = \begin{cases} \dfrac{\sqrt{216c + (5+\delta\alpha(1-\alpha))^2} - (5+\delta\alpha(1-\alpha))}{3 - 3\delta\alpha(1-\alpha)} \\ \quad \text{if } 0 < c \le \hat{c}, \\ 1 \quad \text{otherwise}; \end{cases}$$

$$\hat{c} = \tfrac{1}{72}\big[(13 - \delta\alpha(1-\alpha))(1 - \delta\alpha(1-\alpha))\big].$$

In the following we will concentrate on the case where $0 < c \le \hat{c}$, since for $c > \hat{c}$ no information is disclosed by either firm, making it a less interesting case for analysis. In addition, for tractability we replace the threshold disclosure cost $\hat{c}$ with its infimum, which is $\frac{17}{128}$. Note that $2\alpha(1-\alpha)$, which is the proportion of consumers who are ex ante partially informed, is maximized at $\alpha = \frac{1}{2}$. Therefore, as α approaches $\frac{1}{2}$ either from the left (from 0) or from the right (from 1), the proportion of consumers who are ex ante partially informed also increases. In the following, for expositional clarity, we discuss firms' changes in disclosure policy and equilibrium profit in terms of changes in the share of partially informed consumers, bearing in mind that such changes are the direct result of changes in the viewership/attentiveness parameter α.

[11] Note that if $\alpha = 0$, 1 or $s = 0$ the equilibrium prices and profit converge to the ones outlined in Levin et al. (2009).

In particular, in the following we use the terminology "increase in the share of ex ante partially informed consumers" to indicate that α moves closer to $\frac{1}{2}$.

We begin by analyzing how the disclosure threshold $\hat{q}$ changes with respect to viewership α, search cost δ, and disclosure cost c.

Proposition 1. *In the interior equilibrium with* $\alpha \in [0,1]$, $\delta \in (0, \min[\bar{\delta}, \frac{1}{2}])$, *and* $c \in (0, \frac{17}{128})$,

(i) *in equilibrium, the threshold for quality information disclosure increases (i.e., less information is disclosed) as the share of ex ante partially informed consumers increases* (α *approaches* $\frac{1}{2}$);

(ii) *in equilibrium, the threshold for quality information disclosure increases (i.e., less information is disclosed) as the search cost* δ *increases* ($d\hat{q}/d\delta \geq 0$); *and*

(iii) *in equilibrium, the threshold for quality information disclosure increases (i.e., less information is disclosed) as the disclosure cost* c *increases* ($d\hat{q}/dc \geq 0$).

The intuition for part (i) of Proposition 1 is as follows. Consider the disclosure decision for firm i when its quality is above $\bar{q}$. For a given quality realization and search cost, Equation (17) implies that an increase in firm i's share of partially informed consumers (which is $\alpha(1-\alpha)$) reduces firm i's price. Intuitively, a lower price from firm i discourages consumers who are informed only about firm i's product to engage in search for information regarding the competing product. Thus, in effect, the competing firm's reward from disclosing a higher quality is diminished (since such disclosure is less likely to be observed), and the incentive to engage in costly disclosure is reduced. This lower propensity to disclose in turn increases $\bar{q}$ (the expected quality from nondisclosure) because consumers are aware that firms will not disclose unless the quality realization is high, and thus a product whose quality is not disclosed can still be of high quality. An increase in $\bar{q}$ means that $q_i - \bar{q}$, which is the difference between true quality and expected quality in the case of nondisclosure, decreases. In other words, there is a smaller premium to truthful quality disclosure. This, in turn, further reduces firms' incentive to disclose.[12]

What Proposition 1 highlights is that a proportion of ex ante partially informed consumers is central to the firm's disclosure policy. Because of inattention, these consumers, in effect, face asymmetric search costs—zero search cost for the firm whose disclosure decision they know and positive search cost for the other firm. This asymmetry in search cost induces the firm whose quality the consumer is aware of to compete via price reduction, in turn, increasing the opportunity cost of search and dissuading the consumer searching from becoming fully informed.[13] This price competition affects disclosure policies, as detailed above.[14]

Two additional perspectives on the preceding discussion are worth noting here. First, although the Proposition 1 is stated in terms of α approaching $\frac{1}{2}$ so that the share of ex ante partially informed consumers increases, the proposition can also be used to analyze firm disclosure strategies as the share of uninformed or fully informed consumers increases (α approaches 0 or 1, respectively). Interestingly, the firm discloses more information as α approaches 0 or 1. As α approaches these extremes, the price compression created as a result of the presence of partially informed consumers diminishes, and the incentive to disclose information increases commensurately.

Second, notice that the above analysis can be used to examine profit implications for firms who have high (or low) realized quality. A firm is of high (low) quality if its realized quality is above (below) $\hat{q}$. Differentiating the profit from disclosure with respect to the share of partially informed consumers shows that profit is increasing for both q_A and $\hat{q}$ below a threshold and decreasing otherwise. This means that a firm with the highest quality realization has the lowest incentive to disclose as the share of partially informed consumers increases. On the other hand, profit from nondisclosure increases monotonically with respect to the share of partially informed consumers.

The other two components of Proposition 1, parts (ii) and (iii), are quite intuitive. As one would expect, as consumer search costs increase, the firm tends to disclose less (part (ii)), since consumers who have not observed the firm's quality are less likely to

[12] The net benefit from disclosure, which is the ex ante profit from disclosure minus the profit from no disclosure, strictly decreases as the share of consumers who are partially informed increases. For instance, consider the disclosure decision for firm A. Assuming that firm B discloses for all $q_B \geq \hat{q}$, the change in net profit with respect to α from disclosure is given simply by $(\partial/\partial\alpha)(\Pi^A_{\text{Disclose}} - \Pi^A_{\text{Nondisclose}}) = (\delta/36)(2\tilde{q}_A - \hat{q})(2\alpha - 1)(4 + 2\tilde{q}_A + \hat{q} + \alpha\delta(1-\alpha)(2 - 2\tilde{q}_A - \hat{q}))$, which is nonpositive for $0 < \alpha \leq \frac{1}{2}$ and positive for $\alpha > \frac{1}{2}$.

[13] We thank an anonymous reviewer for helping us develop the intuition for this proposition.

[14] The importance of endogenous search as a moderating effect on firm disclosure policy can be seen by analyzing a model when search cost is prohibitively high and no partially informed (or uninformed) consumers engage in search. One can show that in such a model, the monotonic effect of an increase in the share of partially informed consumers does not hold. The results in such a model are to a large extent driven by the proportion of uninformed consumers in the market. When α is low and there are mostly uninformed consumers in the market, the firm discloses less information because these consumers make purchase decisions solely on the basis of price. With no possibility of search, uninformed consumers do not get to know about or form expectations about quality and take decisions solely on the basis of price. Hence, when α is low, firms are better off decreasing costly disclosures. The opposite holds true, and firms disclose more information, when α is high. Analysis of such a model is available from the authors.

search for it when the cost to do so is higher (all else being equal). Finally, consistent with Guo and Zhao (2009), we find that, as expected, disclosure decreases with disclosure cost c (part (iii)).

