De-targeting to Signal Quality*

Xingyi Liu†

October, 2019

Abstract

It is important for firms to signal the high quality of their products to consumers in experience goods markets. Conventional wisdom suggests that a high price can be a signal of high quality. However, we argue that the role of price in signaling quality could be weakened when firms resort to the intensive use of targeting in advertising, which could attenuate the informational content of a high price. As a consequence, a high quality firm needs to distort its price more to signal its quality. However, when different levels of targeting are available, a high quality firm may find it optimal to signal its quality with a lower level of targeting.

*I am grateful to the editor, a senior editor, and three anonymous referees for numerous comments and suggestions that have greatly improved the paper. All the remaining errors are mine.

†Aston Business School, Aston University, Birmingham B4 7ET, United Kingdom. Email: x.liu29@aston.ac.uk

1 Introduction

The use of targeting technology has become an important strategy in marketing. It allows a seller to identify with higher accuracy consumers who are likely to be interested in its product, which leads to more efficient use of marketing resources. While most digital advertising channels offer better targeting than traditional mass-media such as TV and newspapers, the development of digital technology also provides sellers various means of targeting with different levels of accuracy. For instance, search advertising allows targeting with keywords, locations, or search/browsing history. Social media nowadays offer advertisers much more options of narrow targeted audience according to their locations, demographics, interests, behavior, connections, etc. Banner and display ads, especially re-targeted ones, can show ads according to what a consumer is browsing and what he/she has previously been interested in. In spite of being more accurate at reaching the desired audience, the highly targeted social media and online banner ads are outperformed by search advertising in terms of conversion rates. For instance, according to HEAP, search engines like Google and Bing almost double Facebook in conversion rates[1]. The average conversion rate for Google search ads is almost five times higher than display ads, with travel and hospitality service having seven times higher conversion rate on search than on display ads[2]. Such differences in conversion rates are, to a large extent, due to the different objectives of advertising channels. For instance, while search advertising aims more directly at generating sales, social media and display

[1] "4 Key Facts You Should Know Before Allocating Ad Spend"(March 2018), available at https://heap.io/blog/data-stories/4-key-facts-you-should-know-before-allocating-ad-spend.

[2] "Google Ads Benchmarks for YOUR Industry", available at https://www.wordstream.com/blog/ws/2016/02/29/google-adwords-industry-benchmarks.

ads focus more on generating awareness. Yet, another important factor in determining the conversion rates is consumers' trust, which is diverging for these advertising channels. For instance, according to Nielson[3], consumers trust most traditional mass-media and they trust search advertising more than social media, followed by banner ads.[4]

A key element underlining consumer trust is the uncertainty over product quality, which may be difficult or impossible to learn prior to purchase (e.g., experience goods such as travel and hospitality services, financial services, medical and dietary products). Hence, high quality firms may want to signal their quality to consumers before purchases. Conventional wisdom suggests that with repeated purchases, a high price can be a credible signal of high quality. However, with the possibility of targeting, even a firm with a low quality product can charge a high price to its advertised consumers, provided that these consumers are carefully selected to have stronger preferences for the firm's product. Thus, when receiving an ad promoting a new product at a high price, a consumer may wonder whether the product is of real good quality or just he/she is being targeted and offered a high price (i.e., a low quality firm pretending to be of a high quality). For instance, a consumer may be more skeptical when he/she sees a highly personalized display ad which is clearly related to his purchase or browsing history, compared to when he/she sees a search ad knowing that all consumers in a similar geographical area would receive the same ads when searching the keyword. That is, targeted advertising may dilute the informational content of the ads,

[3] "Global Trust in Advertising", September 2015.

[4] Similar results are found in a more recent survey by MarketingSherpa (2017), which shows the level of trust for different advertising channels when making a purchase decision: Print ads (82%), TV ads (80%), Search engine ads (61%), Social media ads (43%), Online banner ads (39%), Online pop-ups (25%). Available at https://www.marketingsherpa.com/article/chart/channels-customers-trust-most-when-purchasing.

especially the signaling value of a high price, and interfere with consumers' perception of the quality of the advertised product. This becomes more likely as more and more consumers become aware of targeted ads[5] and worry about being exploited[6]. Hence, a high quality firm may adopt a marketing strategy with less targeting, so as to make its quality signal more credible. This may have the further consequence that consumer trust deteriorates on the highly targeted advertising channel as more high quality firms opt for less targeting. Our results then offer an insight into the decline of banner and display ads[7], the varying conversion rates for different advertising channels, and may also shed light on the move of Facebook towards more transparency for advertising on its platform by disclosing to its users if an ad they're seeing is served up because of info supplied by a data broker[8].

Specifically, we investigate the impact of targeting on quality signaling in a two-period model à la Milgrom and Roberts (1986): A monopoly firm sells an experience good, of which a consumer's valuation depends on both the quality and a horizontal match value. To reach consumers, the firm engages in informative advertising by sending out advertising messages informing consumers about the existence, characteristics, and price of the product. A consumer learns the existence of the product, the match value, and the price when he receives an ad from the firm. However, the quality, which can be high or low, is known by

[5] "Survey: 3 Out Of 4 Consumers Now Notice Retargeted Ads", December 12 2013, https://marketingland.com/3-out-4-consumers-notice-retargeted-ads-67813.

[6] According to Samat et al. (2017), being exploited for money is the second biggest concern apart form privacy concerns for targeted advertising.

[7] MAGNA Advertising Forecast, Spring 2018, available at https://magnaglobal.com/video-global-ad-forecast-june-2018/.

[8] "Facebook sets new rules to regulate targeted advertising", June 13 2018, https://www.cnet.com/news/facebook-sets-new-rules-to-regulate-targeted-advertising/.

the firm but can only be learned by a consumer after consumption in the first period.[9] To guide his/her purchase decision in the first period, a consumer makes inferences about the quality from the observed price, and the consumer returns to the firm to purchase in the second period again if the learned quality justifies the advertised price. As shown in the literature, with repeated-business effect at work, the high quality firm can signal its quality with a high price in equilibrium: the low quality firm charges the complete information price, whereas the high quality firm distorts its price upwards and charges a price higher than the complete information level.

The use of targeting technology provides the firm with an informative but imperfect signal about a consumer's match value, this allows the firm to target its ads towards consumers with higher match values. We consider this effect of targeting in a simple way: a higher level of targeting increases the match values of the advertised audience in the sense of First-Order Stochastic Dominance, i.e., the proportion of consumers with match value higher than a threshold is higher with a higher level of targeting. This has a direct positive effect on the profit of the firm regardless of its quality. But this also has an indirect effect on the signaling cost, i.e., it affects the inference of a consumer about the unobserved quality. As what becomes clear in the analysis, the signaling cost depends crucially on the mass of departing consumers from the mimicking low quality firm in the second period. When this mass is decreasing as the level of targeting increases, the incentive of the low quality firm to mimic the strategy of the high quality firm becomes higher, as the future loss is reduced. This makes the high price alone a less credible signal of high quality. Thus, in order to signal its

[9] Although different sources of information, e.g. customer reviews, provide some information on the quality, such information is inaccurate, especially when it is confounded with consumer-specific preferences.

quality and induce the correct inference on quality from consumers, the high quality firm needs to distort its price even more, which reduces the premium earned by the high quality firm.

Therefore, when consumers can perceive the difference in the extent of targeting, the high quality firm may find it optimal to opt for less targeting so as to better signal its quality. For instance, different advertising channels have different capacity of targeting. A general newspaper offers less targeting than a specialized one (e.g., a sports newspaper); Online markets usually offer more targeting capacity than offline markets (e.g., social network vs. TV). Different online advertising channels also offer different options of targeting as we discussed at the beginning, where in general search advertising is less targeted compared to social media advertising and banner ads. Firms may also opt out of targeting completely by appearing only in the organic search results. This is further facilitated by the fact that with more and more transparency of data collection and data usage on the Internet, it has become easier for consumers to tell whether they are seeing targeted or non-targeted ads. For instance, Google Sponsored Ads are displayed separately from generic search results, similarly for Amazon Sponsored Products. Facebook also moves towards more transparency for advertising on its platform. Since July 2018, Facebook requires advertisers to tell its users if an ad they're seeing is served up because of info supplied by a data broker.

Thus, when the level of targeting adopted by the firm can be observed/perceived by consumers, it can serve as an additional tool for signaling quality. Specifically, a high price in association with a low level of targeting becomes a more credible signal of quality, as it reduces the low quality firm's incentive to cheat. Yet, the high quality firm faces a trade-off: choosing a low targeting level reduces the signaling cost, but also forgoes the benefit from targeting. We show that, when the proportion of departing consumers from the mimicking low quality firm in the second period is decreasing in the level of targeting, adjusting the level of targeting becomes a more effective way to deter the low quality firm from mimicking and the high quality firm finds it optimal to signal its quality with a lower level of targeting (or no targeting at all). We also show that de-targeting is more likely to be profitable for the high quality firm in a mass-market situation where quality is relatively more important than the match value.

The article proceeds as follows: Section 2 reviews the related literature; Section 3 presents the setup; Section 4 contains the main analysis, with cases of signaling through price only and signaling through price and level of targeting; Section 5 provides further discussions and implications of the analysis, and Section 6 concludes with managerial implications and future research directions. All proofs are included in the Appendix.

2 Related Literature

Our analysis builds on the literature studying the role of price in signaling quality, Milgrom and Roberts (1986) and Bagwell and Riordan (1991) are among the most influential articles. Generally, the literature shows that a high price can be a credible signal of high quality. We further investigate this signaling role of price with the recent development of targeting technology. This brings our paper in close relation to the emerging literature studying the impact of targeting. This literature shows how targeting allows firms to segment the market and perform finer price discrimination or product customization, which affects competition both in the product market (e.g., Iyer et al. (2005), Yang (2013), Esteves and Resende

(2016)) and in the advertising market (e.g., Athey and Gans (2010), Levin and Milgrom (2010), Bergemann and Bonatti (2011), de Corniere and de Nijs (2016)). Yet, the interaction between targeting and quality signaling remains unexplored in the literature and we try to bridge the two strands of literature and fill the gap.

