Buyer-Initiated versus Seller-Initiated Information Revelation

Pradeep Bhardwaj, Yuxin Chen and David Godes*

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*Pradeep Bhardwaj (pbhardwa@anderson.ucla.edu) is Assistant Professor at the Anderson School of Management, UCLA; Yuxin Chen (ychen@stern.nyu.edu) is Associate Professor at the Stern School of Management, NYU and David Godes (dgodes@hbs.edu) is Assistant Professor at Harvard Business School. The authors are listed alphabetically and have contributed equally to this work. We would like to thank Sridhar Balasubramanian, Dina Mayzlin and Birger Wernerfelt for helpful comments on earlier versions of the paper as well as seminar participants at Yale and Washington University.
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Abstract

In many selling situations, the firm can choose between a selling format in which the buyer determines which information about the product will be revealed and one in which the seller makes this determination. We model this choice of information revelation format and its interaction with product quality. In a monopoly with exogenous quality, if the firm offers a high quality product it prefers a buyer-initiated format. This choice helps the firm to signal its type perfectly. When product quality is endogenous, we find that high-quality products are again associated with buyer-initiated formats. Moreover, when the cost of a seller-initiated format decreases, firms switch to this format which is consistent with lower-quality products. As a result, product quality declines as the cost of communication declines. In a duopoly, as the cost of a buyer initiated format decreases, both firms offer higher quality products via a buyer initiated format. The incentive to undercut the rival’s price is mitigated by the possibility of lower demand. This results in a softening of price competition, an increase in profits, and higher consumer surplus.

(Key Words: Selling Formats, Information Economics, Product Quality, Marketing Communication, Game Theory)
1 Introduction

A reporter covering a recently-opened retail store by Apple Computer described it in the following way: “Mac-savvy salespeople wait at a ‘Genius Bar’ to answer questions, but don’t hover.”¹ This decision to eschew a high-pressure sales environment in favor of a more pleasurable shopping experience is not unique to Apple. At Sephora, the French cosmetics retailer, for example, the customer is also in control. Salespeople are available, but the firm has designed the experience to offer customers the option of self-service. Salespeople have tremendous product knowledge yet the customer maintains control of the entire shopping experience: “Sales clerks leave you alone unless you need them.”² Finally, in a recent convention held in New Orleans for owners of car dealership franchises, Ford Motor Company presented their vision of the Ford “dealership of the future.” The proposed shopping experience was described as one in which customers would be “encouraged to browse in electronic kiosks, [with] salespeople available only on demand.”³ It is clear in all of these cases – and many others that are similar including Sony, Bose and NikeTown – that the retail experience is not in any sense characterized by less service. On the contrary, these are high service environments but only to the extent that this is what the customer wants.

While it seems that firms are increasingly adopting this selling format, it is clear that not all firms are doing so. The attraction to the firm of this “new” selling environment is clear: by making the shopping experience more enjoyable, the firm might encourage the customer to visit more often and, perhaps, stay longer. However, one wonders about the impact such an environment has on the persuasive effects of the salesperson. If the customer is in total control of the experience, then she is asking for information that she feels she needs. This is in direct contrast to the “traditional” selling model in which the firm – via the salesperson – chooses what aspects of the product the customer will learn about. Is there a risk that the firm might give up too much control? In particular, should all firms adopt this “customer empowerment strategy?”

In this paper we address this question by comparing two alternative information-revelation formats that the firm can choose to implement. On one hand, the firm could adopt a traditional “seller-initiated revelation” format in which the salesperson determines what information is given to the customer. On the other hand, it might adopt a format more similar to that embraced by Apple, Sephora and Ford: “buyer-initiated revelation.” In the latter format, the customer determines which information she will be given. Since the customer can rarely acquire and process all of the available information, it is clear that the decision as to what information will be revealed is an important one.\(^4\)

We compare the profits available to the firm under these two information-revelation formats. Our core result is that “high-quality” firms – those with products that match the preferences of a broader set of customers – can signal their quality by a combination of price and the adoption of the buyer-initiated revelation format. When a firm allows the customer to direct her own learning, it enhances the credibility of the message. We extend this result in two directions. First, we endogenize product quality. Besides finding that, again, high quality is associated with the adoption of buyer-initiated revelation, we note that as the cost of buyer initiated revelation decreases we see higher quality products. However, as the cost of seller initiated revelation decreases, firms also prefer to adopt this revelation format. Since seller-initiated revelation is never adopted when the firm produces higher-quality products, this change in the cost of communication results in the production of lower-quality products.

The second major extension of the model is to a duopoly context, again with endogenous quality. In this model, we find that buyer initiated learning may soften price competition. Though each firm has an incentive to undercut the rival’s price to “steal the market,” this incentive is counter-balanced by consumers’ inferences about quality. In some cases, the firm cannot undercut its rival without the consumer inferring that such a price is inconsistent with a high-quality product. Thus, the firm will not do so. Importantly, by handing over the revelation authority to the consumer, the firm ensures that she will inspect the product in a way to ensure that it is of high-quality. High-quality products are, of course, better for the consumer as well. Thus, we find that the

\(^4\)To appreciate this, note that a recent visit to www.cnet.com revealed that high end notebook computers had more than 60 attributes for consumers to consider; high end digital camcorders had over 80.
adoption of buyer-initiated revelation by both firms can lead to both (a) positive profits even though the firms are *ex ante* symmetric and (b) increased consumer surplus, a win-win outcome.

The current work is directly related to two important streams in the literature. On one hand, our question is similar in nature to those addressed by previous researchers into the strategic implications of selling formats and sales tactics. Wernerfelt (1994a) analyzes the role of “sales assistants” and argues that their main function is to perform a “matching” between the customer and the firm’s offerings. The author begins by comparing two ways in which the assistant can perform this matching function: a “monologue” and a “dialogue.” In the former, the customer arrives and the sales assistant simply tells her what she should buy. In the latter, the customer announces her preferences and, based on this announcement, the sales assistant performs the matching task. Based on an efficiency argument, the paper assumes that dialogue is better and focuses predominantly on the question of whether or not the sales assistant’s matching is performed honestly. In particular, if the store does not have the right product to match her preferences, does the sales assistant reveal this? In a multi-stage game, the answer turns out to be “yes” due, primarily, to reputational concerns. Our approach in this paper differs in that we endogenize the format choice (while he imposes it exogenously). On the other hand, while he investigated honesty, we impose it by assuming the attributes in question are observable upon inspection.

The same author addresses a related question on selling formats in Wernerfelt (1994b): should the firm post non-negotiable prices or haggle with the customer once she arrives? He finds that firm (i.e., non-negotiable) prices are often optimal since they represent a commitment to the consumer that she will not be “held up” if she incurs the expense of visiting the store. Gerstner and Hess (1990) ask whether the adoption of a bait and switch policy can actually benefit consumers. They show that the answer may be ‘yes’ because, if allowed, bait and switch – accompanied by low prices on advertised brands – might result in increased price competition. A similarly surprising result is presented by Chu et al. (1995). They find that annoying, “hard-selling” may be optimal in a competitive setting because of the differentiated equilibrium it may facilitate. Intuitively, if some customers experience less disutility from hard selling than others, then there may exist an asymmetric equilibrium in which they buy from a hard selling firm and those with higher disutilities.
buy from soft-selling firms. The resulting differentiated offerings mitigate price competition. It is important to note that, in each of this latter set of papers, the firm engages strictly in monologues with the customer (using the language of Wernerfelt (1994a)). Moreover, we investigate here a very different dimension of the selling format: information revelation.

The second major area of research to which the current study relates is that concerning the firm’s ability to signal its unobservable quality via its choice of some action. The question, in particular, of whether price and/or advertising can signal quality has been the subject of extensive research (Nelson, 1974; Schmalensee, 1978; Milgrom and Roberts, 1986; Bagwell and Riordan, 1991). While we find that price will signal quality in our model as well, the intuition behind this result is strikingly different. The extant models have generally depended on a dynamic context to endow price and/or advertising with signaling power. The argument in (Nelson, 1974), for example, is that higher quality firms will benefit more from acquiring a new customer since these new customers are more likely to remain customers over the long term. Thus, they are willing to spend more money on advertising. On the other hand, our model differs in two important respects. First, ours is a purely static model. Moreover, “quality” in our model is defined as the extent to which the firm’s products match the preferences of consumers; higher quality implies that the product matches more consumers’ preferences. In our model, the information revelation format plays a similar role in our model to that played by the dynamic context in previous research in that it facilitates the role of price as a credible signal. Of course, other researchers have shown that tools other than just price or advertising may signal quality. These have included performance warranties (Spence, 1977; Lutz, 1989), money-back guarantees (Moorthy and Srinivasan, 1995; Soberman, 2003), promotional chat (Mayzlin, 2001), sale signs (Anderson and Simester, 1998) and umbrella branding (Wernerfelt, 1988).