4.5. Ex Ante Equilibrium Firm Profits

We now turn our attention to firm profits given equilibrium pricing and disclosure decisions. The ex ante equilibrium profit of a firm depends on its disclosure policy as well as the disclosure policy of its competitor. Recall that firm i discloses iff $q_i \geq \hat{q}$. Define $\hat{\Pi}_i^*$ as the profit accruing to firm i given the disclosure decision. One of four scenarios may be realized. The first two scenarios give the ex ante profit from nondisclosure by firm i: (i) both firm i and firm j choose nondisclosure, or (ii) firm i chooses nondisclosure but firm j chooses disclosure. The last two scenarios give the ex ante profit from disclosure by firm i: (iii) firm i chooses disclosure but firm j chooses nondisclosure, or (iv) both firms choose disclosure. Since firm i chooses nondisclosure (disclosure) for $q_i < \hat{q}$ ($q_i \geq \hat{q}$), we ought to integrate over $[0, q_i)$ (or $[q_i, \hat{q}]$) to get the profit contribution from nondisclosure (disclosure) in the total expected profit. Summarizing the above, the ex ante profit function for firm i may be written as

$$\begin{aligned}\hat{\Pi}_i^* &= \underbrace{\int_0^{\hat{q}} \left(\hat{q}/2 + \int_{\hat{q}}^1 \Pi_i^*(\hat{q}/2, q_j)\, dq_j\right) dq_i}_{\text{Profit for Nondisclosure (scenarios i and ii)}} \\ &\quad + \underbrace{\int_{\hat{q}}^1 \left(\hat{q}\Pi_i^*(q_i, \hat{q}/2) + \int_{\hat{q}}^1 \Pi_i^*(q_i, q_j)\, dq_j\right) dq_i - c}_{\text{Profit from disclosure (scenarios iii and iv)}} \\ &= \tfrac{1}{108}(55 - 108c(1-\hat{q}) - \delta\alpha(1-\alpha)(2-\delta\alpha(1-\alpha)) \\ &\qquad - \hat{q}^3(1-\delta\alpha(1-\alpha))^2), \qquad (19)\end{aligned}$$

where the expression for Π_i^* is given in Equation (18). We begin our analysis of equilibrium profits by examining the effect of a change in viewership α, which again we state in terms of changes in the number of ex ante partially informed consumers. Proposition 2 summarizes the result.

Proposition 2. *In the interior equilibrium with* $\alpha \in [0, 1]$, $\delta \in (0, \min[\bar{\delta}, \frac{1}{2}])$, *and* $c \in (0, \frac{17}{128})$,

(i) *when disclosure cost* c *is low,* $0 < c \leq \frac{1}{25}$, *ex ante equilibrium profits* decrease *with an increase in the share of ex ante partially informed consumers* (*i.e., profits are U shaped in* α *around* $\alpha = \frac{1}{2}$);

(ii) *when disclosure cost* c *is high,* $\frac{3}{50} < c \leq \frac{17}{128}$, *ex ante equilibrium profits* increase *with an increase in the share of ex ante partially informed consumers* (*i.e., profits have an inverted U shape in* α *around* $\alpha = \frac{1}{2}$); *and*

(iiia) *when disclosure cost* c *is intermediate,* $\frac{1}{25} < c \leq \frac{3}{50}$, *and the search cost* δ *is sufficiently low, ex ante equilibrium profits* decrease *with an increase in the share of ex ante partially informed consumers* (*i.e., profits are U shaped in* α *around* $\alpha = \frac{1}{2}$); *and*

(iiib) *when* c *is intermediate,* $\frac{1}{25} < c \leq \frac{3}{50}$, *and search cost* δ *is sufficiently high, the profit response also depends on the current level of* α (*or, equivalently, the current share of ex ante partially informed consumers*). *If* α *is such that there are relatively more ex ante partially informed consumers, any change in* α *that increases the share of partially informed consumers also* increases *profit. Conversely, if* α *is close to the extremes of either* 0 *or* 1 (*relatively few ex ante partially informed consumers*), *any change in* α *that further reduces the share of partially informed consumers* increases *profit*.

The intuition of the above result rests on the interplay of two factors—the consumer's perception of quality when the firm decides *not* to disclose quality and how the firm's disclosure policy changes with viewership (as outlined in part (i) of Proposition 1). The first two parts of Proposition 2 demonstrate that the net profit impact of this interplay depends solely on the level of disclosure cost c. From the consumer perspective, at low levels of c (part (i) of Proposition 2), consumers will expect firms to disclose quality simply because disclosure is relatively inexpensive. In this case, if firms do not disclose quality, with Bayesian updating, consumers infer the quality to be low and hence are willing to pay less for the product. From the perspective of the firm disclosure decision, Proposition 1 shows that, irrespective of c, in equilibrium, firms disclose less information as the share of partially informed consumers increases. When c is low, this causes consumers to infer a lower quality, and lower profits result. Using a similar intuition, it can be seen why the opposite results are found when c is relatively high (part (ii) of Proposition 2). In this case, because of high disclosure costs, consumers expect firms to disclose less, which is exactly what the firms are doing as the share of partially informed consumers increases, and the resulting cost savings drive profits higher.

The first two parts of Proposition 2 are rather straightforward to interpret because the profit impact of changes in viewership depends on just one other parameter, c. Given Bayesian updating, this makes intuitive sense because when c is at the extremes, consumers find it easier to infer what a firm's disclosure policy should be, and this is directly reflected in how much they want to pay for a product whose quality goes undisclosed ($\bar{q}$). However, when c is in the intermediate region (parts (iiia) and (iiib) of Proposition 2), the impact of changes in viewership on profits is more nuanced, and it depends on the magnitude of the search cost δ. Note that the effect of δ on consumers' perception of quality (as reflected in $\bar{q}$) is similar to the effect of c on $\bar{q}$ in that $\bar{q}$ is increasing in both c and δ. This suggests that at low values of δ (part (iiia)), higher information disclosure increases equilibrium profits. Since firms reduce disclosure, the share of partially informed consumers increases, and profits fall.

Finally, the intuition becomes even more nuanced when the cost to disclose quality information is intermediate and search cost δ is sufficiently high (part (iiib)). In this case, the impact of changes in viewership on equilibrium profit depends not only on the magnitude of c and δ but also on the current level of α. Note that the consumer's perception of quality $\bar{q}$ is at its maximum when $\alpha = \frac{1}{2}$, and so is the share of ex ante partially informed consumers. When there are relatively more partially informed consumers (α is near $\frac{1}{2}$), any movement of α that further increases the share of partially informed consumers magnifies the positive profit impact that results from a higher inferred quality by consumers, and this positive impact is not fully offset by the extra disclosure costs incurred by firms. The opposite holds when α is close to the extremes.

To summarize, the change in equilibrium profits with respect to attentiveness depends on consumers' willingness to pay for a product of undisclosed quality and the firm's disclosure policy, which is a function of the current level of attentiveness. Our results suggest that the net profit impact of changes in attentiveness always depends on firm disclosure cost, and consumer search cost and the current level of attentiveness also play a role when disclosure cost is at intermediate levels. The dynamics presented in Proposition 2, although complex, effectively define the profit impact of increases versus decreases in consumer attentiveness and comprise a key contribution of this paper.

