

# Information Gathering and Marketing<sup>1</sup>

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## Abstract

Consumers have only partial knowledge before making a purchase decision, but can choose to acquire more-detailed information. A firm can make it easier or harder for these consumers to obtain such information. We explore consumers' information gathering and the firm's integrated strategy for marketing, pricing, and investment in ensuring quality. In particular, we highlight that when consumers are *ex-ante* heterogeneous, the firm might choose an intermediate marketing strategy for two quite different reasons. First, it serves as a non-price means of discrimination—it can make information only partially available, in a way that induces some, but not all, consumers to acquire the information. Second, when the firm cannot commit to a given investment in ensuring quality, it can still convince all consumers of its provision by designing a pricing and marketing policy that induces some consumers to actively gather further information. This mass of consumers is sufficiently large to discipline the monopolist to invest.

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## 1 Introduction

Before deciding whether to buy a good or service, consumers often have the opportunity to gather information or simply spend time thinking about how much they would enjoy the good. Gathering or processing information is costly, in terms of money, time, and effort. A firm, through its advertising, product design, and marketing strategies, can affect these costs and make it easier or harder for consumers to assess whether a product is a good match for their needs or preferences. In this paper, we explore a monopolist firm's marketing strategy by characterizing the firm's choice of how costly it is for consumers to learn their valuations of the good. The marketing decision, of course, interacts with the firm's investment in ensuring quality and its pricing decision.

To take a specific example, a firm selling software determines prices and how much to invest in development. It can also choose how easy it is for customers to figure out their valuation of the software before they purchase it: The firm could simply list or advertise some of the applications and features; it could, additionally, illustrate these through describing the software's performance in standard tasks; or it could even allow trial versions that permit potential consumers to try the product for a period. Consumers have some initial idea of how much the software might be worth to them, but the access to additional information would allow them to research further, revise their opinions, and attain a more precise valuation of the software.

If consumers could fully inspect the good, their perceptions of it still might differ because of idiosyncratic taste differences. From the firm's perspective, making it easier for consumers to learn their valuations could have the positive effect that some of them will be willing to pay a relatively high price when they learn that the product is a good match for them; however, it, also, might have the negative effect that others learn that the product is a bad match and their willingness to pay is accordingly reduced.

When consumers are ex-ante identical in their expectations about the good, this trade-off resolves itself to one extreme or the other. Either the firm prefers to make it impossible for consumers to learn their valuations, choosing an *opaque* policy, and sells with probability one at the average valuation, or else it chooses a *transparent* policy and sells to those with high realized valuation at high prices. This is precisely the trade-off between a broad, full-market strategy or a niche-targeting one. Similar considerations have been described, for example, in Lewis and Sappington (1994) and

Johnson and Myatt (2006).<sup>2</sup> Further, it can readily be shown that if marginal costs of production are higher, the firm is more likely to prefer the costless information (niche) strategy.

However, if consumers are *ex-ante* heterogeneous (if a good match is worth more to some consumers than to others), the firm might prefer to design an *intermediate* marketing strategy, whereby consumers have access to further information about the product, but at a cost. In this case, some consumers choose to get informed, while others prefer to buy without getting informed. Indeed, the firm might prefer an intermediate information strategy even if, when dealing with each type separately, it would use the same extreme policy. In particular, a firm might pursue the same marketing strategy in two different markets, but, following integration of these markets, choose a different strategy for the combined market.

This result can arise for two different reasons. First, the firm's marketing strategy is integrated with its pricing strategy; therefore, when dealing with *ex-ante* heterogeneous consumers, an intermediate marketing strategy can act as a non-price means of discriminating between different consumer types. Highly interested consumers prefer to buy immediately, without any extra information, while less interested consumers buy only after having checked for quality. Second, an intermediate marketing strategy can also serve as an indirect form of commitment to provide quality. When some consumers verify the quality of the good and buy based on their observations, they implicitly act as monitors for the other consumers, who can buy without assessing. In other words, those assessing give the firm sufficiently strong incentives to invest in quality, even when this investment is not directly observable. This is important, for example, in the case of a new firm without an established reputation for the quality of its product.

We first provide some intuition for the first of these two considerations in a simple two-type example and, then, illustrate both in a general model. We prove that a firms are more likely to choose an intermediate marketing strategy when high-value consumers are relatively insensitive to the idiosyncratic match quality, as compared to low-value consumers. The intuition for this last result is that, in these circumstances, intermediate marketing strategies bring the *ex-post* valuations (after their choices of whether or not to acquire more information) of higher- and lower-type consumers closer to each other, and so allow the firm to extract a relatively large fraction of the surplus from the units traded. We then extend our study to the case in which firms cannot

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<sup>2</sup>See, also, Creane (2008) for a recent and interesting application of this intuition.

commit to quality and show that qualitatively the previous results also hold in this environment. In particular, intermediate marketing may also be optimal. This might result surprising, as the firm could choose a transparent strategy to overcome the commitment problem. Still, the non-price discrimination effect is strong enough to prevent the firm from completely transmitting information through marketing.

Our approach and discussion complement some recent work on the economics of advertising that is in contrast to much of the earlier literature (see Bagwell, 2007, for an excellent and thorough survey). In particular, we explain the diversity of advertising and marketing strategies by focusing on the informational content of advertising and its strategic use. We abstract from the more traditional views that advertising is a costly signaling device, or that it enters into preferences directly. Closest to this paper, in terms of the question and model is Zettelmeyer (2000); however, there, the primary concern is competition, and so the model makes some restrictions in other respects. In particular, it assumes that customers are identical ex-ante; as a consequence, with a monopoly provider, agents never pay to gather information in equilibrium, in contrast to a central result and intuition in our paper. Further, Zettelmeyer does not consider the firm's commitment to investment—another central concern of our work.

In our environment, consumers make independent decisions about whether to gather information and whether to buy the good. In contrast, in search models, a consumer cannot buy the good without gathering information. In such a search model, Anderson and Renault (2006) show that an intermediate information policy (consisting in releasing some, but not all, information to consumers) can be optimal. In their setup, the optimality of intermediate information relies on overcoming the holdup associated with the costs of going to the store (the Diamond paradox) and so arises through a very different channel from the one we discuss.

Another strand of literature, considers consumers who are passive in terms of information-gathering. Johnson and Myatt (2006), for example, consider information provision to consumers, but work with an aggregate demand function, and, so, do not consider individual consumers' decisions and cannot identify the particular mechanisms that we discuss. Saak (2006) also considers a monopolist's choice of information provision to passive consumers, and shows that the firm would like to provide (ex-ante homogeneous) consumers with information that induces their posteriors to be above or below marginal cost. Anand and Shachar (2005) consider the role of advertising in

affecting a consumer’s beliefs about match quality both theoretically and empirically. Sun (2007) examines how the extent of (known) vertical quality affects a firm’s decision to release information about horizontal attributes. Finally, in related work, Bar-Isaac, Caruana, and Cuiñat (2008) explore a multidimensional good setting in which, as in this paper, consumers also gather information, but do so attribute by attribute. The study suggests that firms have strong incentives to influence the consumers’ assessment behavior.

Outside of the literature on branding and advertising, our work is related to Courty and Li (1999, 2000), in which the information that consumers have about their valuation for a good increases (exogenously) over time.<sup>3</sup> A firm can exploit this by charging different prices at different times or can offer a menu of refund contracts. Their work nicely characterizes the impact and the comparative statics of different information structures for the consumer types. Our work differs from this and other work on information disclosure, in a number of respects. First, and most significantly, we allow no discrimination through prices: There is only one “contract” offered, and all products are sold at an identical price. Second, our consumers are active in information gathering: They choose whether or not to incur a cost in learning their valuations, and the firm chooses this cost directly.<sup>4,5</sup>

## 2 Model

We consider a firm that decides: (i) how much to investment in ensuring quality for a single good; (ii) the price of the good; and (iii) the ease with which consumers can learn their valuations for it. Consumers have expectations of how much they are likely to value the good based on how much the firm has invested or, in the case in which the firm cannot commit to a given quality provision, on their inferences of how much the firm has invested. Consumers’ valuation of the good depends on their type and an idiosyncratic component. We model investment as leading to a product that is more likely to appeal to a broader range of consumers of any type. By incurring some effort that depends on the firm’s marketing strategy, consumers can learn their realized valuation before deciding whether or not to buy.