In summary, the primary contribution of our analysis is that we endogenize the firm’s decision about its information revelation format. When the firm has such a choice, we demonstrate that the adoption of buyer-initiated revelation allows the firm to signal its quality to the consumer. Moreover, we demonstrate that the relationship between quality and the buyer-initiated format is robust to a variety of modeling assumptions. Finally, our model also provides an explanation for
why symmetric firms may earn positive profits, even in a static setting.

The rest of the paper is organized as follows. In Section 2 we develop the models for buyer-initiated and seller-initiated revelation in a context in which the nature of the product is exogenously given. In Section 3, we extend our analysis and endogenize the firm’s product design choice. In Section 4 we model a duopolistic market. The final section summarizes the results and gives future research directions.

2 Basic Model - Exogenous Product Quality

Assume that a single firm possesses the capability to produce a product with up to two attributes \( \alpha_1 \) and \( \alpha_2 \). The firm is endowed with this technology at some point previous to the playing of the game. The firm’s product either contains attribute \( i \), which we denote by \( \alpha_i = 1 \), or not, which we refer to as \( \alpha_i = 0 \).\(^{5}\) We denote the firm’s type as \( A = \alpha_1 \times \alpha_2 \). Moreover, we interpret the existence of attributes in quality terms. Thus, we think about 11 as the high-quality firm and firms 10 and 01 as the “low quality” firms. This interpretation of horizontal attributes in quality terms is similar to the approach taken by Godes (2003). It is natural to think about this in quality terms since a randomly-chosen customer will always place higher value on 11 than on either of the other two products under full information about product attributes. We assume that there exists no firm 00.\(^{6}\) It is important to note that the restriction of the product to one with two attributes is not important to our results. In fact, one could interpret these attributes as “sets of attributes.” What is important is that the firm is not able to communicate to the customer information about each and every attribute (which is discussed in detail below). Two is the minimum number of attributes with which we can capture this concept of limited ability to communicate. The model could be extended readily to \( n \) attributes.

A proportion \( \phi > \frac{1}{2} \) of consumers have a reservation price of 1 on \( \alpha_1 \) and a reservation price of 0 on \( \alpha_2 \). The remaining \( 1 - \phi \) consumers have a reservation price 1 on \( \alpha_2 \) and a reservation price 0

\(^{5}\)Alternatively, one could think about \( \alpha_i = 1 \) as meaning that the firm offers a “high:” level of attribute \( i \) and \( \alpha_i = 0 \) meaning that the firm offers a “low:” level.

\(^{6}\)In fact, it is straightforward to show in equilibrium that such a firm could never earn positive profits.
on $\alpha_1$. Consumer’s have uncertainty in two respects. First, they do not observe \textit{ex ante} whether or not the firm’s product contains an attribute or not. Specifically, we assume that consumers prior beliefs over the firm’s product are given by

$$\Pr[1,1] = p$$
$$\Pr[1,0] = \Pr[0,1] = \frac{1-p}{2}$$

The firm knows the status of $\alpha_1$ and $\alpha_2$ perfectly. Second, consumers are also uncertain about their preferences. Specifically, like the firm, they assign probability $\phi$ to the fact that they value $\alpha_1$ and $1-\phi$ that they value $\alpha_2$. This set-up captures in a parsimonious way a context in which the consumer is not a frequent purchaser of the category. Imagine, for example, the purchase of a DVD player. For many, this is likely to be a first-time purchase in the category. Short of having spent significant time and effort prior to the shopping trip, then, the customer is likely to show up at the retailer with non-negligible uncertainty as to her valuation for various underlying attributes. How important is it for my DVD to be MP3 compatible? How much am I willing to pay for a DVD player with a better dynamic range? Is a video equalizer valuable? Similarly, the set-up captures the idea that the underlying features and attributes may be changing fairly rapidly. In such a context, the customer is likely to be uncertain about both which attributes are important and which attributes are present.

It is assumed that this uncertainty over preference is resolved only through usage. No matter what the salesperson might tell the customer, she won’t really know how much MP3 compatibility is worth until she uses it. On the other hand, uncertainty over attributes is assumed to be partially resolvable by consumers prior to purchase. For example, a buyer of a new DVD player may not be able to learn every possible feature and technical specification of the product in a single visit to the Sony Store. We assume, however, that she is able to learn about a single attribute (such as its MP3 compatibility). However, exhaustive learning about all of the attributes is not possible.

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7 One could certainly argue that there is an asymmetry which we do not capture. This exists in the sense that the amount of learning one experiences as a result of purchasing a product with the attribute is not necessarily the same as (in fact, one might conjecture, is strictly higher than) if one had purchased a product without the attribute.

8 One could also imagine that legal restrictions (e.g., false advertising) or reputation might enforce this truth-telling, though we do not model this formally.
These limits could be driven by both supply- and demand-side factors. With respect to the former, all marketing impressions – from those generated via television ads to personal selling interactions – are finite in duration. Thus not all information can be transmitted in any of them. Moreover, it is well-known that consumers’ ability to process information is not without bound. Beginning with Bettman (1979) and Shugan (1980), there has been considerable attention paid to the costly nature of the decision-making process and the role of information processing. This assumption of the implication of “information overload” has been investigated by other modelers as well. For example, Villas-Boas (2003) makes the assumption that the effectiveness of advertising declines in the number of products featured and investigates the impact on product line design.

Given this limit on information revelation, the decision as to which information gets revealed to the consumer – which attributes are demonstrated – is an important one. It is assumed that, in addition to choosing the price $P^A$, firm $A$ also selects an “information revelation format” $f^A \in \{B, S\}$. When $f^A = S$, the firm (the “seller”) decides which information to reveal to the consumer. When $f^A = B$, the consumer (the “buyer”) decides. Information revelation is costly for the firm in either format. The firm bears a cost $c_B$ when $f^A = B$ and $c_S$ when $f^A = S$. We assume that these costs are “small” ensuring positive profits. Under buyer-initiated information revelation, the firm would, for example, bear costs associated with training its salespeople to ensure that they are prepared to answer a range of questions from different types of customers. Some customers might ask about MP3 compatibility while others might ask about the dynamic range. On the other hand, under seller-initiated information revelation, the firm decides which attribute the salesperson should know best. In this case, the training costs might be related to convincing the customer that this attribute is the most important. Another way to think about the distinction between buyer-initiated and seller-initiated information revelation might be in terms of whether or not to make information available via a kiosk which allows the customers more leeway in terms of which information to gather. Since the specific options available to the firm in terms of implementing either a buyer-initiated or seller-initiated strategy would necessarily vary across industries, we make no ex ante assumption regarding the relative levels of $c_B$ or $c_S$.

We denote by $\tilde{\alpha}^A \in \{\tilde{\alpha}_1, \tilde{\alpha}_2\}$ the attribute that is revealed by the firm when $f^A = S$ and
\( \tilde{\alpha} \in \{\tilde{\alpha}_1, \tilde{\alpha}_2\} \) the attribute that is inspected by the consumer when \( f^A = B \). Note that, since the consumer is uncertain about her preferences, we do not need to condition this choice on her type. The sequence of the game is as follows. In stage 1, the firm sets the price \( P^A \) and decides on the information revelation format \( f^A \). In stage 2, the information is revealed. Specifically, if \( f^A = S \), then the firm chooses to reveal either \( \alpha_1 \) or \( \alpha_2 \). If, on the other hand, \( f^A = B \), then the consumer decides which attribute she wants to inspect. We define \( q \) as the probability that she inspects \( \alpha_1 \).

\[
q \equiv \Pr[\tilde{\alpha} = \tilde{\alpha}_1|f = B] \tag{3}
\]

\[
1 - q \equiv \Pr[\tilde{\alpha} = \tilde{\alpha}_2|f = B] \tag{4}
\]

If the consumer is indifferent between inspecting and not inspecting, we assume that she inspects.

In the final stage, consumers make purchase decisions. For notational convenience, we define the vector \( s^A \equiv \{P^A, f^A, \tilde{\alpha}^A\} \) as the vector of all firm actions and \( F \equiv \{f^{11}, f^{10}, f^{01}\} \) as the vector of revelation formats.