Our main insight that a low level of targeting can help a firm signal its high quality is also related to the literature showing that de-marketing, i.e., reducing marketing intensity and advertising expenditure, can help a firm establish a high quality image. For instance, Zhao (2000) shows that a high quality firm spends less in advertising when the ad carries both roles of attracting awareness and signaling quality, which is then generalized by Bagwell and Overgaard (2006) to both informative and persuasive advertising. More recently, Miklos-Thal and Zhang (2013) show that firms can benefit from reducing marketing activities, which leads consumers to attribute lower sales in earlier periods to insufficient marketing and improves the perception of quality. Complementary to this literature, we show that de-targeting can serve as an additional quality signaling tool. Anand and Shachar (2009) also studies the role of targeting in signaling. However, our approach differs in two ways. First, they focus on the signaling of horizontal differentiation rather than vertical differentiation, and thus price is not their main focus. Second, they assume that consumer preference is correlated with media channel, which makes advertising on a specific channel (targeting) a signal of horizontal match. In our model, although different media channels can be correlated with consumers' match value, it is not necessary for our mechanism to work. Specifically, in our model, the same group of consumers may be present on different media channels and targeting can serve as a signaling tool as long as consumers can perceive the difference in targeting levels across different media channels.

3 The Setup

A monopoly firm sells a new product of quality q, which can be either high (H) or low (L) with $L < H$. The quality difference is denoted by $\Delta = H - L$. For simplicity, we assume the cost of producing both qualities to be zero. A consumer's valuation for the product is given by

$$v = q^e + x,$$

where x is an idiosyncratic match value, and q^e is the inferred quality of the product.

To reach consumers, the firm needs to send out advertising messages. We assume that these messages are informative of the existence of the new product, the price of the product, and the idiosyncratic match value.[10] However, the ad itself does not convey verifiable information about the quality. We also assume that a consumer does not observe how many advertising messages the firm has sent out,[11] and thus total advertising expenditure cannot be used as a signal for quality. Hence, to convey information about quality, the firm needs to resort to other tools. Here, we focus on the use of price as a tool of signaling quality.

Specifically, we consider a simple two period model, following Milgrom and Roberts (1986), where both consumers and the firm stay in the market for two periods, and the firm discounts the second period profit by β. We assume that the firm has a fixed budget which allows it to advertise to a unit mass of consumers.[12] At the beginning of the first period,

[10] That is, receiving an ad fully reveals the match value. In a related article, Anand and Shachar (2009) studies a model where the ad message does not reveal the match value, but receiving a targeted advertising message itself signals the match value of a product.

[11] This is likely true for online advertising, where a consumer is unlikely to observe the amount of advertising messages the firm sends to other consumers.

[12] We will study variable cost of advertising in Section 5. This assumption also isolates the mechanism

the firm commits to a price p for its new product and sends out advertising messages. A consumer is informed about the existence of the product, the price, and the match value x when he receives one advertising message from the firm. However, the consumer only learns the true quality of the product in the second period if he/she had purchased in the first period. Thus, to guide his/her purchase decision in the first period, a consumer needs to make inference about the quality based on the observed price. If his/her utility based on the inferred quality is higher than the price, the consumer purchases in the first period. In the second period, the firm does not send further messages to its advertised audience in the first period.[13] A consumer who purchased in the first period returns to the firm to purchase again if his/her utility based on the learned true quality is higher than the price. Otherwise, if a consumer did not purchase in the first period based on the inferred quality, he/she does not purchase in the second period either, as no further information on the quality is generated. It is well-known in the literature (e.g., Milgrom and Roberts (1986), Bagwell and Riordan (1991)) that in situations like this, a high price can serve as a credible signal of a high quality (detailed analysis in the next section), as fewer consumers will return in the second period to purchase its product at a high price if the low quality firm mimics the strategy of the high quality firm by charging a high price. This is the "*repeated business*" effect.

Our analysis aims to investigate how this signaling role of a high price is affected by the possibility of targeting. To proceed, we work with a very general model of targeting.

discussed in this paper from the mechanism discussed in the literature of de-marketing, for instance, Zhao (2000) and Miklos-Thal and Zhang (2013).

[13]As they are already informed about everything of the product, there is no need to advertise to these "old" customers. However, the firm can advertise to new customers, for which it faces the same problem as in the first period.

Specifically, the firm knows the distribution of the match value in the population, given by $F(x)$, but does not observe the realization of x for each consumer.[14] Without targeting, the firm sends out ad messages randomly and thus the match value among the advertised audience is still given by $F(x)$. By making use of the targeting technology, the firm is able to observe an informative but imperfect signal of the match value of a consumer, and then sends out ad messages to those consumers with higher signals. Thus, on average, the firm is able to reach consumers with higher match values within its budget. We capture this simple property of targeting by assuming that the distribution of match value among the advertised audience is given by $F(x;t)$, where $t \in [\underline{t}, T]$ represents the available levels of targeting with the property that: given $t' > t$, $F(x;t') \leq F(x;t)$ for all x and the inequality is strict for some x (When $F(x;t)$ is differentiable in t, this means that $\partial F(x;t)/\partial t \leq 0$). That is, a higher level of targeting leads to more high value consumers in the advertised audience in the sense of First-Order Stochastic Dominance. Better targeting generates more precise signals and allows the firm to advertise more accurately to those high value consumers. However, to keep our analysis concise and focus on the main insights, we assume that while targeted advertising is possible, targeted pricing is ruled out.[15]

Furthermore, we assume that $F(x;t)$ satisfies the following regularity condition:

Assumption 1. *$F(p-q;t)+pf(p-q;t)$ is increasing in p, decreasing in q and decreasing in t.*

The first and second part of the assumption is standard in the literature, which ensures

[14]This also means that the firm cannot price discriminate based on the match value.

[15]Thus, our analysis is more closely related to the practice of firms targeting a segment of the market, but relatively less to the practice of deep data mining and personalized offers.

that the profit maximization problem of a monopolist is well-defined with an interior optimal price, and the optimal price is increasing with quality. The last part of the assumption is specific to our setup, it implies that the monopoly price is increasing in the level of targeting. Hence, as more targeting reaches consumers with higher match values, the firm optimally adjusts its price upwards. This reflects the benefit of targeting in discovering high value consumers rather than in expansion of market size.

Lastly, we assume that the structure of the two-period game is common knowledge, except that the quality of the product is private information of the firm. In the following, we first study the case when the firm can only signal its quality through price, and then we study the case when both price and the level of targeting can be used as signals of quality.

4 Quality Signaling with Targeted Advertising

4.1 Benchmark: Complete Information

We start with the benchmark where the quality of the firm's product can be easily verified by consumers before purchase. Hence, there is no asymmetric information and no need of signaling. For a given level of targeting t, the firm simply chooses a price to maximize its total profit across two periods. That is, the firm with quality $q \in \{L, H\}$ chooses its price p to

$$\max_p \pi^M(p, q; t) = (1+\beta)p \cdot [1 - F(p - q; t)].$$

Let $p^M(q; t)$ and $\pi^M(q; t)$ for $q = H, L$ be the profit maximizing prices and the corresponding profits under complete information, under Assumption 1, it is straightforward to show that:

Lemma 1. *The complete information price of the high quality firm is higher, i.e.,* $p^M(H;t) \geq p^M(L;t)$*; The complete information price and profit are increasing in the level of targeting, i.e.,* $p^M(q;t') \geq p^M(q;t)$ *and* $\pi^M(q;t') \geq \pi^M(q;t)$ *for* $t' > t$.

Proof. See Appendix A.1. □

That is, regardless of its quality, the firm charges a higher price and obtains a higher profit with better targeting under complete information. This is due to the fact that targeting allows the firm to reach more high value consumers, which has been one of the main advantages of targeting.

4.2 Quality Signaling: Separating Equilibrium

Now we turn to the situation when the quality is not observable or cannot be verified by consumers prior to purchase. The complete information prices continue to be an equilibrium outcome if they are incentive compatible, specifically, if the low quality firm has no incentive to mimic the strategy of the high quality firm, i.e.,

$$\pi^M(L;t) \geq p^M(H;t)(1 - F(p^M(H;t) - H;t)) + \beta p^M(H;t)(1 - F(p^M(H;t) - L;t)). \quad (1)$$

That is, if the low quality firm decides to charge the complete information price of the high quality firm $p^M(H;t)$, consumers (who wrongly believe that the firm is of high quality) with match value higher than $p^M(H;t) - H$ will purchase in the first period. However, in the second period, only consumers with match value higher than $p^M(H;t) - L$ will return to purchase again as the true quality L is revealed. Condition (1) says that such a strategy is not profitable for the low quality firm.

In the following, we focus on the more interesting case when Condition (1) is not satisfied, and thus signaling quality becomes a relevant issue for the high quality firm. As we illustrate in our model, the observed price is the only tool that the firm can use to signal its quality, for a given level of targeting. As shown in the literature, e.g., Overgaard (1993), pooling equilibrium (i.e., the firm charges the same price regardless of its quality) can be ruled out by the Intuitive Criterion of Cho and Kreps (1987).[16] Hence, we try to look for a separating equilibrium (p_L, p_H). Define $\pi(p, q_1, q_2; t)$ as the profit of the firm with true quality q_2 (in the second period, the true quality is learned by consumers), while being perceived by consumers as of quality q_1 in the first period. That is,

$$\pi(p, q_1, q_2; t) = p(1 - F(p - q_1; t)) + \beta p(1 - F(p - q_2; t)).$$

If (p_L, p_H) constitutes a separating equilibrium, it must satisfy the following two incentive compatibility constraints:

$$\pi(p_L, L, L; t) \geq \pi(p_H, H, L; t), \quad (IC_L)$$

$$\pi(p_H, H, H; t) \geq \pi(p_L, L, L; t). \quad (IC_H)^{17}$$

That is, the low quality firm has no incentive to mimic the strategy of the high quality firm by charging a high price (IC_L), and vice versa (IC_H). Using the definition above, they can

[16] We provide a formal argument in Appendix A.2.

[17] Notice that on the right hand side of IC_H, we have $\pi(p_L, L, L; t)$ instead of $\pi(p_L, L, H; t)$, following our definition of $\pi(p, q_1, q_2; t)$. This is because only consumers who have purchased in the first period will return to purchase again in the second period. Hence, even though returning consumers learn that the true quality is H, the demand remains the same as if the quality is L. We follow the same notation in all of the following analysis.

be rewritten as

$$\pi(p_L, L, L; t) \geq \pi(p_H, H, H; t) - \beta p_H[F(p_H - L; t) - F(p_H - H; t)], \quad (IC_L)$$

$$\pi(p_H, H, H; t) \geq \pi(p_L, L, L; t). \quad (IC_H)$$

As a first step, we have the following result:

Lemma 2. *In the separating equilibrium,* $p_L^*(t) = p^M(L; t)$ *and* $\pi_L^*(t) = \pi^M(L; t)$.

