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Conference Paper

Excessive Targeting

Beiträge zur Jahrestagung des Vereins für Socialpolitik 2019: 30 Jahre Mauerfall - Demokratie und Marktwirtschaft - Session: Industrial Organisation, No. A24-V3

Provided in Cooperation with:

Verein für Socialpolitik / German Economic Association

Suggested Citation: Karle, Heiko (2019) : Excessive Targeting, Beiträge zur Jahrestagung des Vereins für Socialpolitik 2019: 30 Jahre Mauerfall - Demokratie und Marktwirtschaft - Session: Industrial Organisation, No. A24-V3, ZBW - Leibniz-Informationszentrum Wirtschaft, Kiel, Hamburg

This Version is available at:

<https://hdl.handle.net/10419/203626>

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Excessive Targeting*

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September 3, 2019

PRELIMINARY VERSION

Abstract

We consider a market with two symmetric firms and two asymmetric consumer groups. Firms send advertising messages which inform consumers about the existence and the price of their product (Butters, 1977). Targeting a specific consumer is imperfect as with some probability the consumer is not reached. We show that a higher targeting probability has a non-monotone effect on firms' profit. If the probability of successfully targeting a specific consumer is low, all firms target the high-type consumer and more fine-tuned targeting amplifies price competition between firms and decreases firms' profit (competition for cherries). If the probability of successfully targeting is sufficiently high, however, more fine-tuned targeting increases firms' profit because firms segment the market by targeting different consumers. This reduces the competitive pressure for firms. We also characterize conditions under which firms prefer no targeting to perfect targeting technologies.

Keywords: Targeted advertising, Informative advertising, price competition.

JEL-classification: D43, M37.

*We are grateful to Nadia Abou Nabout, Alessandro Bonatti, Emilio Calvano, Siham El Kihal, David Myatt, and Nicolas Schutz as well as seminar audiences at EARIE in Athens and the IO Workshop in Bergamo 2018 for their valuable comments and suggestions. The usual disclaimer applies.

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1 Introduction

In the twenty-first century, most individuals use the internet for an increasing amount of activities and, basically, the internet affects almost any aspect of our daily lives. There is little doubt that this trend will continue or even amplify and that this will foster both, the availability of consumer data as well as the possibility of firms to interact with a particular consumer online. As a consequence, advertising firms will be enabled to better target the most valuable consumer groups. For example, already in 2012, a survey of around 2,000 adults in the US found that 59% of the participants noticed that they were targeted by online advertisements.¹ Although the ability to target consumers improves, targeting is (and very likely will always be) imperfect and an advertising message will reach a consumer not interested in it. As a consequence, it is important to study the implications of imperfect targeting at various levels.

In this paper, we provide a theoretical framework to analyze the implications of imperfect targeting taking competitive effects between advertising firms into account. Incorporating competitive effects is crucial as more fine-tuned targeting may backfire on advertising firms, for example, when the consumer group with the highest willingness to pay coincides for several firms. As an example, consider two competing firms that attempt to target the same high-type consumer via display advertising; one firm via the consumer's preferred news provider and its competitor via the consumer's preferred blog or social media. It could then well be that a high-type consumer interested in buying one unit of the firms' products has seen both messages which increases the competitive pressure for price-setting firms.

In our theoretical framework, we investigate whether an increase in the success rate of targeting is profitable for competing firms when consumer groups differ in their willingness to pay. This enables us to answer the question of whether improved targeting technologies increase firms' profit. We consider a duopoly model with two symmetric firms and two asymmetric consumer groups. Each firm can send up to two advertising messages which inform targeted consumers about the existence and the price of its product (cf. Butters, 1977). Targeting is imperfect, i.e. the probability of successfully targeting a specific consumer is lower than one.

In this setup, we show that more fine-tuned targeting has a non-monotone effect on firms' profit. If the probability of successfully targeting a specific consumer is low, both firms tar-

¹<https://marketingland.com/pew-survey-targeted-ads-negatively-7548>, last accessed February 25, 2019.

get the high-type consumer group and more fine-tuned targeting increases the probability that a high-type consumer observes both prices. This indeed amplifies price competition between firms as described in the display-advertising example above (competition for cherries). If the probability of successfully targeting a specific consumer is sufficiently high, then more fine-tuned targeting increases firms' profit because the firms segment the market and target different consumer groups, which reduces competitive pressure for firms. Market segmentation arises when the probability of successfully targeting is sufficiently high such that targeting the low-type consumer—given that the competing firm targets the high-type consumer—leads to a higher profit than also targeting the high-type consumer.

Our results hold for various different model specifications, representing different industries. First, they hold if firms decide about their targeting and pricing strategy in sequential manner but also when both decisions need to be made simultaneously. The former represent industries in which the consumer segment to which firms cater is chosen long-term (e.g., through the product quality offered by firms or through reputation). Instead, the latter reflects industries with short product life cycles and high turnover. Second, our results also hold if firms can send advertising messages to both consumer groups, which implies that some messages are lost but the probability to reach the targeted consumer is larger. We show that then a firm may abstain from sending multiple messages—even if they are costless—to avoid fierce price competition.

In the remainder of this section, we discuss the related literature. In Section 2, we introduce our model and, in Section 3 and 4, characterize the equilibrium. In Section 5, we provide some generalizations of our model and Section 6 concludes. All proofs missing from the text are relegated to the Appendix.

Related Literature: The existing literature has analyzed targeting in monopoly and oligopoly contexts focusing on consumer groups with symmetric willingness to pay for preferred products. The general finding of that literature is that more fine-tuned targeting has a monotone effect on profits. In particular, more fine-tuned targeting has been found to either monotonically increase profits due to market segmentation or a reduction in total advertising expenditure (cf. Roy, 2000, Esteban, Gil and Hernandez, 2001, Iyer, Soberman and Villas-Boas, 2005, Gal-Or et al., 2006, Galeotti and Moraga-Gonzalez, 2008, Anand and Shachar, 2009, and Chandra, 2009) or monotonically decrease profits from advertising due to intensified competition (cf.

de Corniere, 2016 and Karle and Peitz, 2017).² This stands in contrast to our main result that more fine-tuned targeting of consumer groups with asymmetric willingness to pay has a non-monotone effect and, in particular, first decreases and then increases profits of competitive advertisers.