Since the firm’s type is unknown to the customer and the firm’s optimal strategy will be a function of that type, the solution concept we utilize in this Section is Bayes Nash Equilibrium (BNE). In such an equilibrium, the firm’s and consumer’s actions must be at least as good as any unilateral deviation from the equilibrium. Moreover, the consumer’s beliefs about the firm’s type must be consistent with both the firm’s equilibrium strategy and with Bayes’ Rule, when applicable. An important aspect of the BNE for our purposes here is that off-path beliefs must be specified exogenously which define what the consumer believes if a non-equilibrium action is observed. Bayes’ Rule is of no use in this case since the non-equilibrium action is, technically, a probability zero event. As a result, it is commonly the case that there are multiple BNEs corresponding to different assumptions regarding off-path beliefs.

### 2.1 Benchmark Models

Before presenting the results of the model, we discuss briefly two special cases. First, we look at a case in which the firm is not able to disseminate any information to the consumer. In other words, we assume that \( c_S, c_B \rightarrow \infty \). By comparing this result to the more general case, this will help us to better appreciate the impact of the explicit consideration of this decision by the firm. This
context may arise for several reasons. First, one might imagine a case in which the product is so complicated that both the firm and the customer are unable to effectively communicate about the underlying attributes in the product. Alternatively, one might imagine this to be the case when the customer is not at all motivated to engage in a discussion, perhaps due to the low importance of the product. In such a model, it should be clear that there is only a pooling equilibrium in which all firms charge \( P = E[U] = p + \frac{(1-p)}{2} \). This is, obviously, particularly costly for the highest quality firm, 11. On the other hand, in this one shot game, the lower quality firms are quite satisfied with this situation since they are “free-riding” on the high-quality firm.

We can also consider a context in which the firm is able to communicate information about the product but is forced – perhaps for technological reasons or reasons related to industry norms – to adopt seller-initiated information revelation. In other words, \( c_B \rightarrow \infty \). We address this context in the following Lemma.

**Lemma 1** *When the firm is restricted to implementing seller-initiated information revelation, there exists no fully-separating equilibrium in which type 11 earns higher profits than both of the other types.*

All proofs are contained in the Appendix. As this Lemma shows, when the firms are restricted to the use of seller-initiated information revelation, high quality firms are not able to fully reap the benefits of being high quality. This is important since seller-initiated revelation is in many ways the “traditional” medium of communication.

### 2.2 Results

The following Proposition shows that, when we explicitly allow the firm to select the information revelation format, the high quality firm may benefit.

**Proposition 1** *For high enough \( \phi \), there are only two classes of equilibria in this model: (i) Full Separating Equilibrium in which \( f^{11} = B \) and (ii) Semi-Separating Equilibrium in which \( f^{11} = S \).*

Thus, we find that only two equilibria may occur in this simple model. In one, the high quality firm can separate and, in so doing, capture the value associated with its superior product. The
only way it can do so, moreover, is by implementing buyer-initiated information revelation. In this equilibrium, the high quality firm is being paid for “hidden” value that no consumer has seen but which the firm can credibly claim exists. It is interesting to note that, as shown in the proof of the Proposition, a “cheap” separating equilibrium exists in which the high-quality firm achieves the highest profit level possible. That is, firm 11 is able to extract all rents from the consumer associated with its high quality. In the semi-separating equilibrium, the high quality firm implements seller-initiated information revelation but cannot separate itself from a low quality firm. Thus, it is the buyer-initiated information revelation format that allows the firm to signal its type perfectly.

So, in the separating equilibrium, the high quality firm with the “most to say” always prefers to say nothing. The intuition behind this result lies in the fact that when the seller retains control over the information, it must in some sense “commit” to the message ex ante. This is not a significant cost for firms of low quality who have less to say. On the other hand, the high-quality firm gives up something when it commits to saying either $\alpha_1$ or $\alpha_2$. It is, therefore, the existence of customer heterogeneity along with the firm’s inability to communicate everything that gives rise to the buyer-initiated format.

It is useful to compare this result to the traditional signaling models in which price and/or advertising signal quality (Nelson, 1974; Milgrom and Roberts, 1986). The typical approach taken in these models is to show that the high quality firm derives a higher marginal benefit from, say, advertising. This is the case because, in the long run, people will learn which product is good and which isn’t and therefore the consumer attracted to a low-quality product is unlikely to remain loyal while the consumer attracted to a high quality product is more likely to do so. In our static context here, such reputational concerns are, of course, irrelevant. However, it is important to notice that the revelation format plays an analogous role here. That is, it facilitates the use of price as a signaling mechanism by creating a situation in which the high-quality firm benefits more from charging a high price than does a low-quality firm. To see this, note that a high-quality firm will deliver utility of 1 to all customers in the separating equilibrium. Thus, relative to a lower price $P'$, charging the price $P = 1$ yields incremental profit of $1 - P'$. On the other hand,
a low-quality firm – say 10 – attempting to “mimic” 11 will deliver an expected utility of 1 if the consumer inspects $\alpha_1$ and $\phi$ if she inspects $\alpha_2$. Thus, since 10 will sell only in the former case if it sets price to 1, the expected revenue from a high price of 1 relative to $P' \leq \phi$ is only $q(1 - P')$.

The result is interesting in that it suggests that it is not always optimal to “move first.” This seems contrary to the result in most models of non-cooperative behavior. For example, the classic Stackelberg game (McGuire and Staelin, 1983; Moorthy, 1988) yields higher profits to the leader than to the follower. Moreover, the Stackelberg model yields higher profits to the leader than to the symmetric firms in a Cournot game. Similarly, the Rubinstein (1982) model of alternating offers shows that the first-mover has an advantage regardless of how long the game is played. On the contrary, Proposition 1 suggests that the firm optimally allows the consumer to “move first” in some sense. Rather than stating, “we have attribute $\alpha_i$,” the firm allows the consumer to ask, “show me $\alpha_i$.” Finally, the result suggests that we ought to observe in practice a range of information-revelation strategies. Within industry, for example, we might observe differences contingent, in part, on the underlying quality of the product. Cross-sectional differences might be observed as a function of the relative magnitudes of $c_B$ and $c_S$.

Equilibrium (ii) is a semi-separating one where firm 11 and 10 offer the same price and adopt seller-initiated information revelation. The following Corollary shows that, under appropriate off-path beliefs, only the separating equilibria survive.

**Corollary 1** Let $\overline{P} = \text{Max}_A P^A$ be the maximum price charged in a potential equilibrium. Then:

(a) there exists a $\mu$ such that for all off-path belief in which $\Pr[A = 11|P^A > \overline{P}] > \mu$ then the Semi-Separating Equilibria in Proposition 1 does not exist; and (b) the Fully Separating Equilibrium in Proposition 1 exists for all $\mu$.

To further strengthen the result, we might impose a more stringent set of off-path beliefs in order to offer sufficient conditions for the uniqueness of the Fully-Separating Equilibrium in (i). The off-path beliefs in Corollary 1 reflect the idea that higher price might be associated, in the eye of the consumer, with somewhat higher expected quality. Thus, we find that the idea that high-quality firms will optimally adopt buyer-initiated learning mechanisms while lower-quality firms will not is an even stronger one in some cases.
2.3 Customer Preference over Format

One important aspect of the model set-up is that the customer is extremely “passive.” We assume that she is willing to go along with whatever the firm prefers in terms of information revelation. If the firm wants her to lead, she leads. If the firm wants to lead, she allows it to do so. This is, of course, somewhat unrealistic. In fact, it is likely to be the case that some consumers have a strong preference for one format or the other. For example, Ariely (2000) showed that consumers do have such a preference which varies with the cognitive requirements of the task. Specifically, we might imagine that there is a proportion of consumers $\lambda_S$ that always want the firm to initiate the information revelation process. They might, for example, lack the confidence or background to assess the existence of the attributes in question. On the other hand, there might a proportion $\lambda_B$ of consumers that always wants to initiate the process themselves. The following Proposition shows that the Separating Equilibrium described above still exists in such a context.

**Proposition 2** For any $\lambda_B \in (0, 1)$ and $\lambda_S$ low enough relative to $\phi$, the Fully-Separating Equilibrium exists. Moreover, in such an equilibrium $P_{11} < 1$.

The fact that the equilibrium is now costly to the high-quality firm (in that $P_{11} < 1$) comes from the fact that the firm can no longer charge $P_{11} = 1$ and separate. Because of the expectation that a non-zero proportion of customers will come into the store and say, “I have no idea what I want. You tell me,” the lower-quality firms are more willing to deviate. It is, in some sense, less risky to mimic $11$ the higher is this proportion. In order to make this deviation less attractive, $11$ decreases its equilibrium price. Thus, it is interesting to note that all consumers earn rents from $11$ due to the existence of this segment of consumers who prefer seller-initiated revelation.