Next, we examine the changes in equilibrium profit with respect to search cost δ, all else fixed. Proposition 3 summarizes the result, the intuition of which follows the same basic logic as that of Proposition 2.

Proposition 3. *In the interior equilibrium with* $\alpha \in [0, 1]$, $\delta \in (0, \min[\bar{\delta}, \frac{1}{2}])$, *and* $c \in (0, \frac{17}{128})$,

(i) *when disclosure cost c is low,* $0 < c \le \frac{1}{25}$, *profits* decrease *with search cost* δ;

(ii) *when c is high,* $\frac{3}{50} < c \le \frac{17}{128}$, *profits* increase *with search cost* δ; *and*

(iii) *when c is intermediate,* $\frac{1}{25} < c \le \frac{3}{50}$, *equilibrium profits* increase *with* δ *when* δ *is sufficiently low. When* δ *is sufficiently high, profits* decrease *with* δ *if viewership* α *is close to the extremes of either* 0 *or* 1 (*mostly fully informed consumers ex post*), *and they increase with* δ *if* α *is arbitrarily close to* $\frac{1}{2}$ (*relatively more ex ante partially informed consumers*).

As with Proposition 2, the insights from Proposition 3 are straightforward when c is either low or high. For low c, as search costs increase, fewer consumers search, and they will infer a lower quality for any undisclosed quality, hurting profits. When c is very high, decreased consumer searching leads to high inferred qualities, increasing profits. This positive profit impact remains for intermediate c provided that the current search cost is low. However, for intermediate c and high current search costs, the level of viewership α becomes relevant, following the same intuition as in part (iiib) of Proposition 2.

Clearly, the disclosure cost c plays a critical moderating role in the results presented above. Thus, it is instructive to examine the direct effect of changes in equilibrium profit with respect to disclosure cost c, as outlined in the following proposition.

Proposition 4. *In the interior equilibrium with* $\alpha \in [0, 1]$, $\delta \in (0, \min[\bar{\delta}, \frac{1}{2}])$, *and* $c \in (0, \frac{17}{128})$,

(i) *firm profit decreases with* c *for* $c \in (0, c^*]$ *and increases with* c *for* $c \in (c^*, \frac{17}{128})$, *where*

$$c^* = \big[7 - 98\alpha(1-\alpha)\delta + 19\alpha^2(1-\alpha)^2\delta^2 + 2(7 - 4\alpha(1-\alpha)\delta) \cdot \sqrt{119 + \alpha(1-\alpha)\delta(14 + 11\alpha(1-\alpha)\delta}\big]/1764; \quad \textit{and}$$

(ii) *the threshold disclosure cost* c^* *decreases with an increase in share of partially informed consumers. Moreover, the threshold* c^* *decreases with search cost* δ.

The intuition of Proposition 4 is driven by the opposing effects of c on profit identified in Guo and Zhao (2009). Since c is a cost incurred by the firm, a higher c has a *direct* negative effect on profits. On the other hand, a higher c makes firms less inclined to disclose. This lack of disclosure increases consumers' willingness to pay for the product with undisclosed quality (recall from Proposition 1(iii) that, all else equal, $\bar{q}$ increases with c). In this way, a higher c exerts an *indirect* positive effect on profits. We find that, when c is above a threshold, this positive effect dominates the negative one, and equilibrium profits increase with c. This result is consistent with Guo and Zhao (2009), who establish that, in a market with perfect attentiveness and no consumer search, profits change nonmonotonically with c. We find that this nonmonotonicity persists when consumers are inattentive. In our context, the interesting insight is the sensitivity of the threshold c^* to the share of partially informed consumers and the magnitude of consumer search costs. An increase in either the share of partially informed consumers or the search cost increases $\bar{q}$, implying that consumers are willing to pay more for a product of undisclosed quality. This bolsters the indirect effect described above, decreasing c^*. In other words, equilibrium profits increase over a larger range of costs. Since the number of partially informed consumers increases as α approaches

$\frac{1}{2}$ from either side, we can say that equilibrium profits increase with disclosure cost c over a larger range of c when there are relatively more partially informed consumers prior to search.

In the next section we discuss the managerial implications and limitations of this work, and we suggest some directions for future research.

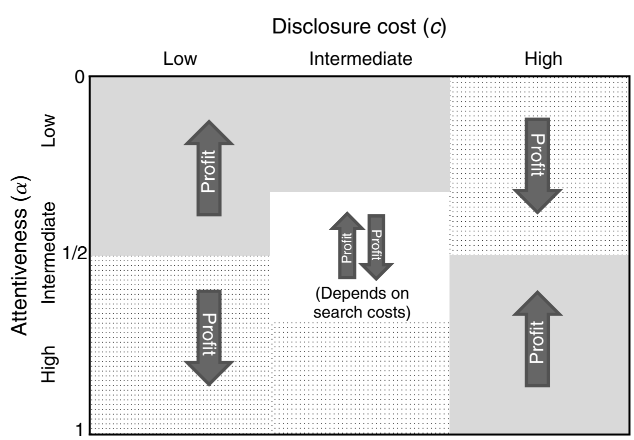
5. Discussion

Recent technological trends such as DVRs have increased the ease with which consumers can be inattentive to firm quality disclosures. At the same time, emerging tools such as aggregator websites are enabling consumers to search for the quality of products with increasing ease. These trends in consumer attentiveness and search behavior have arguably created an environment in which the decisions regarding a firm's investments in quality disclosure are more complex than ever. The results outlined above can help managers understand how these trends should affect strategic decisions regarding quality disclosure and, ultimately, firm profits.

First, consider the trend toward lower attentiveness. In terms of our model, this implies a trend toward a lower α. Thus, whereas the propositions above are stated in terms of the effect of an increase in α, for easier managerial interpretation, we discuss them here in terms of the effect of a *decrease* in α (lower attentiveness). Figure 3 shows the profit impact of a decrease in attentiveness, based on Proposition 2.

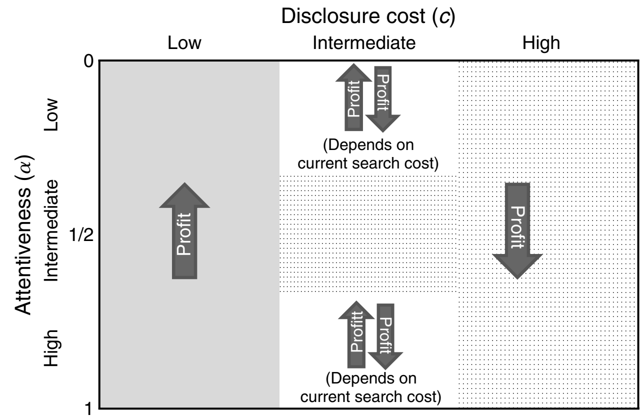
In Figure 3 one can see that there are situations in which a decrease in attentiveness will *increase* equilibrium profits (the solidly shaded regions). Thus, our model suggests that a trend toward lower attentiveness should not be expected to hurt profits in a competitive market when current attentiveness and firm disclosure costs are either both high or both low (with the case of intermediate disclosure costs being

Figure 3 **The Effect of a Decrease in Attentiveness on Equilibrium Profits**



more nuanced, at times depending on search costs, as indicated in the figure). Furthermore, if one suggests that, following the current trend, attentiveness has already become quite low, then our model suggests that a continuation of this trend toward lower attentiveness will enable higher profits for firms that do not face high disclosure costs.