This is a standard result in signaling games: when its quality is revealed in the separating equilibrium, the low quality firm can do no better than charging its complete information price and earning the complete information profit.[18] However, there exists a continuum of p_H that can be supported as an equilibrium for an appropriately specified belief.[19] To further narrow down the equilibrium set, we focus on the *undominated separating equilibrium*, which is unique in such a setup (see, for instance, Overgaard (1993)). In such an equilibrium, the price of the high quality firm satisfies (binding incentive compatibility constraint)

$$\pi_L^*(t) = \pi(p_H, H, L; t),$$

under the belief that the firm must be of low quality if it offered a different price. In the following, we simply refer this *undominated separating equilibrium* as the *separating equilibrium.* In fact, this refinement selects the profit-maximizing price for the high quality firm that satisfies the incentive compatibility constraints (this is the approach taken by, for instance, Zhao (2000)). That is, the price of the high quality firm p_H is the unique solution

[18] See, for instance, Overgaard (1993) and Zhao (2000).

[19] Specifically, any price p'_H such that $\pi(p'_H, H, H; t) > \max_p \pi(p, L, L; t)$ and $\pi(p'_H, H, L; t) < \pi_L^*(t)$ can be supported as an equilibrium with the belief that the firm is of low quality for any price different from p'_H.

to the following problem:[20]

$$\begin{aligned} \max_p \quad & \pi(p, H, H; t) \\ s.t. \quad & \pi_L^*(t) \geq \pi(p, H, L; t), \\ & p \geq 0. \end{aligned}$$

Let $p_H^*(t)$ be the solution to the above problem, and $\pi_H^*(t) = \pi(p_H^*(t), H, H; t)$ be the corresponding profit of the high quality firm. Condition (1) being violated means that in the separating equilibrium, we must have $p_H^*(t) > p^M(H; t)$:[21] due to the repeated business effect, the low quality firm faces a larger loss if it charged a high price, as fewer consumers would return in the second period. Thus, an upward distorted price can deter the low quality firm from mimicking and signal high quality.

We are interested in how targeting affects the profit difference between the high quality firm and the low quality firm, i.e. $\Delta\pi = \pi_H^*(t) - \pi_L^*(t)$, as this determines whether the high quality firm or the low quality firm benefits more from targeting, taking into consideration the signaling cost, which further determines the incentive of the firm to invest in quality improvement (discussed in Section 5).

We start with a sufficient condition under which the high quality firm benefits more from targeting. Define $\mathbb{L}(t) = F(p_H^*(t) - L; t) - F(p_H^*(t) - H; t)$, we can show that:

Proposition 1. *If $\mathbb{L}(t)$ is increasing in t, the profit difference $\Delta\pi$ in the separating equilibrium is increasing in t.*

Proof. See Appendix A.3. $\square$

[20] Clearly, if $p_H \geq 0$ and IC_L is satisfied with equality, then IC_H is also satisfied.

[21] This is because the right-hand side of IC_L is decreasing in p.

To be more specific, in the separating equilibrium, IC_L must be binding. Thus, the profit difference is given by

$$\Delta\pi = \beta p_H^*(t)[F(p_H^*(t)-L;t) - F(p_H^*(t)-H;t)].$$

The direct effect of increasing the level of targeting from t to t' on the profit difference is

$$\beta p_H^*(t)\big([F(p_H^*(t)-L;t') - F(p_H^*(t)-H;t')] - [F(p_H^*(t)-L;t) - F(p_H^*(t)-H;t)]\big),$$

which is positive as $\mathbb{L}(t)$ is increasing. Moreover, the indirect effect of targeting on the profit difference due to price change,

$$\beta\int_{p_H^*(t)}^{p_H^*(t')} [\underbrace{F(p_H-L;t') + p_H f(p_H-L;t') - (F(p_H-H;t') + p_H f(p_H-H;t'))}_{+}]dp_H,$$

is also positive as $p_H^*(t') > p_H^*(t)$ (see the proof for detail) and the integrand is positive due to Assumption 1. Thus, the profit difference must be increasing in the level of targeting.

In other words, the condition means that the mass of consumers who would leave the mimicking low quality firm in the second period is increasing in the level of targeting. Thus, the low quality firm has lower incentives to mimic the strategy of the high quality firm, as the future loss is higher when targeting improves. When $F(x;t)$ is differentiable in t, the condition is equivalent to $\frac{\partial F(p_H^*(t)-L;t)}{\partial t} > \frac{\partial F(p_H^*(t)-H;t)}{\partial t}$,[22] which means that targeting is more effective at excluding low value consumers and increases demand more when price is lower.

[22]For this, we need $F(x;t)$ to be differentiable in t for x in the relevant range. To be more precise, let $\mathbb{S} = [\min_{\{t\in[\underline{t},T]\}} p_H^*(t)-H, \max_{\{t\in[\underline{t},T]\}} p_H^*(t)-L]$, where $p_H^*(t)-H$ is match value of the marginal consumer for the high quality firm and $p_H^*(t)-L$ is the match value of the marginal consumer if the low quality firm mimics the strategy of the high quality firm. Then we need $F(x;t)$ to have full support on $\mathbb{S}$ and differentiable in t for $x \in \mathbb{S}$ for all t. A sufficient condition for $\frac{\partial F(p_H^*(t)-L;t)}{\partial t} > \frac{\partial F(p_H^*(t)-H;t)}{\partial t}$ is that $\frac{\partial^2 F(x;t)}{\partial x \partial t} \geq 0$ for $x \in \mathbb{S}$.

In sum, in this situation, with a slight increase in the level of targeting, the high quality firm can reduce the upward distortion of its price, while still make sure that consumers make the correct inference on its quality. Put differently, the informational/signaling value of a high price increases with targeting, by further deterring the low quality firm from cheating.

Things become more complicated when $\mathbb{L}(t)$ is decreasing in t. In this case, the direct effect of targeting on profit difference becomes negative, while the indirect effect of price change may still be positive and dominate. Intuitively, by continuity, if $\mathbb{L}(t)$ is decreasing in t but only at a slow rate, the high quality firm still benefits more from targeting according to Proposition 1. Thus, $\mathbb{L}(t)$ being decreasing in t is not enough to reverse the result of Proposition 1. Define

$$\mathbb{L}_\pi(t) = \pi_L^*(t)\frac{F(p_H^*(t) - L; t) - F(p_H^*(t) - H; t)}{1 - F(p_H^*(t) - H; t) + \beta(1 - F(p_H^*(t) - L; t))},$$

i.e., the lost profit due to leaving consumers in the second period as a proportion of the total demand, should the low quality firm mimic the price of the high quality firm, we can show that:

Proposition 2. *In the separating equilibrium, the profit difference $\Delta\pi$ is decreasing in t if $\mathbb{L}_\pi(t)$ is decreasing in t.*

Proof. See Appendix A.4. □

Simply speaking, the condition means that the (proportional) lost profit from departing consumers in the second period is lower as the level of targeting improves. Hence, the cost of mimicking is lower for the low quality firm, which exacerbates the quality signaling problem for the high quality firm and leads to a lower profit premium. In the case of differentiable

$F(x;t)$, the condition is equivalent to

$$\frac{p_L^*(t)\frac{\partial F(p_L^*(t)-L;t)}{\partial t} - p_H^*(t)\frac{\partial F(p_H^*(t)-H;t)}{\partial t}}{p_L^*(t)\frac{\partial F(p_L^*(t)-L;t)}{\partial t} - p_H^*(t)\frac{\partial F(p_H^*(t)-L;t)}{\partial t}} < \frac{1-F(p_H^*(t)-H;t)-p_H^*(t)f(p_H^*(t)-H;t)}{1-F(p_H^*(t)-L;t)-p_H^*(t)f(p_H^*(t)-L;t)}, \quad (2)$$

which can be alternatively rewritten as

$$\frac{\overbrace{\frac{\partial(\pi_{HH}-\pi_{HL})}{\partial t}}^{`-'}}{\underbrace{\frac{\partial(\pi_{HH}-\pi_{HL})}{\partial p_H}}_{`+'}} < \frac{\overbrace{\frac{\partial(\pi_{LL}-\pi_{HL})}{\partial t}}^{`-'}}{\underbrace{\frac{\partial(\pi_{LL}-\pi_{HL})}{\partial p_H}}_{`+'}}, \quad (3)$$

where $\pi_{s,r} = p_s[1-F(p_s-r;t)]$ for $s \in \{H,L\}$ and $r \in \{H,L\}$. That is, the (negative) impact of targeting on the profit premium earned by the high quality firm is sufficiently stronger than the (positive) impact of price on the premium,[23] which reduces the profit difference. Further insights can be gained by noticing that Condition (2) could only be satisfied when $\frac{\partial F(p_H^*(t)-H;t)}{\partial t} > \frac{\partial F(p_H^*(t)-L;t)}{\partial t}$.[24] That is, targeting is more effective at discovering high value consumers and increases demand more when price is higher, i.e., the benefit of targeting is higher at a higher price. Thus, as the level of targeting improves, which pushes up the equilibrium prices, the benefit of targeting grows as well. Hence, the lower quality firm has a higher incentive to pretend to be the high quality firm to reap the increasing benefit of targeting. This means that, as the level of targeting increases, the high quality firm needs to distort its price more upward, in order to deter the low quality firm from

[23]The term $\pi_{HH} - \pi_{HL}$ is the premium the high quality firm earns in the second period compared to a cheating low quality firm, and $\pi_{LL} - \pi_{HL}$ is the loss incurred by the low quality firm in the second period compared to when it acts honestly.

[24]Specifically, the right-hand side of Condition (2) is smaller than 1 and the denominator on the left-hand side is positive from Assumption 1. Thus, the condition can only be satisfied if $0 > \frac{\partial F(p_H^*(t)-H;t)}{\partial t} > \frac{\partial F(p_H^*(t)-L;t)}{\partial t}$.

mimicking and make sure that consumers make the correct inference on its quality. That is, the informational/signaling value of a high price decreases with the level of targeting, which increases the signaling cost.

4.3 Signaling through De-Targeting

Since targeting may raise the signaling cost and reduce the premium that the high quality firm earns, it may have incentives to signal its quality with a lower level of targeting, when the choice of targeting level can be observed by consumers, or, when consumers can infer whether the ad they see is targeted or not. As we discussed in the introduction, this can be done through different media channels where traditional mass media feature less targeting than digital marketing channels. Among digital marketing channels, search advertising is less targeted than banner ads. As information transparency improves on the Internet, consumers also get to know how their information are used and whether they are seeing targeted ads.[25]

Specifically, in addition to the price of its product, the firm now also chooses a level of targeting $t \in [\underline{t}, T]$, which is observed by consumers. We assume all levels of targeting are available at no cost and we consider advertising of different levels of targeting which also differ in effectiveness and costs in the next section. As above, we focus on the separating equilibrium[26] where the high quality firm chooses (t_H, p_H), whereas the low quality firm

[25]Such observation/perception of targeting does not require previous interaction with the firm or information from peers. Moreover, the ad itself may not contain direct information about whether it is a targeted ad, but where and why a consumer sees the ad provides such information.