2.4 Customer Learning

While Section 2.3 relaxes our assumption about the consumer’s passivity, one might also note that we make a strong assumption in the core model with respect to the consumer’s learning about her preferences. In particular, we assume that this takes place only after purchase. It is worthwhile to explore the implications of relaxing this assumption as well. To do so, we allow for the fact
that in the course of selling interaction the consumer might learn about her preferences but that
this learning may not be perfect. Specifically, we define \( \hat{\theta} \in \{1, 2\} \) as the “signal” she received
about her true preferences \( \theta \in \{1, 2\} \) where the value of \( \theta \) represents which of the two product
attributes on which she places value. This signal is received with the following precision:

\[
\Pr[\hat{\theta} = \theta] = 1 - \varepsilon
\]

(5)

That is, the signal is wrong with probability \( \varepsilon \). We assume that \( \varepsilon \) is small. Note that given our set-
up in which we have only two attributes and two types of consumers, the (reasonable) assumption
that one would only learn about one’s type if one inspected that attribute is superfluous. Given
the prior \( \phi \), posterior probabilities over preference, then, are given by:

\[
\Pr[\theta = 1 | \hat{\theta} = 1] = \frac{(1 - \varepsilon) \phi}{(1 - \varepsilon) \phi + \varepsilon (1 - \phi)}
\]

(6)

\[
\Pr[\theta = 2 | \hat{\theta} = 2] = \frac{\varepsilon (1 - \phi)}{\varepsilon \phi + (1 - \varepsilon) (1 - \phi)}
\]

(7)

Given this set-up, each of the low quality firms has to choose from among two price levels in
any separating equilibrium which represent the posterior probability conditional on the customer
receiving a signal that (a) the firm’s attribute is the valued one, or (b) the firm’s attribute is not
valued. As long as \( \varepsilon \) is low enough, it should be clear that the firms will choose (a). To see this
for firm 10, note that the expected revenue under (a) is:

\[
\Pr[\theta = 1 | \hat{\theta} = 1] \cdot \Pr[\hat{\theta} = 1] = (1 - \varepsilon) \phi
\]

(8)

since the firm sells with probability \( \Pr[\hat{\theta} = 1] \). On the other hand, under (b), the firm always
sells so expected revenue is:

\[
\Pr[\theta = 1 | \hat{\theta} = 2] = \frac{\varepsilon (1 - \phi)}{(1 - \varepsilon) \phi + \varepsilon (1 - \phi)}
\]

(9)

It is clear that as \( \varepsilon \to 0 \), the former dominates.

The following Proposition shows that a separating equilibrium still exists in such a model but
that the separation is costly to the high-quality firm.

**Proposition 3** For \( \varepsilon \) small, there exists a Fully-Separating equilibrium. Moreover, in such an
equilibrium \( P^{11} < 1 \).
It is worth noting that this separating equilibrium is again costly while in the core model, the high-quality firm was able to separate at no cost. Specifically, in the core model, $\Pi^{11} = 1$ while here $\Pi^{11} = 1 - \varepsilon$. Similarly, when we allow for customer learning, $\Pi^{10}$ and $\Pi^{01}$ go from $\phi$ to $(1 - \varepsilon)\phi$ and $(1 - \phi)$ to $(1 - \varepsilon) (1 - \phi)$, respectively. The low-quality firms lose because the information added to the system creates meaningful heterogeneity. As a result, some customers buy and others don’t. In the core model, all customer bought. In this learning model – as in the core model – the high-quality firm sells to all customers. Its profits suffer, however, because of the indirect impact of the information on the low-quality firms’ profits. Because their equilibrium profits are lower, any potential deviation is more attractive. Thus, firm 11 is forced to decrease the attractiveness of the low-quality firms’ deviations by decreasing the price.

It is interesting also to note that the profit loss experienced by the firms is equal to the noise in the signal. This may be somewhat surprising in that one would typically expect the customer’s “power” to be increasing in the precision of her information and, conversely, the firm’s profits to be decreasing in the precision. The reason that this does not hold is that less-precise information translates into lower expected valuations and, thus, possible lower prices for 10 and 01. Moreover, for firm 11, the lower the low-quality firms’ profits, the more it has to distort its price in order to maintain separation.

3 Endogenous Quality

To this point, we have shown that the choice of revelation format is a function – and, in fact, a credible signal – of the firm’s exogenously-endowed underlying quality, operationalized as the expected utility delivered to a randomly-chosen consumer. Given this, it would seem important to consider what impact this relationship would have on the firm’s choice of quality itself. Since the optimal revelation format is also a function of other model parameters, these would, in turn, be expected to impact the optimal quality level. Previous research has addressed the firm’s product design decision in different contexts. In particular, other researchers have investigated the extent of the firms’ differentiation (Moorthy, 1988; Vandenbosch and Weinberg, 1995) as well as the firm’s product design choices as a function of consumer search costs (Kuksov, 2004), number of firms
(Banker et al., 1998; Liu et al., 2004) and customer heterogeneity (Rhee, 1996). Here, we add to this literature by investigating such decisions as a function of the firm’s cost of communicating the product’s characteristics to the consumer.

The monopolist will now choose whether it will offer a high quality or a low quality product (that is, one with zero, one or two of the attributes). Further, if the firm decides to offer a product with only one attribute, it can choose which attribute to have in the product. We assume that the production cost for providing each attribute is $c$ and is known by both the firm and the customer. This game gives rise to three possible equilibrium outcome scenarios. We define the vector $(\alpha_1, \alpha_2, f)$ as the equilibrium vector of firm actions. Note that, since $\phi > \frac{1}{2}$, $(0, 1, \cdot)$ will never be an equilibrium. Of course, $(1, 1, S)$ could also never be an equilibrium in this game since the firm would be investing in quality it could never communicate.

**Scenario 1 - (1, 0, $S$):** The firm uses seller-initiated information revelation. It is optimal to provide one attribute only and inform consumers about it. The profit to the firm under this scenario is $\Pi^1 = \phi - c_S - c$.

**Scenario 2 - (1, 0, $B$):** The firm uses buyer-initiated information revelation and provides one attribute only. The profit to the firm is $\Pi^2 = \phi - c_B - c$. In this scenario, consumers will optimally inspect attribute $\alpha_1$. They will buy if they find that the attribute is there and will not buy otherwise.

**Scenario 3 - (1, 1, $B$):** The firm uses buyer-initiated information revelation and provides both attributes. It is optimal for the firm to set price at $P = 1$. Consumers inspect attribute $\alpha_1$ with probability $q$ and attribute $\alpha_2$ with probability $1 - q$. They will buy if they find the attribute they search for and will not buy otherwise. Firm profit is $\Pi^3 = 1 - c_B - 2c$. The probability $q$ must satisfy the following pair of inequalities.

\begin{align*}
q - c_B - c &< 1 - c_B - 2c \quad (10) \\
(1 - q) - c_B - c &< 1 - c_B - 2c \quad (11)
\end{align*}

9In fact, there is a fourth, pathological, case in which the firm offers no attributes. However, this will always give rise to negative profits since $c_s, c_B > 0$. Thus, we rule it out. Alternatively, one could simply assume that $c_B, c_s, c$ are not too large to ensure that $\alpha_1 = 1$. 

\[15\]
i.e.

\[ c < q < 1 - c \] (12)

Equation (10) ensures that the firm will not deviate and offer only attribute \( \alpha_1 \) and equation (11) ensures that the firm will not deviate and offer only attribute \( \alpha_2 \). Note that, conceptually, all we have done in this case – as compared with the exogenous quality case – is to endow the firm with the power to choose its type. Since this type is still unobservable by the customer, we continue to utilize the Bayes Nash Equilibrium concept. Thus, we need to define off-path beliefs. The approach we take is to apply the ideas captured in the Intuitive Criterion (Cho and Kreps, 1987). These authors suggest an equilibrium refinement that explicitly rules out off-path beliefs that are “unreasonable” in a specific sense. They argue that, if player \( A \) observes an action by player \( B \) that is not expected in equilibrium and that some type of player \( B, \theta_B' \), would never have chosen this action no matter what player \( A \)’s inference based on this action would have been, then we should assign probability 0 to the state in which player \( B \) is of type \( \theta_B' \). That is, if it never makes sense for a type to deviate in this way, then we should assume that we are not seeing this type.

In equilibrium, it will be the case that the price will be 1 if the firm produces a product with both attributes and \( \phi \) if it only has one attribute. The question is what the consumer should infer if she sees some \( P' \in (\phi, 1) \)? Applying the concepts contained in the Intuitive Criterion, note that a firm producing 11 would never do this since its on-path profits would be strictly higher, even if the customer assigned probability 1 to the fact that it is of type 11. Thus, the consumer must infer with probability 1 that the firm is, in fact, of type 10. Given this set-up, the following Proposition characterizes the monopolist’s optimal decision.

