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## Targeted information and limited attention

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# **Targeted Information and Limited Attention**

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# Targeted Information and Limited Attention

Andreas Hefti and Shuo Liu\*

## Abstract

We study targeted information in a duopoly model with differentiated products, allowing for consumers with limited attention. The presence of inattentive consumers incentivizes firms to behave as if they were mass-advertisers, despite their ability to direct their messages precisely towards consumers with the strongest preferences. We show that the scope for targeting as an efficient marketing instrument can be severely reduced, for both firms and consumers, if the standard assumption of unbounded attention capacities is dropped. A central insight of our model is that limited attention may explain the recent evidence on increased ad-blocking, which has become a key concern to the entire advertising industry. Our main findings are robust to several variations, including price and salience competition as well as varying quality of the available marketing data.

**Keywords:** Targeting; Limited Attention; Advertising Avoidance; Salience Competition

**JEL classification:** D43; L13; M37

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# 1 Introduction

Modern information systems, above all the Internet, allow sellers to gather an enormous amount of data about their potential consumers. The availability of such data allows a firm to target its ads towards a precisely identified subsample of consumers. Advertising research leaves little doubt that targeted information has become a dominant source of advertising revenues. Large businesses such as Axiom, IRI or Nielsen make their revenues by selling consumer data to individual companies. Sponsored search advertising, allowing firms to advertise towards consumers who indicate an interest by their web search queries, has become “the largest source of revenues for search engines” (Ghose and Yang, 2009). According to the annual report by the Interactive Advertising Bureau, search advertising alone already has a steady 40% of total digital ad revenues which was about \$6.76 billion in 2006 and nearly trippled to \$18.81 billion in 2014. Similarly, sponsored advertising has grown annually by around 30% from \$1.12 billion in 2011 to \$1.88 billion in 2013 and is expected to grow further.<sup>1</sup>

Given the unprecedented array of customer information and information sharing technologies, including email, SMS, tweeting and social networks, it may come as a surprise that several recent press releases shed doubt on the extent to which real-world targeting behavior really benefits both firms and consumers.<sup>2</sup> If the data about consumers is so comprehensive and detailed, and tailored advertising opportunities are as easy and cheap as never before,<sup>3</sup> why do many consumers complain about receiving too much information or ads that are only of little relevance? This contrasts with the conjecture, voiced a decade ago by a principal analyst of Forrester Research, that the possibility to send targeted messages should lead to “the end of the era of mass marketing” because “nobody can afford it anymore, and consumers are overloaded with messages”.<sup>4</sup>

In this article we reprise the question about the positive and normative consequences of

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<sup>1</sup>Data available online on [www.iab.com/insights](http://www.iab.com/insights) and [www.emarketer.com](http://www.emarketer.com). See Yao and Mela (2011) for similar facts on the importance of sponsored search in advertising, and Evans (2009) for a general survey on advertising data.

<sup>2</sup>Examples include the articles “Does Sponsored Content Work for Advertisers?”, *Wall Street Journal*, March 23, 2014 and “Does targeting work?”, *The Ad Contrarian*, Feb 01, 2012, and the IAB report “Online Consumers View and Usage of Ad Blocking Technologies” (available online on [www.iab.com](http://www.iab.com)). Farahat (2013) demonstrates that previous studies on the effectiveness of targeted advertising may have largely overestimated its effectiveness due to not accounting for selection bias

<sup>3</sup>See, e.g., “How online advertisers read your mind”, *The Economist*, Sep 21, 2014.

<sup>4</sup><http://www.nytimes.com/2004/12/28/business/media/cruise-ship-campaign-aims-at-vacationers-tired-of-snow.html>

firms' abilities to send targeted messages to consumers, possibly at arbitrary precision. We contribute by generalizing a standard model of targeted information to encompass the case of consumers with limited attention, where limited attention is an upper bound on how many alternatives a consumer perceives. This is a natural path to take, given that the superabundance of information and the concomitant scarcity of attention is a characteristic feature of the modern digitized economy. Indeed, the preoccupation that an advertising firm's information could be overlooked by consumers is a major real-world concern of the advertising industry.<sup>5</sup>

In the baseline analysis we study a locational duopoly model with *ex ante* uninformed consumers. Firms, being endowed with complete information about consumer preferences and perfect targeting abilities, need to choose their targeting strategies, i.e. the subset of consumers that receive information. We provide a complete characterization of how the equilibrium set depends on the degree of inattention, consumer tastes, product characteristics (quality and diversity) and firm-side information costs. Our core result, derived in Section 2, establishes that the presence of inattentive consumers can have a substantial impact on the equilibrium targeting behavior. Specifically, if most consumers are fully attentive, as assumed in standard models, there exists an essentially unique targeting equilibrium, where firms send their messages only to their respective prime consumers, i.e. the consumers who find the firm to be their first-best choice. The reason is that the potential competition induced by attentive consumers forces firms to restrict their communication to the most interested consumers, independent of any possible advantage or disadvantage in the information costs. With a sufficient fraction of inattentive receivers, however, firms have an incentive to strategically behave *as if* they were mass advertising by sending their messages to all consumers, despite the availability of perfect data about consumer tastes and a precise targeting technology. This change of strategies follows because information dissemination to a prime consumer works as a reliable shield against intrusive targeting of the competitor if and only if the consumer is fully attentive. If all consumers in the market are attentive, sending a message to a prime consumer assures a transaction, no matter how many messages this consumer receives from the competitor. This protective role of information provision disciplines each firm to restrict the targeting to its respective prime consumers, even if the costs of information provision are arbitrarily small. On

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<sup>5</sup>See, e.g., "Advertising and Technology", *The Economist*, Sep 2014, Special Report.

the contrary, the presence of inattentive consumers induces an incentive to send messages to consumers in the competitor's prime segment as there is a non-negligible chance to win these consumers' attention, but it also cripples the ability to protect the own prime segment. If information costs are sufficiently low, this leads both firms to mass-advertise in the unique equilibrium. With high information costs, firms face a coordination problem with a continuum of possible equilibria.

Limited attention has implications for market shares and consumer welfare. With attentive consumers the equilibrium market shares of firms, as determined by their targeting strategies, entirely reflect the underlying distribution of consumer tastes and firm locations. Attentive consumers force firms to send their messages only to where they induce the highest benefits in the strategic equilibrium, which leads to an informationally efficient ex-post partitioning of the market between firms. As the degree of inattention increases, the importance of traditional fundamentals, such as preferences and product differentiation, for the equilibrium market shares declines, and they even become irrelevant in the limiting case of only inattentive consumers. In its extreme this can mean that if a firm has a systematic advantage in attracting attention, its competitor may not survive despite an advantage, e.g., in consumer preferences. Similarly, a weaker firm (in terms of quality or match value of its products) has a stronger incentive to obfuscate, e.g. by increasing the cognitive complexity of its products, if such activities reduce overall consumer attentiveness. The bottom line of these observations is that with inattentive consumers the ability to attract attention may be far more decisive for business success than standard determinants, such as the taste distribution, consumer willingness-to-pay or the prevalent degree of product diversity. Moreover, inattention leads to inefficiency because of excess advertising in the low-cost (mass-advertising) equilibrium, and because of generic mis-targeting in case of the high-cost (coordination) equilibria.