Bergemann and Bonatti (2011) develop a model with a continuum of heterogeneous products (firms) and a continuum of heterogeneous advertising markets (media outlets) where a continuum of consumers is distributed over these two dimensions (reflecting the complementary view of advertising in the terminology of Bagwell, 2007). Bergemann and Bonatti analyze the price of advertisements in the competitive equilibrium when the price of products is given exogenously and is the same for all products. They find that better targeting may have an inversely U-shaped effect on the equilibrium price of advertisements which is opposed to the U-shaped effect on firms' profit in our model (firms' profit in our model can be interpreted as the price firms are willing to pay for sending targeted advertisements). This difference seems to be driven by the fact that in model of Bergemann and Bonatti, all consumers have the same willingness to pay in all product markets. Our model therefore alludes to the relevance of considering distinct consumer groups with respect to their willingness to pay in the product market in predicting the impact of more fine-tuned targeting.

Levin and Milgrom (2010) describe the costs of excessively fine targeting in the internet advertising market which arise due to cherry-picking by savvy advertisers and the occurrence of thinner markets creating problems for the accurate pricing of advertisements. In this paper, we provide a formal characterization of markets in which targeting can be excessive for advertisers.

2 The Model

Suppose there are two consumers with valuation $B > A \geq 0$ and two symmetric single-product firms 1 and 2. Consumers have unit demand and receive zero utility when they don't buy a product. Each firm can target either consumer A or B and send up to 2 advertising messages which possibly inform the targeted consumer about the existence and the price of its product. Let $\alpha \in [1/2, 1]$ be the probability of successfully targeting the intended consumer by a firm's

²A different mechanism that generates lower profits under targeting requires targeted pricing: firms can condition price on consumer tastes, as pointed out in the literature on customer recognition. Then, better information on consumer tastes leads to more intense competition (e.g., Fudenberg and Tirole, 2000). For a model on targeted pricing that includes advertising, see Esteves and Resende (2016).

message. We assume that firms tailor their product to a specific consumer which implies that if the intended consumer is not reached, the firm does not sell.³ If targeting is successful, the consumer buys from the firm with the lower price. We will refer to $\alpha = 1/2$ as *no targeting*, $\alpha \in (1/2, 1)$ as *imperfect targeting*, and $\alpha = 1$ as *perfect targeting*.⁴ Production costs and advertising costs for the first message are zero and advertising costs for the second message are $b \geq 0$.

Timing. We consider two setups. In Section 3, we analyse a sequential targeting and pricing decision by firms. In a first stage, firms choose which consumer to target with their product and whether to send 1 or 2 messages. Firms observe the targeting decisions and then simultaneously set prices. Finally, the success of targeting realizes and consumers make their purchase decision. This scenario is relevant in industries where firms' quality choice is observable and long term as, for example, for expensive durable goods. In Section 4, we examine a simultaneous targeting and pricing decision by firms which better describes industries with short product life cycles and high turnover such as retailing. The solution concept is subgame perfect Nash equilibrium (SPNE).

Interpretation of market structure. We consider a market structure in which firms access consumer data symmetrically.⁵ A justification could be that firms have access to similar targeting technologies or to several data providers such as advertisement exchanges. In the latter case, although we do not model the costs of advertising explicitly, it is reasonable to assume that each advertisement exchange serving one firm would charge a fraction of the firm's profit for targeting intended consumers. This would not affect any of our results.⁶

3 Sequential Targeting and Pricing

3.1 Sequential Targeting and Pricing: One Message

As a starting point, suppose firms decide which consumer to target and send only one message each, i.e. in line with Butters (1977) it is impossible or too expensive to send a message

³In the next version of this paper, we will show how our results are affected if we relax this assumption.

⁴Note that sending 2 messages always leads to perfect targeting independent of α .

⁵This is a mere simplification and could be relaxed.

⁶Note, however, that a single data provider acting as a data monopolist would sell targeting messages for each consumer group exclusively to either one or the other firm. This would enable firms to fully extract the surplus from all consumers who buy a product and lead to constant prices and different results overall.

to all consumers (in our setup this implies that the costs of sending a second message b are sufficiently high). First, suppose firms segment the market and target different consumers—for example, firm 1 targets consumer A and firm 2 targets consumer B . Then, there is a pure-strategy Nash equilibrium with prices $p_1 = A$ and $p_2 = B$. The expected profits equal $\pi_1^{AB} = \alpha A$ and $\pi_2^{AB} = \alpha B$, where superscript AB refers to firm 1 targeting consumer A with 1 message and firm 2 targeting consumer B with 1 message.

Second, when both firms target the high-type consumer B , then setting $p_1 = p_2 = B$ leads to $\pi_i^{BB} = [\frac{\alpha^2}{2} + \alpha(1 - \alpha)]B$ for all i . Note however this is not an equilibrium because it is profitable for firm $-i$ to slightly undercut $p_i = B$. We show next that there exists a symmetric mixed-strategy equilibrium which yields an expected profit of $\alpha(1 - \alpha)B$.

Note that no firm has an incentive to set a price higher than B as no consumer would buy a product which leads to zero profits. Thus, in any Nash equilibrium it holds that $p_i \leq B$ for all i . The expected profit as function of prices is characterized by

$$E[\pi_i^{BB}(p_i, p_{-i})] = \begin{cases} \alpha p_i, & \text{if } p_i < p_{-i}; \\ \left(\frac{\alpha^2}{2} + \alpha(1 - \alpha)\right) p_i, & \text{if } p_i = p_{-i}; \\ \alpha(1 - \alpha)p_i, & \text{if } p_i > p_{-i}. \end{cases}$$

Setting $p_i = B$ grants a profit of at least $\alpha(1 - \alpha)B$, where $\alpha(1 - \alpha)$ is the probability that consumer B only observes firm i 's price. As a consequence, undercutting firm $-i$ is profitable for firm i as long as the resulting price level is not lower than $p_i = (1 - \alpha)B$. Thus, the price range of a potential mixed strategy equilibrium equals $[(1 - \alpha)B, B]$.

Suppose firm i plays a mixed strategy and draws its price from the cdf $F(p_i)$ on $[(1 - \alpha)B, B]$. Then, firm $-i$ is indifferent between setting any price on $[(1 - \alpha)B, B]$ if

$$\alpha p(1 - F(p)) + \alpha(1 - \alpha)pF(p) = \alpha(1 - \alpha)B.$$

This yields

$$F(p) = \frac{1}{\alpha} - \frac{(1 - \alpha)B}{\alpha p} \quad (1)$$

with $F((1 - \alpha)B) = 0$ and $F(B) = 1$.