**Proposition 4** For \( c_B, c_S, c \) not too large, the unique BNE in this model is: (i) If \( \phi > (1 - c) + c_S - c_B \) and \( c_S < c_B \): \( (1, 0, S), \ P = \phi \ and \ q^* = 1 \); (ii) If \( \phi > (1 - c) \) and \( c_S > c_B \): \( (1, 0, B), \ P = \phi \ and \ q^* = 1 \); and (iii) Otherwise, \( (1, 1, B), \ P = 1 \ and \ c < q^* < 1 - c \). A consumer will purchase if and only if the attribute she inspects is observed.

The firm’s equilibrium actions as a function of the underlying parameters are shown in Figure 1 below. Based on this equilibrium, we are able to make several remarks. First, it is clear that,
Figure 1: Equilibria in the Endogenous Quality Context
when there is little customer heterogeneity, we are less likely to observe buyer-initiated formats, all else equal. This is intuitive in that the principal benefit of the buyer-initiated format is that it obviates the need for the firm to commit to a buyer-independent message. The less heterogeneity, then, the less important this benefit becomes.

These results also reinforce the fact that higher-quality products are optimally communicated through buyer-initiated formats. Moreover, as is clear in Figure 1, when $c_B$ is too high relative to $c_S$, the high quality equilibrium disappears completely. As the cost of buyer-initiated revelation drops, we might expect to observe an increase in product quality. So, for example, as the Internet makes the communication of complex product information—and, in particular, the customization of that information to individual tastes—easier and more affordable, this might result in better products. When the cost of such information revelation is too high, there is less of a reason for the firm to invest in the development and production of these high-quality products.

One ex ante surprising implication of Proposition 4 is that, as $c_S$ drops, we may observe lower quality products. This, is somewhat counter-intuitive in that one might expect that any decrease in communication costs would only serve to increase the quality of products produced. The driving force behind this is the impact of the revelation format decision. Specifically, as the cost of seller-driven revelation falls, the firm finds it more attractive to adopt seller-initiated information revelation. By the arguments developed above, the firm will never produce a highest quality product when adopting a seller-directed format because it can never communicate that it is Firm 11.

## 3.1 Cost Uncertainty

The above derivation is based on the assumption that the consumer knows $c$, the cost of including a given attribute in the product. This may not be a realistic assumption in many product contexts. For example, if $\phi < 1 - c$ and the consumer sees that $\alpha_1 = 1$, only knowledge of the relative sizes of $c_B$ and $c_S$ will reveal whether the product is 11 or 10. Assume that beliefs about $c$ are captured in the pdf $f_c$ with support over the range $[c, \bar{c}]$. The following Corollary addresses this issue and points out that the same intuitive results persist in a model containing uncertainty.
Corollary 2 Each of the three equilibria in Proposition 4 persist after explicit consideration of cost uncertainty.

In this context of cost uncertainty, the only difference is that we need to be more specific about the consumers’ inspection policy. So, while (10) and (11) are sufficient for Proposition 4, Corollary 2 requires that consumers use \( \frac{1}{2} < q < \phi \).

4 Duopoly Model

Thus far we have analyzed a monopolist and its choice of attributes and information revelation format. In this section we move to a competitive scenario. By investigating the firms’ choices of revelation format and product attributes in a non-cooperative context, we are able to assess their impact on the intensity of competition. It also serves as a robustness check of our core results. We consider a duopoly in which both firms are characterized by the same costs — \( c_B, c_S \), and \( c \) — which are common knowledge. Buyers purchase from the firm that gives them their maximum expected surplus. If both firms offer the same surplus to a consumer, they buy from each with probability \( \frac{1}{2} \). We consider only the non-trivial cases in which \( c \) and \( \min(c_S, c_B) \) are small enough so that each firm offers at least one attribute in equilibrium. The firms choose product attributes, prices and revelation format simultaneously.

It is again useful to consider as a benchmark a context in which the firms can only adopt seller-directed revelation. The following Lemma addresses this.

Lemma 2 In a duopoly in which both firms are restricted to implementing seller-initiated information revelation, the unique equilibrium yields equal prices of \( c_S + c \), both firms offering only \( \alpha_1 \) and zero profits.

Thus, the firms are not able to escape ruinous Bertrand competition when they are restricted to seller-initiated revelation. Intuitively, given the assumptions on consumer preferences and beliefs, the firms face symmetric demands and, thus, bargain prices down to marginal cost. Moreover, note that this context is characterized by low prices and relatively low-quality products.
4.1 Buyer-initiated Information Revelation in a Competitive Model

When the firm can choose the revelation format, it has three possible strategy vectors: $(1, 0, S)$, $(1, 0, B)$ or $(1, 1, B)$. If $c_S > c_B$, $(1, 0, S)$ cannot be an equilibrium for either firm because by adopting $(1, 0, B)$ the firm can offer consumers the same surplus at lower cost. Similarly, $(1, 0, B)$ cannot be an equilibrium if $c_B > c_S$. This restricts the set of potential equilibria to three generic classes, which we define as follows: (i) “symmetric low quality” equilibria in which both firms choose $(1, 0, f)$ where $f$ is driven by the aforementioned efficiency considerations, (ii) “asymmetric” equilibria in which one firm chooses $(1, 1, B)$ and the other chooses $(1, 0, f)$ where, again, $f$ is driven by efficiency, and (iii) “symmetric high quality” equilibria in which both firms choose $(1, 1, B)$. As above, we let $q(f, p)$ be the probability that a consumer searches for attribute $\alpha_1$ and $1 - q(f, p)$ be the probability that she searches for attribute $\alpha_2$. In this context, the search probability may be a function of the observable actions taken by the firm. The key implication of this assumption is that the customer may have a different shopping strategy for firms that “look” different. We address each of these equilibria below.

4.1.1 Symmetric Low-Quality Equilibria

To begin, we need to define the consumer’s off-path beliefs upon observing an out-of-equilibrium action. Formally, let $(f_i^*, p_i^*)$ represent the equilibrium actions for firm $i$. Then, consistent with our approach in the monopoly case, we define off-path beliefs $\mu(f, p)$ as follows:

$$\mu(f, p) \equiv \Pr(1, 1| f \neq f_i^* \text{ or } p \neq p_i^*)$$  \hspace{1cm} (13)

We adopt a relatively conservative assumption on these beliefs. Specifically, we assume that

$$\mu(f, p) = \begin{cases} 1 & \text{if } f = B \text{ and } \Pi(1, 1, p) > \Pi(1, 0, p) \\ 0 & \text{otherwise} \end{cases}$$  \hspace{1cm} (14)

In this belief structure, we specify the consumer as believing that she is looking at a low-quality firm unless the firm adopts buyer-initiated revelation and, given the price, the firm is better off producing a high-quality than a low-quality product for any consumer inference. Again, these
conditions represent no more than a rational constraint on the consumer’s beliefs: she believes the firm adopts high-quality if and only if it can do better by doing so.

The following Lemma shows that, as one might expect, this class of equilibria yields Bertrand outcomes:

**Lemma 3** Let $p \equiv \min\{c_S, c_B\} + c$. Then, symmetric low-quality equilibria are always characterized by both firms setting prices equal to $p$ and earning zero profits.

Since the firm would never increase the quality of its product without also increasing its price (and vice versa), a sufficient condition for the existence of this equilibrium must be that neither firm has an incentive to deviate to $(1, 1, B)$ and some price $p' > p$. The firms will do so if they can offer the consumer higher surplus ($\sigma$) and also earn higher profits, i.e.

$$\sigma = \mu (B, p') - p' > \phi - p$$  \hspace{1cm} (15)

$$p' - c_B - 2c > 0$$  \hspace{1cm} (16)

$$p' > p$$  \hspace{1cm} (17)

The condition in (15) ensures that the consumer places a “high enough” probability on the fact that the firm is of high quality. Based on the specification of beliefs in (14), this is necessarily based on the customer’s shopping policy. In particular, for the firm to find it profitable to deviate to $(1, 1, B)$, given the consumer’s policy, we need the following to hold:

$$q (B, p') - c_B - c \leq p' - c_B - 2c$$

$$(1 - q (B, p')) - c_B - c \leq p' - c_B - 2c$$

i.e.

$$1 - (p' - c) \leq q (B, p) \leq p' - c$$  \hspace{1cm} (18)

These conditions ensure that, given the customer’s shopping strategy, the firm does not find it strictly more profitable to produce a low-quality product of either type. Note that the LHS of (18) is decreasing in $p'$ and the RHS is increasing in $p'$. Thus, for a given $q (B, p')$, the joint
condition in (18) will hold for “high” prices. Prices must be high enough for the feasible region defined by (18) to be non-empty. The minimum such price \( p' \) is given by:

\[
1 - (p' - c) = p' - c \quad \Rightarrow \quad p' = \frac{1}{2} + c
\]  

We can rewrite the three conditions above as follows:

\[
\sigma = 1 - p' > \phi - p \quad \Rightarrow \quad p' > \text{Max}\left\{\text{Min}\{c_B, c_S\}, \frac{1}{2}, c_B + c\right\} + c
\]

Or:

\[
1 - \phi + p > p' > \text{Max}\left\{p, \frac{1}{2} + c, c_B + 2c\right\}
\]

A necessary condition for the lack of existence of a \( p' \) that satisfies all of these conditions and, thus, for the existence of the symmetric low quality equilibrium is that:

\[
1 - \phi + p \leq \text{Max}\left\{p, \frac{1}{2} + c, c_B + 2c\right\}
\]

Since \( 1 - \phi > 0 \) by assumption, the first thing we notice is that this equilibrium requires that \( p < \text{Max}\left\{\frac{1}{2} + c, c_B + 2c\right\} \).