[26]A pooling equilibrium can be ruled out similarly as in Section 4.2.

chooses (t_L, p_L), which must satisfy the incentive compatibility constraints:

$$\pi(p_L, L, L; t_L) \geq \pi(p_H, H, L; t_H), \quad (IC_L)$$

$$\pi(p_H, H, H; t_H) \geq \pi(p_L, L, L; t_L). \quad (IC_H)$$

This can be similarly rewritten as

$$\pi(p_L, L, L; t_L) \geq \pi(p_H, H, H; t_H) - \beta p_H[F(p_H - L; t_H) - F(p_H - H; t_H)] \text{ and } p_H \geq 0.$$

Similar to Lemma 2, in the separating equilibrium, we must have $p_L^*(t_L) = p^M(L; t_L)$, as it can do no better than charging its complete information price when its quality is revealed in the separating equilibrium. Since $\pi^M(L; t_L)$ is increasing in t_L by Assumption 1, in the separating equilibrium, the low quality firm must choose the highest level of targeting, T, and the corresponding price $p_L^*(T) = p^M(L; T)$.

The price and level of targeting for the high quality firm in the separating equilibrium is then the solution to the following problem:[27]

$$\begin{aligned} \max_{p,t} \quad & \pi(p, H, H; t) \\ s.t. \quad & \pi(p_L^*(T), L, L; T) \geq \pi(p, H, H; t) - \beta p[F(p - L; t) - F(p - H; t)], \\ & p \geq 0, \end{aligned}$$

under the belief that the firm must be of low quality if it offered a different price and/or it chose a different level of targeting. To facilitate our analysis, define $p_H^*(t_H)$ as the equilibrium price and $\pi_H^*(t_H)$ as the equilibrium profit for the high quality firm when the low quality firm chooses targeting level T and the high quality firm chooses targeting level t_H, that is,

[27] Here, we follow the simple approach as in Zhao (2000) to formulate the equilibrium as a solution to the high quality firm's profit-maximizing problem. Similarly, this selects the unique undominated separating equilibrium.

$p_H^*(t_H)$ is the solution to the following problem:

$$\max_p \quad \pi(p, H, H; t_H)$$
$$s.t. \quad \pi(p_L^*(T), L, L; T) \geq \pi(p, H, H; t_H) - \beta p[F(p - L; t_H) - F(p - H; t_H)],$$
$$p \geq 0.$$

Define

$$\mathbb{L}_d(t_H) = \frac{F(p_H^*(t_H) - L; t_H) - F(p_H^*(t_H) - H; t_H)}{1 - F(p_H^*(t_H) - H; t_H)},$$

i.e., the proportion of departing consumers from the mimicking low quality firm in the second period compared to the number of purchasing consumers in the first period. We can show that:

Proposition 3. *The high quality firm's profit $\pi_H^*(t_H)$ is decreasing in its level of targeting and it chooses the lowest targeting level $\underline{t}$ if $\mathbb{L}_d(t_H)$ is decreasing in t_H.*

Proof. See Appendix A.5. □

Notice that, when the level of targeting can be used as an additional signal (more specifically, when the low quality firm and the high quality firm can choose different levels of targeting), the profit of the low quality firm is invariant to the level of targeting chosen by the high quality firm. Hence, as the proportion of consumers departing from the mimicking low quality firm gets smaller when the high quality firm targets more, the cost of mimicking becomes lower as well, which leads to a stronger incentive of mimicking and makes it optimal for the high quality firm to choose a lower level of targeting. In the differentiable case, the condition is equivalent to

$$\frac{\frac{\partial F(p_H^*(t_H) - H; t_H)}{\partial t}}{\frac{\partial F(p_H^*(t_H) - L; t_H)}{\partial t}} < \frac{1 - F(p_H^*(t_H) - H; t_H) - p_H^*(t_H) f(p_H^*(t_H) - H; t_H)}{1 - F(p_H^*(t_H) - L; t_H) - p_H^*(t_H) f(p_H^*(t_H) - L; t_H)}, \tag{4}$$

which can be rewrite, similar to Condition (3), as[28]

$$\frac{\partial \pi_{HH}/\partial t}{-\partial \pi_{HH}/\partial p} < \frac{\partial \pi_{HL}/\partial t}{-\partial \pi_{HL}/\partial p}.$$

That is, the benefit of targeting compared to the damage of high price is relatively smaller for the high quality firm than the mimicking low quality firm. Consequently, adjusting downward the targeting level becomes a more effective tool in deterring the low quality firm from mimicking, and the high quality firm can save signaling cost by opting for a lower level of targeting.

Moreover, it is easy to check that Condition (4) is more stringent than Condition (2) when evaluated at $t_H = T$. Thus, it could occur that the high quality firm benefits less from improved targeting, yet it still chooses a high level of targeting. In addition, the condition is sufficient for the high quality firm's profit to be decreasing in its chosen level of targeting, hence, it chooses the lowest level of targeting. When it is not satisfied for all t, we may have a non-monotone relationship between the level of targeting and the profit of the high quality firm, i.e., the high quality firm's optimal level of targeting could be interior for some $t_H \in (\underline{t}, T)$[29]. This highlights the trade-off faced by the high quality firm: opting for less targeting can save signaling cost but also forgoes the benefit from targeting. Hence, it is only optimal to do so when the signaling cost due to targeting is significant enough, i.e.,

[28]Alternatively, the condition can be rewritten as $\epsilon_{\frac{\partial \pi}{\partial t},q} < \epsilon_{\frac{\partial \pi}{\partial p},q}$, where $\pi(p,q;t)$ is the per-period profit $\pi(p,q;t) = p[1 - F(p-q;t)]$, $\epsilon_{\frac{\partial \pi}{\partial t},q} = q\frac{\partial^2 \pi}{\partial t \partial q}/\frac{\partial \pi}{\partial t}$ is the elasticity of $\partial \pi/\partial t$ with respect to quality q, and $\epsilon_{\frac{\partial \pi}{\partial p},q} = q\frac{\partial^2 \pi}{\partial p \partial q}/\frac{\partial \pi}{\partial p}$ is the elasticity of $\partial \pi/\partial p$ with respect to quality q.

[29]A non-monotone relationship could also occur when the incentive compatibility constraint is not binding for small enough t_H. See Appendix B for an example with exponential distribution, which always satisfies that $\mathbb{L}_d(t_H)$ is decreasing in t_H.

when the decrease in the profit difference is large enough as the level of targeting increases.

4.4 An Illustrative Example

We present a concrete example in this section to illustrate our results and generate additional insights. Consider the following example of the match value with a cumulative distribution function $F(x;t)$ on the support of $[0,1]$ and a targeting level $t \in [0,1]$:

$$F(x;t) = (1-t)x + tx^2,$$

the corresponding density function is

$$f(x;t) = 1 - t + 2tx.$$

The distribution function is illustrated in the left panel of Figure 1. Clearly, $F(x,t)$ is decreasing in t, i.e., as the targeting level becomes higher, the proportion of consumers with high match values increases. This is demonstrated more clearly in the corresponding probability density function. As t increases from 0 to 1, $f(x;t)$ rotates counterclockwise around $(\frac{1}{2}, 1)$, which is illustrated in the right panel of Figure 1.

$F(x;t)$ is differentiable in both x and t in the interior of the support with $\frac{\partial^2 F(x;t)}{\partial x \partial t} = \frac{\partial f(x;t)}{\partial t} < 0$ if $x < 1/2$ and $\frac{\partial^2 F(x;t)}{\partial x \partial t} = \frac{\partial f(x;t)}{\partial t} > 0$ if $x > 1/2$. Thus, a necessary condition for both Condition (2) and (4) to be satisfied is that the price-quality difference (the match value of the marginal consumer) in the separating equilibrium locates at the lower-half of the match value distribution. To be more specific, the profit difference between the high quality firm and the low quality firm is increasing in the level of targeting if the equilibrium price-quality difference (the match value of the marginal consumer) is relatively high, which

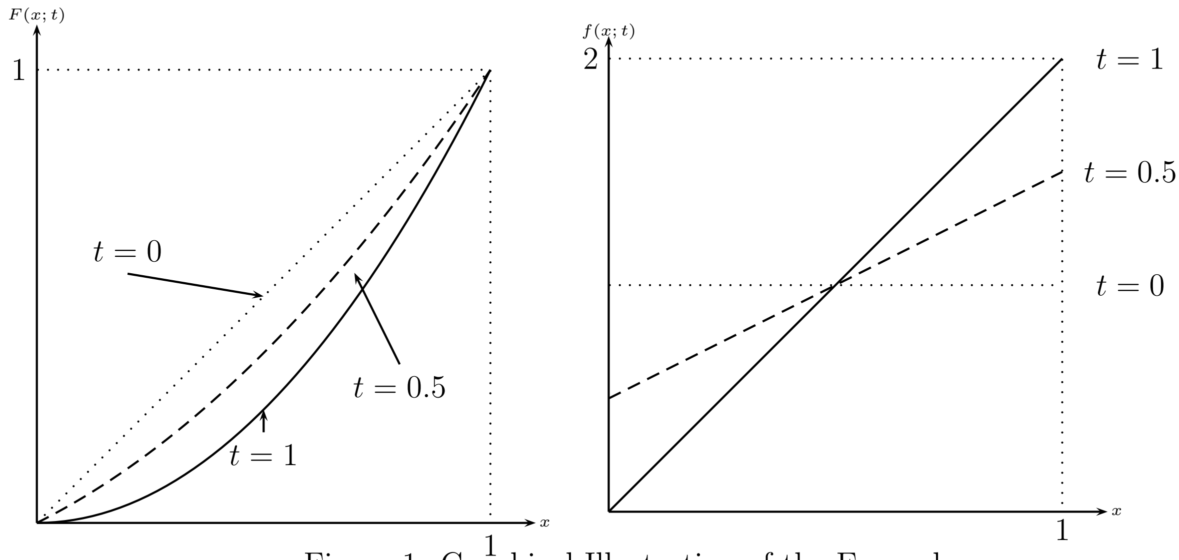

Figure 1: Graphical Illustration of the Example

occurs when the quality is relatively low compared to the match value and/or the targeting level is relatively high. In this case, we say that the firm faces a niche market position, as it only sells to high value consumers. On the other hand, when the quality is relatively high compared to the match value and/or when the targeting level is relatively low, the equilibrium price-quality difference (the match value of the marginal consumer) is relatively low and it is more likely that the profit difference is decreasing in the level of targeting. We say, in this case, that the firm faces a mass market position, as it sells to both low and high value consumers. The impact of targeting on the profit difference is further illustrated in the left panel of Figure 2[30].