When is this symmetric mixed-strategy equilibrium on the equilibrium path of the SPNE of

the entire game? Both firms have an incentive to target consumer B if the profit of the symmetric mixed-strategy equilibrium is larger than the lowest profit under market segmentation, i.e.

$$\alpha(1 - \alpha)B \geq \alpha A.$$

This is equivalent to

$$\alpha \leq 1 - \frac{A}{B} \equiv \hat{\alpha}(A/B). \quad (2)$$

Proposition 1. *Suppose firms first announce their targeting strategy (sending one message each) and then set prices.*

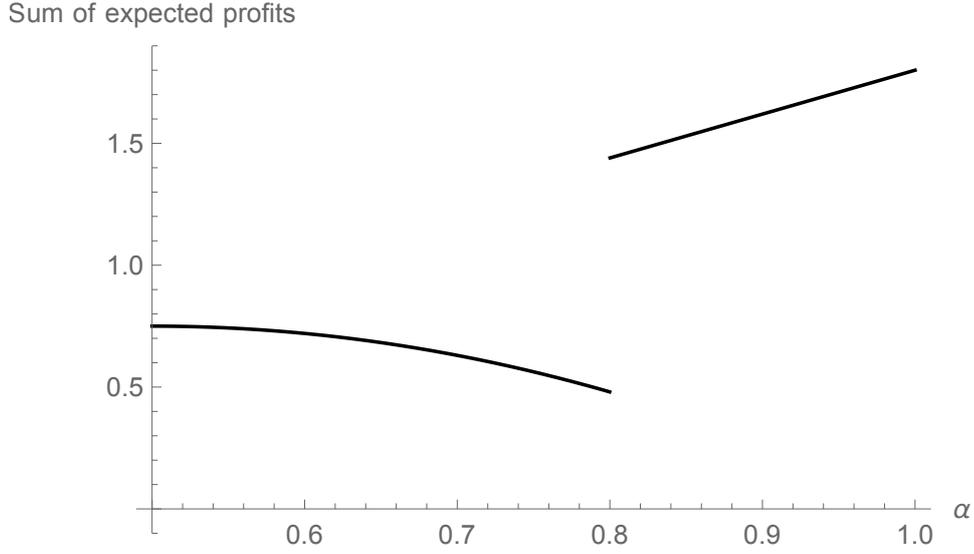
1. *If $\alpha \in [1/2, \hat{\alpha}(A/B)]$, both firms target consumer B and there is a symmetric mixed-strategy equilibrium, in which firms set prices in the domain $p_i \in [(1 - \alpha)B, B]$. The mixing probability is characterized by the cumulative distribution function $F(p_i)$ in (1). The expected profit is $\pi_i^* = \alpha(1 - \alpha)B$ for all i .*
2. *If $\alpha \in (\hat{\alpha}(A/B), 1]$, in equilibrium, firms segment the market, prices are $p_i^* = A$, $p_{-i}^* = B$, and firms' profits are $\pi_i^* = \alpha A$, $\pi_{-i}^* = \alpha B$.*

The sum of expected profits as a function of α is given by

$$\sum_i E[\pi_i^*(\alpha)] = \begin{cases} 2\alpha(1 - \alpha)B, & \text{if } \alpha \in [1/2, \hat{\alpha}(A/B)]; \\ \alpha(A + B), & \text{if } \alpha \in (\hat{\alpha}(A/B), 1]. \end{cases}$$

As illustrated in Figure 1, the sum of expected profits is strictly decreasing and strictly concave in α for $\alpha \in [1/2, \hat{\alpha}(A/B)]$ (where both firms target consumer B) and strictly increasing in α for $\alpha \in (\hat{\alpha}(A/B), 1]$ (where firms segment the market). That is, the sum of expected profits is non-monotone in the success probability of advertising α .

In addition, there is a discontinuity with an upward jump at $\hat{\alpha}(A/B)$. At $\hat{\alpha}(A/B)$, given that firm $-i$ targets the high-type consumer, firm i is indifferent between targeting the low-type consumer and targeting the high-type consumer. However, when firm i targets the low-type consumer, then firm $-i$ targeting the high-type consumer has the pure strategy to set $p_{-i} = B$ which boosts its profit. We conclude that whenever it is optimal for firms to both target consumer B , then firms' profits are strictly decreasing in α for some range before firms' profits



The sum of expected profits as a function of the probability of successfully targeting α . The decreasing part of the expected profit function arises when both firms target the high consumer type B , and the increasing part arises when firms segment the market. Parameter values are $A = 0.3$, $B = 1.5$ and $\hat{\alpha}(A/B) = 0.8$.

Figure 1: Sum of Expected Profits with One Message: Seq. Targeting and Pricing

start increasing again because firms segment the market. In the decreasing part, targeting is excessive in the sense that firms would benefit from not having access to targeting technologies with $\alpha > 1/2$ because more fine-tuned targeting intensifies price competition when both firms target B . Note that if $B \geq 2A$, this range is non-empty, i.e. excessive targeting occurs for some $\alpha \in [1/2, 1]$.

3.2 Sequential Targeting and Pricing: Two Messages

Suppose next that each firm decides which consumer to target and sends up to two messages for free (i.e. the costs of sending a second message b are zero). First, if firms segment the market and target different consumers with two messages, there exists a pure-strategy Nash equilibrium with prices $p_i = A$ and $p_{-i} = B$. For purpose of illustration, assume that $i = 1$. Then, the corresponding expected profits equal $\pi_1^{A(2)B(2)} = A \geq \alpha A$ and $\pi_2^{A(2)B(2)} = B \geq \alpha B$, where superscript $A(2)B(2)$ refers to firm 1 targeting consumer A with 2 messages and firm 2 targeting consumer B with 2 messages. Note that those profits exceed those with only one message by factor $1/\alpha \in [1, 2]$. The reason is that sending two messages implies perfect targeting such that all A -consumers pay a price of A and all B -consumers pay a price of B ,

respectively.

Second, suppose both firms target consumer B with two messages. Then, Bertrand competition in the pricing stage arises and leads to zeros profits. Firms could earn positive profits, however, by both targeting consumer B using a different number of messages. Suppose, for example, firm 1 sends only 1 message and firm 2 sends 2 messages. Then, firm 1's expected profit as function of prices ($p_1, p_2 \in [0, B]$) equals

$$E[\pi_1^{B(1)B(2)}(p_1, p_2)] = \begin{cases} \alpha p_1, & \text{if } p_1 < p_2; \\ \frac{\alpha}{2} p_1, & \text{if } p_1 = p_2; \\ 0, & \text{if } p_1 > p_2. \end{cases}$$

Firm 2's expected profit as function of prices equals

$$E[\pi_2^{B(1)B(2)}(p_1, p_2)] = \begin{cases} p_2, & \text{if } p_2 < p_1; \\ (1 - \alpha)p_2 + \frac{\alpha}{2} p_2, & \text{if } p_2 = p_1; \\ (1 - \alpha)p_2, & \text{if } p_2 > p_1. \end{cases}$$

Hence, setting $p_2 = B$ grants firm 2 a profit of at least $(1 - \alpha)B$. It follows that undercutting firm 1 is profitable for firm 2 as long as the resulting price level is not lower than $p_2 = (1 - \alpha)B$. Thus, the price range of a potential mixed strategy equilibrium is $[(1 - \alpha)B, B]$ yielding an expected profit of $(1 - \alpha)B$ to firm 2. Then, by setting p_1 slightly below $(1 - \alpha)B$, firm 1 earns an expected profit of (almost) $\alpha(1 - \alpha)B$. In the proof of Proposition 2 in the Appendix, we characterize the asymmetric mixed-strategy equilibrium with mixing probability $G(p)$ and $H(p)$ on $[(1 - \alpha)B, B]$ which arises when firm 1 sends only 1 message and firm 2 sends 2 messages.