For the time being, we suppose that investment is observed by consumers, and later, in Section

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<sup>3</sup>See, also, Möller and Watanabe (2008) and Nocke and Peitz (2008).

<sup>4</sup>There is a wide literature that has considered information gathering and more-general price mechanisms. See Cremer and Khalil (1992), Lewis and Sappington (1997), Cremer et al. (1998a,b), and Bergemann and Välimäki (2002) or, in the context of auctions, Ganuza and Penalva (2006) and references therein.

<sup>5</sup>Matthews and Persico (2005) study refund policies, but their work is related to this paper inasmuch as they do so in a framework with information acquisition, and posted prices.

6, we consider the case in which it is not. The specific timing is, therefore, as follows. First, the firm decides on marketing, price, and investment strategies. Consumers observe all these choices and decide whether to acquire more information on the product and, subsequently, whether to buy it.

## 2.1 Firm

A monopoly produces a single product incurring a cost  $c(q)$  to produce  $q$  units. The product can be a good or a bad match for each consumer, and this is determined stochastically. The firm can invest a variable amount  $x$  to affect the probability that its product is a good match for a consumer. In particular, any consumer has a probability of finding a good match of  $\gamma(x) \in [0, 1]$ , where  $\gamma$  is a non-decreasing function.<sup>6</sup> Where there is no ambiguity, and, in particular, when investment is observable, we will suppress the argument for  $\gamma(x)$  and simply write  $\gamma$ .

In addition to choosing its investment strategy, the firm posts a price  $p$  for the good, and, costlessly, chooses a marketing strategy  $A \in \mathbb{R}^+$ . Consumers can choose to incur a cost  $A$  to learn the realization of their valuations before buying the good. We will refer to *transparency*, when the firm makes it costless for consumers to learn their valuation ( $A = 0$ ). When the firm makes it prohibitively costly ( $A = \infty$  or, equivalently, an  $A$  that is high enough so that no consumer verifies), we term this *opacity*. Finally, an *intermediate* marketing strategy corresponds to those interior choices of  $A$  in which some (but not all) consumers pay to learn the realization of their valuation. Introducing costs to the firm for choosing different marketing strategies would be a natural extension; however, we abstract from it to highlight the economic forces at work.<sup>7</sup>

Summarizing, the firm in this model is risk-neutral and chooses  $A$ ,  $p$ , and  $x$  to maximize its profits.

## 2.2 Consumers

There is a mass one of consumers, each of whom is potentially interested in buying one unit of the good. Consumers have a taste for quality represented by  $\theta \in [0, 1]$ , where type  $\theta$  is distributed according to some atomless probability density function  $f(\cdot)$ . Higher values of  $\theta$  correspond to

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<sup>6</sup>Matches could be independent across consumers (for example, the firm could introduce additional features that appeal to some, but not all, consumers) or correlated (in which case the investment improves the probability that the good will be of high vertical quality).

<sup>7</sup>It is not clear how these costs should change. Providing good and accurate information to consumers is costly; but it is also costly to deliberately hide and obfuscate information.

consumers who have higher valuations, on average.

However, the valuation of the good depends not only on  $\theta$ , but also on some ex-ante unknown idiosyncratic aspect that makes it a good or a bad match for the consumer. The probability that a match is good is  $\gamma(x)$ .<sup>8</sup> The utility of an agent of type  $\theta$  who purchases the good at a price  $p$  is  $g(\theta) - p$  if it is a good match and  $b(\theta) - p$  if it is bad. We assume that  $g(\theta) \geq b(\theta)$  for all  $\theta$  and that  $g(\theta)$  and  $b(\theta)$  are non-decreasing in  $\theta$ .

Before purchasing, the agent may decide to assess the quality of the good by spending  $A$ . There is no point in assessing the quality of the good if the agent plans to buy the good regardless of the quality level. Thus, assessment will take place only if the subsequent purchase decision is conditional on finding high quality.<sup>9</sup> In particular, assessment is valuable only as a form of protection or insurance against the possibility of buying a bad match. Therefore, there are only three reasonable strategies for an agent of type  $\theta$  and the corresponding expected utilities:

- Buy unconditionally without assessing  $EU_B(\theta) = \gamma g(\theta) + (1 - \gamma)b(\theta) - p$ .
- Buy conditionally after assessing  $EU_A(\theta) = \gamma(g(\theta) - p) - A$ .
- Do not buy (do not assess or buy)  $EU_N(\theta) = 0$ .

### 3 A Simple Example

To gain some intuition and to reinforce the description of the model, we briefly introduce a simple example with only two types of consumers (a “high-” and “low-type” one) and no investment decision.

The firm produces a good that, with probability  $\frac{1}{2}$ , becomes a good match and, with probability  $\frac{1}{2}$ , becomes a bad match. A low-type consumer values a bad realization of the match at 1 and a good one at 3. The high-type consumer values a bad match at 2 and a good one at 4. Suppose that half of the population are low-type consumers and that there is a constant marginal cost of production  $c$ .<sup>10</sup>

For very high or very low marginal costs, the optimal marketing strategy is going to be extreme. The intuition is in the spirit of Lewis and Sappington (1994). If  $c$  is low enough, extracting as much

<sup>8</sup>Note that the probability of a good or bad match is independent of  $\theta$ .

<sup>9</sup>For expositional purposes, and without loss of generality, we assume that, when  $A = 0$ , those consumers who do not condition their purchase on what they see, do not assess.

<sup>10</sup>In the notation of our model, this corresponds to  $b(0) = 1$ ,  $b(1) = 2$ ,  $g(0) = 3$ ,  $g(1) = 4$ ,  $c(q) = cq$ ,  $\gamma(x) = \frac{1}{2}$  for all  $x \geq 0$ , and there is a degenerate type distribution with  $f(0) = \frac{1}{2}$  and  $f(1) = \frac{1}{2}$ .

profit as possible entails choosing an opaque marketing strategy ( $A = \infty$ ) and a price at the low agent's average valuation ( $p = \frac{1+3}{2}$ ). The opaque marketing strategy allows the firm to maximize the price at which it can sell to all consumers. Instead, if the marginal cost of production is high enough, then many trades would be inefficient if the firm sold to all consumers regardless of the match. The firm in this case achieves maximum profits by making it costless for consumers to learn their valuation ( $A = 0$ ) and charging a price equal to the high-type consumer's valuation when he has a good match ( $p = 4$ ).

Finally, consider an intermediate value of the marginal cost. If the firm could price discriminate, it would prefer to keep both consumer-types in the dark (by setting  $A = \infty$ ) and extract the full surplus from each, or to make it costless for them to learn their ex-post valuation and charge a different high-valuation price according to the consumer's type. However, without the ability to price discriminate, the firm's optimal strategy may be different from the extreme strategies studied above. It can set the smallest positive  $A$  and highest price  $p$  in a way that a high-type consumer (just) prefers buying the good without assessing (to buying conditionally after assessing), and a low-type consumer (just) prefers buying conditionally (to not buying the good at all). Here, this entails  $p = \frac{5}{2}$  and  $A = \frac{1}{4}$ . This allows the firm to extract much of the surplus from a high-type consumer regardless of the match, and from a low-type consumer who has a good match.<sup>11</sup> This is a form of discriminating: low-types pay a price  $p$  but only half of the time.

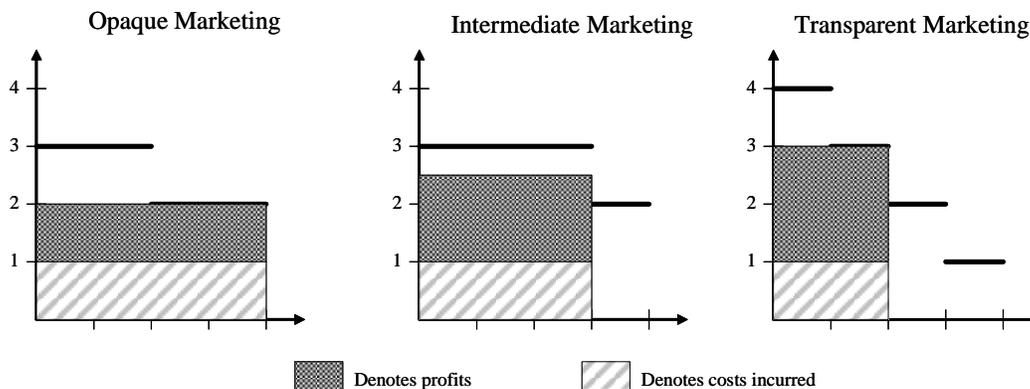


Figure 1: Ex-post demands and profits for different marketing strategies ( $c = 1$ ).