As explained above, when the quality is relatively high (the solid line with $L = 0.9$ and $H = 1$), the firm faces a mass-market position, the profit difference first decreases with targeting (for approximately $t < 0.2$) and then increases with targeting (for approximately $t > 0.2$). The reason is that, as targeting level increases, the equilibrium price also increases and the firm sells to more high-value consumers. This moves the firm gradually from a mass-

[30]The Figure is drawn for $\beta = 1$.

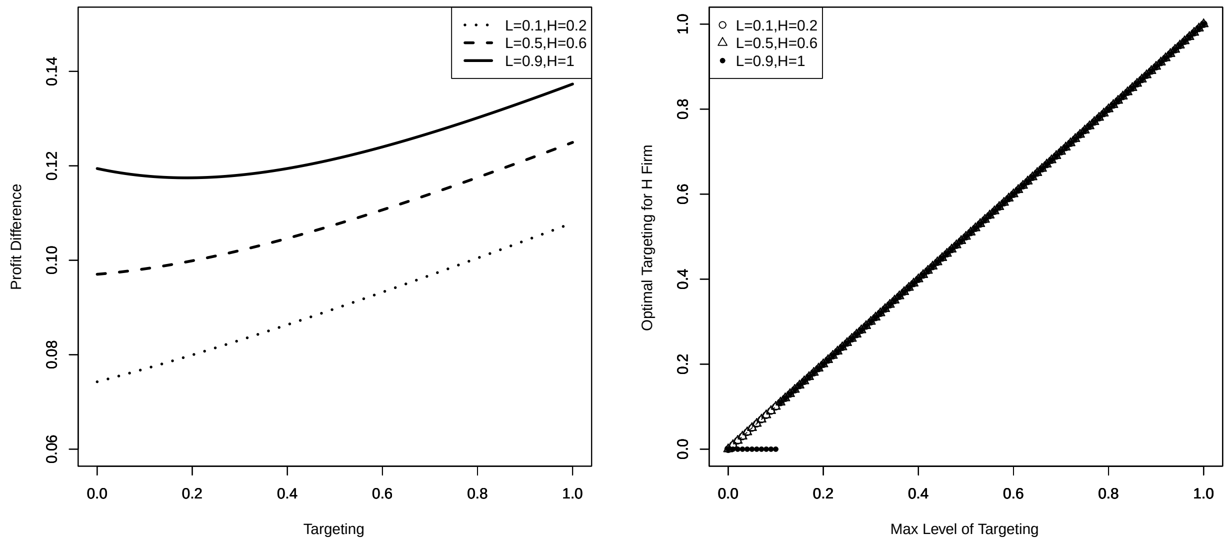

Figure 2: Impact of Targeting on Profit Difference and Optimal Targeting

market position to a niche-market position, which reverses the impact of targeting. On the other hand, when the quality is relatively low (the dashed line with $L = 0.5$ and $H = 0.6$, the dotted line with $L = 0.1$ and $H = 0.2$), the firm moves to a more niche-market position and thus targeting is more likely to increase profit difference.

The right panel of Figure 2 demonstrates the optimal choice of targeting by the high quality firm as a function of the maximally available level of targeting, when the lowest level of targeting is $t = 0$. From our analysis in Section 4.3, the low quality firm always chooses the highest available level of targeting (the 45° degree line). In the medium quality (the triangular with $L = 0.5$ and $H = 0.6$) and low quality (the circle with $L = 0.1$ and $H = 0.2$) case, the high quality firm also chooses the highest level of targeting, i.e., it signals only through price. In the high quality case (the solid circle with $L = 0.9$ and $H = 1$), the figure shows that when the available targeting level is relatively low, the high quality firm optimally chooses no targeting to signal its quality. However, when the available targeting level is relatively high, the high quality firm instead chooses the highest level of targeting as well to exploit the benefit of targeting. Recall from above, in this case, the firm faces a mass-market position, and thus the high quality firm is more likely to be hurt by targeting.[31] Furthermore, Figure 2 illustrates that Condition (4) is more stringent than Condition (2). In the high quality case, while the profit difference is decreasing in the level of targeting for $t < 0.2$, the high quality firm only chooses the lowest level of targeting for $t < 0.1$, which highlights the trade-off between cost-saving from de-targeting and the forgone benefit of targeting.

5 Further Discussions

5.1 General Targeting Technology

In the analysis above, we focus on costless targeting, i.e. targeted advertising is available at no additional cost. When the firm can choose different levels of targeting, for example, when it relies on different media channels, advertising with different levels of targeting may come with different degrees of effectiveness and costs. A natural case would be a higher level of targeting is more effective but also more costly. We capture this by assuming that a level of targeting t is of effectiveness $\lambda(t) \in (0, 1)$ and is available at a cost of $c(t)$, which satisfies $\lambda'(t) \geq 0$ and $c'(t) \geq 0$. In this case, the complete information profit of the firm with quality

[31] This insight also generalizes to other density functions that satisfy a single-cross property: $f(x;t)$ is decreasing in t for $x < x^*(t)$ and increasing in t for $x > x^*(t)$, where $x^*(t)$ is the rotation point. A number of commonly used distributions satisfy this property, e.g., exponential, chi-square, chi distribution, etc.

$q \in \{L, H\}$ is

$$\pi^M(p, q; t) = (1 + \beta)\lambda(t)p[1 - F(p - q; t)] - c(t).$$

That is, an ad with a targeting level t only turns a potential customer (whose value $q+x > p$) into an actual customer (who purchases the product) with probability $\lambda(t)$. Without loss of generality, assuming the complete information profit is increasing with the targeting level,[32] we can show the same result as Proposition 3:

Proposition 4. *In the separating equilibrium, the low quality firm chooses the highest targeting level T; the high quality firm's profit is decreasing with its level of targeting and it chooses the lowest targeting level $\underline{t}$ if*

$$\mathbb{L}_c = \frac{F(p_H^*(t_H) - L; t_H) - F(p_H^*(t_H) - H; t_H)}{1 - F(p_H^*(t_H) - H; t_H) - \frac{c(t_H)}{\lambda(t_H)p_H^*(t_H)}}$$

is decreasing in t_H.

Proof. See Appendix A.6. □

That is, with a general targeting technology characterized by $(\lambda(t), c(t))$, the high quality firm chooses a low targeting level when the proportion of departing consumers from the mimicking low quality firm, adjusted for cost and efficiency of targeting, is decreasing with the level of targeting. When $F(x; t)$ is differentiable, this is equivalent to

$$\frac{\partial\tilde{\pi}(p_H, H; t_H)/\partial t}{-\partial\tilde{\pi}(p_H, H; t_H)/\partial p_H} < \frac{\partial\tilde{\pi}(p_H, L; t_H)/\partial t}{-\partial\tilde{\pi}(p_H, L; t_H)/\partial p_H}.$$

where $\tilde{\pi}$ is the per period profit adjusted for efficiency and cost of targeting $\tilde{\pi}(p, q; t) = \lambda(t)p[1 - F(p - q; t)] - \frac{c(t)}{1+\beta}$. Thus, our result naturally extends to incorporate differences in

[32]Otherwise, no firm would choose a positive level of targeting. This amounts to say that the cost of targeted advertising does not increase too fast with the level of targeting.

effectiveness and cost of advertising with different targeting levels. To get more insights into the result, similar as in Proposition 3, a sufficient condition for the above condition is

$$\epsilon_{\frac{\partial \tilde{\pi}}{\partial t},q} < \epsilon_{\frac{\partial \tilde{\pi}}{\partial p},q}. \tag{5}$$

We focus on the left-hand side of Condition (5), as it is straightforward to show that the right-hand side of Condition (5) is independent of $\lambda(t)$ and $c(t)$. We consider first the case where advertising with different levels of targeting only differs in costs, i.e., $\lambda'(t) = 0$, in which we have

$$\epsilon_{\frac{\partial \tilde{\pi}}{\partial t},q} = q \frac{p \frac{\partial f(p-q;t)}{\partial t}}{-p \frac{\partial F(p-q;t)}{\partial t} - \frac{c'(t)}{1+\beta}},$$

which is clearly decreasing when $c'(t)$ becomes larger (recall that a necessary condition for (5) to be satisfied is $\partial f / \partial t < 0$). That is, it is more likely that the high quality firm chooses low targeting when the cost of targeted advertising increases fast with the level of targeting. This reason is simple: choosing lower targeting not only saves the signaling cost but also saves the direct cost of advertising. Now consider the case where advertising with different levels of targeting only differs in effectiveness, i.e. $c'(t) = 0$, in which we have

$$\epsilon_{\frac{\partial \tilde{\pi}}{\partial t},q} = q \frac{\frac{\lambda'(t)}{\lambda(t)} f(p-q;t) + \frac{\partial f(p-q;t)}{\partial t}}{\frac{\lambda'(t)}{\lambda(t)} [1 - F(p-q;t)] - \frac{\partial F(p-q;t)}{\partial t}},$$

which is increasing in $\lambda'(t)/\lambda(t)$ under Assumption 1. That is, it is less likely that the high quality firm chooses low targeting when the elasticity of effectiveness with respect to targeting is large. The intuition is also straightforward: as the elasticity becomes larger, the firm forgoes a larger benefit when opting for a lower level of targeting.

The simple reasoning highlights the three-fold trade-off faced by the high quality firm when choosing a lower level of targeting: it is less effective, but it is less costly and also saves signaling cost. Hence, when the benefit (direct advertising cost saving and signaling cost saving) outweighs the cost (less effective advertising), it is in the interest of the high quality firm to opt for less targeting.

5.2 Investment in Quality

The analysis can be easily adapted to incorporate the firm's investment in quality. One way is to assume that by exerting a level of effort e, at cost $C(e)$, the firm produces a high quality product with probability e and a low quality product with probability $1 - e$. Neither the level of effort nor the outcome/product quality is observable to consumers. The expected profit of the firm, for a given level of targeting, is

$$E\pi = e\pi_H^*(t) + (1 - e)\pi_L^*(t) - C(e),$$

which leads to the optimal investment e^* satisfying

$$C'(e^*) = \pi_H^*(t) - \pi_L^*(t) = \Delta\pi.$$

Our results then imply that if $F(p - L; t) - F(p - H; t)$ is increasing in t, better targeting increases a firm's incentive to invest in improving quality; On the other hand, if $F(p-L;t) - F(p-H;t)$ is decreasing in t and the condition in Proposition 2 is satisfied, better targeting reduces the incentive to invest in improving quality. When different levels of targeting can be used, a lower level of targeting then not only signals high quality but also high investment.