We extend our baseline model in various directions. In Section 2.2.1 we allow for price competition, and in Section 2.2.2 we incorporate strategic salience competition as a natural way of endogenizing the perception probabilities and the information costs. We find that the way of how limited attention affects equilibrium targeting is essentially unchanged, while both variations yield additional novel predictions.

In Section 3 we introduce the consumer decision to block information. Each consumer is described by a private nuisance cost of receiving information, and needs to decide whether or not to block the incoming information by weighting the anticipated nuisance of advertising against expected benefits of the perceived information. We establish that the prevalence of limited attention provides an explanation for the well-documented recent increase of ad-blocking by consumers, which has become a major challenge to the entire advertising industry.<sup>6</sup> This increase in ad blocking came as a surprise, especially since the involved blocking technology has ostensibly not improved that much during the last decade.<sup>7</sup> While such a development is indeed puzzling from a standard perspective – we show that if consumers have unbounded attention capacities such blocking should not arise since each firm targets only its respective prime segment – it is the main prediction if consumers are attention-constrained. Then, some consumers choose to block because they do not believe that the market will enable them to *perceive* the most useful information, while the firms remain locked in their role as mass-advertisers. As a consequence, firms end up sharing a smaller pie, despite possibly investing a lot in advertising. We thus identify an additional channel of inefficiency due to limited attention, which is particularly problematic given that there is social surplus from any match between firms and consumers in our model. This meets the worries of many ad consultancies.

In Section 4 we ask how limited attention affects the firm-side information gathering process by relaxing the assumption that firms hold perfect marketing data about consumer preferences. Besides adding realism this allows us to obtain a refined understanding of previous results. We find that the incentives for information acquisition of the firms depend on consumer attention. With fully attentive consumers, the firm with the better marketing data saves on ad costs and makes a higher equilibrium profit. Moreover, a possibly unilaterally increase in the quality of

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<sup>6</sup>According to the report “The cost of ad blocking” by PageFair and Adobe (2015) the year 2014 has seen 48% increase of ad blocking in the US. The estimated revenue loss to the industry is \$21 billion or 14% of global ad spending. The report “Online Consumers Views and Usage of Ad Blocking Technologies” by IAB.net (2014) states that more than 1/3 of US adults use ad blockers. Both studies identify an increase in the exposure to ads together with an intrusive view on advertising to be among the main reasons why people start to use ad blocking software. These findings are confirmed by the report “B2B ad blocker study of the OVK” (2015) in case of Germany. This study lists retargeting among the most important reasons for the use of ad blockers. Also see “Invisible ads, phantom readers”, The Economist, Mar 26, 2016.

<sup>7</sup>Examples of media reports on ad blocking are <http://techcrunch.com/2012/05/18/clarityray-ad-blockers> or <https://www.linkedin.com/pulse/does-targeted-advertising-work-2015-jay-dillon>. See “Ad Blocking: The Unnecessary Internet Apocalypse”, September 22, 2015 (<http://adage.com/article/digitalnext/ad-blocking-unnecessary-internet-apocalypse/300470>) for company advice how to respond to increased ad blocking.

the marketing data reduces the measure of consumers that, inefficiently, receive messages from both firm. Therefore, firms would always want better marketing data, and consumers would be willing to share their data with them. These results collapse with inattentive consumers: More precise marketing data becomes obsolete because firms resort to mass advertising, and consumers would not benefit from sharing information with them. Accordingly, limited attention provides a new explanation for why consumers may be reluctant to share information about their tastes with advertising firms.<sup>8</sup>

## 2 A Baseline Model of Targeted Information

Consider two firms, indexed by  $j \in \{A, B\}$ , that sit on a Hotelling line  $[0, 1]$ . Let  $x_j \in [0, 1]$  be the location of firm  $j$ , where always  $x_A < x_B$ . A unit mass of consumers is uniformly distributed over the line. If a consumer  $i \in [0, 1]$  transacts with firm  $j$  this induces a consumer-side benefit

$$U_i(j) = \mathcal{V}_j - t|i - x_j|,$$

where  $t|i - x_j|$ ,  $t > 0$ , quantifies the consumer-specific (transportation) cost while  $\mathcal{V}_j$  represents a consumer-independent but possibly firm-specific value of consumption to  $i$ . We impose the standard specification that  $\mathcal{V}_j = V_j - p_j$ , where  $V_j$  reflects  $j$ 's product quality and  $p_j$  is the price charged by  $j$ , but most of our results do not hinge on this particular structure. For the moment we take  $\mathcal{V}_j \in \mathbb{R}_+$  as exogenously given, and restrict attention to parameters such that  $\mathcal{V}_j \geq t$ ; hence  $U_i(j) \geq 0 \forall i \in [0, 1], j \in \{A, B\}$ . Let  $\mathcal{P}_j \equiv \{i \in [0, 1] : U_i(j) \geq U_i(-j)\}$ ,  $j \in \{A, B\}$  denote firm  $j$ 's *prime segment* of consumers. Note that  $\mathcal{P}_A \cup \mathcal{P}_B = [0, 1]$ , and  $\mathcal{P}_A \cap \mathcal{P}_B = \{i_0\}$ ,  $i_0 \in (0, 1)$ , iff

$$\frac{|\mathcal{V}_A - \mathcal{V}_B|}{x_B - x_A} < t. \quad (1)$$

If (1) is satisfied, the segmentation point  $i_0$  is

$$i_0 = \frac{\mathcal{V}_A - \mathcal{V}_B}{2t} + \frac{x_A + x_B}{2} \quad (2)$$

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<sup>8</sup>Previous studies on the determinants of the consumers' willingness to share information with advertisers have mainly focused on privacy concerns, the sensitivity of the information, and the scope of the collection and use of information (see, e.g., Nam et al., 2006; Ur et al., 2012; Leon et al., 2015).



and  $\mathcal{P}_A = [0, i_0]$ ,  $\mathcal{P}_B = [i_0, 1]$ . If (1) is violated, the prime segment of one firm coincides with the entire consumer population. Note that prime segments are, by definition, only determined by traditional fundamentals, such as product characteristics and consumer preferences.

**Information, limited attention (LA) and consumer choice** Each consumer faces an information set  $X_i \subseteq \{A, B\}$ , recording from which firm(s) a consumer receives information. We follow the literature on informative advertising by assuming that  $j \in X_i$  iff consumer  $i$  has been informed by  $j$  (e.g., Butters, 1977; Grossman and Shapiro, 1984). The novel feature is that each consumer is further described by her attentiveness  $R_i \in \{1, 2\}$ , where the capacity limit  $R_i$  is the maximal number of alternatives that  $i$  can perceive.<sup>9</sup> Since there are only two firms,  $R_i > 2$  and  $R_i = 2$  need not be distinguished. We do not require, in general, that  $R_i = 1$  literally means that a consumer perceives only a single product, but rather only one menu of products, like an IKEA catalogue, where  $j$  is the corresponding brand.