When is this asymmetric mixed-strategy equilibrium on the equilibrium path of the SPNE of the entire game? Both firms have an incentive to target consumer B with 1 or 2 messages if their profit in the asymmetric mixed-strategy equilibrium is larger than the lowest profit under market segmentation. For firm 1, this condition is satisfied as long as

$$\alpha(1 - \alpha)B \geq A.$$

Hence, solving for α , this leads to the following condition

$$\alpha \leq \frac{1 + \sqrt{1 - 4\frac{A}{B}}}{2} \equiv \hat{\alpha}_2(A/B). \quad (3)$$

Proposition 2. *Suppose firms first announce their targeting strategy and second whether they send 1 or 2 messages each, and then set prices.*

1. *If $\alpha \in [1/2, \hat{\alpha}_2(A/B)]$, both firms target consumer B (firm i by 1 message and firm $-i$ by 2 messages) and there is an asymmetric mixed-strategy equilibrium, in which firms set prices in the domain $p_i \in [(1 - \alpha)B, B]$. The mixing probabilities are characterized by the cumulative distribution functions $G(p_i) = F(p_i)$ in (1) and*

$$H(p_{-i}) = \begin{cases} \frac{p_{-i} - (1 - \alpha)B}{p_{-i}}, & \text{if } p_{-i} \in [(1 - \alpha)B, B]; \\ 1, & \text{if } p_{-i} = B. \end{cases} \quad (4)$$

with a mass point of $(1 - \alpha)$ at $p_{-i} = B$. The expected profits are $\pi_i^ = \alpha(1 - \alpha)B$ and $\pi_{-i}^* = (1 - \alpha)B$.*

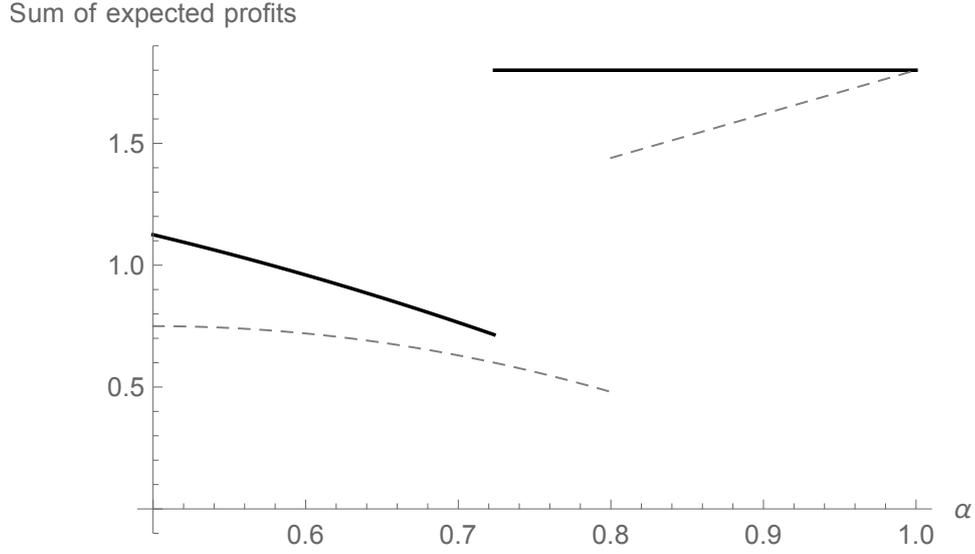
2. *If $\alpha \in (\hat{\alpha}_2(A/B), 1]$, in equilibrium, firms segment the market sending 2 messages each, prices are $p_i^* = A$, $p_{-i}^* = B$, and firms' profits are $\pi_i^* = A$, $\pi_{-i}^* = B$.*

The sum of expected profits as a function of α is given by

$$\sum_i E[\pi_i^*(\alpha)] = \begin{cases} (1 - \alpha^2)B, & \text{if } \alpha \in [1/2, \hat{\alpha}_2(A/B)]; \\ A + B, & \text{if } \alpha \in (\hat{\alpha}_2(A/B), 1]. \end{cases}$$

As illustrated in Figure 2, the sum of expected profits is strictly decreasing and strictly concave in α for $\alpha \in [1/2, \hat{\alpha}_2(A/B)]$ and constant for $\alpha \in (\hat{\alpha}_2(A/B), 1]$. There is a discontinuity with an upward jump at $\hat{\alpha}_2(A/B)$. We conclude that whenever it is optimal for firms to both target consumer B , then profits are strictly decreasing in α for some range before they become constant when firms segment the market (with perfect targeting, i.e. sending two messages each).

In the decreasing part, targeting is excessive (i.e. imperfect targeting leads to lower profits than no targeting) as in the setup where only one message can be sent. This is surprising because by sending two messages firms could individually provide perfect targeting without



The sum of expected profits as a function of the probability of successfully targeting α (black, bold line). The decreasing part of the expected profit function arises when both firms target the high consumer type B , and the constant part arises when firms segment the market. Parameter values are $A = 0.3$ and $B = 1.5$ and $\hat{\alpha}_2(A/B) \approx 0.7236$.

Figure 2: Sum of Expected Profits with Two Messages: Seq. Targeting and Pricing

bearing any additional costs. Yet, competitive forces prevent firms from providing perfect targeting in equilibrium. The decreasing range is non-empty, whenever $B \geq 4A$. Furthermore, $\hat{\alpha}_2(A/B) < \hat{\alpha}(A/B)$ for all $A/B > 0$, i.e., market segmentation occurs for lower targeting probabilities when up to 2 messages can be sent per firm instead of only 1 message. In addition, collecting consumer data up to the maximum level (corresponding to perfect targeting in our model) is always valuable when firms can credibly commit to targeting strategies before setting prices.

4 Simultaneous Targeting and Pricing

So far, we have assumed that firms first announce their targeting strategy and then set prices. In this section, we consider a simultaneous targeting and pricing decision which better describes industries with short product life cycles and high turnover such as retailing. We start again with the case where each firm can send one targeting message only.