Figure 1 illustrates the different induced demand functions (that is, after consumers have chosen

<sup>11</sup>Note that the firm cannot extract all this surplus, since it chooses its marketing and pricing to deter the high-type from assessing and must provide enough surplus to induce the low-type consumer to assess.

whether or not to assess) depending on the marketing strategy chosen. Given that the marginal cost in the figure is set at an intermediate value,  $c = 1$ , an intermediate marketing strategy outperforms the other two options. It is also easy to verify on the graph that, if the marginal cost is sufficiently lower (higher), an opaque (transparent) strategy becomes optimal. Note that, at  $c = 1$  if the two types of markets were segmented, the firm would choose an opaque strategy in both of them. This apparently paradoxical result in terms of marketing strategies is not surprising once one recognizes that marketing and pricing are an integrated strategy.<sup>12</sup>

Concluding, intermediate marketing may be a valuable tool to extract surplus from consumers. It is most appealing when: (i) there is a good mix of consumer types and where, (ii) the induced valuations (after low-types choose to assess and high-types do not) are “relatively” close; and (iii) the surplus that is not captured (the difference between the value of bad matches for the low types and the marginal cost of production) is not too high.

## 4 General Results

We turn back to the general model set up in Section 2. First, we focus on consumer strategies, taking the firm’s strategy as given.

### 4.1 Characterizing Consumer Behavior

We begin by introducing two lemmas that allow the behavior of every consumer to be described in a simple way.

**Lemma 1** *If an agent of type  $\theta$  prefers assessing to buying unconditionally, then so do all agents of type  $\phi \leq \theta$ .*

**Proof.**  $\theta$  prefers assessing to buying unconditionally, and so

$$\gamma(g(\theta) - p) - A > \gamma g(\theta) + (1 - \gamma)b(\theta) - p, \tag{1}$$

which holds if and only if

$$p - \frac{A}{1 - \gamma} > b(\theta). \tag{2}$$

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<sup>12</sup>Under an opaque strategy, the firm would charge prices equal to 3 for the high-type consumers and 2 for the low-type ones. In this particular example, the firm would be indifferent between an opaque and a transparent strategy for the low-type consumers, but marginal changes to their valuations would make opaque strictly preferred while keeping the intermediate strategy as the optimal one for the integrated market.

Since  $b(\theta)$  is non-decreasing in  $\theta$ , then condition (2) holds for all  $\phi \leq \theta$ . ■

**Lemma 2** *If a consumer of type  $\theta$  prefers not to buy, then all consumers with  $\phi \leq \theta$  also prefer not to buy.*

**Proof.**  $\theta$  prefers not to buy when

$$0 > \max \{ \gamma(g(\theta) - p) - A, \gamma g(\theta) + (1 - \gamma)b(\theta) - p \}. \quad (3)$$

Both arguments of the max are non-decreasing in  $\theta$ , and so condition (3) holds for all  $\phi \leq \theta$ . ■

As a consequence of Lemmas 1 and 2, to characterize consumer behavior, it is sufficient to identify the consumers who are indifferent between buying unconditionally and assessing, between buying unconditionally and not buying, and between assessing and not buying. Consumer strategies are homogeneous within the intervals determined by such consumers.<sup>13</sup>

Let  $T_{BA}$  denote the consumer indifferent between buying unconditionally and assessing. Then,  $T_{BA}$  is implicitly defined by  $EU_B(T_{BA}) = EU_A(T_{BA})$ . By Lemmas 1 and 2, there can be, at most, one solution. If there is no solution, it is because all consumers prefer one option over the other. If  $EU_B(\theta) > EU_A(\theta)$  holds for all  $\theta$ , we define  $T_{BA} = 0$ . This is with some abuse, but has no consequences, as the mass of consumers with  $\theta = 0$  is zero. When  $EU_B(\theta) < EU_A(\theta)$  holds for all  $\theta$ , we define in a similar fashion  $T_{BA} = 1$ .

Similarly, we define  $T_{BN}$  as the consumer who is indifferent between buying without assessment and not buying.  $T_{BN}$  is implicitly defined by the equation  $EU_B(T_{BN}) = 0$ . Again, if  $EU_B(\theta) > 0$  for all  $\theta$  denote  $T_{BN} = 0$ ; and if  $EU_B(\theta) < 0$ , then  $T_{BN} = 1$ . Finally, let  $T_{AN}$  denote the consumer indifferent between assessing and not buying, implicitly defined by  $EU_A(T_{AN}) = 0$ , and if no solution exists, denote  $T_{AN} = 0$  if  $EU_A(\theta) > 0$  and  $T_{AN} = 1$  otherwise.

Note that  $T_{BN}$ ,  $T_{BA}$  and  $T_{AN}$  depend on the firm's choice of price,  $p$ , marketing,  $A$ , and investment (which appears indirectly through  $\gamma$ ), as well as all exogenous parameters of the model; however, we often suppress these arguments for notational simplicity. In the case that  $T_{BN}$ ,  $T_{BA}$

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<sup>13</sup>Note that, in some circumstances, all consumers may have the same strict preferences over some (or all) of these assessment strategies, so that no consumer is indifferent between two of these strategies.

and  $T_{AN}$  are interior they are implicitly defined as follows:

$$\gamma g(T_{BN}) + (1 - \gamma)b(T_{BN}) = p, \quad (4)$$

$$b(T_{BA}) = p - \frac{A}{1 - \gamma}, \quad (5)$$

$$g(T_{AN}) = p + \frac{A}{\gamma}. \quad (6)$$

## 4.2 The Firm's Problem

With these definitions and preliminary results, the firm's sales can be simply written down as:

$$S = \int_{\max\{T_{BN}, T_{BA}\}}^1 f(\theta)d\theta + \gamma 1_{T_{BA} > T_{AN}} \int_{T_{AN}}^{T_{BA}} f(\theta)d\theta, \quad (7)$$

where  $1_{T_{BA} > T_{AN}}$  is an indicator function that takes the value 1 if  $T_{BA} > T_{AN}$  and 0 otherwise. The first integral in (7) corresponds to sales to consumers who buy without assessment, and the second expression corresponds to those who assess and buy only when they find high quality, which occurs with probability  $\gamma$ .

The firm's problem, then, is to choose  $(A, p, x)$  in order to maximize profits:

$$\Pi = pS - c(S) - x. \quad (8)$$

Note that sales  $S$  depend on  $T_{BN}$ ,  $T_{BA}$  and  $T_{AN}$  and, therefore, on  $(A, p, x)$ .

Proposition 1 highlights implications for consumer behavior when the firm optimally chooses an intermediate marketing strategy—that is,  $0 < A < \infty$  with some consumers assessing, rather than either an opaque ( $A = \infty$ ) or a transparent ( $A = 0$ ) one.

**Proposition 1** *If intermediate marketing is strictly optimal in equilibrium, there are both consumers who assess, and consumers who buy without assessment.*

**Proof.** Suppose that the firm's optimal strategy is to choose some intermediate  $A \in (0, \infty)$ . If all consumers assess, then the firm can do better by increasing the price, and reducing  $A$  accordingly (thereby inducing identical assessment and purchase behavior). If no one assesses, then the firm can do no worse by choosing the same price and  $A = \infty$ . ■

Proposition 1 illustrates one of the two mechanisms outlined in the introduction. It is at the heart of the idea of using the marketing strategy as a non-price means of discriminating between different consumer types. Proposition 1 suggests (and this is verified below) that the marketing strategy can be profitably used as a means of inducing different consumer types to behave differently.

All of the above has the following implications.