LA implies that received information and perceived information may disagree. Let  $A_i \subseteq X_i$  denote  $i$ 's attention set. The two sets  $A_i$  and  $X_i$  are identical iff  $X_i \subsetneq \{A, B\}$  or  $X_i = \{A, B\}$  and  $R_i = 2$ . Given that  $R_i = 1$ , firm  $j$ 's perception chance  $P(j \in A_i)$  is

$$P(j \in A_i) = \begin{cases} 1 & \text{if } j \in X_i \text{ and } |X_i| = 1, \\ \pi_j & \text{if } j \in X_i \text{ and } |X_i| = 2, \\ 0 & \text{otherwise,} \end{cases} \quad (3)$$

where  $|X_i|$  is the size of the information set,  $\pi_A, \pi_B \in (0, 1)$  and  $\pi_A + \pi_B = 1$ .<sup>10</sup> A consumer always transacts with her best perceived firm if  $A_i \neq \emptyset$ , and not at all otherwise. For simplicity we assume, for the moment, that the perception probabilities (or salience parameters)  $\pi_A$  and  $\pi_B$  are exogenous.

**Firm strategies** Each firm needs to choose which consumers to target. Formally, a targeting strategy is a (Lebesgue-)measurable function  $g_j : [0, 1] \rightarrow \{0, 1\}$ , where  $g_j(i) = 1$  indicates that

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<sup>9</sup>LA as a capacity threshold on the number of distinguishable objects has been used, e.g., by Van Zandt (2004), Anderson and De Palma (2009, 2012) and Hefti (2015). Other approaches to LA work with a volume-based threshold (Falkinger, 2007) or a threshold on the processable amount of bits in noisy signals (Sims, 2003). See Hefti and Heinke (2015) for a recent survey.

<sup>10</sup>The assumption that  $\pi_A + \pi_B = 1$  could easily be relaxed without any substantial changes to our results. Note that  $\pi_A + \pi_B < 1$  could be the case, e.g., if consumers feature a “trade-off avoidance” (Bachi and Spiegler, 2015).

consumer  $i$  has been targeted by firm  $j$ , and accordingly  $j \in X_i$ . We denote the set of all measurable indicator functions on  $[0, 1]$  by  $\mathcal{L}$ , and the measure of a (measurable) set  $S \subseteq [0, 1]$  by  $\lambda(S)$ . Firm  $j$ 's total expenditure on the information campaign is given by  $c_j \lambda(\mathcal{I}_j)$ , where  $\mathcal{I}_j = \{i \in [0, 1] : g_j(i) = 1\}$  is the set of consumers that are targeted by firm  $j$ , and  $c_j > 0$  is the marginal information cost.<sup>11</sup> To make the main effects of LA on firms' targeting decisions most evident we assume, for the moment, that each firm  $j$  earns an exogenous revenue  $p_j > c_j$  for each transaction, and is endowed with perfect information about each consumer's preference.<sup>12</sup>

## 2.1 Targeting Equilibrium

Firms simultaneously and non-cooperatively choose their targeting strategies to maximize expected payoffs. A *targeting equilibrium* is a targeting profile  $(g_A, g_B) \in \mathcal{L}^2$ , such that neither firm can gain a strict advantage by unilaterally deviating to any alternative targeting strategy.

**Definition 1** *A targeting profile is intrusive if  $\exists j \in \{A, B\}$  such that  $\lambda(\mathcal{I}_j \cap \mathcal{P}_{-j}) > 0$ . A targeting profile is overlapping if  $\lambda(\mathcal{I}_A \cap \mathcal{I}_B) > 0$ .*

A targeting profile is intrusive if a firm targets non-prime consumers, and it is overlapping if it features jointly targeted consumers. We say that an equilibrium is non-intrusive (non-overlapping) if its targeting profile is not intrusive (overlapping). Note that overlapping targeting is sufficient but not necessary for intrusive targeting.

In the following we suppose that  $\forall i \in [0, 1]$ ,  $R_i$  is a binary i.i.d. draw with  $\Pr(R_i = 1) = q$  and  $\Pr(R_i = 2) = 1 - q$ , where  $q \in [0, 1]$ . The parameter  $q$  is the measure of inattentive consumers in the market. Our main theorem fully characterizes the equilibria that may arise in the targeting game, depending on the degree of inattentiveness ( $q$ ), the firms' abilities to attract attention-constrained clients  $(\pi_A, \pi_B)$  and information costs.

**Theorem 1 (Targeting equilibrium)** *Let  $p_j > c_j > 0$  and  $\pi_j \in (0, 1)$  for  $j = A, B$ .*

- (i) *If  $c_j > q\pi_j p_j$  and  $c_j < q\pi_j p_j + (1 - q)p_j \forall j \in \{A, B\}$ , then any targeting equilibrium is non-intrusive, i.e.,  $\lambda(\mathcal{I}_j \cap \mathcal{P}_{-j}) = 0$ , and  $\lambda(\mathcal{I}_j \cap \mathcal{P}_j) = \lambda(\mathcal{P}_j)$ ,  $\forall j \in \{A, B\}$ .*

<sup>11</sup>This is a standard type of cost function in the targeting literature. See, e.g., Van Zandt (2004), Iyer et al. (2005), Bergemann and Bonatti (2011) or Johnson (2013).

<sup>12</sup>Many recent contributions on targeted advertising have abstracted away from price competition (e.g., Van Zandt, 2004; Athey and Gans, 2010; Johnson, 2013). We show in Section 2.2.1 and 4 respectively that our main result on how LA affects equilibrium targeting is robust to both endogenous pricing and imperfect information.

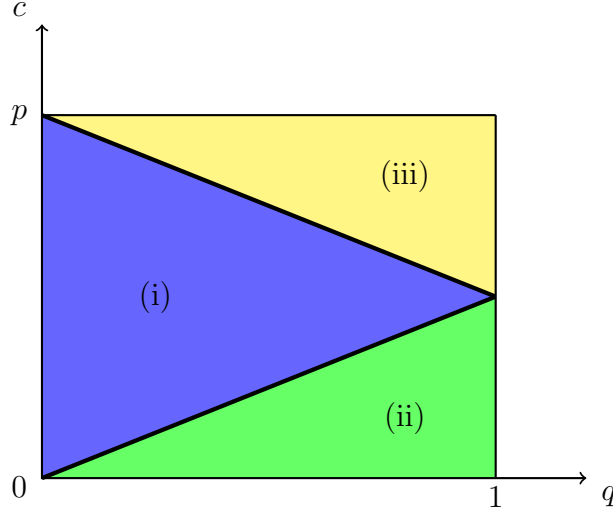


Figure 1: Equilibrium Regimes

- (ii) If  $c_j < q\pi_j p_j \forall j \in \{A, B\}$ , then in any targeting equilibrium both firms behave as mass-advertisers, i.e.,  $\lambda(\mathcal{I}_j) = 1 \forall j \in \{A, B\}$ .
- (iii) If  $c_j > q\pi_j p_j \forall j \in \{A, B\}$ , then any targeting equilibrium is non-overlapping. If, in addition,  $c_j > q\pi_j p_j + (1 - q)p_j \forall j \in \{A, B\}$ , then any non-overlapping targeting profile that satisfies  $\lambda(\mathcal{I}_A \cap \mathcal{I}_B) = 1$  constitutes an equilibrium.
- (iv) If  $c_j < q\pi_j p_j$  and  $c_{-j} \in (q\pi_{-j}p_{-j}, q\pi_{-j}p_{-j} + (1 - q)p_{-j})$ , then in any targeting equilibrium  $\lambda(\mathcal{I}_j) = 1, \lambda(\mathcal{I}_{-j} \cap \mathcal{P}_{-j}) = 1$  and  $\lambda(\mathcal{I}_{-j} \cap \mathcal{P}_j) = 0$ . If instead  $c_{-j} > q\pi_{-j}p_{-j} + (1 - q)p_{-j}$ , then in any targeting equilibrium  $\lambda(\mathcal{I}_j) = 1$  and  $\lambda(\mathcal{I}_{-j}) = 0$ .