4.1 Simultaneous Targeting and Pricing: One Message

When firms decide simultaneously about targeting and pricing, a pure-strategy equilibrium of market segmentation no longer exists. On the one hand, the firm that targets A has a profitable deviation to target B and undercut any price $p > A$, whereas, on the other hand, the firm that targets B never wants to set $p = A$ but deviates to $p = B$. There exists, however, an asymmetric mixed-strategy equilibrium granting an expected profit of αA to both firms where firm $-i$ always targets B and mixes prices and firm i targets A and B with a positive probability. Firm i is indifferent between targeting A and B because firm $-i$'s mixing probability has a mass point at $p_{-i} = B$. For $\alpha \leq \hat{\alpha}(A/B)$, the symmetric mixed-strategy equilibrium where both firm target B and mix prices still exists. For $\alpha > \hat{\alpha}(A/B)$, the expected profit of $\alpha(1 - \alpha)B$ gets lower than αA . Thus, there exists a profitable deviation where one firm targets A , sets $p = A$ and makes a profit of αA .

For $\alpha > \hat{\alpha}(A/B)$, we derive the asymmetric mixed-strategy equilibrium where firm $-i$ always targets B and mixes prices and firm i targets A and B with a positive probability. When targeting A , the price is equal to $p_i = A$ and otherwise it is mixed. The expected profit for both firms is equal to αA . Firm i is indifferent between targeting A and B because firm $-i$'s mixing probability has a mass point at $p_{-i} = B$.

For $\alpha > \hat{\alpha}(A/B)$ or, equivalently, $\alpha A > \alpha(1 - \alpha)B$, if both firms target B , undercutting firm $-i$ is profitable for firm i as long as the resulting price level is not lower than $p_i = A$ which leads to a profit of αA . Thus, the price range of a potential mixed strategy equilibrium equals $[A, B]$.

Proposition 3. *Suppose firms decide simultaneously on their targeting strategy (sending one message each) and on their pricing strategy.*

1. *If $\alpha \in [1/2, \hat{\alpha}(A/B)]$, both firms target consumer B and there is a symmetric mixed-strategy equilibrium, in which firms set prices in the domain $p_i \in [(1 - \alpha)B, B]$. The mixing probability is characterized by the cumulative distribution function $F(p_i)$ in (1). The expected profit is $\pi_i^* = \alpha(1 - \alpha)B$.*
2. *If $\alpha \in (\hat{\alpha}(A/B), 1]$, there is an asymmetric mixed-strategy equilibrium, in which firm i targets consumer A with probability $\sigma_A = (A - (1 - \alpha)B) / (\alpha B)$ and sets $p_i = A$ and, with probability $1 - \sigma_A$, it targets consumer B and sets prices in the domain $p_i \in [A, B]$*

and firm $-i$ always targets consumer B and sets prices in the domain $p_{-i} \in [A, B]$. The mixing probabilities are characterized by the cumulative distribution function

$$J(p_i) = \frac{B(p_i - A)}{(B - A)p_i} \quad (5)$$

and

$$I(p_{-i}) = \begin{cases} \frac{p_{-i}-A}{\alpha p_{-i}}, & \text{if } p_{-i} \in [A, B); \\ 1, & \text{if } p_{-i} = B. \end{cases} \quad (6)$$

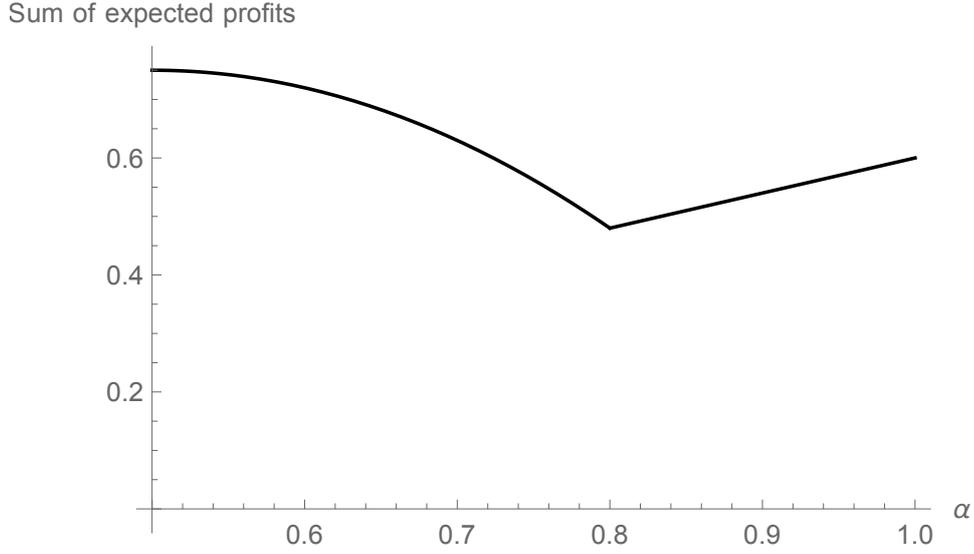
with a mass point of $(A - (1 - \alpha)B) / (\alpha B)$ at $p_{-i} = B$. The expected profit is $\pi_i^* = \alpha A$ for all i .

The sum of expected profits as a function of α is given by

$$\sum_i E[\pi_i^*(\alpha)] = \begin{cases} 2\alpha(1 - \alpha)B, & \text{if } \alpha \in [1/2, \hat{\alpha}(A/B)]; \\ 2\alpha A, & \text{if } \alpha \in (\hat{\alpha}(A/B), 1]. \end{cases}$$

Figure 3 illustrates that also in the simultaneous-move game, the sum of expected profits is strictly decreasing and strictly concave in α for $\alpha \in [1/2, \hat{\alpha}(A/B)]$ and strictly increasing in α for $\alpha \in (\hat{\alpha}(A/B), 1]$. It is continuous everywhere. We conclude that whenever it is optimal for firms to both target consumer B , then profits are strictly decreasing in α for some range before they start increasing again because firms segment the market with some positive probability.

Note that the sum of expected profits could be higher or lower under perfect targeting ($\alpha = 1$) than under no targeting ($\alpha = 1/2$) depending on whether $4A > B$ or $4A \leq B$. This shows that the degree of market segmentation which is achievable in a competitive industry is relevant for the value of consumer data. Collecting consumer data up to the maximum level (corresponding to perfect targeting in our model) may be valuable only if advertising firms manage to segment the market with probability one (as in the sequential game in Section 3). Our results therefore suggest that the opportunity of firms to credibly commit to targeting strategies may determine whether collecting consumer data is profitable in an industry or not.