**Corollary 1** *If intermediate marketing is strictly optimal, there is some interior threshold  $T_{BA}$  above which all types buy without assessment and lower types assess and, possibly, another threshold  $T_{AN}$  below which consumers do not buy.*

**Proof.** Immediate consequence of Lemmas 1 and 2, and Proposition 1. ■

**Corollary 2** *If intermediate marketing is optimal for the firm, there must be variation in the value of a bad match—i.e.,  $b(\theta)$  cannot be constant. In particular, agents must be heterogeneous.*

**Proof.** By Proposition 1, it is necessary that some agents prefer to assess and others buy without assessment. Suppose that some type  $\theta$  prefers to buy without assessment and some type  $\phi$  prefers to assess. Then, as in (2), it must be that  $p - \frac{A}{1-\gamma} \leq b(\theta)$  and  $p - \frac{A}{1-\gamma} > b(\phi)$ , which would contradict that  $b(\theta)$  is constant in  $\theta$ . ■

Another necessary condition for intermediate marketing to be optimal is that  $b(1) > \min_q \frac{c(q)}{q}$ . Indeed, if this condition fails, the optimal marketing strategy is either transparency or simply to make no sales. The intuition is clear: Intermediate or opaque marketing strategies allow the firm to make sales even when matches are bad. However, if bad matches unambiguously destroy surplus, there is no advantage to making such sales.

Corollaries 1 and 2 contain the main intuition for why intermediate marketing can be used as a means of non-price discrimination. When intermediate marketing is optimal, there is a mass of consumers with high ex-ante valuations of the good (consumers with high  $\theta$ ) that buys without assessment. There is also a mass of consumers with lower ex-ante valuations for the good (lower  $\theta$ ) that assesses and buys only upon finding a good match. Finally, there may be a group that has very low ex-ante valuations and decides not to assess or buy. The firm is, therefore, using the marketing strategy as a way to induce consumers with low ex-ante valuations to base their consumption decision on their ex-post valuations. The firm can sell to those with a good idiosyncratic match

even if their ex-ante expected valuation is below the price. At the same time, consumers with high ex-ante valuations remain “in the dark” and base their purchase on their ex-ante average valuations.<sup>14</sup> Just as in Section 3, the valuations after the information-gathering decisions might end up relatively less-dispersed and allow, the monopolist to extract relatively more of the consumer surplus.<sup>15</sup>

However, the firm cannot directly discriminate between consumers in terms of information provision, so different assessment behaviors have to be achieved indirectly through the right marketing policy  $A$ . Assessment can be seen as paying a premium  $A$  that insures against a bad match. Therefore, for some consumers to assess and for some not to, there must be heterogeneity in their valuations of a bad match. Given that low valuations are increasing in the type, the firm can select an  $A$  such that high  $\theta$  consumers do not verify, while some low  $\theta$  ones do.

It is important to stress that the results, so far, are fairly general, as they do not depend on the particular choice of consumer utility functions or the type distribution. In the following section, we focus on the family of linear utility functions with uniformly distributed types. This allows us to write explicit expressions for  $p$  and  $A$  to gain additional intuition about when each marketing strategy is optimal. In particular, we show that there exist a range of parameters for which an intermediate marketing policy becomes optimal.

## 5 The Linear-Uniform Case

In this section, we make some more-specific assumptions on the model to fully characterize the equilibrium. We demonstrate that intermediate marketing and discrimination can arise, and we explore the role of consumers’ preferences for these phenomena to happen. Specifically, suppose that  $c(q) = cq$ , the distributions of consumers is uniform on  $[0, 1]$ , and valuations are linear in type so that  $b(\theta) = b + s\theta$  and  $g(\theta) = g + (s + \Delta)\theta$ . Suppose, also, that investment is a binary decision and (abusing our notation slightly) that the probability of a good match is  $\gamma$  if the firm makes an investment at cost  $k$  and 0 otherwise. Note that our earlier assumptions on  $b(\theta)$  and  $g(\theta)$  require that  $g \geq b$ ,  $s \geq 0$ ,  $\Delta > (b - g)$  and  $s + \Delta \geq 0$ .

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<sup>14</sup>In other words, intermediate marketing acts as a broad market strategy with high ex-ante valuation consumers, while it acts as a niche strategy with low ex-ante valuation ones.

<sup>15</sup>A similar desire to induce ex-post similar valuations is familiar from the literature on bundling, as in Adams and Yellen (1976), in which negative correlation in valuations of different bundle components leads to relatively similar valuations of the bundle, and so allows the seller to, in effect, more accurately assess the consumer’s valuation and, thus, extract more surplus.

The firm wants to maximize profits by choosing  $(A, p, x)$ . From Equations (7) and (8), we can write down the firm's profit function (using the assumption that  $\theta$  is uniformly distributed) as:

$$\Pi = (p - c) [(1 - \max\{T_{BN}, T_{BA}\}) + \gamma(T_{BA} - T_{AN}) \cdot 1_{T_{BA} > T_{AN}}] - k \cdot 1_{invest}, \quad (9)$$

where  $1_{T_{BA} > T_{AN}}$  is an indicator function that takes the value 1 when  $T_{BA} > T_{AN}$  and 0 otherwise, and  $1_{invest}$  is an indicator function that takes the value 1 when the firm invests and 0 otherwise.

Given that the investment decision is binary, we treat each case separately. First, we consider the (less interesting) case in which the firm makes no investment. Then, the marketing strategy is irrelevant: Consumers never consider assessing as they have no doubts that the match will be bad. Thus, we can conclude that  $T_{BA} = T_{AN} = 0$ . Using Equation (4), we obtain  $T_{BN} = \max(\min(\frac{p-b}{s}, 1), 0)$  and profits simplify to  $\Pi = (p - c)(1 - T_{BN})$ . Depending on the values of the parameters, the optimal price results in either an interior solution with  $p_{NI}^* = \frac{b+c+s}{2}$  and profits of  $\Pi_{NI}^* = \frac{(b-c+s)^2}{4s}$ , or a corner solution of either  $p_{NI}^* = b$  and  $\Pi_{NI}^* = b - c$ , or  $p_{NI}^* \geq b + s$  and  $\Pi_{NI}^* = 0$  (which is equivalent to not operating and no sales).

Now, we analyze the more interesting case in which the firm invests in quality. We can characterize consumer behavior in terms of the parameters using Equations (4), (5), and (6), as follows:

$$T_{BN} = \max(\min(\frac{p - g\gamma - (1 - \gamma)b}{s + \Delta\gamma}, 1), 0), \quad (10)$$

$$T_{BA} = \max(\min(\frac{(p - b)(1 - \gamma) - A}{s(1 - \gamma)}, 1), 0), \text{ and} \quad (11)$$

$$T_{AN} = \max(\min(\frac{A - (g - p)\gamma}{(s + \Delta)\gamma}, 1), 0). \quad (12)$$

These are illustrated in Figure 2 below for the intermediate case. Note that by assessing rather than always buying, an agent saves the cost of paying a price  $p$  that is above his valuation (in case of a low realization). He gains this benefit (equal to  $p - b + \theta s$ ) with probability  $1 - \gamma$ , but must pay a cost  $A$ . Similarly, in assessing rather than never buying, a consumer gains a surplus  $\gamma(g + (s + \Delta)\theta - p)$  (by buying the well-matched product with probability  $\gamma$ ), which must outweigh the cost of assessment  $A$  (which is always paid) for assessment to be worthwhile.

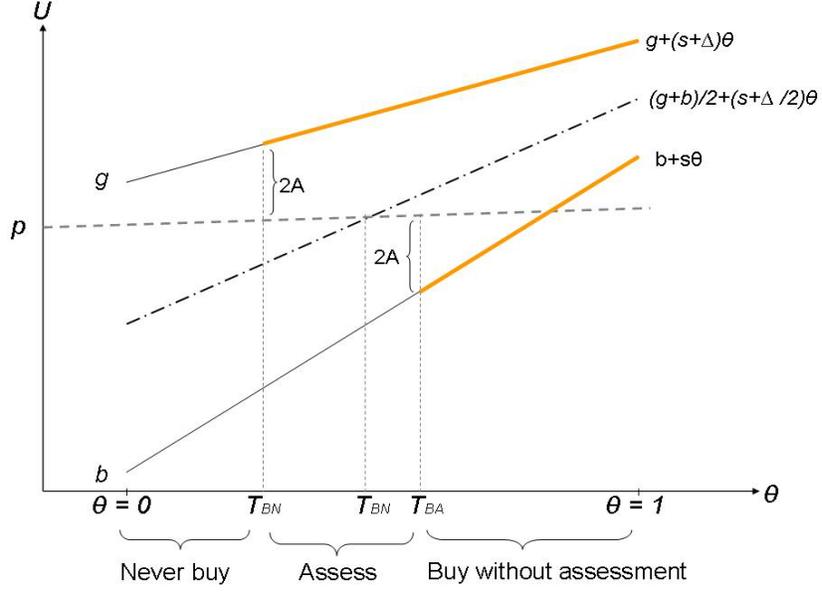


Figure 2: Characterizing consumer behavior.