Figure 1 illustrates Theorem 1 in the symmetric case where  $c_j = c$ ,  $p_j = p$  and  $\pi_j = 1/2$ ,  $j = A, B$ . For given information cost, the equilibrium information flow corresponds to the respective prime segments (almost surely) if and only if enough consumers are attentive (blue area). If information cost is low and enough consumers are inattentive (green area), both firms start to behave as mass advertisers, resulting in fully intrusive targeting. Finally, if information costs and consumer inattention are high (yellow area), the firms are caught in a coordination game where the market could be split in any arbitrary way. Note that with symmetric firms, case (iv) cannot arise.

Theorem 1 shows that the presence of a sufficient degree of inattention in a market has a profound effect on the nature of the targeting equilibrium. If  $q$  is sufficiently small then (i) applies always. This includes the standard case where nobody is attention-constrained ( $q = 0$ ).

The only type of equilibrium that can occur is non-intrusive (hence also non-overlapping), and the sets of targeted consumers (essentially) coincide with the respective prime segments.<sup>13</sup> Such a segmenting nature of equilibrium targeting strategies with differentiated products and fully attentive consumers has been found, e.g., by Iyer et al. (2005), Esteban and Hernandez (2007), Brahim et al. (2011) and Esteves and Resende (2016).<sup>14</sup> The picture changes substantially if the degree of inattentiveness in the market increases. For  $q$  large enough ( $q = 1$  at its extreme) (i) can no longer apply and the targeting equilibrium is described by either (ii), (iii) or (iv). In particular, if information costs  $c_j$  are low enough, then (ii) applies, meaning that each firm targets the entire market and thus behaves like a *mass advertiser*, despite the availability of perfect consumer data. More generally, any equilibrium features intrusive targeting since at least one firm mass-advertises, provided that information costs are not so high that (iii) applies. With mutually high information costs the equilibrium targeting strategies reflect a coordination problem. While any such equilibrium is non-overlapping it most likely will be intrusive. In fact, the perverse case where  $\mathcal{I}_j = \mathcal{P}_{-j}$  for  $j = A, B$  is among the possible equilibria.

Finally, it should be remarked that since we allow for general Lebesgue-measurable targeting functions we never get uniqueness of equilibrium in a narrow sense, but all equilibria pertaining to cases (i), (ii) and (iv) in Theorem 1 are unique in the measure  $\lambda$  of targeted consumers they induce. For example, if conditions (1) and (i) hold a natural targeting equilibrium is given by the interval strategies

$$g_A(i) = \begin{cases} 1 & \text{if } i \in [0, i_0], \\ 0 & \text{otherwise,} \end{cases} \quad g_B(i) = \begin{cases} 1 & \text{if } i \in [i_0, 1], \\ 0 & \text{otherwise,} \end{cases} \quad (4)$$

where  $i_0$  is determined by (2). Any other equilibrium then differs from (4) only by a zero-measure set.

### 2.1.1 Discussion

The reason why the targeting equilibrium changes with sufficient inattention is that limited attention affects the strategic role of information provision. On the one hand, informing a

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<sup>13</sup>The non-intrusion property is a general result and not driven by zero-mass consumers. Further, if the set of indifferent consumers is of a positive measure, these consumers could possibly be targeted by both firms (hence there is overlap) but, by definition, targeting would not be intrusive.

<sup>14</sup>A weaker form of segmentation is found by Galeotti and Moraga-Gonzalez (2008) with homogeneous goods, where the mixed-strategy targeting equilibrium suggests that fragmentation occurs only from time-to-time.

consumer is a prerequisite for any possible transaction in our model, independent of whether or not the consumer has LA. On the other hand information targeted at prime consumers works as an effective shield against business stealing by the competitor *if and only if* the consumer is attentive to the message. If consumers pay attention to all incoming information, sending a message to a prime consumer is necessary and sufficient for transacting. Moreover,  $j$  would never rationally send any messages to a non-prime consumer with  $-j \in X_i$  because its messages could never crowd-out the ones of the superior competitor. Since business stealing is nearly impossible if information almost certainly implies attention, this disciplines the targeting behavior of firms in such a way that they restrict the targeting to their respective prime segments. The protective role of information provision is diminished with an inattentive consumer, because there is always a chance that such a consumer perceives the non-prime firm whenever  $X_i = \{A, B\}$ . Each firm then has an incentive to target non-prime consumers, while at the same time it cannot protect its own prime consumers.<sup>15</sup> With a high degree of inattention and a low enough information cost  $c_j$  it is profitable for  $j$  to invade the competitor's prime segment, because for many consumers in that segment  $-j$  cannot secure their attention. It follows that mass-advertising becomes  $j$ 's dominant strategy, and the equilibria of either type (ii) or (iv) arise. If both firms face high information costs, then neither firm would want its targeting strategy to overlap with the other's because its information expenditure is not covered by the expected revenue. Consequently, there are many possible equilibria that could emerge, reflecting the coordination problem that firms do not know ex ante which targeting behavior the competitor chooses. Summarizing, the existence of a positive measure of inattentive consumers is a necessary condition for targeting equilibria to be intrusive, and also sufficient provided that the information costs are small enough.

The main difference between equilibria with or without LA does not hinge on the assumption of ex ante uninformed consumers, nor are the insights about the equilibrium targeting strategies stated in Theorem 1 restricted to the Hotelling line. The second point can be seen in the proof of the theorem as it does not use the line structure other than by the fact that it separates consumers into prime segments. It follows that whenever preferences allow for a

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<sup>15</sup>One could therefore imagine that if  $j$  sends a lot of messages, using up the attention capacities of the consumer, this crowds out the competitor's messages, which increases  $\pi_j$  and diminishes  $\pi_{-j}$ . We study such *salience competition* in Section 2.2.2.

meaningful assignment of prime segments to consumers, the equilibrium targeting strategies follow the paradigm stated in Theorem 1. We chose to work with the locational model because it allows us to quantify welfare effects (see below), and is useful in some of our later extensions. To illustrate the first point, suppose that a measurable subset  $\hat{\mathcal{I}}_j \subset [0, 1]$  of consumers has ex ante information about  $j$ . Hence if  $i \in \hat{\mathcal{I}}_j$  but  $i \notin \hat{\mathcal{I}}_{-j}$  firm  $j$  is  $i$ 's default choice.<sup>16</sup> Given unbounded attention capacities, it follows from the proof of Theorem 1 that each firm will target the subset  $\mathcal{P}_j \setminus \hat{\mathcal{I}}_j$  of consumers. Hence the resulting equilibrium has the partitional property known from Theorem 1 (i) but possibly at lower costs, because no firm  $j$  would send a message to an attentive consumer  $i \in \mathcal{P}_{-j}$  nor to an attentive consumer with  $i \in \hat{\mathcal{I}}_j \cap \mathcal{P}_j$ . This is different with inattentive consumers. For example, if  $c_j < q\pi_j p_j$ ,  $j = A, B$ , then both firms set  $\lambda(\mathcal{I}_j) = 1$  as in (ii), because the default assignment does not assure transaction, and intrusion becomes profitable.