Figure 4 **The Effect of a Decrease in Search Costs on Equilibrium Profits**



Similarly, we can also use our results to examine the potential profit impact of the trend toward lower consumer search costs. In terms of our model, this implies a trend toward a lower δ. Figure 4 shows the profit impact of a decrease in search costs, based on Proposition 3 (note that, as in the previous figure, we are interested from a managerial standpoint in the effect of a decrease in this parameter, whereas the proposition is stated in terms of an increase).

As with the case of the trend toward lower attentiveness, we find that there are business contexts in which the trend toward lower search costs can be expected to *increase* equilibrium profits in a competitive setting (the solidly shaded region). Firms will benefit from this trend toward easier consumer search if disclosure costs are low, whereas they will not if disclosure costs are high. Together, Figures 3 and 4 provide guidance for managers seeking to understand how trends in consumer behavior can be expected to affect their profits going forward. Finally, in terms of quality disclosure guidance, our findings suggest that firms should disclose less quality information as consumer search costs increase or when the proportion of partially informed consumers is relatively high—the latter a situation that is most likely when the degree of viewership is moderate (not too high and not too low).

We conclude by noting that the context modeled in this paper includes several assumptions that could be relaxed in future work. First, we assume that the base valuations for the products are sufficiently high such that the market is completely covered in equilibrium. A model in which some consumers choose not to purchase could lead to additional insights. Second, we assume that quality information is the sole source of differences in product knowledge. A more complex representation of heterogeneity in product knowledge would be an interesting extension of our framework. Third, in this paper we consider simultaneous search by uninformed consumers, but a model of sequential searching might also be relevant in some cases. Finally, our model precludes any signal-based communication between consumers and firms. As shown by Daughety and Reinganum (2008), signal-based communications and direct credible disclosure of quality information are not mutually exclusive, and the role of signaling in a model with consumer inattentiveness would be an interesting direction for future study.

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Appendix

Firm Notation

- i: Index for firm, $i \in \{A, B\}$
- v: Base valuation of both products
- q_i: Quality (exogenous)
- p_i: Price (decision variable)
- I_i: Indicator of whether to disclose quality (decision variable)
- c: Cost to disclose quality
- $\hat{q}$: Threshold above which a firm will disclose quality (see Lemma 1)
- $\hat{c}$: Threshold disclosure cost above which $\hat{q}=1$
- $Q^i_{\text{partial }i}$: Demand faced by firm i from its own turf
- $Q^i_{\text{partial }j}$: Demand faced by firm i from firm j's turf
- Q^i_f: Demand faced by firm i from fully informed consumers
- Q^i: Total demand faced by firm i

Consumer Notation

- x: Consumer's location on the Hotelling line, $x \in [0,1]$
- α: Consumer's level of attentiveness, $\alpha \in [0,1]$
- s: Consumer search cost
- δ: Transform of consumer search cost for algebraic simplicity, $\delta = \sqrt{2s}$
- $\bar{q}$: Expected quality per consumers that have observed a firm's decision not to disclose, $\bar{q} = \frac{\hat{q}}{2}$
- $\tilde{q}_i$: Quality perceived by consumers that have observed a firm's disclosure decision, $\tilde{q}_i = q_i$ when $I_i = 1$ and $\tilde{q}_i = \bar{q}$ when $I_i = 0$
- $\Delta_i(x)$: Benefit to a consumer located at x of searching for quality information on firm i's product
- q_i^*: Threshold quality above which a consumer will buy from firm i, post search
- $\hat{x}_i$: Location of the consumer who is indifferent between searching and not searching for quality information on firm i's product
- x_f: Location of the consumer who is indifferent between purchasing the two products

Proof of Lemma 1. Define

$$\Omega_U(\tilde{q}_A) \equiv \left(\int_0^{q_B^*} (v - s - x - p_A + \tilde{q}_A)\, d\tilde{q}_B + \int_{q_B^*}^1 (v - s - (1-x) - p_B + \tilde{q}_B)\, d\tilde{q}_B\right), \quad (20)$$

$$q_B^* = 1 - p_A + p_B + \tilde{q}_A - 2x, \quad x \in [0,1], \quad \text{and}$$

$$\forall\, \tilde{q}_A = \{\bar{q}, q_A\}, \quad q_A \in [\hat{q}, 1].$$

The benefit of search for an uninformed consumer located at $x \in [0,1]$ is Ω_U and is given by

$$\begin{aligned}\Omega_U &= \hat{q}\Omega_U(\bar{q}) + \int_{\hat{q}}^1 \Omega_U(q_A)\, dq_A - \max[v - p_A - x + \bar{q},\, v - p_B - (1-x) + \bar{q}] \\ &= \begin{cases} \frac{1}{6}[(3p_B - 2(-2+3\bar{q}+\bar{q}^3+3s+3x) + 3(p_A^2 + (p_B-2x)^2 \\ \quad + p_A(-1-2p_B+4x)))] \quad \text{for all } x \in [\hat{x}_{u_1}, \hat{x}_u], \\ \frac{1}{6}[(9p_B - 2(-5+3\bar{q}+\bar{q}^3+3s+9x) + 3(p_A^2 + (p_B-2x)^2 \\ \quad + p_A(-3-2p_B+4x)))] \quad \text{for all } x \in (\hat{x}_u, \hat{x}_{u_2}]. \end{cases}\end{aligned} \quad (21)$$

The minimum of Ω_U as a function of x is at $x = (2p_B - 2p_A + 1)/4$ if $x \in [\hat{x}_{u_1}, \hat{x}_u]$ and at $x = (3 - 2p_A + 2p_B)/4$ if $x \in (\hat{x}_u, \hat{x}_{u_2}]$. In other words, the minimum of Ω_U (the minimum benefit of searching) is given by $\underline{\Omega}_U$ as follows:

$$\underline{\Omega}_U = \tfrac{13}{24} - \tfrac{1}{3}\bar{q}(3+\bar{q}^2) - s = \tfrac{13}{24} - \tfrac{1}{3}\bar{q}(3+\bar{q}^2) - \frac{\delta^2}{2}. \quad (22)$$

The result follows directly from (22). □

Proof of Lemma 2. The structure of the proof follows Levin et al. (2009). For ease of exposition, we focus on the disclosure decision for firm A. The expected profit from disclosure for firm A depends on whether firm B discloses or not. If firm A discloses q_A, its expected profit is given as follows:

$$\Pi^A_{\text{Disclose}} = \hat{q}\left(\tfrac{1}{18}(3+(q_A - \hat{q}/2)(1-\delta\alpha(1-\alpha)))\right)^2 + \int_{\hat{q}}^1 \tfrac{1}{18}(3+(q_A - q_B)(1-\delta\alpha(1-\alpha)))^2\, dq_2 - c. \quad (23)$$

Noting that firm has the same disclosure policy, the first term is the profit to firm A if firm B does not disclose and the second term corresponds to the profit to firm A if firm B does disclose.