5.3 Targeting Technology

Our analysis is carried out with targeting represented by a general functional form. It is useful to apply our analysis to some specific forms of targeting.

A commonly used form of targeting is that firms send advertising messages to those consumers with a value/signal of value higher than a threshold. This strategy can be easily incorporated in our general analysis. Assuming the distribution of consumers' valuations is given by $G(x)$ (the density function is denoted by $g(x)$), a targeting level t allows the firm to send ad messages to consumers with valuations above t. Hence, the distribution of consumers' valuations associated with a targeting level t is

$$F(x;t) = \frac{G(x) - G(t)}{1 - G(t)}.$$

It is easy to show that $F(x;t)$ is decreasing in t (strictly decreasing for x in the interior of the support). Moreover, we have $f(x;t) = \frac{g(x)}{1-G(t)}$, which is increasing in t (strictly increasing for x in the interior of the support). Hence, we must have $F(p - L;t) - F(p - H;t)$ increasing in t whenever price is interior. Thus, with this type of threshold targeting, the high quality firm benefits more according to Proposition 1.

Another way is to target consumers from different groups. Consider two groups of consumers, group 1 and group 2, the valuation distribution of which are given by $G_1(x)$ and $G_2(x)$ respectively, with $G_2(x) < G_1(x)$, i.e. group 2 is the more valuable group in the sense of First-Order Stochastic Dominance. A targeting level t identifies a consumer from group 2 with probability t, i.e. the associated valuation distribution is

$$F(x;t) = (1 - t)G_1(x) + tG_2(x).$$

In this differentiable case, we have $\frac{\partial^2 F(x;t)}{\partial x \partial t} = g_2(x) - g_1(x)$. Thus, a necessary condition for the high quality firm to prefer a lower level of targeting is $g_2(x) < g_1(x)$, which could occur when the valuation of Group 2 consumers is distributed on a support with greater upper bound compared to that of Group 1 consumers, that is, when Group 2 consumers have higher but also more dispersed valuations.

6 Concluding Remarks

We conclude our paper with discussions on the managerial implications and directions for future work.

In this paper, we show that a high level of targeting may increase the signaling cost of a high quality firm by attenuating the informational content of a high price, and thus the high quality firm may find it optimal to choose a lower level of targeting. In general, this is the case when the profit is less elastic to targeting and more elastic to price, hence, the signaling cost-saving from reducing price distortion outweighs the forgone benefit of targeting. Such a de-targeting strategy is more likely to be optimal when the product features a mass-market position, i.e., when quality is relatively important compared to the horizontal preferences and/or when the available targeting technology is not too accurate. More specifically, this is the case when targeting allows the firm to reduce the mass of marginal consumers, who have relatively low horizontal match values. Such a strategy is especially relevant for new experience goods with a large variation of quality, for which the asymmetric information problem is more severe. In the meantime, such a de-targeting strategy is more appropriate when the aim of the marketing campaign is to generate sales, so that consumer trust and quality inference become more important. Hence, for an established brand with known quality, highly targeted ads (e.g., social media, display ads, emails) can be an effective way to reach potential consumers and distribute information about new products. For a new brand/product with uncertain quality that aims at raising market share, de-targeting (e.g., search ads, direct mails, offline ads) becomes more effective in building consumer trust and promoting sales. When continuous investment is needed to sustain a high quality, for instance, for credence goods, de-targeting can further serve as a signal of such investment.

Our results also have implications on advertising agencies. Our analysis applies to situations where firms advertise directly to consumers or indirectly through competitive advertising agencies, as long as the cost/price of advertising is not strategically chosen. In the latter situation, our results suggest that competitive advertising agencies with different levels of targeting may attract different types of firms. This points to an interesting extension of our analysis: it would be valuable to investigate how advertising agencies with pricing power would strategically choose their levels of targeting[33] and prices of their advertising services. This would provide useful insights and deepen our understanding of the advertising market.

References

Anand, B. and R. Shachar (2009). Targeted advertising as a signal. *Quantitative Marketing and Economics* *7*(3), 237–266.

Athey, S. and J. Gans (2010). The Impact of Targeting Technology on Advertising Markets and Media Competition. *American Economic Review* *100*(2), 608–613.

Bagwell, K. and P. B. Overgaard (2006). Look how little I'm advertising. *working paper*.

[33]For instance, they can choose different privacy policies with different extents of data collection.

Bagwell, K. and M. Riordan (1991). High and declining prices signal product quality. *American Economic Review 81*(1), 224–239.

Bergemann, D. and A. Bonatti (2011). Targeting in Advertising Markets : Implications for Offline vs . Online Media. *The RAND Journal of Economics 42*, 417–443.

Cho, I.-K. and D. Kreps (1987). Signaling games and stable equilibria. *The Quarterly Journal of Economics 102*(2), 179–221.

de Corniere, A. and R. de Nijs (2016). Online Advertising and Privacy. *RAND Journal of Economics 47*(1), 48–72.

Esteves, R.-B. and J. Resende (2016). Competitive targeted advertising with price discrimination. *Marketing Science 35*(4), 576–587.

Iyer, G., D. Soberman, and J. M. Villas-Boas (2005). The Targeting of Advertising. *Marketing Science 24*(3), 461–476.

Levin, J. and P. Milgrom (2010). Online Advertising : Heterogeneity and Conflation in Market Design. *American Economic Review 100*(2).

Miklos-Thal, J. and J. Zhang (2013). (De)marketing to manage consumer quality inferences. *Journal of Marketing Research 50*(1), 55–69.

Milgrom, P. and J. Roberts (1986). Price and advertising signals of product quality. *Journal of Political Economy 94*(4), 796–821.

Overgaard, P. B. (1993). Price as a signal of quality: A discussion of equilibrium concepts in signalling games. *European Journal of Political Economy 9*, 483–504.

Samat, S., A. Acquisti, and L. Babcock (2017). Raise the curtains: The effect of awareness about targeting on consumer attitudes and purchase intentions. *Proceedings of the Thirteenth Symposium on Usable Privacy and Security*.

Yang, H. (2013). Targeted Search and the Long Tail Effect. *The RAND Journal of Economics 44*(4), 733–756.

Zhao, H. (2000). Raising awareness and signaling quality to uninformed consumers: A price-advertising model. *Marketing Science 19*(4), 390–396.

A Omitted Proofs

A.1 Proof of Lemma 1

The profit maximization problem of the firm with quality q is

$$\max \pi^M(p, q; t) = p \cdot [(1+\beta)(1 - F(p - q; t))].$$

The profit-maximizing price satisfies the first order condition:

$$(1+\beta)[1 - F(p - q; t) - pf(p - q; t)] = 0.$$

By Assumption 1, the left-hand side is decreasing in p, increasing in q, and increasing in t. Thus, the complete information price is a well-defined interior solution, which is increasing in q and increasing in t. Furthermore, by the principle of revealed preference, for $t' > t$, we have

$$\pi^M(p(t'), q; t') \geq \pi^M(p(t), q; t') \geq \pi^M(p(t), q; t),$$

hence, the complete information profit is increasing in t.

A.2 Pooling Equilibrium

We provide an argument for the non-existence of pooling equilibrium. Intuitive criterion says that if a deviation is profitable for one type of firm, but not for the other type of firm even with the most favorable expectation, then upon observing such a deviation, consumers believe it is from the profiting firm. Suppose a pooling equilibrium with price p^p exists, define a price p' such that

$$\pi^p(p^p, q^e, L; t) = \pi(p', H, L; t),$$

i.e. p' is such that the low quality firm is indifferent between staying with the pooling equilibrium and deviating to p' when such a deviation is believed to be from a high quality firm. That is, p' satisfies

$$\begin{aligned} & p^p[1 - F(p^p - q^e, t) + \beta(1 - F(p^p - L; t)] \\ = \quad & p'[1 - F(p' - H; t) + \beta(1 - F(p' - L; t)]. \end{aligned}$$

Then it is easy to show that

$$\begin{aligned} & p^p[1 - F(p^p - q^e; t) + \beta(1 - F(p^p - q^e; t)] \\ < \quad & p'[1 - F(p' - H; t) + \beta(1 - F(p' - H; t)], \end{aligned}$$

as $0 > \frac{dp[1-F(p-H;t)]}{dp} > \frac{dp[1-F(p-L;t)]}{dp}$. Thus, a deviation from the pooling price p^p to $p > p'$ is only profitable for the high quality firm, but not for the low quality firm even when consumer believes the deviating firm is of high quality. Therefore, the high quality firm always has a profitable deviation from the pooling equilibrium, and hence a pooling equilibrium does not exist.