The prevalence of LA has implications for market shares and consumer welfare, which are now discussed in detail.

**Market shares** One implication of Theorem 1 is that the importance of preferences and the degree of product differentiation or diversity as traditional determinants of a firm's market share decreases with inattention, while the importance of salience and attention-seeking increases. To see this, fix  $c_j, p_j, \pi_j$  for  $j = A, B$  such that  $c_j < \pi_j p_j$ . Note first that if  $q < \frac{c_j}{\pi_j p_j}$  for  $j = A, B$  then, by (i), equilibrium targeting, market shares  $m_j = \lambda(\mathcal{P}_j)$  and profits  $\Pi_j = (p_j - c_j)m_j$  depend only on the size of the prime segment, and are invariant to the degree of inattention  $q$ . If  $q > \frac{c_j}{\pi_j p_j}$  for  $j = A, B$  then, by (ii), equilibrium targeting is independent of  $\mathcal{P}_j$  (i.e. independent of valuations  $\mathcal{V}_j$  and firm locations  $x_j$ ), and firm  $j$ 's market share  $m_j = q\pi_j + (1 - q)\lambda(\mathcal{P}_j)$  as well as profit  $\Pi_j = m_j p_j - c_j$  are increasing in  $q$  if and only if  $\pi_j \geq \lambda(\mathcal{P}_j)$ . This also implies that an increase in  $q$  redistributes some market share (and profit) to the firm that has a comparative advantage in attention-seeking, because if  $\pi_{j'} \neq \lambda(\mathcal{P}_{j'})$  for some  $j' \in \{A, B\}$  then necessarily  $\pi_j > \lambda(\mathcal{P}_j)$  and  $\pi_{-j} < \lambda(\mathcal{P}_{-j})$ .

Further, note from (iv) that being a comparably strong attention-seeker may be the only way how an otherwise inferior firm can gain a substantial market share, while failing to attract

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<sup>16</sup>A complete assignment of such default firms to consumers is a central ingredient in the homogeneous-duopoly model of strategic advertising by Eliaz and Spiegler (2011).

attention may annihilate any competitive advantage from offering a superior product. Indeed, if  $\mathcal{P}_j = \emptyset$  but  $q > \frac{c_j}{\pi_j p_j}$  then  $m_j \geq q\pi_j$ , where even  $m_j = 1$  if  $\pi_{-j} < \frac{1}{q} \left( \frac{c_j}{p_j} - (1 - q) \right)$ . Hence if an otherwise completely inferior firm can find a way to make its product significantly more salient ( $\pi_j \approx 1$ ), it can drive its competitor out of the market and become the monopolist without the necessity to improve the quality ( $\mathcal{V}_j$ ) or the match ( $x_j$ ) of its products. This exemplifies a potential asymmetry between the firms in their desire for inattention in a market. As an illustration, suppose that the firms play a two-stage game, where consumers initially are fully attentive ( $q = 0$ ), but in the first stage each firm may use some (possibly costly) obfuscation device with the effect that  $q = 1$  results. Such obfuscation strategies could involve, e.g., increasing the mental load on consumers required to “decode” the product by making the product appear more complex (Ellison and Wolitzky, 2012; Hefti, 2015), by trapping consumer attention on intentionally designed webpages (Ellison and Ellison, 2009) or by trying to imitate the appearance of the competitors product by using similar packaging etc. to suggest to consumers that there is no need to pay close attention as existing alternatives are near substitutes. Let  $V_A = V_B = V$ ,  $x_A = 0$  and  $x_B > 0$  as well as  $\frac{c_B}{p_B} < \pi_B \leq 1 - \frac{x_B}{2}$  and  $\pi_A \geq \frac{c_A}{p_A} + \frac{x_B}{2}$ .<sup>17</sup> Using Theorem 1 it easily follows that the superior firm  $B$  would never wish to obfuscate the market while the inferior firm always benefits from obfuscation. Provided that obfuscation is cheap enough, there is an (essentially) unique subgame-perfect equilibrium, where firm  $A$  obfuscates the market in the first stage, and both firms target the entire market in the second stage.<sup>18</sup>

**Welfare** A central consequence of Theorem 1 is that the targeting equilibrium is generically efficient, from the consumer viewpoint, if and only if inattention in the market is sufficiently low. Since information is costly, efficiency requires that each firm only targets the consumers in its prime segment. Inefficiency occurs if a positive mass of consumers perceives and therefore transacts only with the respectively inferior firm. This can happen, in principle, if a consumer receives only information from the wrong firm or chooses the wrong firm due to LA.<sup>19</sup> If  $q < \min\left\{\frac{c_j}{\pi_j p_j}, \frac{p_j - c_j}{p_j(1 - \pi_j)}\right\}$ ,  $j = A, B$ , which is equivalent to the qualifying condition in (i), then

<sup>17</sup>The last two inequality conditions hold if the information costs are sufficiently low and firm  $B$  is located sufficiently close to firm  $A$ .

<sup>18</sup>A further observation is that in a *symmetric* environment, where  $V_A = V_B$ ,  $x_A = 1 - x_B$ ,  $\pi_A = \pi_B$  and  $p_A = p_B > 2c$  no firm has an incentive to obfuscate the market even if obfuscation were free.

<sup>19</sup>A further possible source of inefficiency, known from models of informative advertising, is that some consumers remain uninformed (Butters, 1977; Grossman and Shapiro, 1984). This type of inefficiency does not arise here given the way the model has been set up.

equilibrium information provision is always efficient, because intruding a competitor's prime segment would be beneficial if and only if the competitor were careless about informing her prime segment, which cannot occur with rational firms.<sup>20</sup> In the other direction, by (ii), the equilibrium is always inefficient if  $q > \frac{c_j}{\pi_j p_j}$  for some  $j \in \{A, B\}$ , because then the equilibrium targeting profile is intrusive and at least a measure of  $q\lambda(\mathcal{P}_{-j})$  consumers transacts with  $j$  instead of  $-j$ . If  $q > \frac{p_j - c_j}{p_j(1 - \pi_j)}$ ,  $j = A, B$  then, by (iii), the efficient targeting profile is in the equilibrium set but a zero-measure event. Also, the efficient equilibrium would never arise if firms choose targeting strategies sequentially rather than simultaneously given the coordination nature of the equilibrium. In this case, the first-mover targets the entire market while the follower shuts down.