A straight first-order condition approach to obtain the optimal marketing and price choices is cumbersome because of the possibility of corner solutions. Thus, we consider different cases separately, depending on the choice of marketing. In Appendix A, we fully characterize the optimal solutions under transparency ( $A = 0$ ) and opacity ( $A = \infty$ ). Each of them is a standard monopolist problem with a simple linear demand (piece-wise linear in the case of  $A = 0$ ). Here, we consider the intermediate marketing case in detail, as this is the case that best provides intuitions. An optimal intermediate marketing strategy, following Proposition 1, requires  $1 > T_{BA} > T_{AN} \geq 0$ . In this case and using (11) and (12), we can rewrite the firm's profits from Equation (9) as

$$\Pi_{Int} = (p - c) \left[ 1 - \frac{(p - b)(1 - \gamma) - A}{s(1 - \gamma)} + \gamma \left[ \frac{(p - b)(1 - \gamma) - A}{s(1 - \gamma)} - \max\left(\frac{A - (g - p)\gamma}{(s + \Delta)\gamma}, 0\right) \right] \right] - k. \quad (13)$$

Note that, as a consequence of our assumptions on the linearity of valuations in the type and the uniform distribution of types, this expression is linear in  $A$ . Thus, it is optimal to increase or decrease  $A$  up to the point where some constraint is binding. Since intermediate marketing requires that  $1 > T_{BA} > T_{AN} \geq 0$ , the only constraint that might bind is that  $T_{AN} \geq 0$ . In particular, this

constraint binds when  $\Pi_{Int}$  is decreasing in  $A$ , which, in turn, requires that  $\frac{1}{s(1-\gamma)} + \gamma(-\frac{1}{s(1-\gamma)} - \frac{1}{(s+\Delta)\gamma}) = \frac{1}{s} \frac{\Delta}{s+\Delta} < 0$ . A necessary and sufficient condition is that  $\Delta < 0$ .<sup>16</sup> Further, the optimality of intermediate marketing requires that  $T_{BA} \in (0, 1)$  which can be shown to require that  $s$  is sufficiently high.

**Proposition 2** *If there is more variation in the value of bad matches than of good matches (that is  $s > s + \Delta > 0$ ), and there is sufficient variation in the value of bad types ( $s > 0$ ), then intermediate marketing is optimal in the linear-uniform case with observable investment. In this case, the optimal marketing strategy is given by  $A^* = (g - p)\gamma$ , the optimal price is given by  $p_{Int}^* = \frac{s+c+b(1-\gamma)+g\gamma}{2}$  and maximized profits are given by  $\Pi_{Int}^* = \frac{(s-c+b(1-\gamma)+g\gamma)^2}{4s} - k$ .*

**Proof.** It follows from the above discussion: Note that setting  $T_{AN} = \frac{A-(g-p)\gamma}{(s+\Delta)\gamma} = 0$  determines  $A^*$ . Then solving the firm's pricing problem leads to the optimal price and maximized profits derived in the statement of the proposition. Finally, the feasibility of this solution requires  $T_{BA}^{Int} = \frac{s+c-b(1-\gamma)-g\gamma}{2s} \in (0, 1)$ , which is satisfied if  $s$  is sufficiently high. Finally, note that our setup requires that  $s + \Delta \geq 0$ ; that this inequality should hold strictly follows from Corollary 2. ■

Proposition 2 states that a necessary condition for intermediate marketing to be optimal is that high-value customers are relatively insensitive to quality ( $\Delta < 0$ ). The intuition for this is similar to an intuition discussed above. When  $\Delta < 0$ , the ex-post valuations induced by an intermediate strategy (that is, the value of good matches for lower types, and average valuations for higher types) might all be fairly similar, so that a single price allows the monopolist to extract much of the surplus.

Note that assuming a higher or lower sensitivity to quality for high-types are both plausible alternatives, depending on the setting. For example, if consumers have similar preferences but vary in income, then wealthier (high-value) consumers are likely to be more sensitive to quality.<sup>17</sup> In contrast, if someone has a greater need, he might have higher willingness to pay but be less sensitive to quality (for example, a starving person). Another possible example of low sensitive types are extremists/aficionados. Think of a science-fiction film, a fanatic of the genre might have a higher average valuation but be relatively insensitive to quality compared to an occasional viewer, who would gain only by watching a film that is a good match.

<sup>16</sup>Note, that parametric restrictions already require that  $s + \Delta \geq 0$ .

<sup>17</sup>This is the standard model of vertical differentiation, as articulated, for example, in Tirole (1988) p.96.

**Comparing alternative marketing strategies.** With a characterization of optimal profits and feasibility conditions for all the possible different regimes (intermediate above, and transparent and opaque in Appendix A), we can compare them and choose the highest feasible profit among them. Figure 3 illustrates this for a particular choice of parameters. It shows how the optimal marketing and investment strategies vary with  $s$  and  $c$ , when  $b = 1$ ,  $g = 3$ ,  $\Delta = -0.5$ ,  $k = 0.2$  and  $\gamma = 0.5$ .

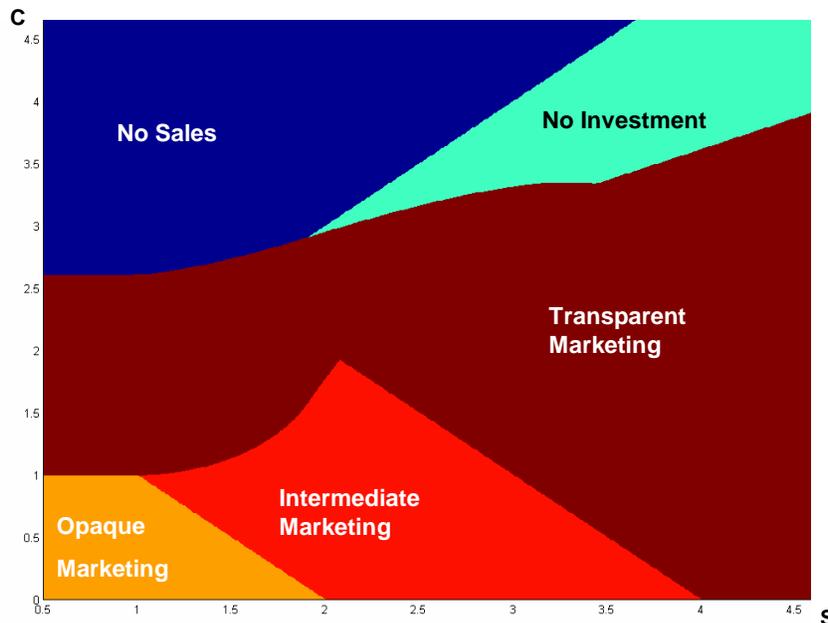


Figure 3: Marketing and investment strategies with observable investment.

First, it is clear that when  $c$  increases, the trade-off between higher margin and higher volume tilts in the direction of increasing margins. This implies that the firm should choose a more transparent marketing strategy. This can also be easily formalized by comparing the derivatives with respect to  $c$  of the profit functions of each of the marketing strategies. For example, when  $s = 1.5$ , then the marketing strategy changes from opaque, to intermediate, to transparent, and, finally, the firm would make no sales as  $c$  increases (a shift up in the graph). Note that in regions where both  $s$  and  $c$  are relatively high, in equilibrium, the firm sells a relatively low quantity: Since investment is a fixed cost, the firm prefers not to invest. In this case, since  $s$  is high, it can still make sales to high  $\theta$  consumers, but in this region, since consumers are certain of bad matches, the marketing strategy is irrelevant.