4.1.2 Asymmetric Equilibria

The following Lemma characterizes the asymmetric equilibrium:

**Lemma 4** Let \( p \equiv \text{Max}\left\{c_B + 2c, \frac{1}{2} + c\right\} \). In an asymmetric equilibrium, firms 11 and 10 charge prices \( p \) and \( p \), respectively and both firms earn zero profits.

Given the prices and zero-profit result described in Lemma 4, a necessary condition for the equilibrium is that the firm offering the high-quality product charges a price that satisfies:

\[
p = c_B + 2c \geq \frac{1}{2} + c
\]

\[
\Leftrightarrow \quad c_B + c \geq \frac{1}{2}
\]
If this does not hold, the high-quality firm would earn positive profit. Moreover, since the consumer surplus offered by the two firms needs to be equal, the equilibrium requires that:

\[
\sigma = \phi - p = 1 - p \tag{27}
\]

\[
\Leftrightarrow 1 - \phi = c_B + 2c - p \tag{28}
\]

This condition makes clear the fact this equilibrium will exist only in a “knife edge” region in the parameter space. The low-quality chooses \( f = S(B) \) if \( c_S < c_B \) (\( c_S > c_B \)). Substituting the expression for \( p \) into (18), we find that consumers search attribute \( \alpha_1 \) at the high-quality firm with probability

\[
1 - (c_B + c) \leq q(B, p) \leq c_B + c \tag{29}
\]

and attribute \( \alpha_2 \) with probability \( 1 - q(B, p) \). They search attribute \( \alpha_1 \) at the low-quality firm with probability \( q(B, p) = 1 \). For “low” values of \( c_B \) and \( c \) – when \( c_B + c < \frac{1}{2} \) – the feasible region associated with the constraint in (29) is empty and, thus, the asymmetric equilibrium will not exist.

### 4.1.3 Symmetric High-Quality Equilibria

The following Lemma shows that, as we would expect, this equilibrium is characterized by equal prices. A surprising aspect of this equilibrium, however, is that firms may earn positive profits.

**Lemma 5** *In the symmetric high quality equilibrium, each firm charges price \( p \). Moreover, if \( c \) and \( c_B \) are low enough, then firms earn positive profits in such an equilibrium.*

The positive profit result is somewhat surprising and, thus, warrants a brief discussion. As a basis of comparison, recall that the standard “Bertrand” model of price competition between undifferentiated products always yields zero profits (Tirole, 1988). The reason for this is that any proposed positive profit equilibrium is broken by an \( \varepsilon \) price cut which delivers the entire market to the firm cutting price at only a second-order per-customer loss. Such an opportunity may not exist for the firms in the current model. To understand why, note that consumers will infer that a price cut must necessarily be accompanied by a quality cut. To see why this inference is rational,
recall from Lemma 4 that \( p \) can take on one of two values. If \( p = c_B + 2c \), then any price cut to \( p' < p \) would yield the firm negative profits if it didn’t also cut quality. Therefore, it must be the case that the firm cuts quality as it cuts price. If \( p = \frac{1}{2} + c \), on the other hand, any cut in price would imply that there exists no shopping policy \( q(f, p) \in (0, 1) \) that prevents the firm from deviating to low quality. This was shown above in (19).

This inference, in turn, implies that – unlike the standard model – the firm has to cut by a \textit{first-order amount} in order to induce the customer to steal the market from the other firm, given the inferred decrease in quality. A cut of \( \varepsilon \) will no longer do. This “wedge” created by customer inference prevents opportunistic price cuts by the firms and enforces a positive profit equilibrium.

Now, note that each firm’s profit from charging \( p \) in equilibrium is:

\[
\Pi = \frac{1}{2}(p - c_B - 2c)
\]

since the firms split the market. A deviation to (a) low quality and (b) some price \( p' < p \) would only be attractive if:

\[
p' - [\min(c_S, c_B) + c] > \frac{1}{2}(p - c_B - 2c) \tag{30}
\]

\[
\sigma = 1 - p < \phi - p' \tag{31}
\]

i.e.

\[
p' > \frac{1}{2}(p - c_B - 2c) + p \tag{32}
\]

\[
p' < p + \phi - 1 \tag{33}
\]

Condition (32) ensures that the firm earns higher profits from the deviation while (33) means that the customer earns a higher surplus from the deviating firm, ensuring that the firm sells to the entire market. Since we know that \( p' < p \) always holds, our assumption on off-path beliefs means that, if a consumer observes \( p' \) in the high-quality symmetric equilibrium, she will infer that the firm must be of low-quality. Therefore, the condition to rule out the existence of any such price deviation, \( p' \), is:

\[
\frac{1}{2}(p - c_B - 2c) + p \geq p + \phi - 1
\]

\[
\iff p \leq 2(1 - \phi + \min(c_S, c_B)) - c_B \tag{34}
\]
Supporting this equilibrium is a shopping policy by consumers in which they inspect attribute $\alpha_1$ with probability

$$1 - (p - c) \leq q \leq (p - c)$$

and attribute $\alpha_2$ with probability $1 - q$. The existence of such a $q$, of course, requires that $p \geq \frac{1}{2} + c$ which always holds as shown in Lemma 4.

### 4.1.4 Combining the Results

The following Proposition summarizes our analysis of the competitive model.

**Proposition 5**  (i) if $(1 - \phi) \leq c_B + 2c - p$, there exists a symmetric low-quality equilibrium (SLQ), (ii) if $(1 - \phi) = c_B + 2c - p$ and $c_B + c \geq \frac{1}{2}$, then there exists an asymmetric equilibrium (AS), (iii) if $p \leq 2(1 - \phi + \min(c_S, c_B)) - c_B$, then there exists a symmetric high-quality equilibrium (SHQ).

Since these conditions are not necessarily mutually exclusive, multiple equilibria are possible as can be seen in Figure 2. In particular, the symmetric high- and low-quality equilibria overlap when $c_B$ is low. Nonetheless, for high values of $c_B$, the equilibria are unique. Moreover, the equilibrium of most interest, the symmetric high-quality case in which firms earn positive profits, is always unique when $\phi$ is relatively low. Even in contexts in which the SLQ and SHQ equilibria overlap, one can argue that the firms will select the pareto-dominant SHQ equilibrium in which they both earn positive profits.

Since firms may earn positive profit in the SHQ equilibrium due to the enforcement of high prices, one might expect that consumers would be worse off as a result. However, this is not necessarily the case. As compared to the case in which only seller-initiated information revelation is allowed, consumers are better off under SHQ when:

$$\sigma = 1 - (\frac{1}{2} + c) > \phi - (c_S + c)$$

$$\Leftrightarrow \phi < \frac{1}{2} + c_S$$  \hspace{1cm} (35)

In fact, it is straightforward to show that the condition in (35) holds for all parameter values in which the SHQ equilibrium is unique. Thus, as we see in Figure 2, there exist parameter values
Figure 2: Equilibria in the Duopoly Context

Firms earn positive profits in SHQ for $c_B < 0.5 - c$. Consumers are better off in SHQ when $\phi < 0.5 + c_S$. Firms earn positive profits in SHQ for $c_B < 0.5 - c$. The figure illustrates the equilibria in the duopoly context with the indicated conditions for positive profits and consumer welfare.
for which the firm earns positive profits and consumers get higher utility. Both of these are a direct result of buyer-initiated information revelation. For the firms, as noted above, this learning format allows them to charge higher prices since lower prices would not be consistent with the high-quality product. As a result, the consumers infer from lower prices that the quality is lower as well. On the consumer side, the buyer-initiated learning format allows the firms to produce higher-quality products. Since this happens in a competitive context, some of that additional utility is passed on to the consumer.