Similarly, the expected profit from nondisclosure of quality information for firm A is given by

$$\Pi^A_{\text{Nondisclose}} = \hat{q}/2 + \int_{\hat{q}}^1 \tfrac{1}{18}\left[3 + (\hat{q}/2 - q_B) \cdot (1 - \delta\alpha(1-\alpha))\right]^2 dq_2. \quad (24)$$

By definition of $\hat{q}$, firm A is indifferent between disclosing and not disclosing quality information at $q_A = \hat{q}$. In other words,

$$\begin{aligned}&\Pi^A_{\text{Disclose}|\, q_A = \hat{q}} - \Pi^A_{\text{Nondisclose}} \\ &= \tfrac{1}{72}\big(-72c - \hat{q}(1-\delta\alpha(1-\alpha)) \cdot (-10 - 3\hat{q} - \delta(2-3\hat{q})\alpha(1-\alpha))\big) = 0. \end{aligned} \quad (25)$$

It can easily be verified that Equation (25) has two roots, with one of the roots being strictly less than 0. Now, as a result of Bayesian updating, disclosing a quality of 0 is costly for firms, and they disclose if the true quality is above a threshold given by $\hat{q} > 0$. Thus the only $\hat{q}$ that qualifies to be on the equilibrium path is[15]

$$\hat{q} = \frac{\sqrt{216c + (5+\delta\alpha(1-\alpha))^2} - (5+\delta\alpha(1-\alpha))}{3 - 3\delta\alpha(1-\alpha)}. \tag{26}$$

Since $\hat{q}$ above is a function of the parameters of the model, we need the following restriction to guarantee that $\hat{q} \in [0, 1]$:

$$0 < c \le \hat{c} = \tfrac{1}{72}\big[(13 - \delta\alpha(1-\alpha))(1 - \delta\alpha(1-\alpha))\big]. \tag{27}$$

In other words, for $c > \hat{c}$, $\hat{q} = 1$, and firm A never discloses quality information. However, for tractability, and without any loss of generality, we simplify the upper bound of c by using the infimum of $\hat{c}$ as a sufficient condition to restrict $\hat{q} \in [0, 1)$. It is easy to see that the infimum of $\hat{c}$ is $\frac{17}{128}$. □

Proof of Proposition 1. Differentiating $\hat{q}$ in Equation (26) with respect to α, δ, and c yields the following:

$$\frac{d\hat{q}}{d\alpha} = (1-2\alpha) \cdot \left[\frac{2\delta(5+36c+\delta\alpha(1-\alpha)+\sqrt{216c+(5+\delta\alpha(1-\alpha))^2})}{(1-\delta\alpha(1-\alpha))^2\sqrt{216c+(5+\delta\alpha(1-\alpha))^2}}\right], \tag{28}$$

$$\frac{d\hat{q}}{d\delta} = \frac{2\alpha(1-\alpha)}{\delta} \cdot \left[\frac{2\delta(5+36c+\delta\alpha(1-\alpha)+\sqrt{216c+(5+\delta\alpha(1-\alpha))^2})}{(1-\delta\alpha(1-\alpha))^2\sqrt{216c+(5+\delta\alpha(1-\alpha))^2}}\right], \tag{29}$$

$$\frac{d\hat{q}}{dc} = \frac{36}{(1-\delta\alpha(1-\alpha))\sqrt{216c+(5+\delta\alpha(1-\alpha))^2}}. \tag{30}$$

From these expressions it is straightforward to see that $d\hat{q}/d\alpha \ge 0$ for $\alpha \le 1/2$ and $d\hat{q}/d\alpha < 0$ otherwise. Moreover, $d\hat{q}/d\delta \ge 0$ and $d\hat{q}/dc \ge 0$. □

Proof of Proposition 2. Substituting

$$\hat{q} = \frac{\sqrt{216c + (5+\delta\alpha(1-\alpha))^2} - (5+\delta\alpha(1-\alpha))}{3 - 3\delta\alpha(1-\alpha)}$$

into Equation (19), which gives us $\hat{\Pi}_i^*$, we get the following equilibrium profit for firm i as a function of underlying parameters:

$$\begin{aligned}\hat{\Pi}_i^*(\alpha,\delta,c) &= \frac{1}{108}\Bigg[55-\alpha(1-\alpha)\delta(2-\alpha(1-\alpha)\delta) \\ &\quad - \frac{(-5-\alpha(1-\alpha)\delta+\sqrt{216c+(5+\delta\alpha(1-\alpha))^2})^3}{27(1-\alpha(1-\alpha)\delta)} \\ &\quad + \frac{36c(-8+2\alpha(1-\alpha)\delta+\sqrt{216c+(5+\delta\alpha(1-\alpha))^2})}{1-\alpha(1-\alpha)\delta}\Bigg]. \end{aligned} \tag{31}$$

[15] Note that the threshold $\hat{q}$ converges to the the quality threshold outlined in Levin et al. (2009) for $s = 0$, or $\alpha = 0, 1$.

However, this expression is fairly cumbersome to manipulate for purposes of comparative statics, especially with respect to α and δ. In the following we therefore substitute $\beta = \alpha(1-\alpha)$ to establish the results in Propositions 2–4. Making the substitution and differentiating with respect to β yields

$$\begin{aligned}\frac{d\hat{\Pi}_i^*(\beta,\delta,c)}{d\beta} &= \delta\Bigg[\frac{1}{2{,}916}\Bigg(27\beta\delta - 27(2-\beta\delta) \\ &\quad + \frac{972c}{1-\beta\delta}\left(2 + \frac{5+\beta\delta}{\sqrt{216c+(5+\delta\beta)^2}}\right) \\ &\quad + \frac{(5+\beta\delta-\sqrt{216c+(5+\delta\beta)^2})^3}{(1-\beta\delta)^2} \\ &\quad - \frac{3(5+\beta\delta-\sqrt{216c+(5+\delta\beta)^2})^3}{(1-\beta\delta)\sqrt{216c+(5+\delta\beta)^2}} \\ &\quad + \frac{972c(-8+2\beta\delta+\sqrt{216c+(5+\delta\beta)^2})}{(-\beta\delta)^2}\Bigg)\Bigg] \\ &= \delta \cdot \Gamma(\beta,\delta,c). \end{aligned} \tag{32}$$

For a given δ, define $\Gamma(\beta,\delta,c) \equiv F(\beta)$. Note that if $F(\beta) \ge 0$ over the range of $f(\alpha) = \alpha(1-\alpha)$, that implies $F(\beta) \ge 0$ for any β such that $\beta = \alpha(1-\alpha)$ for some α in the domain of f. Hence $F(f(\alpha)) > 0$ for each α in the domain of $f\colon \alpha \to \beta$. Since the domain of f is $[0,1]$, the codomain of f specifies all possible values that β is restricted to, which is $[0, \frac{1}{4}]$. Finally, note that $d\beta = (1-2\alpha)d\alpha$. Given this, we note that $d\hat{\Pi}_A^*/d\alpha = (d\hat{\Pi}_i^*(\beta,\delta)/d\beta)(d\beta/d\alpha) \ge 0$ for all (α,β) such that $\{F(\beta) \ge 0,\ \alpha \le \frac{1}{2}\} \cup \{F(\beta) < 0,\ \alpha > \frac{1}{2}\}$. Similarly, $d\hat{\Pi}_A^*/d\alpha < 0$ for all α,β such that $\{F(\beta) \le 0,\ \alpha \le \frac{1}{2}\} \cup \{F(\beta) > 0,\ \alpha > \frac{1}{2}\}$.