Fixing  $c$ , increasing  $s$  increases the dispersion in the valuations of different types of agents. As suggested by Corollary 2 and Proposition 2, intermediate marketing is optimal only when  $s$  is sufficiently high, so that there is dispersion in valuations of different types of agent, who, therefore, choose different assessment strategies. Note that while increasing  $s$  continues to increase such dispersion in valuations, for high enough values of  $s$  (in particular, for  $s > 2$ ), bad matches for the highest types are more valuable than good matches for lower types. When  $s$  is high enough, therefore, the firm can discriminate between consumers and induce different behaviors with a transparent marketing strategy (with the highest type buying regardless of the realized match and lower types buying only after observing that the match is good). Moreover, assessment is a deadweight loss in this environment. As a result, for high enough values of  $s$ , transparent marketing is preferred to intermediate marketing.

Note that Corollary 2 implies that when consumers are homogeneous, the marketing strategy has to be extreme (transparent or opaque). If the firm could perfectly discriminate among heterogeneous consumers, it might choose the same extreme marketing strategy for all of them (albeit with different prices). Surprisingly, if the firm were then forced not to discriminate, intermediate marketing could be optimal.<sup>18</sup> As a consequence, a firm that served two markets and employed the same marketing strategy in each, could choose a different marketing strategy if these two markets were integrated.

## 6 Unobserved Investment

So far, we have assumed that consumers directly observe the level of investment. However, there are applications in which it is not observable—in particular, when the firm is not sufficiently established that it can commit to a given quality standard through reputation. In this case, consumers that assess and buy conditionally play an additional role: namely, as quality monitors for those that buy unconditionally. Marketing can act as a form of indirect commitment: By inducing the right number of consumers to verify, the firm will invest in quality.

We now adapt the model and suppose that consumers do not observe the firm's investment level. Consumer behavior depends on the actual price and quantity, as above; however, it depends

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<sup>18</sup>When the firm can discriminate, for each  $\theta$ , it can choose (i) either an opaque strategy with an optimal  $p = \frac{b+s\theta+g+(s+\Delta)\theta}{2}$  and earn  $(p - c)$ ; or (ii) a transparent one at  $p = g + (s + \Delta)\theta$  and earn  $\frac{p-c}{2}$ . Trivially, if  $b > c$ , the firm prefers an opaque strategy for every type. However, when discrimination is not possible, as can be seen in Figure 3, for example, at  $c = 0.5 < 1 = b$ , any marketing strategy (and, in particular, an intermediate one) can be optimal. A similar result is shown in the example in Section 3.

on anticipated (rather than actual) investment. That is,  $T_{BN}$ ,  $T_{BA}$  and  $T_{AN}$  will be functions of  $(A, p, x^e)$  where  $x^e$  represents the consumers' expectation of firm behavior. In equilibrium, consumers will accurately anticipate the firm's investment.

As in Section 4.2, the firm's problem is still to choose  $A$ ,  $p$  and  $x$  in order to maximize profits, which are given by:

$$\Pi = pS - c(S) - x, \quad (14)$$

where the sales  $S$  depend on  $T_{BN}$ ,  $T_{BA}$  and  $T_{AN}$  and through them on  $(A, p, x^e)$ . As already mentioned, in equilibrium,  $x^e = x$ . Thus, in equilibrium, it is as if there were an additional "incentive-compatibility" constraint: The firm must have no desire to choose an investment level from different the expected one. Note that the purchase behavior of consumers who buy without assessment (or regardless of the outcome) and of consumers who never buy are based on expected investment and are entirely unaffected by the firm's actual investment. The firm's actual investment affects only the purchase of those who assess and condition their purchase on the realization. Thus, to sustain an investment  $x^* > 0$ , the firm must be optimizing with respect to those who are assessing:

$$x^* = \arg \max_x (p - c) \left( \gamma(x) 1_{T_{BA} > T_{AN}} \int_{T_{AN}}^{T_{BA}} f(\theta) d\theta \right) - x \quad (15)$$

There are a couple of consequences. First, note that Proposition 1 also applies when investment is unobservable, since the deviations suggested in its proof would not change the consumer behavior, and, so, would not change the level of investment in equilibrium. Second, and perhaps more directly, when investment is unobserved, if a firm chooses an opaque strategy, then sales do not depend on investment (the right-hand side of Equation (15) is 0). As a consequence, the firm would not invest and consumers would anticipate this, proving the following result.

**Proposition 3** *When investment is unobservable, opaque marketing ( $A = \infty$ ) is strictly optimal only if there is no investment ( $x = 0$ ).*

This proposition is central to understanding the second mechanism described in the introduction. It is at the heart of the idea that the marketing strategy is employed as a means of committing to investment.

Next, we prove a couple of results. The first one compares different equilibria when investment is not observable. The second compares the case in which investment is observed to the one in which it is not.

When the firm's investment cannot be observed, in principle, there may be multiple equilibria. For example, suppose that  $\gamma(0) = 0$ , and consider a set of parameters for which there exists an equilibrium with positive quality investment and some consumers assessing. For this same case, there also exists another equilibrium in which there is no investment: If consumers believe that the firm makes no investment, they will be certain of a bad match; therefore, they would have no reason to assess the product (even if it is costless to do so). Given this, the firm, indeed, has no reason for investment.

The following result shows that taking the observed choices as fixed, all consumers and the firm agree on the ranking among multiple equilibria. This leads to a natural equilibrium selection criterion: We assume that for a given price and marketing strategy, the equilibrium played is the Pareto dominant one. This criterion is later used for the characterization and comparative statics of Section 7.

**Proposition 4** *Given fixed values of  $A$  and  $p$ , for any two equilibria with different investment levels, there is one that Pareto dominates the other. That is, the equilibrium with higher profits is also the one preferred by all consumers.*

**Proof.** Suppose that there are two equilibria, 1 and 2, and denote profits, quantity sold and investment by  $\Pi_i$ ,  $S_i$  and  $x_i$  for  $i = 1, 2$ , respectively, with  $x_1 > x_2$ .

First, note that in equilibrium 1, a consumer could behave as in equilibrium 2, and achieve at least the same expected utility as in equilibrium 2. Thus, given that  $x_1 > x_2$ , each consumer is at least as well off in equilibrium 1 as in equilibrium 2.

Second, note that  $S_1 \geq S_2$ . The logic here is as follows: If a given type  $\theta$  buys without assessment in equilibrium 2, then she buys without assessment in equilibrium 1. If a type  $\theta$  assesses in equilibrium 2, then in equilibrium 1, she will either assess or buy without assessment. Finally, if a type  $\theta$  does not buy in equilibrium 2, then she is only more likely to buy in equilibrium 1. In all cases, since  $x_1 > x_2$ , sales in 1 can be no lower than sales in 2.

Finally, we show that  $\Pi_1 \geq \Pi_2$ . Suppose, for contradiction, that  $\Pi_2 > \Pi_1$ . Then, in equilibrium

1, the firm would have a profitable deviation to invest  $x_2$ . This follows since sales under this deviation,  $S_D$ , can be no lower than the sales in equilibrium 2: The investment is the same and consumers are only more prone to assess and buy if they believe they are in equilibrium 1 (any consumer-type who buys without assessment in equilibrium 2 will do the same in this deviation, while the rest of consumers are only more likely to buy in the deviation). Therefore, deviation profits  $\Pi_D = pS_D - x_2 \geq pS_2 - x_2 = \Pi_2 > \Pi_1$ , which provides the contradiction. ■

Our final result contrasts the cases in which investment is observed and is not observed.

**Proposition 5** *If transparent marketing ( $A = 0$ ) is optimal for a firm when investment is observable, then it is also optimal when investment is not observable.*

**Proof.** When  $A = 0$ , consumer behavior is entirely determined by  $b(\theta)$ ,  $g(\theta)$  and  $p$ . A consumer  $\theta$  buys unconditionally if  $p < b(\theta)$ , buys conditionally if  $b(\theta) < p < g(\theta)$ , and never buys if  $p > g(\theta)$ . Thus, for a given  $p$ , when  $A = 0$ , consumer behavior is independent of the investment  $x$ .