5 Discussion and Conclusion

In this research, we model the effect on profits of the manner in which the firm reveals (or allows to be revealed) information about its products. When the product quality is exogenously determined, the firm with the highest quality product prefers to adopt buyer-initiated learning. By allowing the buyers to determine which attribute to inspect, the firm sends a credible signal that – along with the price – ensures that its product is of high quality. When the quality decision is endogenous, seller-initiated learning is not associated with high quality. On the other hand, higher quality products are always associated with buyer-initiated learning. When the cost of buyer-initiated learning is much higher relative to seller-initiated, the high quality equilibrium does not exist. This leads to a surprising insight that we may observe lower-quality products if the cost of (seller-initiated) communication declines sufficiently. In a competitive scenario, buyer-initiated learning by both firms can lead to increase in profits and consumer surplus. The high quality - high price association results in a mitigation of the incentive to undercut the rival’s price which in turn softens price competition.

These insights offer several important implications for managers. First and foremost, we provide a clear justification for the adoption of a selling format in which the customer – not the firm – determines which information about the product will be revealed. That is, this approach represents an effective way to communicate to consumers that the product is a high quality one. Second, we provide interpretable and implementable conditions for the adoption of such a format. In particular, high quality firms – those with products matching the preferences of a broader set
of customers – should do so while lower-quality firms should not. In the latter case, the risk of revealing unflattering information outweighs the potential “signaling” gains. Finally, we argue that an ancillary benefit of the widespread adoption of such a format in an industry is that this would decrease the intensity of price competition. Recall that the adoption of buyer-initiated revelation represents a commitment to the consumer that the product is of high quality. Epsilon price cuts bring with them an inference that the product has also dropped in quality and, thus, do not capture the whole market.

There are several directions in which this research could be extended. The current model is a static one and thus precludes repeat purchases. However, many consumer categories are characterized by such dynamic behavior. Incorporating this into the model would allow one to investigate the impact of consumers’ “punishment” of the firm for cheating on quality. Another useful extension would be the incorporation of two-way communication between the consumer and the firm. In the approach we have taken here, the customer asks a question and the firm answers it. However, the “conversation” can be far richer and more complex. For example, a consumer might ask about an attribute and the seller can decide to tell about another attribute that it thinks is more important for the product category. One might also investigate more deeply the knowledge structure surrounding the consumer’s preferences. For example, the firm’s expertise in the product category is likely to allow salespeople to infer the customer’s optimal product based on several questions or a profile. Thus, the information it chooses to send may be informative about the underlying preferences to the extent that this information is chosen as a function of the inferred customer type. In a multi-channel situation, the level of information provided by a direct marketer has strategic implications (Balasubramanian, 1998). It would be interesting to model the effect of buyer-initiated and seller-initiated learning in a similar, multi-channel setting.
References


Appendix

Proof of Lemma 1: Assume that such an equilibrium did exist. Each type’s strategy is a pair $\{P^A, \bar{\alpha}^A\}$. If $\bar{\alpha}^{11} = \alpha_1$ then 10 will deviate to $\alpha_1$ and $P^{11}$. The analogous is true if $\bar{\alpha}^{11} = \alpha_2$. With carefully-chosen off-path beliefs, one could construct an equilibrium in which the types fully separate but indifference prevents deviation. For example, if $\bar{\alpha}^{11} = \alpha_1 = 1$, $\bar{\alpha}^{10} = \alpha_2 = 0$ and $\bar{\alpha}^{01} = \alpha_2 = 1$. Then, as long as $P^{11} = P^{10} = \phi$, there is no incentive for 10 to deviate on $\bar{\alpha}^{10}$.

To enforce such an equal-profit equilibrium, however, one would need to specify off-path beliefs in which the observation of the action pair $\{P' > P^{11}, \alpha_1 = 1\}$ yields a posterior probability that $A = 11$ is very low. □

Proof of Proposition 1: We’ll walk through the three potential types of price equilibria: (a) full separating, (b) full pooling and (c) semi-separating. (a) We begin with full separating equilibria in which the firms charge different prices. In this case, the firms will charge prices equal to the customer’s expected value upon purchase: $P^{11} = 1$, $P^{10} = \phi$ and $P^{01} = 1 - \phi$. Now, assume that $f^{11} = S$. It should be clear that firm 10 and/or firm 01 could imitate 11 and earn strictly higher profits. Even randomization by firm 11 would not prevent such imitation since the consumer sees realizations not randomizations. Thus, such an equilibrium can only hold with $f^{11} = B$. Next, notice that it can’t be the case that $f^{10} \neq f^{01}$. This is because, conditional on full separation on price, the revelation format is solely a function of efficiency: if $c_B > c_S$, then $f^{10} = f^{01} = S$ and vice versa.

To enforce the $\{B, B, B\}$ separating equilibrium, then, we need to consider the consumer’s revelation decision. Assume that $c_B < c_S$. In equilibrium, $\Pi^{11} = 1 - c_B$, $\Pi^{10} = \phi - c_B$ and $\Pi^{01} = 1 - \phi - c_B$. If 10 deviates to $P = 1$, then its profits become $q - c_B$. Similarly, if 01 deviates to $P = 1$, its profits become $1 - q - c_B$. Thus, we need $q^* = \phi$ to enforce the equilibrium.

Now, consider $\{B, S, S\}$. In this case, $c_B > c_S$. Clearly, at $q^* = \phi$, the equilibrium is still enforced. Now, however, we need to worry about 11’s deviation to $f^{11} = S$. We can surely assign off path beliefs such that this equilibrium is enforced, however. For example, if $Pr [A = 11|f^A = S] = 0$, this would be enforced.
(b) Full Pooling: In these equilibria, it must be the case that $P^{11} = P^{10} = P^0$. Of course, it must be the case that only $BBB$ and $SSS$ are possible. First, check $BBB$. Assume that the firms pool on some price $\bar{P} > E[U|\alpha_2 = 1] = 1 - \phi + \phi \frac{2p}{1+p}$. Then, firm 01 earns zero profits. A deviation to $P = E[U|\alpha_2 = 1]$ is therefore strictly profitable. Note that this is true regardless of off-path beliefs. Even in the worst case in which $Pr[01|P' = E[U|\alpha_2 = 1]] = 1$, the firm earns positive profits since it is sell with positive probability at a positive price. Consider a pooling price of $\bar{P} \leq E[U|\alpha_2 = 1]$. But, then firm 10 will deviate to $P = E[U|\alpha_2 = 0]$ which is strictly higher. The same arguments hold for $SSS$. Thus, there can be no full pooling equilibrium.

(c) Semi-Separating: (i) First consider $P^{11} = P^{10} = E[U|\alpha_1 = 1] = \phi + (1 - \phi) \frac{2p}{1+p}$. Note that, since it is fully revealed by price, 01 will choose $f^{01}$ based purely on cost. Of course, we must have $f^{11} = f^{10}$. Try first $f^{11} = f^{10} = B$. In this case, conditional on $P = \phi + (1 - \phi) \frac{2p}{1+p}$, the consumer earns zero expected utility under the equilibrium information revelation strategy $q^*$. However, if $q = 0$ (i.e., she always inspected attribute 2), then she’d only buy if $\alpha_2 = 1$ and $E[U] > 0$. On the other hand, notice that it cannot be the case that $q = 0$ in a $BBB$ equilibrium since 10 deviates to a lower price (like $\phi$, for example). Now, try $f^{11} = f^{10} = S$. It is clear that, with appropriate off path beliefs, this will hold. For example, let $\tilde{\alpha}^{11} = \tilde{\alpha}^{10} = \alpha_1$. Then, if we say that $Pr[11|\tilde{\alpha}^{10} = S] = 0$, this will be enforced. Moreover, it can never be the case that 01 will deviate.

(ii) Now, consider the context in which 11 and 01 pool: $P^{11} = P^{01} = E[U|\alpha_2 = 1] = 1 - \phi + \phi \frac{2p}{1+p}$, and $P^{10} = \phi$. For the same reasons as (i) above, this can’t hold with $f^{11} = f^{01} = B$. So, try $S$. If $\phi$ is high enough, 11 will deviate to imitate 10. Specifically, in equilibrium, $\Pi^{11} = 1 - \phi + \phi \frac{2p}{1+p} - c_S$. Assume that $c_S < c_B$. Then, $P^{11} - P^{10} = 1 - \frac{2}{1+p} \phi$. This is negative for high $\phi$ and low $p$. In these cases, firm 11 will always deviate. If $c_B < c_S$, then $f^{10} = B$ and there’s an even stronger motive for 11 to deviate.