A.3 Proof of Proposition 1

As a standard procedure in signaling games, we can solve a relaxed problem with only IC_L and then check the second constraint $p_H \geq 0$ is satisfied. To keep the notations concise, we simply let $p_L = p_L^*(t)$ and $p_H = p_H^*(t)$. Following such a procedure, in the separating equilibrium, IC_L must be binding and the price p_H satisfies

$$\begin{aligned}
& \underbrace{(1+\beta)p_L[1-F(p_L-L;t)]}_{\pi_L^*(t)} \\
= \;& p_H[1-F(p_H-H;t)] + \beta p_H[1-F(p_H-L;t)] \qquad (6)\\
= \;& \underbrace{(1+\beta)p_H[1-F(p_H-H;t)]}_{\pi_H^*(t)} - \underbrace{\beta p_H[F(p_H-L;t)-F(p_H-H;t)]}_{\Delta\pi}.
\end{aligned}$$

Consider an increase in the level of targeting from t to t', with the corresponding prices changing from (p_L, p_H) to (p'_L, p'_H). The change in the profit difference $\Delta\pi$ can be decomposed as

$$\begin{aligned}
\Delta\pi' - \Delta\pi = \; & \underbrace{\beta p_H[F(p_H-L;t')-F(p_H-H;t')] - \beta p_H[F(p_H-L;t)-F(p_H-H;t)]}_{\text{Direct Effect of Targeting } \Delta_t} \\
& + \underbrace{\beta p'_H[F(p'_H-L;t')-F(p'_H-H;t')] - \beta p_H[F(p_H-L;t')-F(p_H-H;t')]}_{\text{Indirect Effect of Price } \Delta_p}
\end{aligned}$$

The direct effect of targeting Δ_t is positive by assumption that $\mathbb{L}$ is increasing in t. The indirect price effect can be written as

$$\Delta_p = \int_{p_H}^{p'_H} \big[F(p-L;t') + pf(p-L;t') - (F(p-H;t') + pf(p-H;t'))\big]dp$$

The integrand is positive following from Assumption 1 (specifically, $F(p-q;t)+pf(p-q;t)$ is decreasing in q). Furthermore, we also have $p'_H > p_H$. To see this, notice that (p_L, p_H) satisfies

$$(1+\beta)p_L[1-F(p_L-L;t)] = p_H[1-F(p_H-H;t)] + \beta p_H[1-F(p_H-L;t)].$$

The right hand side is decreasing in p_H, hence, $p'_H > p_H$ is equivalent to

$$\begin{aligned}
& (1+\beta)[p'_L(1-F(p'_L-L;t')) - p_L(1-F(p_L-L;t))] \\
< \; & p_H[F(p_H-H;t)-F(p_H-H;t')] + \beta p_H[F(p_H-L;t)-F(p_H-L;t')].
\end{aligned} \qquad (7)$$

By assumption, we have $F(p_H - L; t') - F(p_H - H; t') > F(p_H - L; t) - F(p_H - H; t)$, hence,

$$F(p_H - H; t) - F(p_H - H; t') > F(p_H - L; t) - F(p_H - L; t').$$

Thus, a sufficient condition for Condition (7) is

$$p'_L(1 - F(p'_L - L; t')) - p_L(1 - F(p_L - L; t)) < p_H[F(p_H - L; t) - F(p_H - L; t')].$$

Or equivalently,

$$p'_L(1 - F(p'_L - L; t')) - p_H(1 - F(p_H - L; t')) < p_L(1 - F(p_L - L; t)) - p_H(1 - F(p_H - L; t)).$$

In fact, we have

$$\begin{aligned}
& p'_L(1 - F(p'_L - L; t')) - p_H(1 - F(p_H - L; t')) \\
= \; & -\int_{p'_L}^{p_H} [1 - F(p - L; t') - pf(p - L; t')] dp \\
< \; & -\int_{p'_L}^{p_H} [1 - F(p - L; t) - pf(p - L; t)] dp \\
< \; & -\int_{p_L}^{p_H} [1 - F(p - L; t) - pf(p - L; t)] dp \\
= \; & p_L(1 - F(p_L - L; t)) - p_H(1 - F(p_H - L; t)),
\end{aligned}$$

where the first inequality follows from Assumption 1 and the integrand being negative, and the second inequality follows from $p_L < p'_L$, which also follows from Assumption 1. In sum, this means $p'_H > p_H$ and hence Δ_p is also positive. Thus, $\Delta\pi' > \Delta\pi$.

A.4 Proof of Proposition 2

As above, let $p_L = p^*_L(t)$ and $p_H = p^*_H(t)$. From Equation (6), $\Delta\pi$ is decreasing in t if $p_H[F(p_H - L; t) - F(p_H - H; t)]$ is decreasing in t, and we have

$$p_H = \frac{(1 + \beta)\pi^*_L(t)}{1 - F(p_H - H; t) + \beta[1 - F(p_H - L; t)]}.$$

Hence, $\Delta\pi$ is decreasing in t if

$$\mathbb{L}_\pi = \pi_L^*(t)\frac{F(p_H - L;t) - F(p_H - H;t)}{1 - F(p_H - H;t) + \beta(1 - F(p_H - L;t))}$$

is decreasing in t. Notice that, in this case, the direct effect of targeting becomes negative while the indirect effect of price can still be positive and dominate. Thus, to quantify these two effects, we turn to the case when $F(x;t)$ is differentiable in t, which allows us to apply the Implicit Function Theorem to quantify the price effect. Specifically, $d\Delta\pi/dt < 0$ if (where we have eliminated β from both sides)

$$\begin{aligned}
& p_H[\tfrac{\partial F(p_H-L;t)}{\partial t} - \tfrac{\partial F(p_H-H;t)}{\partial t}] \\
< \; & [F(p_H - L;t) + p_H f(p_H - L;t) - (F(p_H - H;t) + p_H f(p_H - H;t)] \\
& \cdot \tfrac{p_L \frac{\partial F(p_L-L;t)}{\partial t} - p_H \frac{\partial F(p_H-H;t)}{\partial t} + \beta(p_L \frac{\partial F(p_L-L;t)}{\partial t} - p_H \frac{\partial F(p_H-L;t)}{\partial t})}{[1-F(p_H-H;t)-p_H f(p_H-H;t)]+\beta[1-F(p_H-L;t)-p_H f(p_H-L;t)]},
\end{aligned}$$

which can be rewritten as

$$\begin{aligned}
& \frac{[1 - F(p_H - H;t) - p_H f(p_H - H;t)] + \beta[1 - F(p_H - L;t) - p_H f(p_H - L;t)]}{[1 - F(p_H - H;t) - p_H f(p_H - H;t)] - [1 - F(p_H - L;t) - p_H f(p_H - L;t)]} \\
< \; & \frac{p_L \frac{\partial F(p_L-L;t)}{\partial t} - p_H \frac{\partial F(p_H-H;t)}{\partial t} + \beta(p_L \frac{\partial F(p_L-L;t)}{\partial t} - p_H \frac{\partial F(p_H-L;t)}{\partial t})}{p_H \frac{\partial F(p_H-L;t)}{\partial t} - p_L \frac{\partial F(p_L-L;t)}{\partial t} + p_L \frac{\partial F(p_L-L;t)}{\partial t} - p_H \frac{\partial F(p_H-H;t)}{\partial t}}.
\end{aligned}$$

We can further write this as

$$\frac{A+\beta}{A-1} < \frac{B+\beta}{B-1},$$

where

$$A = \frac{1 - F(p_H - H;t) - p_H f(p_H - H;t)}{1 - F(p_H - L;t) - p_H f(p_H - L;t)}; B = \frac{p_L \frac{\partial F(p_L-L;t)}{\partial t} - p_H \frac{\partial F(p_H-H;t)}{\partial t}}{p_L \frac{\partial F(p_L-L;t)}{\partial t} - p_H \frac{\partial F(p_H-L;t)}{\partial t}}.$$

Notice that the denominator on both sides are negative and this can be further simplified to

$$\frac{p_L \frac{\partial F(p_L-L;t)}{\partial t} - p_H \frac{\partial F(p_H-H;t)}{\partial t}}{p_L \frac{\partial F(p_L-L;t)}{\partial t} - p_H \frac{\partial F(p_H-L;t)}{\partial t}} < \frac{1 - F(p_H - H;t) - p_H f(p_H - H;t)}{1 - F(p_H - L;t) - p_H f(p_H - L;t)}.$$

A.5 Proof of Proposition 3

In the separating equilibrium, the low quality firm chooses targeting level T and the corresponding complete information price $p_L^*(T) = p^M(L;T)$. If the high quality firm chooses targeting level t_H, the corresponding equilibrium price satisfies

$$\begin{aligned}&(1+\beta)\underbrace{p_L^*(T)[1-F(p_L^*(T)-L;T)]}_{\pi_{LL}} \\ =\;& \underbrace{p_H^*(t_H)[1-F(p_H^*(t_H)-H;t_H)]}_{\pi_{HH}} + \beta\underbrace{p_H^*(t_H)[1-F(p_H^*(t_H)-L;t_H)]}_{\pi_{HL}}.\end{aligned} \tag{8}$$

The profit of the high quality firm is simply $\pi_H^*(t_H) = (1+\beta)\pi_{HH}$. The high quality firm will thus choose the lowest targeting level if π_{HH} is decreasing in t_H. As above, to simplify the exposition, we simply let $p_H = p_H^*(t_H)$. Notice that, since π_{LL} no longer depends on t_H, the left hand side of Equation (8) is constant. Hence, π_{HH} is decreasing in t_H if π_{HL}/π_{HH} is increasing in t_H. That is, if

$$\frac{1-F(p_H^*(t_H)-L;t_H)}{1-F(p_H^*(t_H)-H;t_H)}$$

is increasing in t_H, which is equivalent to

$$\mathbb{L}_d = \frac{F(p_H^*(t_H)-L;t_H)-F(p_H^*(t_H)-H;t_H)}{1-F(p_H^*(t_H)-H;t_H)}$$

is decreasing in t_H. If $p_H^*(t_H)$ is invariant to t_H, then $\mathbb{L}_d$ is clearly decreasing in t_H when $F(p-L;t_H)-F(p-H;t_H)$ is decreasing in t_H. Yet, $p_H^*(t_H)$ also increases as t_H becomes higher (as the right hand side of Equation (8) is decreasing in p_H). Hence, to quantify the effects of t_H on π_{HH}, we again turn to the case when $F(x;t)$ is differentiable. We have:

$$\frac{d\pi_{HH}}{dt} = -p_H\frac{\partial F(p_H-H;t_H)}{\partial t} + [1-F(p_H-H;t_H)-p_H f(p_H-H;t_H)]\frac{\partial p_H}{\partial t} < 0,$$

where

$$\frac{\partial p_H}{\partial t} = -\frac{-p_H \frac{\partial F(p_H - H; t_H)}{\partial t} - \beta p_H \frac{\partial F(p_H - L; t_H)}{\partial t}}{[1 - F(p_H - H; t_H) - p_H f(p_H - H; t_H) + \beta[1 - F(p_H - L; t_H) - p_H f(p_H - L; t_H)}, $$

by applying the Implicit Function Theorem to the above Equation (8). After simplification, this becomes

$$\frac{\frac{\partial F(p_H - H; t_H)}{\partial t}}{\frac{\partial F(p_H - L; t_H)}{\partial t}} < \frac{1 - F(p_H - H; t_H) - p_H f(p_H - H; t_H)}{1 - F(p_H - L; t_H) - p_H f(p_H - L; t_H)}.$$