Take the optimal choice  $(A^* = 0, p^*, x^*)$  by the firm when investment is observable.  $x^*$  is the solution to the maximization of  $(p^* - c)S(x) - x$ , where  $S(x)$  is given by (7) evaluated at  $A^* = 0$  and  $p^*$ . Note that when  $A^* = 0$ , given the above,  $T_{BA}$ ,  $T_{AN}$ , and  $T_{BN}$  do not depend on  $x$ . So, one can easily see that this program is equivalent to the one in (15). It follows, therefore, that  $(A^* = 0, p^*, x^*)$  is feasible when investment is unobservable, as well. Trivially, this is, then, the solution to the unobservable investment case. ■

The main message of this section is that when quality investment is unobservable, the only incentive of the firm to invest comes from the consumers that verify quality and buy conditionally. This suggests that, compared to the case in which the firm can commit to quality, the inability to commit leads to higher transparency. Again, to fully characterize equilibrium, demonstrate the existence of regions where intermediate marketing does indeed arise, and to run some comparative statics, we use linear utility functions and a uniform distribution of consumer types.

## 7 The Linear-Uniform Case with Unobserved Investment

We can follow the analysis in Section 5 and, now, consider the case in which consumers do not observe investment. We use Proposition 4 to select the Pareto optimal equilibrium among the multiple ones that may arise for a given choice of  $A$  and  $p$  (which are observed by all consumers and chosen by the firm).

Recall that, for the linear-uniform case, we assume a simple investment function, whereby with no investment a bad match is realized with certainty, but if the firm invests at cost  $k$ , the probability of a good match is  $\gamma$ . The condition that determines the investment level, Equation (15), yields that there is investment if and only if

$$\gamma(p - c)(T_{BA} - T_{AN})1_{T_{BA} > T_{AN}} \geq k. \quad (16)$$

That is, the firm invests only if the costs of doing so are smaller than the profits generated from those consumers buying conditionally.

As in Section 5, when the firm makes no investment, it earns  $\Pi_{NI}^* = \max\{0, \frac{(b-c+s)^2}{4s}, b - c\}$ . Suppose that the firm invests in quality in equilibrium; following Proposition 3, it cannot be choosing an opaque strategy. Thus, if the firm does invest, it does so while choosing either an intermediate or a transparent marketing policy. As in Section 5, we can consider maximized profits under these marketing strategies, recognizing that (16) may bind. The analysis in Appendix B allows us to compare these different strategies.

**Comparing alternative marketing strategies.** In parameter ranges in which the investment incentive constraint (16) does not bind, all results must be identical to those in Section 5. Further, the first part of Proposition 2 (that the optimality of intermediate marketing requires  $s > 0$ ) applies for a firm with unobservable investment. This is easily verified, since, if  $s = 0$ , with intermediate marketing either  $T_{BA}^{Int} = \infty$  or  $T_{BA}^{Int} = T_{AN}^{Int}$ ; both these outcomes suggest that intermediate marketing cannot be optimal.

Outside of these parameter ranges, however, the remaining results need not be true. In particular, when  $\Delta > 0$ , for example, at  $b = 1$ ,  $g = 3$ ,  $s = 2$ ,  $\Delta = 1$ ,  $k = 0.2$ ,  $\gamma = 0.5$  and  $c = 0.1$ , it can be easily verified that intermediate marketing is preferred.

Figure 4 illustrates optimal marketing strategies at the same parameter values as Figure 3 ( $b = 1$ ,  $g = 3$ ,  $\Delta = -0.5$ ,  $k = 0.2$  and  $\gamma = 0.5$ ).

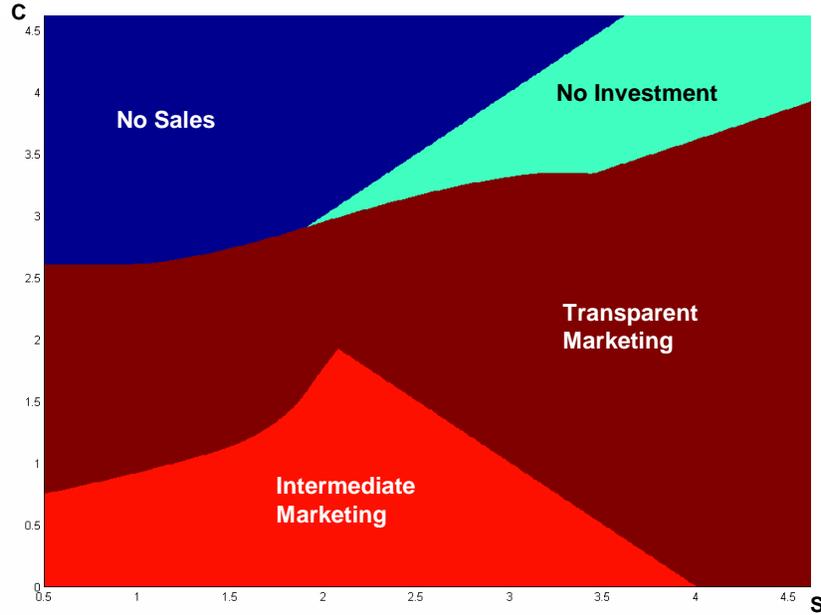


Figure 4: Optimal investment and marketing strategies with unobservable investment.

Comparing the optimal strategies in the two figures, when investment is not observable, opaque marketing is never optimal, as proven in Proposition 3. However, although reducing  $A$  is a way to commit to investment, the non-price discrimination effect continues to operate and may prevent the firm from allowing consumers free access to information. In particular, in the parameter region for which opaque marketing is optimal when investment is observable, then under non-observable investment, both transparent marketing and intermediate marketing can become optimal. For low values of  $s$  and  $c$  (where the profit per unit earned is relatively high, so the IC condition is easier to satisfy), intermediate marketing is preferred; but for higher values of  $c$ , where the firm charges a higher price and sells fewer units, it is more difficult to satisfy (16) under intermediate marketing, and transparent marketing is preferred.

## 8 Conclusions

We have presented a simple framework in which marketing strategies interact with investment in quality provision and pricing policies in an environment in which agents need to exert effort to learn their valuation of a good and are heterogeneous in their tastes. Marketing strategies are modeled in a reduced form in which the firm can make it more or less difficult for consumers to learn their

true valuation for the good. Quality provision is modeled as a productive effort that improves the probability of a good match between consumers and the good.

With heterogeneous consumers, the firm may decide on an intermediate marketing strategy to sort different types of consumers into different assessment behaviors. This may happen even when, in isolation, each consumer would face the same extreme marketing. Summarizing, we show that both informative advertising and obfuscation strategies can be the result of optimal behavior by firms and, further, that (in contrast to the case of ex-ante homogeneous consumers) extreme marketing strategies may not always be optimal. The interior marketing strategy can be considered as a (non-price) means of discriminating between consumers, as suggested in Proposition 1.

In addition to this trade-off of quantity vs. markup, if the firm cannot publicly commit to providing high quality, a further effect is at work, as highlighted in Proposition 3. Here, a way to indirectly commit to invest in quality is to choose a sufficiently transparent policy that induces consumer assessment and disciplines the firm. However, the non-price discrimination concern still operates and the inability to commit need not lead to transparency. In particular, there are cases with intermediate marketing in which some consumers verify the quality of the good and buy conditionally, while others buy unconditionally. In this case, there is an externality at work: The consumers that verify the quality of the good force the firm to exert effort in quality provision that also benefits consumers who buy unconditionally.

The paper has considered a monopoly provider. In a competitive market, information provision can play an additional role—it can soften price competition by creating some product differentiation, as in Meurer and Stahl (1994) and Hotz and Xiao (2007). Therefore, this differentiation motive can push towards more transparent marketing policies. However, and particularly if firms offer ex-ante differentiated products, the effects highlighted in this paper should still play a role. A full analysis of these issues lies outside the scope of this paper.

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## A Opacity and Transparency in the Linear-Uniform Case with Observable Investment

Here, we characterize the optimal pricing strategies and profits under the assumption that the firm invests, first in the case that the firm chooses opaque marketing, and, next, transparent marketing.