The line structure of the model allows for additional insights on when the consumer welfare loss associated with LA is particularly pronounced. In the following we compare consumer welfare in the two polar cases  $q = 0$  and  $q = 1$ , where we let  $V_A = V_B = V$  and, for  $q = 1$ ,  $c_j < \pi_j p_j$ ,  $j = A, B$ , such that  $\lambda(\mathcal{I}_A) = \lambda(\mathcal{I}_B) = 1$  in this case. The welfare loss due to LA then is given by the (normalized) difference of aggregate transportation costs:

$$\begin{aligned} \frac{T_{LA} - T_{UA}}{t} &= \sum_{j=A,B} \pi_j \left( \frac{1}{2} - x_j(1 - x_j) \right) - \left( \frac{1}{2} + \frac{3}{4}(x_A^2 + x_B^2) - x_B - \frac{x_A x_B}{2} \right) \\ &= (x_B - x_A) \left( \pi_A \left( 1 - \frac{1}{4}x_A - \frac{3}{4}x_B \right) + \pi_B \left( \frac{3}{4}x_A + \frac{1}{4}x_B \right) \right). \end{aligned}$$

While LA always implies existence of a welfare loss, this becomes arbitrarily small if products are close substitutes ( $x_A \approx x_B$ ), because with weak differentiation it is not important which alternative is consumed. Increasing differentiation tends to increase the welfare loss. Especially, with symmetric firm locations, i.e.  $x_A = 1 - x_B$ , the welfare loss is independent of the salience parameters  $\pi_A, \pi_B$  (a consequence of symmetry) and increases in the distance between  $x_A$  and  $x_B$ .<sup>21</sup> The latter holds because average disutility of choosing the wrong firm increases with more polarized firms.

While the possibility of a mismatch is not an issue for an attentive consumer, she may still

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<sup>20</sup>This efficiency result extends to the case where firms hold only imperfect marketing data in such that with attentive consumers firms target their information to prime segments as to the best of their knowledge (see Section 4). Put differently, a possible intrusion of the equilibrium strategies reflects the limits of firm-side information about consumers and not a *strategic* attempt to invade the competitor's prime segment.

<sup>21</sup>For asymmetric cases, the relation is more subtle because a change of  $x_j$  has non-monotone effects on  $T_{LA}$  and  $T_{UA}$ . The maximal welfare loss is  $1/3$  and occurs if  $x_A = 1/3$ ,  $x_B = 1$  and  $\pi_A \approx 0$  or  $x_A = 0$ ,  $x_B = 2/3$  and  $\pi_B \approx 0$ .



strictly prefer the prime-segment targeting equilibria to the mass-advertising equilibria if each message from the firms causes a small nuisance to her.<sup>22</sup> In this case, the presence of inattentive consumers can impose a negative externality on the attentive ones by alluring firms to fill the mailbox of every consumer. This is related to what has been called search externalities between savvy and non-savvy consumers (Armstrong, 2015). In this respect, an interesting observation is that, starting from  $q = 0$ , an incremental increase in inattention has no effect, neither on firms nor on consumers, because equilibrium behavior does not change at all. The fact that if inattention surpasses a certain threshold the equilibrium may switch from segmenting to mass-advertising means that a small increase of inattention may have a large discontinuous negative welfare effect on the measure of all inattentive consumers and, in presence of a nuisance cost, also on attentive consumers.

## 2.2 Extensions

The following two sections extend the baseline targeting model, firstly by considering price competition and secondly by allowing for salience competition. For reasons of simplicity and tractability we set  $V_j = V$  and  $c_j = c \forall j \in \{A, B\}$  throughout this section.

### 2.2.1 Price Competition

Our first extension studies a setting where besides choosing their targeting strategies firms compete in prices. Specifically, we consider a two-stage game of complete information, where each firm sets its price in the first stage and then decides about which subset of consumers to inform.<sup>23</sup> Our main findings of this section can be summarized as follows. As in the baseline model, LA may lead to mass-advertising behavior, whereas firms play segmenting targeting strategies with attentive consumers. Moreover, (in)attention has a differential impact on how certain consumer characteristics influence equilibrium pricing and profits. Without LA, the threat that mutually informed consumers are capable of comparing all received offers implies

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<sup>22</sup>Further implications of nuisance costs are explored in the context of ad avoidance (see Section 3).

<sup>23</sup>This timing structure essentially means that firms have knowledge about each others pricing strategy, prior to launching their advertising campaigns, which is plausible in many circumstances. For example, while iPhone7 is not yet available at the time the current paper is drafted, its price has already been leaked by several websites (see, e.g., <http://bgr.com/2016/06/30/this-is-the-iphone-7-leak-weve-been-waiting-for/>), and such information will be most likely noticed by the competitors of Apple (if they didn't know it already). A related point is the observation that once prices are made, firms may be reluctant to change them later, which is a well-known phenomenon in presence of menu costs (see, e.g., Golosov and Lucas, 2007).

that *relative* characteristics, determining the selection between the products, are the relevant determinants of the firms' equilibrium pricing decisions. With inattentive consumers the relevant threat is that consumers choose the outside option, rather than that they switch to the competitor. This implies that the conventional positive correlation between the transportation cost parameter and equilibrium prices (profits) reverts to a negative one with inattentive consumers.

Throughout this section we assume that  $V \geq c + 2t$ , which assures that a monopolist located at  $x \in [0, 1]$  would always choose to serve the entire market at a price  $p = V - \max\{x, 1 - x\}t$ . In the two-stage game, targeting strategies are contingent on first-stage prices. Firm  $j$ 's strategy is a pair  $p_j \in \mathbb{R}_+$  and  $g_j : [0, 1] \times \mathbb{R}_+^2 \rightarrow \{0, 1\}$ , where  $g_j(i, p_A, p_B) = 1$  iff consumer  $i$  is targeted by firm  $j$  given that the first-stage prices are  $p_A$  and  $p_B$ . As a simplifying tie-breaking rule, we assume that whenever firms are indifferent about targeting a non-zero measure set of consumers they choose to target that set.<sup>24</sup> To see most clearly the effect of LA with endogenous prices, we will derive and compare the Subgame Perfect Equilibria (SPE) that arise in the two polar cases where  $q = 0$  and  $q = 1$ .

**Unlimited attention** To begin with, we characterize the unique SPE outcome of the two-stage game in the benchmark case where attention is unconstrained. For simplicity, we restrict attention to equilibria with interval targeting strategies of the type (4).