The condition can be rewritten as

$$\frac{\frac{\partial F(p_H - H; t_H)}{\partial t}}{1 - F(p_H - H; t_H) - p_H f(p_H - H; t_H)} < \frac{\frac{\partial F(p_H - L; t_H)}{\partial t}}{1 - F(p_H - L; t_H) - p_H f(p_H - L; t_H)},$$

which is equivalent to

$$\frac{\partial \pi(p_H, H; t_H)/\partial t}{\partial \pi(p_H, H; t_H)/\partial p} > \frac{\partial \pi(p_H, L; t_H)/\partial t}{\partial \pi(p_H, L; t_H)/\partial p},$$

where $\pi(p, q, t) = p[1 - F(p - q; t)]$ is the per-period profit. A sufficient condition is then

$$\frac{\partial \frac{\partial \pi(p_H, q; t_H)/\partial t}{\partial \pi(p_H, q; t_H)/\partial p}}{\partial q} > 0,$$

which is satisfied if

$$\frac{\partial^2 \pi(p_H, q; t_H)}{\partial t \partial q} \frac{\partial \pi(p_H, q; t_H)}{\partial p} - \frac{\partial \pi(p_H, q; t_H)}{\partial t} \frac{\partial^2 \pi(p_H, q; t_H)}{\partial p \partial q} > 0,$$

or,

$$\frac{q \frac{\partial^2 \pi(p_H, q; t_H)}{\partial t \partial q}}{\frac{\partial \pi(p_H, q; t_H)}{\partial t}} < \frac{q \frac{\partial^2 \pi(p_H, q; t_H)}{\partial p \partial q}}{\frac{\partial \pi(p_H, q; t_H)}{\partial p}},$$

that is,

$$\epsilon_{\frac{\partial \pi}{\partial t}, q} < \epsilon_{\frac{\partial \pi}{\partial p}, q}.$$

A.6 Proof of Proposition 4

The proof follows similar steps of the proof of Proposition 3. Given that, in the separating equilibrium, the low quality firm chooses T and the corresponding complete information price, the choice of (p_H, t_H) by the high quality firm must satisfy

$$\begin{aligned}
& (1+\beta)\lambda(T)p_L[1-F(p_L-L;T)]-c(T) \\
= \; & \lambda(t_H)p_H[1-F(p_H-H;t_H)]+\beta\lambda(t_H)p_H[1-F(p_H-L;t_H)]-c(t_H),
\end{aligned}$$

which can be rewritten as

$$\begin{aligned}
& (1+\beta)\underbrace{[\lambda(T)p_L[1-F(p_L-L;T)]-\frac{c(T)}{1+\beta}]}_{\pi_{LL}} \\
= \; & \underbrace{[\lambda(t_H)p_H[1-F(p_H-H;t_H)]-\frac{c(t_H)}{1+\beta}]}_{\pi_{HH}}+\beta\underbrace{[\lambda(t_H)p_H[1-F(p_H-L;t_H)]-\frac{c(t_H)}{1+\beta}]}_{\pi_{LH}}.
\end{aligned}$$

The high quality firm chooses the lowest targeting level if $d\pi_{HH}/dt<0$, where

$$\frac{d\pi_{HH}}{dt}=\frac{\partial\pi_{HH}}{\partial t_H}+\frac{\partial\pi_{HH}}{\partial p_H}\frac{dp_H}{dt_H},$$

with

$$\frac{dp_H}{dt_H}=-\frac{\frac{\partial\pi_{HH}}{\partial t_H}+\beta\frac{\partial\pi_{LH}}{\partial t_H}}{\frac{\partial\pi_{HH}}{\partial p_H}+\beta\frac{\partial\pi_{LH}}{\partial p_H}}.$$

Together, the two equation implies that $d\pi_{HH}/dt<0$ if

$$\frac{p_H\frac{\partial[\lambda(t_H)(1-F(p_H-H;t_H))]}{\partial t}-\frac{c'(t_H)}{1+\beta}}{p_H\frac{\partial[\lambda(t_H)(1-F(p_H-L;t_H))]}{\partial t}-\frac{c'(t_H)}{1+\beta}}<\frac{\lambda(t_H)[1-F(p_H-H;t_H)-p_Hf(p_H-H;t_H)]}{\lambda(t_H)[1-F(p_H-L;t_H)-p_Hf(p_H-L;t_H)]},$$

or equivalently,

$$\frac{\partial\tilde{\pi}(p_H,H;t_H)/\partial t}{\partial\tilde{\pi}(p_H,H;t_H)/\partial p_H}>\frac{\partial\tilde{\pi}(p_H,L;t_H)/\partial t}{\partial\tilde{\pi}(p_H,L;t_H)/\partial p_H}.$$

Then, as shown in the proof of Proposition 3, a sufficient condition for this to satisfy is

$$\epsilon_{\frac{\partial\tilde{\pi}}{\partial t},q}<\epsilon_{\frac{\partial\tilde{\pi}}{\partial p},q}.$$

B An Example with Exponential Distribution

We present an example with exponential distribution in this appendix, i.e.,

$$F(x;t) = 1 - e^{-\frac{x}{t}}.$$

The cumulative distribution and density distribution are plotted below for different values of t.

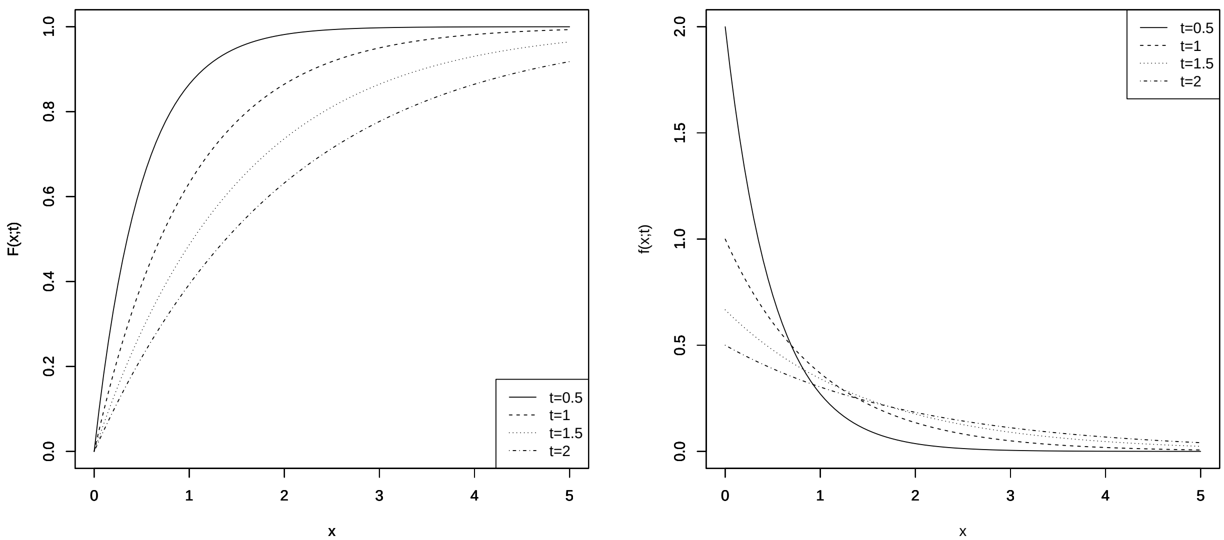

Figure 3: CDF (Left) and PDF (Right) of the Exponential Distribution

However, the exponential distribution does not satisfy Assumption 1. To be more specific, $F(p-q;t) + pf(p-q;t)$ is not everywhere decreasing in q.[34] This means that Proposition 1 no longer applies, the proof of which relies on Assumption 1, and some of our comparison between Proposition 1 and Proposition 2 and 3 does not apply either. Nevertheless, Proposition 2 and 3 still apply as the proof does not rely on Assumption 1. Especially, the

[34]It is decreasing in q for $p < t$ and increasing in q for $p > t$.

condition in Proposition 3 can be simplified to

$$\frac{p_H^*(t_H) - H}{p_H^*(t_H) - L} < 1,$$

which is always satisfied. That is, de-targeting is always optimal in the case of exponential distribution.[35] Although the relationship between the high quality firm's profit and the level of targeting can be non-monotone, it is always profitable for the high quality firm to choose a lower level of targeting than the low quality firm. This is shown in the following figure (drawn for $\beta = 1$ and $t \in [0.5, 1.5]$).

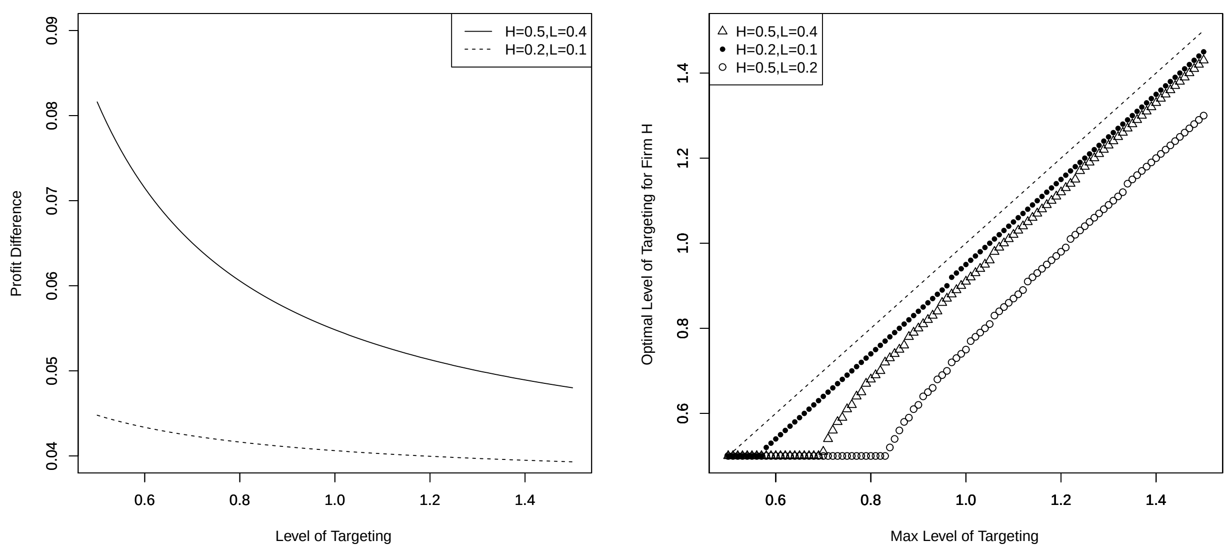

Figure 4: Impact of Targeting on Profit Difference (Left) and Optimal Targeting (Right)

The right panel of Figure 4 illustrates that de-targeting is always optimal for the high quality firm. Furthermore, as in the example of linear density function, a lower level of targeting is chosen when the average quality is higher. It also shows that a lower level of targeting is chosen when the quality difference is large (i.e., the quality uncertainty is large).

[35] Notice that, although exponential distribution does not satisfy Assumption 1, we can check that a pooling equilibrium does not exist. Hence, we can focus on the separating equilibrium.