Now, one can readily verify that $F(\beta) \le 0$ for all $\beta \in [0, \frac{1}{4}]$ when c is low (which corresponds to $0 < c \le \frac{1}{25}$) and $F(\beta) > 0$ for all $\beta \in [0, \frac{1}{4}]$ when c is high (which corresponds to $\frac{3}{50} < c \le \frac{17}{128}$). Following the discussion in the preceding paragraph, therefore, $d\hat{\Pi}_i^*/d\alpha \le 0$ for $\alpha \le \frac{1}{2}$ and $d\hat{\Pi}_i^*/d\alpha > 0$ for $\alpha > \frac{1}{2}$ when c is low. Similarly, $d\hat{\Pi}_i^*/d\alpha \ge 0$ for $\alpha \le \frac{1}{2}$ and $d\Pi_i^*/d\alpha < 0$ for $\alpha > \frac{1}{2}$ when c is high. This establishes parts (i) and (ii) of Proposition 2.

It is somewhat cumbersome to derive the sign of $F(\beta)$ when $\frac{1}{25} < c \le \frac{3}{25}$. However, note that $\Gamma(\beta,\delta) \equiv F(\beta)$ is a continuous function of $\delta \in [0,1]$. Moreover, for δ arbitrarily close to 0,

$$F(\beta) \to \frac{-2(2{,}000-373\sqrt{25+216c}+108c(35-756c+9\sqrt{25+216c}))}{\sqrt{25+216c}} < 0$$

for all $\frac{1}{25} < c \le \frac{3}{50}$. Therefore, there must exist a nonempty interval in the neighborhood of $\delta = 0$ given by $[0, \underline{\delta}]$ such that $F(\beta) < 0$ for all β. In other words, for δ sufficiently small and c in the intermediate region, it must be that $d\hat{\Pi}_i^*/d\alpha \le 0$ for $\alpha \le \frac{1}{2}$ and $d\hat{\Pi}_i^*/d\alpha > 0$ for $\alpha > \frac{1}{2}$. In other words, $d\hat{\Pi}_i^*/d\alpha$ has a U shape with respect to α, around $\alpha = \frac{1}{2}$.

Finally, for $\delta \to 1$, $F(\beta) < 0$ for $\beta \to 0$ and $F(\beta) > 0$ for $\beta \to \frac{1}{4}$. Notice that $\beta = f(\alpha) = \alpha(1-\alpha)$ is very low for α arbitrarily close to 0 or 1 and is very high for α arbitrarily close to $\frac{1}{2}$. It therefore follows that when α is already arbitrarily close to $\frac{1}{2}$ (meaning β is very high), $\digamma(\beta) > 0$ $d\widehat{\Pi}_i^*/d\alpha \geq 0$ for any increase in α as long as $\alpha \leq \frac{1}{2}$ and $d\widehat{\Pi}_i^*/d\alpha < 0$ for any increase in α for $\alpha > \frac{1}{2}$. The opposite holds true when α is arbitrarily close to 0 or 1. □

Proof of Proposition 3. Differentiating $\widehat{\Pi}_i^*(\beta, \delta, c)$ with respect to δ yields

$$\frac{d\widehat{\Pi}_i^*(\beta, \delta, c)}{d\delta} = \beta \cdot \Gamma(\beta, \delta, c), \tag{33}$$

where $\Gamma(\beta, \delta, c)$ is defined as in the previous proof. For a given β, define $\Gamma(\beta, \delta, c) \equiv G(\delta) = \digamma(\beta)$. Indeed, $\operatorname{sgn}(\digamma(\beta)) = \operatorname{sgn}(G(\delta))$. Therefore, one can readily verify that $G(\delta) \leq 0$ for all $\delta \in [0, 1]$ when c is low (which corresponds to $0 < c \leq \frac{1}{25}$) and $G(\delta) > 0$ for all $\delta \in [0, 1]$ when c is high (which corresponds to $\frac{3}{50} < c \leq \frac{17}{128}$). This fact essentially establishes the results corresponding to parts (i) and (ii) of Proposition 3. For intermediate regions of c ($\frac{1}{25} < c \leq \frac{3}{50}$), the analysis is again cumbersome. However, note that $G(\delta)$ is a continuous function of $\delta \in [0, 1]$. Moreover, for δ arbitrarily close to 0,

$$G(\delta) \to \frac{-2(2{,}000 - 373\sqrt{25+216c} + 108c(35 - 756c + 9\sqrt{25+216c})}{\sqrt{25+216c}} < 0$$

for all $\frac{1}{25} < c \leq \frac{3}{50}$. Therefore, there must exist a nonempty interval in the neighborhood of $\delta = 0$ given by $[0, \underline{\delta}]$ such that $G(\delta) < 0$ for all δ. Finally, for $\delta \to 1$, $G(\delta) = \digamma(\beta) < 0$ for $\beta \to 0$ and $G(\delta) = \digamma(\beta) > 0$ for $\beta \to \frac{1}{4}$. Given that $\beta = f(\alpha) = \alpha(1-\alpha)$, the latter part of Proposition 3(iii), which corresponds to high δ, follows immediately. □

Proof of Proposition 4. Differentiating $\widehat{\Pi}_i^*(\beta, \delta, c)$ with respect to c yields

$$\frac{d\widehat{\Pi}_i^*(\beta, \delta, c)}{dc} = \frac{-765c - (5+\beta\delta)^2 + (14 - 8\beta\delta)\sqrt{216c + (5+\beta\delta)^2}}{9(\beta\delta - 1)\sqrt{216c + (5+\beta\delta)^2}}. \tag{34}$$

One can check that the above expression is negative for

$$c \leq \frac{7 - 98\beta\delta + 19\beta^2\delta^2 + 2(7 - 4\beta\delta)\sqrt{119 + \beta\delta(14 + 11\beta\delta)}}{1{,}764}. \tag{35}$$

Substituting $\beta = \alpha(1-\alpha)$ into (35) yields the threshold c^* mentioned in the proposition. Thus for $c \leq c^*$, equilibrium profit declines with respect to c, and equilibrium profit increases with c for $c > c^*$. □

Proof of the Existence of Equilibrium.