Proof of Corollary 1: Θ (a) Assume that the Semi-Separating Equilibria exist for all $\mu$. In particular, assume they hold for $\mu = 1$. First check the case in which 11 and 10 pool. As noted above in the proof of Proposition 1, both have expected profits below 1. However, either of these firms could earn expected profits of 1 by deviating to $P = 1$. This argument holds for all such
Semi-Separating Equilibria.

(b) To see that the Fully-Separating Equilibria hold, note that \( P^{11} = 1 \) in equilibrium. Thus, it can earn no strict rents from deviating to any other price. Moreover, the potential for deviation to \( P = 1 \) has already been shown to be not strictly better for either firm 10 or 01 in the equilibrium. Thus, this must continue to hold under this form of off-path belief. \( \square \)

**Proof of Proposition 2:** \( \triangleright \) We prove this by demonstrating existence directly. In such an equilibrium, the firms will charge prices \( P^{11}, P^{10} = \phi \) and \( P^{01} = 1 - \phi \). Assume first that \( c_B \) is low relative to \( c_S \) so that 10 and 01 prefer to use buyer-initiated revelation. Profits in equilibrium are: \( \Pi^{11} = P^{11} - c_B, \Pi^{10} = \phi - c_B, \Pi^{01} = 1 - \phi - c_B \). A deviation by 10 to \( P^{11} \) is profitable if

\[
P^{11} [\lambda_S + (1 - \lambda_S) q] > \phi
\]

A deviation by 01 is profitable if

\[
P^{11} [\lambda_S + (1 - \lambda_S) (1 - q)] > 1 - \phi
\]

Combined, these two conditions imply that preventing both deviations requires the existence of a \( q \) such that

\[
1 - P^{11} [\lambda_S + (1 - \lambda_S) q] \geq 1 - \phi \geq P^{11} [\lambda_S + (1 - \lambda_S) (1 - q)]
\]

A necessary condition for \( q \) to exist is that \( 1 - P^{11} [\lambda_S + (1 - \lambda_S) q] \geq P^{11} [\lambda_S + (1 - \lambda_S) (1 - q)] \) which implies that

\[
P^{11} \leq \frac{1}{\lambda_S + 1}
\]

This shows that the equilibrium is costly since for \( \lambda_S > 0, P^{11} < 1 \). Moreover, since we also need \( P^{11} \geq \phi \) in order to prevent 11 from deviating, this also implies that

\[
\phi \leq \frac{1}{\lambda_S + 1}
\]

which is the condition in the Proposition.

The BSS case can be proven in a similar fashion. \( \square \)

**Proof of Proposition 3:** \( \triangleright \) As noted in the text, equilibrium prices for the low quality firms will be given by (6) and (7). Assuming that \( f^{10} = f^{01} = B \) in equilibrium (that is, that \( c_B \) is
low), a deviation by 10 to $P^{11}$ is unprofitable if
\[(1 - \varepsilon) \phi \geq P^{11} \lambda (P^{11})\]
where $\lambda (P)$ is the customer’s shopping policy upon seeing price $P$. A deviation by 01 is unprofitable if
\[(1 - \varepsilon) (1 - \phi) \geq P^{11} (1 - \lambda (P^{11}))\]
Combined, these two conditions imply that preventing both deviations requires the existence of a $\lambda$ such that
\[(1 - \varepsilon) \phi \geq P^{11} \lambda (P^{11}) \geq P^{11} - (1 - \varepsilon) (1 - \phi)\]
First, note that if $P^{11} = 1$ such a $\lambda$ cannot exist since this would require that
\[(1 - \varepsilon) \phi \geq \varepsilon + \phi (1 - \varepsilon)\]
which is not possible. $(1 - \varepsilon) \phi - [P^{11} - (1 - \varepsilon) (1 - \phi)] = (1 - \varepsilon) - P^{11}$ so a necessary condition for the separating equilibrium is that $P^{11} \leq (1 - \varepsilon)$. Letting $P^{11} = (1 - \varepsilon)$, then, $\lambda (P^{11}) = \phi$ as before ensures the equilibrium. Note that $P^{10} > P^{11}$ in this equilibrium. To ensure that 11 doesn’t deviate, therefore, we require that $\lambda (P^{10})$ is high enough. For example, if $\lambda (P^{10}) = 1$ – the customer only checks $\alpha_1$ if she sees $P^{10}$ – then a deviation by firm 11 to $P^{10}$ would yield the firm profits of $(1 - \varepsilon) \phi$ (same as 10’s equilibrium profits) as compared with equilibrium $\Pi^{11} = 1 - \varepsilon$.

**Proof of Proposition 4:** ∎ Straightforward from foregoing discussion.

**Proof of Corollary 2:** ∎ The low-quality equilibria do not change due to the addition of uncertainty. For the high-quality equilibrium to obtain, a sufficient condition analogous to (12) would be that $\overline{\sigma} < q < 1 - \underline{c}$. She now needs to choose $q$ to satisfy this condition. To see that this is always possible, note first that it must always be the case that Firm 11 earns non-negative profits if and only if $1 - c_B - 2c > 0$. Thus, it must always be the case that $c < \frac{1}{2}$ and that, in particular, $\overline{\sigma} < \frac{1}{2}$. Moreover, we know that it must always be the case for 11 to occur that $1 - c \geq \phi$. Otherwise, firm 11 would always deviate to 10. This implies that $\phi \leq 1 - \overline{\sigma} \leq 1 - \underline{c}$. Thus, a sufficient condition for $q < 1 - \underline{c}$ would be that $q < \phi$. Bringing this together, then, we find that as long as the consumer can choose a $q$ such that $\frac{1}{2} < q < \phi$ then the condition $\overline{\sigma} < q < 1 - \underline{c}$ surely holds. Since $\phi > \frac{1}{4}$ by assumption, this is always possible. ∎
Proof of Lemma 2: Seller-initiated information revelation restricts the firms to offering only one attribute. It is clear that any equilibrium in which the firms offer the same attribute will be characterized by Bertrand competition. One might propose an asymmetric equilibrium in which the firms offer different attributes. This can not be sustained since the firm offering \( \alpha_2 \) would always deviate to \( \alpha_1 \) at a price \( \varepsilon \) less than the other firm since it offers strictly higher expected value to the customer.\( \square \)

Proof of Lemma 3: Assume that the firms both charge some \( p' > p \). Then, each firm earns \( \Pi' = \frac{(p' - p)}{2} > 0 \). Then, by definition of equilibrium, for any \( \varepsilon \) it must be true that \( \frac{(p' - p)}{2} \geq p' - \varepsilon - p \) since a price drop of \( \varepsilon \) would gain the whole market. This implies that \( \varepsilon \geq \frac{(p' - p)}{2} \) so that any \( \varepsilon < \frac{(p' - p)}{2} \) would be a profitable deviation.\( \square \)

Proof of Lemma 4: In this equilibrium class, the firms must offer the same expected surplus to the customer. Otherwise, one of the firms would have no sales and negative profits leading to a profitable deviation. Moreover, it must be the case that \( \Pi^* (10) = \Pi^* (11) = 0 \). Assume that \( \Pi^* (11) > 0 \) and \( \Pi^* (10) = 0 \). Then 10 will deviate to \( (1, 1, B) \) and charge \( \bar{p} \) and earn \( \frac{\Pi^* (11)}{2} > 0 \). The analogous case holds if \( \Pi^* (11) = 0 \) and \( \Pi^* (10) > 0 \). If both \( \Pi^* (11) > 0 \) and \( \Pi^* (10) > 0 \), since they offer equal surplus and, thus, each sell to \( \frac{1}{2} \) of the customers, there is an incentive to drop price by \( \varepsilon \) to attract the whole market. Thus, profits are zero for both firms. This zero profit condition also implies directly that prices are \( \bar{p} \) and \( p \).\( \square \)

Proof of Lemma 5: Recall that \( \bar{p} = \text{Max} \{ c_B + 2c, \frac{1}{2} + c \} \). First, assume that \( \bar{p} = c_B + 2c \). In this case, firms earn zero profits, so they would never price below \( \bar{p} \). If one firm charged \( p' > \bar{p} \) in equilibrium, the other firm would deviate to \( \bar{p} + \varepsilon \), earning positive profits. If both firms charged some \( p' > \bar{p} \) in equilibrium, the would split the market. Thus, one of them would deviate to \( p' - \varepsilon \) and gain the entire market with only second-order price effects. Now, assume that \( \bar{p} = \frac{1}{2} + c \). Any price below \( \bar{p} \) would, then, not be a symmetric high-quality equilibrium since, from (19), the firm would deviate to \( (1, 0) \). The argument regarding higher prices is analogous to the \( \bar{p} = c_B + 2c \) case.\( \square \)

Proof of Proposition 5: Simply combining conditions developed above.\( \square \)