The sum of expected profits as a function of the probability of successfully targeting α . The decreasing part of the expected profit function arises when both firms target the high consumer type B , and the increasing part arises when firms segment the market with a positive probability. Parameter values are $A = 0.3$, $B = 1.5$ and $\hat{\alpha}(A/B) = 0.8$.

Figure 3: Sum of Expected Profits with One Message: Sim. Targeting and Pricing

4.2 Simultaneous Targeting and Pricing: Two Messages

In this subsection, we consider a simultaneous targeting and pricing decision when each firm can send up to two messages for free.

First, similar to the simultaneous-move game with only one message per firm in the previous subsection, a pure-strategy equilibrium of market segmentation no longer exists. Yet, an asymmetric mixed-strategy equilibrium exists granting an expected profit of A to both firms where firm $-i$ always targets B and mixes prices and firm i targets A and B with a positive probability.

Second, when both firms target consumer B using a different number of messages, they earn positive profits of $\pi_i^* = \alpha(1 - \alpha)B$ and $\pi_{-i}^* = (1 - \alpha)B$, where firm i sends 1 message and firm $-i$ sends 2 messages (cf. the sequential-move game with up to two message per firm). However, the expected profit of $\alpha(1 - \alpha)B$ gets lower than A if $\alpha > \hat{\alpha}_2(A/B)$. In this case, firm i that sends only one message to B has the profitable deviation to send two messages to A and set $p = A$.

For $\alpha > \hat{\alpha}_2(A/B)$, we characterize the asymmetric mixed-strategy equilibrium similar to that in the previous subsection where firm $-i$ always targets B and mixes prices and firm i targets A and B with a positive probability. When targeting A , the price is equal to $p_i = A$ and

otherwise it is mixed. The expected profit for both firms is equal to A . Firm i is indifferent between targeting A and B because firm $-i$'s mixing probability has a mass point at $p_{-i} = B$.

For $A > \alpha(1 - \alpha)B$ or, equivalently, $\alpha > \hat{\alpha}_2(A/B)$, if both firms target B , undercutting firm $-i$ is profitable for firm i as long as the resulting price level is not lower than $p_i = A$ which leads to a profit of A . Thus, the price range of a potential mixed strategy equilibrium equals $[A, B]$.

Proposition 4. *Suppose firms decide simultaneously on their targeting strategy, whether they send 1 or 2 messages each and on their pricing strategy.*

1. *If $\alpha \in [1/2, \hat{\alpha}_2(A/B)]$, both firms target consumer B (firm i by 1 message and firm $-i$ by 2 messages) and there is an asymmetric mixed-strategy equilibrium, in which firms set prices in the domain $p_i \in [(1 - \alpha)B, B]$. The mixing probabilities are characterized by the cumulative distribution functions $F(p_i)$ in (1) and $H(p_{-i})$ in (4). The expected profits are $\pi_i^* = \alpha(1 - \alpha)B$ and $\pi_{-i}^* = (1 - \alpha)B$.*
2. *If $\alpha \in (\hat{\alpha}_2(A/B), 1]$, there is an asymmetric mixed-strategy equilibrium, in which firm i targets consumer A sending 2 messages with probability $\bar{\sigma}_A = A/B$ and sets $p_i = A$ and, with probability $1 - \bar{\sigma}_A$, it targets consumer B sending 2 messages and sets prices in the domain $p_i \in [A, B]$ and firm $-i$ always targets consumer B sending 2 messages and sets prices in the domain $p_{-i} \in [A, B]$. The mixing probabilities are characterized by the cumulative distribution function*

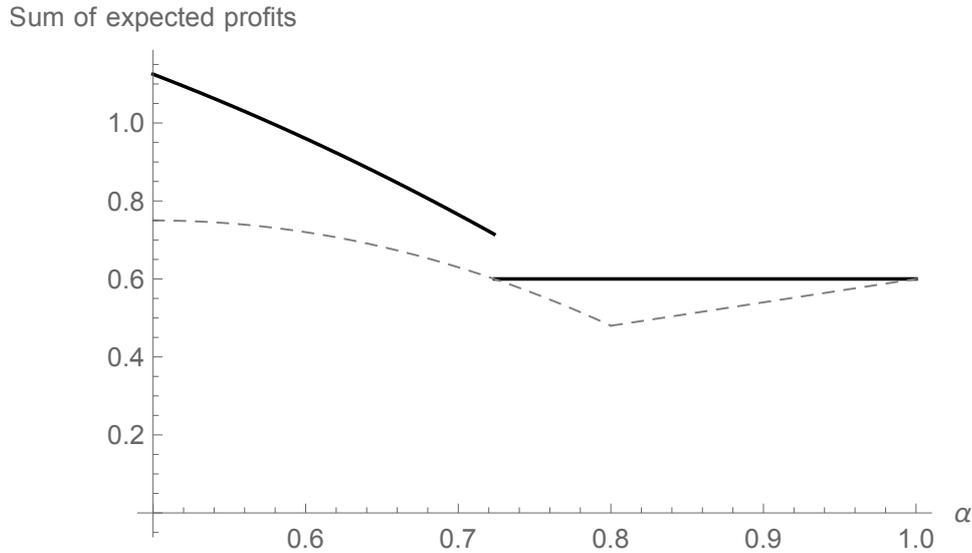
$$K(p_i) = \begin{cases} \frac{p_i - A}{p_i}, & \text{if } p_i \in [A, B]; \\ 1, & \text{if } p_i = B. \end{cases} \quad (7)$$

with a mass point of A/B at $p_i = B$ and $I(p_{-i})$ in (6). The expected profit is $\pi_i^ = A$ for all i .*

The sum of expected profits as a function of α is given by

$$\sum_i E[\pi_i^*(\alpha)] = \begin{cases} (1 - \alpha^2)B, & \text{if } \alpha \in [1/2, \hat{\alpha}_2(A/B)]; \\ 2A, & \text{if } \alpha \in (\hat{\alpha}_2(A/B), 1]. \end{cases}$$

Figure 4 illustrates that in the simultaneous-move game, where each firm can send up to 2 messages, the sum of expected profits is strictly decreasing and strictly concave in α for



The sum of expected profits as a function of the probability of successfully targeting α (black, bold line). The decreasing part of the expected profit function arises when both firms target the high consumer type B , and the constant part arises when firms segment the market with a positive probability. Parameter values are $A = 0.3$ and $B = 1.5$ and $\hat{\alpha}_2(A/B) \approx 0.7236$.