Proposition 5. *For*

$$\delta \in \left(0, \min\left[\sqrt{2\left(\tfrac{13}{24} - \tfrac{1}{3}\bar{q}(3+\bar{q}^2)\right)}, \tfrac{1}{2}\right]\right),$$

there exists an equilibrium as a function of perceived quality, given by

$$p_i^* = \tfrac{1}{3}\big(3 + (\tilde{q}_i - \tilde{q}_j)(1 - \delta\alpha(1-\alpha))\big)$$
$$\Pi_i^* = \tfrac{1}{18}\big(3 + (\tilde{q}_i - \tilde{q}_j)(1 - \delta\alpha(1-\alpha))\big)^2; \quad i, j = A, B.$$

The expressions for p_i^* and Π_i^* are from the paper. It is straightforward to check that the second-order conditions for an interior equilibrium are satisfied; $\delta \leq \sqrt{2(\frac{13}{24} - \frac{1}{3}\bar{q}(3+\bar{q}^2))}$ is from Lemma 1.

For the (p_i^*, Π_i^*) to be an equilibrium profile, we must show that, given $\delta \in (0, \frac{1}{2})$, there does not exist any deviation in prices. In the following we outline the nondeviation conditions for firm A with the understanding that conditions for nondeviation for firm B can be analyzed in a similar fashion. Given the inherent segmentation in the market, we note that there exist five types of unilateral price deviations that firm A can undertake.

Deviation 1 (D1). Firm A deviates to make sure no consumer in its turf (consumers who a priori know the quality information from firm A but not B) searches for B's quality information, thereby gaining the entire market from that segment. In other words, firm A deviates by dropping its price so that $\hat{x}_B^{\text{dev}} = 1$ holds postdeviation.

Deviation 2 (D2). Firm A deviates so that all consumers in firm B's turf decide to search; it also competes for markets it was already competing for in equilibrium. In other words, firm A deviates by dropping its price so that $\hat{x}_A^{\text{dev}} = 1$ holds postdeviation.

Deviation 3 (D3). Firm A deviates to make sure no consumer in its turf searches for B's quality information; at the same time, it steals all consumers from firm B's turf. In other words, firm A deviates by dropping its price so that $\hat{x}_B^{\text{dev}} = 1$ and $\hat{x}_A^{\text{dev}} = 1$ hold postdeviation.

Deviation 4 (D4). Firm A deviates so that all consumers in its turf actually search for quality information from firm B but holds all other segments. In other words, firm A deviates by increasing its price so that $\hat{x}_B^{\text{dev}} = 0$ while $(x_f^{\text{dev}}, \hat{x}_A^{\text{dev}}) \in (0, 1)$ holds postdeviation.

Deviation 5 (D5). Firm A deviates and stops competing for consumers in firm B's turf while holding on to the other segments. In other words, firm A deviates by increasing its price so that $\hat{x}_A^{\text{dev}} = 0$ while $(x_f^{\text{dev}}, \hat{x}_B^{\text{dev}}) \in (0, 1)$ holds postdeviation.

One can check that there do not exist any other types of unilateral deviations. We show that, given $\delta \in (0, \frac{1}{2})$, none of the deviations D1–D5 is profitable for a firm *irrespective* of the quality disclosure decision taken at the second stage of the game. While analyzing each of the above deviations, we define p_A^{dev} as the deviation price for firm A. Firm B does not deviate and stays on the equilibrium path. Hence, we use p_B^* in analyzing unilateral deviations by firm A.

Analysis of D1. For firm A to deter any consumer in its turf from searching, it needs to price the product such that $\hat{x}_B^{\text{dev}} \geq 1$, which implies the following condition to hold:

$$p_A^{\text{dev}} \leq \bar{p}_A^{\text{D1}} = p_B^* + \tilde{q}_A + \delta - 2. \tag{36}$$

The expression on the right side of the inequality above given by $\bar{p}_A^{\text{D1}}$ is the supremum price that firm A can charge to deter any consumer in its turf to engage in search. Let us hypothetically examine the profit that firm A can derive if it is able to charge $\bar{p}_A^{\text{D1}}$ while deviating and steal *all* firm B's consumers (irrespective of their level of information). Indeed, that is likely not to be a possibility. Our idea, however, is to establish that even in the most optimistic scenario, firm A still will find it suboptimal to deviate. The profit thus derived from the counterfactual will serve as an upper bound and is not the actual profit that firm A is able to derive postdeviation. Denote such a profit as $\bar{\Omega}_A^{\mathrm{D1}}$, where

$$\bar{\Omega}_A^{\mathrm{D1}}=\bar{p}_A=\tfrac{1}{3}\big(-3+2\tilde{q}_A+\tilde{q}_B+3\delta(3+\alpha(1-\alpha)(\tilde{q}_A-\tilde{q}_B))\big). \quad (37)$$

We obtained Equation (37) by substituting $p_B=p_B^*=\frac{1}{3}(3+(\tilde{q}_B-\tilde{q}_A)(1-\delta\alpha(1-\alpha)))$.

Define Ξ_A^{D1} as the difference between the equilibrium profit Π_A^* and $\bar{\Omega}_A^{\mathrm{D1}}$. It is straightforward to see that

$$\Xi_A^{\mathrm{D1}} = \tfrac{1}{18}\big(-6\big(-3+2\tilde{q}_A+\tilde{q}_B+3\delta+\delta\alpha(1-\alpha)(\tilde{q}_B-\tilde{q}_A)\big) + \big(3+(\tilde{q}_B-\tilde{q}_A)(1-\delta\alpha(1-\alpha))\big)^2\big). \quad (38)$$

One can check that Ξ_A^{D1} is strictly decreasing in $\tilde{q}_A$ and $\tilde{q}_B$. Thus, by substituting $\tilde{q}_A=\tilde{q}_B=1$ in Ξ_A^{D1}, we get the lower bound on the profit difference:

$$\underline{\Xi}_A^{\mathrm{D1}}=\tfrac{1}{2}-\delta>0. \quad (39)$$

Since $\underline{\Xi}_A^{\mathrm{D1}}$ provides the minimum difference between the equilibrium and deviation profits and still shows that the equilibrium profit is higher, one can readily infer that D1 is never profitable for firm A given $\delta\in(0,\frac{1}{2})$. It can be readily noted that the supremum deviation profit we compute above will also apply when examining D3. Thus, firm A will not be able to derive a profit higher than $\bar{\Omega}_A^{\mathrm{D1}}$ with D3.

Analysis of D2. Firm A deviates on price such that all consumers in firm B's turf decide to search. Therefore, after consumers search, firm A is able to compete for all consumers in this market. Moreover, $(x_f^{\mathrm{dev}},\hat{x}_B^{\mathrm{dev}})\in(0,1)$.