**Proposition 1** *Suppose that  $R_i > 1 \ \forall i \in [0, 1]$ . In any SPE, the targeting profile is non-intrusive, with consumers located in  $[0, i_0^*]$  and  $[i_0^*, 1]$  being targeted by firm A and B, respectively, where  $i_0^* = \frac{1}{3} + \frac{x_A + x_B}{6}$ , and*

$$\begin{aligned} p_A^* &= \left( \frac{2}{3} + \frac{x_A + x_B}{3} \right) t + c, & \Pi_A &= \frac{t(2 + x_A + x_B)^2}{18}, \\ p_B^* &= \left( \frac{4}{3} - \frac{x_A + x_B}{3} \right) t + c, & \Pi_B &= \frac{t(4 - x_A - x_B)^2}{18}. \end{aligned}$$

The intuition is as follows. Any given pricing strategy  $(p_A, p_B)$  defines a deterministic marginal consumer  $i_0 \in [0, 1]$  such that  $U_i(A) > U_i(B)$  if  $i < i_0$  and  $U_i(A) < U_i(B)$  if  $i > i_0$ , and firms equilibrium targeting behavior must match this price-induced segmentation of the market. In

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<sup>24</sup>This tie-breaking rule is only needed for the uniqueness (but not existence) of the SPE in case (i) of Proposition 2, and it would not be needed at all if  $c \leq t$  is satisfied (see the discussion following the proof of Proposition 2).

particular, targeting either “below” or “above”  $i_0$  can never be part of an SPE, because either the firm would forfeit additional revenue from supra-marginal consumers or it would bear unnecessary information costs from non-captive super-marginal consumers.

An interesting observation is that prices and profits in the SPE correspond exactly to their counterparts if consumers had ex-ante complete information and firms could compete only in prices, where  $c$  would have the conventional interpretation of a production cost. In this sense Proposition 1 shows that firms may have limited abilities to “make the price”, despite the fact that the market is informationally partitioned and consumers are aware of only one firm. In particular, deviating to a higher price (e.g. the monopoly price) would not be profitable for any firm, since it would induce its competitor to subsequently deviate to a targeting strategy that will reduce its market share for sure.

Proposition 1 confirms that introducing price competition does not change the main message of its simpler counterpart in Section 2.1 (case (i) of Theorem 1).<sup>25</sup> If attention is unconstrained, the possibility of targeting leads to a non-intrusive (and thus non-overlapping) targeting equilibrium. While, similar to the baseline model, there is no wasteful information provision, the equilibrium with price competition is, in general, only constrained efficient, because the price competition may result in a suboptimal point of segmentation. In addition, the information costs are fully borne by consumers, and higher transportation costs  $t$  imply higher prices, reflecting a decreasing average willingness-to-substitute in the consumer population. As a result, the equilibrium prices are increasing in  $c$ , while equilibrium profits are independent of  $c$  but increasing in  $t$ .

**Limited attention** The next proposition states that with LA and endogenous pricing essentially the same types of targeting behavior as in the simple model of Section 2.1 results.

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<sup>25</sup>Roy (2000) studies a targeting-pricing game with homogeneous goods and exactly the reversed timing. Similar to us, he finds that the targeting strategy profile arises in any SPE must be non-overlapping. However, in his model firms typically face a coordination problem since its SPE outcome is not unique except when information costs converge to zero.

**Proposition 2** *Suppose that  $R_i = 1 \forall i \in [0, 1]$ .*

- (i) *If  $c < \pi_j(V_j - t(1 + \max\{x_j, 1 - x_j\})) \forall j \in \{A, B\}$ , then in any SPE both firms behave as mass-advertisers, i.e.  $\lambda(\mathcal{I}_j) = 1 \forall j \in \{A, B\}$ , and set prices  $p_j^* = V - t \max\{x_j, 1 - x_j\}$  and  $\Pi_j = \pi_j p_j^* - c \forall j \in \{A, B\}$ .*
- (ii) *If  $c > \max\{\pi_A V, \pi_B V\}$ , then in any SPE the targeting profile is non-overlapping,  $p_j^* = \inf_{i \in \mathcal{I}_j} \{V - t|i - x_j|\}$  and  $\Pi_j = (p_j^* - c)\lambda(\mathcal{I}_j) \forall j \in \{A, B\}$ . In addition, any non-overlapping targeting profile together with  $p_j^* = \inf_{i \in \mathcal{I}_j} \{V - t|i - x_j|\}$ ,  $j = A, B$ , can be supported as part of a SPE.*
- (iii) *If  $\pi_{-j}V < c < \pi_j(V - t \max\{x_j, 1 - x_j\})$ , in any SPE  $\lambda(\mathcal{I}_j) = 1$ ,  $\lambda(\mathcal{I}_{-j}) = 0$ ,  $p_j^* = V - t \max\{x_j, 1 - x_j\}$ ,  $\Pi_j = p_j^* - c$  and  $\Pi_{-j} = 0$ .*

The intuition for this result strongly parallels its counterpart in Section 2.1 (cases (ii) - (iv) of Theorem 1). In particular, if the parametric assumption in (i) is satisfied then each firm prices to the *entire* market as an effective monopolist (the monopoly price is location-depending) followed by behaving as a mass-advertiser. This is individually optimal because with a sufficiently low information cost, the inability of firms to fully protect their prime segments by informing consumers always makes intrusive targeting profitable. The qualitative effects of locations  $(x_A, x_B)$  for targeting strategies and equilibrium payoffs with and without LA are similar to those observed in Section 2.1. However, with endogenous pricing LA may have an additional impact on how consumer characteristics influence equilibrium payoffs. For example, in general the taste parameter  $t$  determines both the consumers' willingness-to-substitute between the two firms and their decisions on whether or not to acquire any product. Without LA, this second channel irrelevant, implying that a stronger willingness-to-substitute (lower  $t$ ) leads to lower prices and profits. This follows because the competitive threat that mutually informed consumers are capable of comparing both offers implies that a consumer's propensity to exit the market is not a relevant determinant of the equilibrium. On the contrary, with LA only the threat of consumers to exit matters to firms. A lower  $t$  (and similarly a higher  $V$ ) diminishes this threat and allows firms to maintain higher equilibrium prices. This also explains why the mass-advertising scenario (i) of Proposition 2 becomes more likely if  $V_j$  increases,  $t$  decreases or firms are located towards the midpoint of  $[0, 1]$ . In all cases the sustainable price increases

which, consistent with (i) of Theorem 1, implies that intrusive targeting becomes more profitable.

By comparing result (i) and (ii), one can observe that lowering the information cost might actually be bad for *both* firms, in the sense that it lowers equilibrium profits. To see this, suppose  $x_A = 0, x_B = 1, \pi_A = \pi_B = 1/2$  and  $c > V/2$ . According to Proposition 2, there exists an equilibrium in which each firm sets a price  $p = V - t/2$  and subsequently targets a different half of the consumers in the market. Now if the information cost decreases to  $\hat{c} < V/2 - t$ , in the new equilibrium the two firms will set a new price  $\hat{p} = V - t$  and target every consumer in the market, but will still end up with sharing the market equally. Consequently, the equilibrium profits of firm  $j$  changes from  $\Pi_j = (V - t/2 - c)/2$  to  $\hat{\Pi}_j = (V - t)/2 - \hat{c}$ , and it is easy to see that  $\hat{\Pi}_j < \Pi_j$  if  $\hat{c} > (2c - t)/4$ . Intuitively, a high targeting cost makes the firms able to credibly commit not to penetrate their opponent's market. As a result, each firm can secure a revenue by serving only the consumers in its prime segment without the need to over-advertise its product.