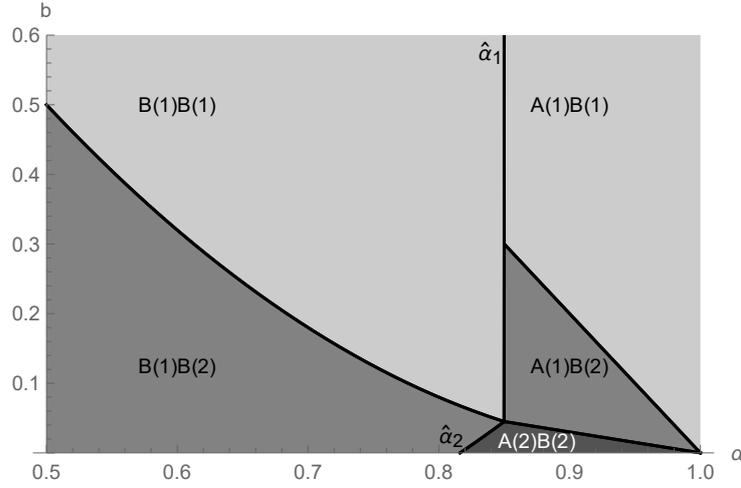
Figure 4: Sum of Expected Profits with Two Messages: Sim. Targeting and Pricing

$\alpha \in [1/2, \hat{\alpha}_2(A/B)]$ and constant for $\alpha \in (\hat{\alpha}_2(A/B), 1]$. The decreasing range is non-empty, whenever $B \geq 4A$. Note, however, that, for $B > 4A$, the sum of expected profits is always lower under perfect targeting ($\alpha = 1$) than under no targeting ($\alpha = 1/2$). This result suggests that the value of collecting consumer data may be negative in competitive industries in which sending messages to all consumers is sufficiently cheap and credible commitment to targeting strategies does not exist.

5 Extension

In the previous sections, we have analyzed the two limiting cases of the costs b for the second message, i.e. $b = 0$ or b sufficiently high such that no second message is used. In this section, we consider the full range of costs b for the second message and show that your qualitative results are robust to this extension.

Figure 5 illustrates the set of equilibrium advertising strategies in the sequential targeting and pricing game. The figure shows that a fifth advertising equilibrium $A(1)B(2)$ arises when b is intermediary and α is rather high. In this equilibrium, the costs b for the second message



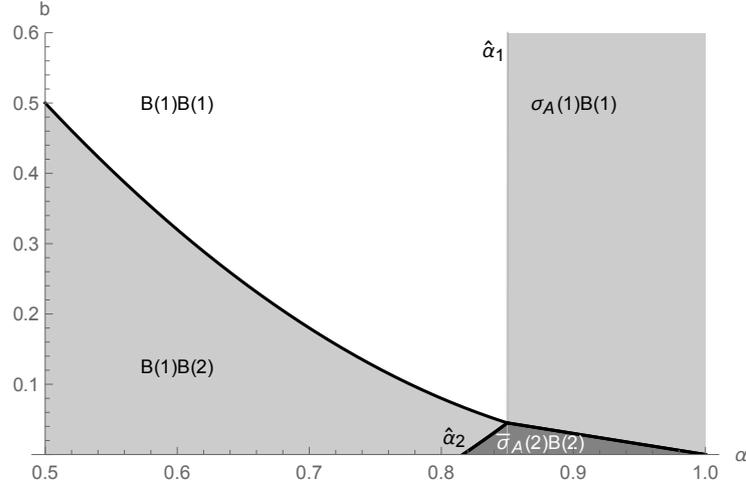
Equilibria of the sequential targeting and pricing game in the (α, b) -graph, where α is the probability of successfully targeting and b is the cost of sending a second message. Parameter values are $A = 0.3$ and $B = 2$ such that $\hat{\alpha}(A/B) = 0.85$ and $\hat{\alpha}_2(A/B) \approx 0.8162$.

Figure 5: Full Range of Costs b for Second Message (Sequential Game)

are so high that the firm that targets the low-value consumer cannot afford the second message, whereas the firm that targets the high-value consumer does. Both firms set a price equal to the willingness to pay of their targeted consumer and earn a profit of αA and $B - b$, respectively. Structurally, this equilibrium is similar to $A(1)B(1)$ and $A(2)B(2)$ described in Proposition 1 and 2.

Overall, comparative statics in α for intermediary levels of b reaches up to 4 different advertising regimes instead of only 2 for b low or high (i.e. $b = 0$ or $b \geq 0.5$ in Figure 5). Note, however, that the non-monotonicity of the firms' profits in α is qualitatively not affected as the sum of firms' profits is bounded by the two limiting cases of b illustrated in Figure 2.

Figure 6 illustrates the set of equilibrium advertising strategies in the simultaneous targeting and pricing game. $\sigma_A(1)B(1)$ and $\bar{\sigma}_A(2)B(2)$ refer to advertising strategies, where firm 1 mixes between targeting consumer A and B , respectively, and firm 2 always targets consumer B (cf. Proposition 3 and 4). In this game, a fifth advertising regime in which firms send a different number of messages under market segmentation does not arise. The reason is that both firms earn the same profit in $\sigma_A(1)B(1)$ or in $\bar{\sigma}_A(2)B(2)$ and therefore have the same incentives to send either one or two messages. Thus, comparative statics in α for intermediary levels of b reaches up to 3 different advertising regimes instead of only 2 for b low or high. Again, it can easily be shown that the comparative static results from Section 4 qualitatively carry over to



Equilibria of the simultaneous targeting and pricing game in the (α, b) -graph, where α is the probability of successfully targeting and b is the cost of sending a second message. Parameter values are $A = 0.3$ and $B = 2$ such that $\hat{\alpha}(A/B) = 0.85$ and $\hat{\alpha}_2(A/B) \approx 0.8162$.

Figure 6: Full Range of Costs b for Second Message (Simultaneous Game)

intermediary levels of b .

6 Conclusion

In this paper, we provide a tractable model to analyze the impact of more fine-tuned targeting on advertising firms' profit. We show under various different model specifications that more fine-tuned targeting has a negative effect on firms' profit when firms compete for high-value consumers, whereas the effect turns positive when firms segment market with some probability. The former arises when targeting is sufficiently imprecise and the latter otherwise.

Future research could address the following open questions. First, it could be interesting to investigate how firms' profits are affected by asymmetric targeting technologies across firms. Second, in the current setup, we assumed that firms tailor their product to a particular consumer group. By relaxing this assumption, the results of our model could be applied to larger set of industries. Finally, in the current model each advertising message is received by some consumer, yet not necessarily by the intended one. It is left to analyze what the impact on optimal advertising strategies and firms' profits is if advertising messages could be lost with some probability.