### A.1 Opaque marketing

Under opaque marketing ( $A = \infty$ ), we have that  $T_{AN} = 1$  and  $T_{BA} = 0$ . Thus, the firm’s profits from Equation (9) can be rewritten as

$$\Pi_{Op} = (p - c)(1 - T_{BN}) - k, \quad (17)$$

where  $T_{BN} = \max(\min(\frac{p - g\gamma - b(1-\gamma)}{s + \Delta\gamma}, 1), 0)$ . Maximizing this expression with respect to  $p$ , leads to either a  $T_{BN}$ -interior optimal price of  $p_{Op}^* = \frac{s + c + b(1-\gamma) + g\gamma + \Delta\gamma}{2}$  (and profits of  $\Pi_{Op}^* = \frac{1}{4} \frac{(s - c + b(1-\gamma) + g\gamma + \Delta\gamma)^2}{s + \Delta\gamma} - k$ ), or a corner  $T_{BN}^{*,Op} = 0$  solution with  $p_{Op}^* = g\gamma + b(1 - \gamma)$  (and profits of  $\Pi_{Op}^* = g\gamma + b(1 - \gamma) - c - k$ ). Note that a corner  $T_{BN} = 1$  solution is always suboptimal, as no sales are realized, but a  $k$  investment cost is incurred.

### A.2 Transparent marketing

Under transparent marketing ( $A = 0$ ),  $T_{BA} \geq T_{BN} \geq T_{AN}$ , which simplifies the firm’s profits from Equation (9) to:

$$\Pi_{Tr} = (p - c) \left[ (1 - T_{BA}) + \frac{1}{2}(T_{BA} - T_{AN}) \right] - k, \quad (18)$$

where  $T_{AN} = \max(\min(\frac{p-g}{s+\Delta}, 1), 0)$  and  $T_{BA} = \max(\min(\frac{p-b}{s}, 1), 0)$ . As one can see, sales are a piecewise linear function of  $p$ . Thus, the optimal price expression differs depending on which part of the piecewise function is the relevant one.

First, we consider the cases in which the price is such that no consumer is excluded ( $T_{AN} = 0$ ). Choosing  $p \leq b$  and selling regardless of the realization cannot be optimal, as the firm would prefer then not to invest in quality at all. Next, if the optimal price is such that  $T_{BA} \in (0, 1)$ , then profits can be written as  $(p - c) [\gamma + (1 - \gamma)(1 - \frac{p-b}{s})] - k$ ; the maximization problem yields  $\Pi_{Tr}^* = \frac{(s+(b-c)(1-\gamma))^2}{4s(1-\gamma)} - k$ , and this happens as long as  $b < p_{Tr}^* = \frac{s+(b+c)(1-\gamma)}{2(1-\gamma)} < \min\{g, b + s\}$ . Finally, the firm can choose  $p = g$ , selling only in the case of a good match-realization, and earning  $\Pi_{Tr} = \gamma(g - c) - k$ .

Alternatively, the firm can choose a price that excludes some consumers ( $T_{AN} > 0$ ).

In the region where  $T_{BA} < 1$ , profits are given by  $(p - c) \left[ 1 - \frac{p-b}{s} + \gamma(\frac{p-b}{s} - \frac{p-g}{s+\Delta}) \right]$ . Maximizing with respect to  $p$  yields  $p_{Tr}^* = \frac{\frac{1}{2}b\Delta + c\Delta + s\Delta + bs + cs + s^2 - bs\gamma + gs\gamma - b\Delta\gamma - c\Delta\gamma}{s + \Delta(1-\gamma)}$  and maximized profits of  $\Pi_{Tr}^* = \frac{\frac{1}{4}(c\Delta - b\Delta - s\Delta - bs + cs - s^2 + bs\gamma - gs\gamma + b\Delta\gamma - c\Delta\gamma)^2}{s(s+\Delta)(s+\Delta-\Delta\gamma)} - k$ . This case requires  $p_{Tr}^* \in (g, \min\{b+s, g+s+\Delta\})$ . Finally, we consider the case with  $T_{BA} = 1$ . Profits are  $(p - c)\gamma(1 - \frac{p-g}{s+\Delta}) - k$ , which are maximized at  $p_{Tr}^* = \frac{c+s+g+\Delta}{2}$  the maximization in this case yields  $\Pi_{Tr}^* = \frac{1}{4}\gamma\frac{(g-c+s+\Delta)^2}{s+\Delta} - k$  so long as  $\max\{g, b+s\} < p_{Tr}^* = \frac{c+s+g+\Delta}{2} < g+s$ .

## B Intermediate and Transparent Marketing in the Linear-Uniform Case with Unobservable Investment

### B.1 Intermediate marketing

Following Proposition 1, an optimal intermediate marketing strategy requires  $1 > T_{BA} > T_{AN} \geq 0$ . As in Section 5, we can use Equation (13) to express profits:

$$\Pi_{Int} = (p - c) \left[ 1 - \frac{(p-b)(1-\gamma) - A}{s(1-\gamma)} + \gamma \left[ \frac{(p-b)(1-\gamma) - A}{s(1-\gamma)} - \max\left(\frac{A - (g-p)\gamma}{(s+\Delta)\gamma}, 0\right) \right] \right] - k. \quad (19)$$

However, here the firm faces the additional constraint stated in (16):

$$(p - c)\gamma \left[ \frac{(p-b)(1-\gamma) - A}{s(1-\gamma)} - \max\left(\frac{A - (g-p)\gamma}{(s+\Delta)\gamma}, 0\right) \right] > k. \quad (20)$$

Note that the left-hand side of this constraint is linear and decreasing in  $A$ . There are a number of possibilities to be considered.

First, Equation (20) might not be binding; then, the analysis of Section 5 applies, and so the firm would choose  $A^* = \gamma(g - p)$ ,  $p_{Int}^* = \frac{s+c+b(1-\gamma)+g\gamma}{2}$  and maximized profits would be  $\Pi_{Int}^* = \frac{(s-c+b(1-\gamma)+g\gamma)^2}{4s}$ . Note that the feasibility of this solution requires  $1 > T_{BA}^{*,Int} = \frac{s+c-b(1-\gamma)-g\gamma}{2s} > 0$  and the new constraint that  $\frac{1}{4}\gamma\frac{s^2 - (b(1-\gamma) + g\gamma - c)^2}{s(1-\gamma)} > k$ .

Alternatively, Equation (20) might bind. Here, there are two cases, depending, on whether  $\gamma(g-p) \geq A$ . In the case that  $\gamma(g-p) < A$ , solving for  $A$  as a function of  $p$  when (20) binds (and no other condition binds), substituting into the profit function and simplifying, we can obtain  $p_{Int}^* = \frac{c+s+\Delta\gamma+b(1-\gamma)+g\gamma}{2}$ ,  $\Pi_{Int}^* = \frac{(s-c+\Delta\gamma+b(1-\gamma)+g\gamma)^2}{2} \frac{1}{s+\Delta\gamma} - k \frac{s+\Delta}{s+\Delta\gamma}$  and the optimal marketing strategy  $A^* = \frac{1}{2}(1-\gamma)\gamma\frac{c\Delta+s\Delta-b\Delta+\Delta^2\gamma-2bs+2gs-b\Delta\gamma+g\Delta\gamma}{s+\Delta\gamma} - 2s(s+\Delta)\frac{1-\gamma}{(s+\Delta\gamma)(s-c+b(1-\gamma)+g\gamma+\Delta\gamma)}k$ . Note that we also require that  $1 > T_{BA} > T_{AN} \geq 0$ .

A final case is that (20) binds and that  $T_{AN} = 0$ , which requires that  $\gamma(g-p) > A$ . In this case, when (20) binds,  $(p-c)\gamma T_{BA} = k$ , and so  $T_{BA} = \frac{k}{(p-c)\gamma}$  and (substituting in for  $T_{BA}$ ),  $A = (p-b)(1-\gamma) - \frac{s(1-\gamma)}{(p-c)\gamma}k$ .

Substituting into the profit function, we obtain  $(p - c)(1 - \frac{1-\gamma}{(p-c)\gamma}k)$ , and so the firm sets the price as high as possible, subject to constraints. Thus, the “new constraint”  $T_{AN} \geq 0$  binds and we require  $\gamma(g - p) = A$ , which yields the two solutions to the quadratic in  $p$  given by  $\gamma(g - p) = (p - b)(1 - \gamma) - \frac{s(1-\gamma)}{(p-c)\gamma}k$ . One can substitute back to obtain maximized profits in this case.

## **B.2 Transparent marketing**

The solutions computed in Appendix A.2 are also the solutions here, because, as the proof of Proposition 5 shows, they also satisfy the incentive-compatibility constraint.