Now, for D2 to be feasible, the following must hold:

$$p_A^{\mathrm{dev}}\le\bar{p}_A^{\mathrm{D2}}=p_B^*-\tilde{q}_B-\delta. \quad (40)$$

The above inequality guarantees that $\hat{x}_A^{\mathrm{dev}}\ge1$. Since firm A holds other markets, the demand that firm A gets with such a deviation is

$$Q_A^{\mathrm{dev}}=(1-\alpha(1-\alpha))x_f^{\mathrm{dev}}+\alpha(1-\alpha)\big(\delta\hat{x}_B^{\mathrm{dev}}+(1-\delta)x_f^{\mathrm{dev}}\big); \quad (41)$$

$$\Pi_A^{\mathrm{dev}}=p_A^{\mathrm{dev}}\cdot Q_A^{\mathrm{dev}}; \quad (42)$$

$$\hat{x}_B^{\mathrm{dev}}=\frac{p_B^*-p_A^{\mathrm{dev}}+\tilde{q}_A+\delta}{2}; \qquad x_f^{\mathrm{dev}}=\frac{p_B^*-p_A^{\mathrm{dev}}+\tilde{q}_A-\tilde{q}_B+1}{2}. \quad (43)$$

The expression Q_A^{D2} can be seen from the fact that both firms compete for fully informed and uninformed consumers (before search), which has a total mass of $1-2\alpha\cdot(1-\alpha)$. Firm A also competes for *all* consumers who are in firm B's turf—a mass of $\alpha(1-\alpha)$ consumers—for a total mass of $1-\alpha(1-\alpha)$ consumers. The rest of the $\alpha(1-\alpha)$ consumers are in firm A's turf—they may or may not search for quality information from firm B.

Again, we compute the upper bound on profit, $\bar{\Omega}_A^{\mathrm{D2}}$, which firm A can earn by charging the supremum price given in (45) above. Thus, substituting $p_A^{\mathrm{dev}}=\bar{p}_A^{\mathrm{D2}}$ into Π_A^{dev} yields $\bar{\Omega}_A^{\mathrm{D2}}$:

$$\bar{\Omega}_A^{\mathrm{D2}} = \tfrac{1}{6}\big(3-3\delta-\tilde{q}_A(1-\alpha(1-\alpha)\delta)-\tilde{q}_B(2+\alpha(1-\alpha)\delta)\big)\cdot\big(1+\tilde{q}_A+\delta(1+\alpha(1-\alpha)(-1+\tilde{q}_B+\delta))\big)\big). \quad (44)$$

Define Ξ_A^{D2} as the difference between the equilibrium profit Π_A^* and $\bar{\Omega}_A^{\mathrm{D2}}$. It is straightforward to see that

$$\Xi_A^{\mathrm{D2}} = \tfrac{1}{18}\big(3+(\tilde{q}_A-\tilde{q}_B)(1-\delta\alpha(1-\alpha))\big)^2 + 3\big(3-3\delta-\tilde{q}_A(1-\alpha(1-\alpha)\delta)-\tilde{q}_B(2+\alpha(1-\alpha)\delta)\big)\cdot\big(1+\tilde{q}_A+\delta(1+\alpha(1-\alpha)(-1+\tilde{q}_B+\delta))\big)\big). \quad (45)$$

Noting that Ξ_A^{D2} is strictly increasing in both $\tilde{q}_A$ and $\tilde{q}_B$, we can substitute $\tilde{q}_A=\tilde{q}_B=1$ to get the infimum difference in profit given by $\underline{\Xi}_A^{\mathrm{D2}}$, where

$$\underline{\Xi}_A^{\mathrm{D2}}=\tfrac{1}{2}\delta\big(\alpha(1-\alpha)(1-\delta)^2+\delta\big)>0. \quad (46)$$

In other words, D2 is never feasible for firm A.

Analysis of D4. Firm A deviates by increasing prices so that all consumers in its turf search for quality information from firm B. This implies that firm A raises its price so that $\hat{x}_B^{\mathrm{dev}}\le0$. In other words,

$$p_A^{\mathrm{dev}}\ge\underline{p}_A^{\mathrm{D4}}=p_B^*+\tilde{q}_A+\delta. \quad (47)$$

Now, since firm A is increasing prices, it also needs to ensure that it is still competitive in all markets. Otherwise, it gets zero demand from any segments in the market. In other words, it needs to ensure that after deviation, its prices are such that $x_f^{\mathrm{dev}}>0$, which gives a supremum on deviation prices as follows:

$$p_A^{\mathrm{dev}}<\bar{p}_A^{\mathrm{D4}}=p_B^*+(\tilde{q}_A-\tilde{q}_B)+1. \quad (48)$$

Since firm A holds other markets, the demand that firm A gets with such a deviation is

$$Q_A^{\mathrm{D4}}=(1-\alpha(1-\alpha))x_f^{\mathrm{dev}}+\alpha(1-\alpha)(\delta\hat{x}_A^{\mathrm{dev}}+(1-\delta)x_f^{\mathrm{dev}}); \quad (49)$$

$$\Pi_A^{\mathrm{D4}}=p_A^{\mathrm{dev}}\cdot Q_A^{\mathrm{dev}}; \quad (50)$$

$$\hat{x}_A^{\mathrm{dev}}=\frac{2+p_B^*-p_A^{\mathrm{dev}}-\tilde{q}_B-\delta}{2}, \qquad x_f^{\mathrm{dev}}=\frac{p_B^*-p_A^{\mathrm{dev}}+\tilde{q}_A-\tilde{q}_B+1}{2}. \quad (51)$$

The derivation of Q_A^{D4} follows a logic similar to the derivation of Q_A^{D2} above.

Now, substituting $p_A=\bar{p}_A^{\mathrm{D4}}$ into the profit function yields the profit upper bound, $\bar{\Omega}_A^{\mathrm{D4}}$, for this deviation, given by

$$\bar{\Omega}_A^{\mathrm{D4}} = -\tfrac{1}{6}\alpha(1-\alpha)\delta(-1+\tilde{q}_A+\delta)\cdot\big(6+\tilde{q}_A(2+\alpha(1-\alpha)\delta)-\tilde{q}_B(2+\alpha(1-\alpha)\delta)\big). \quad (52)$$

The difference between equilibrium profit and the supremum deviation profit is therefore given by

$$\Xi_A^{\mathrm{D4}} = \tfrac{1}{18}\big[(3+(\tilde{q}_A-\tilde{q}_B)(1-\delta\alpha(1-\alpha)))^2 + 3\alpha(1-\alpha)\delta(-1+\tilde{q}_A+\delta)\big(6+\tilde{q}_A(2+\alpha(1-\alpha)\delta) - \tilde{q}_B(2+\alpha(1-\alpha)\delta)\big)\big]. \quad (53)$$

Note that Ξ_A^{D4} is strictly increasing in $\tilde{q}_A$ and strictly decreasing in $\tilde{q}_B$. Thus to get the infimum difference in the equilibrium and deviation profits, we substitute $\tilde{q}_A = 0$ and $\tilde{q}_B = 1$ into Ξ_A^{D4} and get

$$\Xi_A^{d4} = \tfrac{1}{8}\big(4+\alpha(1-\alpha)\delta\big(-8+4(3+\alpha(1-\alpha))\delta-3\alpha(1-\alpha)\delta^2\big)\big) > 0. \tag{54}$$

This establishes that a D4 deviation is never feasible for firm A.

Finally, note that the supremum profit with a deviation of type D5 will always be less than the supremum profit under D4. This is because, with D5, firm A completely jettisons consumers who are in firm B's turf but holds on to other markets. In other words, the market is smaller; however, the supremum price is still given by $\bar{p}_A^{\mathrm{D4}}$ because any price higher than that yields zero demand for firm A. Thus, D5 is never feasible for firm A. One can also check that there does not exist any other feasible deviations for firm A. This concludes the proof of existence of equilibrium. □

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