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Appendix

Proof of Proposition 2. It is left to characterize the asymmetric mixed-strategy equilibrium. Suppose firm 1 plays a mixed strategy and draws its price from the cdf $G(p_1)$ on $[(1 - \alpha)B, B]$. Then, firm 2 is indifferent between setting any price on $[(1 - \alpha)B, B]$ if

$$p(1 - G(p)) + (1 - \alpha)pG(p) = (1 - \alpha)B.$$

This yields

$$G(p) = \frac{1}{\alpha} - \frac{(1 - \alpha)B}{\alpha p}$$

with $G((1 - \alpha)B) = 0$ and $G(B) = 1$. Note that $G(p) = F(p)$ in (1).

Suppose next that firm 2 plays a mixed strategy and draws its price from the cdf $H(p_2)$ on $[(1 - \alpha)B, B]$. Then, firm 1 is indifferent between setting any price on $[(1 - \alpha)B, B]$ if

$$\alpha p \cdot (1 - H(p)) + 0 \cdot H(p) = \alpha(1 - \alpha)B.$$

This is equivalent to

$$H(p) = \begin{cases} \frac{p - (1 - \alpha)B}{p}, & \text{if } p \in [(1 - \alpha)B, B); \\ 1, & \text{if } p = B. \end{cases}$$

with $H((1 - \alpha)B) = 0$ and a mass point of $(1 - \alpha)$ at $p = B$.

Does firm 1 have an incentive to deviate and undercut $p_2 = B$ by setting $p_1 = B - \epsilon$ with $\epsilon > 0$ and close to zero? Firm 1's expected profit of such a deviation equals

$$(1 - \alpha) \cdot \alpha B + \alpha \cdot 0,$$

where the first term arises when firm 2 plays $p_2 = B$ with probability $(1 - \alpha)$ and the second term when firm 2 plays $p_2 < B$ according to $H(p)$. Thus, such a deviation is not profitable for

firm 1. □

Proof of Proposition 3. It is left to characterize the asymmetric mixed-strategy equilibrium. Suppose firm $-i$ targets B with probability one and plays a mixed strategy drawing its price from the cdf $I(p_{-i})$ on $[A, B]$. Then, firm i is indifferent between targeting A setting price $p_i = A$ and targeting B setting any price on $[A, B]$ if

$$\alpha p(1 - I(p)) + \alpha(1 - \alpha)pI(p) = \alpha A.$$

This leads to

$$I(p) = \begin{cases} \frac{p-A}{\alpha p}, & \text{if } p \in [A, B); \\ 1, & \text{if } p = B. \end{cases}$$

with $I(A) = 0$, $(B - A)/(\alpha B) < 1$ and a mass point of $1 - (B - A)/(\alpha B) = (A - (1 - \alpha)B)/(\alpha B)$ at $p = B$.

Suppose firm i targets A with probability σ_A and sets $p_i = A$ and, with probability $1 - \sigma_A$, it targets B and plays a mixed strategy drawing its price from the cdf $J(p_i)$ on $[A, B]$. Then, firm $-i$, always targeting B , is indifferent between any price on $[A, B]$ if

$$\alpha p((1 - \sigma_A)(1 - J(p)) + \sigma_A) + \alpha(1 - \alpha)p(1 - \sigma_A)J(p) = \alpha A.$$

This leads to

$$J(p, \sigma_A) = \frac{p - A}{\alpha p(1 - \sigma_A)} = \frac{I(p)}{(1 - \sigma_A)}.$$

Solving for σ_A such that $J(B, \sigma_A) = 1$ yields

$$\sigma_A = \frac{A - (1 - \alpha)B}{\alpha B}$$

and

$$J(p) = \frac{B(p - A)}{(B - A)p}$$

with $J(A) = 0$, $J(B) = 1$. Note that σ_A is equal to the probability that firm $-i$ sets price equal

to B .

Finally, we show that firm i does not have an incentive to undercut $p_{-i} = B$ slightly with probability one. This is satisfied if and only if firm i 's expected profit of setting $p_i = B - \epsilon$ is not larger than αA . Firm i 's expected deviation profit equals

$$\alpha(1 - \alpha)B(1 - \sigma_A) + \alpha B\sigma_A, \quad (8)$$

where the first term describes firm i 's expected profit when firm $-i$ mixes prices on $[A, B]$ and the second term that when firm $-i$ sets $p_{-i} = B$. Condition (8) simplifies to αA . Therefore, this is not a profitable deviation. \square

Proof of Proposition 4. It is left to characterize the asymmetric mixed-strategy equilibrium. Suppose firm $-i$ targets B with probability one, sends two messages, and plays a mixed strategy drawing its price from the cdf $K(p_{-i})$ on $[A, B]$. Then, firm i is indifferent between targeting A setting price $p_i = A$ and targeting B setting any price on $[A, B]$ if

$$p \cdot (1 - K(p)) + 0 \cdot K(p) = A.$$

This leads to

$$K(p) = \begin{cases} \frac{p-A}{p}, & \text{if } p \in [A, B); \\ 1, & \text{if } p = B. \end{cases}$$

with $K(A) = 0$, $(B - A)/(B) < 1$ and a mass point of A/B at $p = B$.

Suppose firm i sending two messages targets A with probability $\bar{\sigma}_A$ and sets $p_i = A$ and, with probability $1 - \bar{\sigma}_A$, it targets B and plays a mixed strategy drawing its price from the cdf $L(p_i)$ on $[A, B]$. Then, firm $-i$, always targeting B , is indifferent between any price on $[A, B]$ if

$$p \cdot ((1 - \bar{\sigma}_A)(1 - L(p)) + \bar{\sigma}_A) + 0 \cdot (1 - \bar{\sigma}_A)L(p) = A.$$

This leads to

$$L(p, \bar{\sigma}_A) = \frac{p - A}{p(1 - \bar{\sigma}_A)} = \frac{K(p)}{(1 - \bar{\sigma}_A)}.$$

Solving for $\bar{\sigma}_A$ such that $L(B, \bar{\sigma}_A) = 1$ yields

$$\bar{\sigma}_A = \frac{A}{B},$$

$$L(p) = \frac{B(p - A)}{(B - A)p}$$

with $L(A) = 0$ and $L(B) = 1$. Note that $L(p) = I(p)$ in (6) and that $\bar{\sigma}_A$ is equal to the probability that firm $-i$ sets price equal to B .

Finally, we show that firm i does not have an incentive to undercut $p_{-i} = B$ slightly with probability one. This is satisfied if and only if firm i 's expected profit of setting $p_i = B - \epsilon$ is not larger than A . Firm i 's expected deviation profit equals

$$0 \cdot (1 - \bar{\sigma}_A) + B \cdot \bar{\sigma}_A, \tag{9}$$

where the first term describes firm i 's expected profit when firm $-i$ mixes prices on $[A, B)$ and the second term that when firm $-i$ sets $p_{-i} = B$. Condition (9) simplifies to A . Therefore, this is not a profitable deviation. \square