### 2.2.2 Salience Competition

It is conceivable that the attention which firms attract from inattentive consumers depends on the degree of conspicuousness or salience of their ads.<sup>26</sup> Efforts to attract or retain attention can take on many forms, for instance advertising over multiple channels (emails, social network, phone calls, etc.) to the same consumer or by retargeting consumers who showed previous interest in a product. Here, we want to study the consequences of endogenous salience in the context of targeted information. To this end we extend the baseline model by incorporating salience competition, as introduced in Hefti (2015), for mutually targeted consumers. Each firm must decide on how much to invest into the salience of its messages besides choosing its targeting strategy. Salience competition yields a microfoundation for the information costs of the baseline model, and we show that the resulting strategic competition for attention implies that the mass-advertising strategy profile becomes the unique equilibrium prediction.

Competition for attention emerges only if attention is limited. For simplicity, we set  $R_i = 1 \forall i \in [0, 1]$  and take  $p_j = p \in (0, V - t \max\{1 - x_A, x_B\}) \forall j \in \{A, B\}$  as exogenously given.<sup>27</sup>

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<sup>26</sup>See Hefti and Heinke (2015) and the references therein for illustrative examples.

<sup>27</sup>The main conclusion from this section would also apply if prices were endogenized as in Section 2.2.1.

Together with its targeting decision, each firm  $j$  chooses a *salience function*  $s_j : [0, 1] \rightarrow \mathbb{R}_+$ , which specifies the salience level  $s_j(i)$  of the information provided to consumer  $i$ . Thus, firm  $j$ 's strategy is a pair of functions  $(g_j, s_j)$ . The chosen salience levels endogenize the perception probabilities  $(\pi_{Ai}, \pi_{Bi})$  of a mutually targeted consumer. If a consumer  $i$  is targeted only by a single firm, this firm will always be perceived, independent of the salience levels; if the consumer is targeted by both firms, then there is competition for attention and perception chances are determined by the *relative* salience levels according to:

$$\pi_{ji} = \begin{cases} \frac{s_j(i)}{s_A(i) + s_B(i)} & \text{if } s_A(i) + s_B(i) > 0, \\ \frac{1}{2} & \text{otherwise.} \end{cases} \quad (5)$$

Salience generating activities have the effect of increasing own while decreasing the competitor's perception chances. Increasing own salience is costly. In particular, targeting a message to a consumer at a salience level  $s$  requires the firm to incur a cost of  $h(s)$ , where  $h : \mathbb{R}_+ \rightarrow \mathbb{R}_+$  is a convex and strictly increasing  $C^2$ -function with  $h(0) = \lim_{s \rightarrow 0} h'(s) = 0$ . Accordingly, for a given information campaign  $(g_j, s_j)$ , firm  $j$ 's total information expenditure is equal to  $\int_{[0,1]} h(s_j(i)) di$ . It follows that the (marginal) information costs are now endogenous and depend on the chosen salience levels.<sup>28</sup>

To derive the targeting-salience equilibrium first note that in equilibrium the salience levels are pinned down by the targeting profile  $(g_A, g_B)$ . Especially, it is optimal for firm  $j$  to set  $s_j(i) = 0$  if either  $g_j(i) = 0$  or  $g_j(i) = 1$  but  $g_{-j}(i) = 0$ , since a firm will invest into salience only for mutually targeted consumers. It immediately follows that there cannot be a (positive-measure) set of untargeted consumers in equilibrium. Now consider any consumer  $i \in \mathcal{I}_j$  that is targeted by firm  $-j$  at a salience level of  $s_{-j}(i) > 0$ . In this case, firm  $j$ 's optimal salience level set for consumer  $i$  obeys the first-order condition

$$p \frac{s_{-j}(i)}{(s_j(i) + s_{-j}(i))^2} = h'(s_j(i)). \quad (6)$$

In a symmetric equilibrium,  $s_A(i) = s_B(i) = s$ , and (6) reduces to the equation  $p = 4h'(s)s$ , which admits a unique solution  $s^* > 0$  given the assumptions on  $h(\cdot)$ . Hence, firm  $j$ 's expected

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<sup>28</sup>Recall that in the baseline model, firm  $j$ 's total information cost is given by  $c_j \int_{[0,1]} g_j(i) di$ . This can be viewed as a special case of the current model where firm  $j$  is exogenously given the following salience function:  $s_j(i) = 0$  if  $g_j(i) = 0$  and  $s_j(i) = h^{-1}(c_j)$  otherwise.

payoff from targeting such a consumer  $i$  is given by

$$\Pi_j(i) = \frac{p}{2} - h(s^*) = 2h'(s^*)s^* - h(s^*) \geq 2h(s^*) - h(s^*) = h(s^*) > 0, \quad (7)$$

where the second equality follows from (6) and the first inequality follows from the convexity of  $h(\cdot)$  and  $h(0) = 0$ . Consequently, both firms would indeed find it optimal to target the entire market while setting a uniform salience level  $s^*$  for their messages.<sup>29</sup> Because no asymmetric salience equilibrium can exist the symmetric equilibrium is in fact the unique equilibrium:

**Proposition 3** *There exists an essentially unique equilibrium, and both firms behave as mass-advertisers, i.e.  $\lambda(\mathcal{I}_A) = \lambda(\mathcal{I}_B) = 1$ , and set the same salience level  $s^* > 0$  for all mutually targeted consumers, where  $s^*$  uniquely solves  $p = 4h'(s^*)s^*$ .*

Modern advertising firms express huge concerns about whether their messages are even registered by consumers.<sup>30</sup> Consequently, a huge sum of money is invested to remain on top of consumers' minds despite the availability of sophisticated marketing data (Iyer et al., 2005). While such an empirical regularity is hard to rationalize with perfectly attentive consumers, it follows readily from the presence of inattentive consumers as indicated by Proposition 3.

### 3 Information Blocking

In this section we show that LA provides a simple explanation for the recently observed increase of ad-blocking consumers, which seems far less reconcilable with a conventional model of fully attentive consumers. For this purpose, we enrich the demand side of the baseline model by allowing consumers to choose whether or not to block the information they may receive. For simplicity, we fix  $x_A = 0$ ,  $x_B = 1$  and abstract from price competition by assuming that both firms set a price  $p \in (c, V - t]$  for each transaction. The novel element is that each consumer  $i \in [0, 1]$  needs to make a blocking decision  $b_i \in \{0, 1\}$ , simultaneous to the firms' choices of targeting strategies. If  $b_i = 0$  the consumer does not block and decides between the firms in her attention set (and her outside option) as in the baseline model. If  $b_i = 1$  any information received is blocked prior to inspection by the consumer, and  $i$  earns the reservation utility zero.

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<sup>29</sup>To avoid measurability problems, we conveniently restrict attention to functions  $s_j(\cdot)$  that respect (6) at any point  $i \in \mathcal{I}_j$ .

<sup>30</sup>See, e.g., the article "Invisible ads, phantom readers", The Economist, Mar 26, 2016.

To make the blocking decision meaningful we follow Johnson (2013) by assuming that each ad sent by the firms causes a certain disturbance to the consumer who receives it. Specifically, each consumer  $i$  bears a nuisance cost  $\gamma_i \in [0, \bar{\gamma}]$  for each ad that she receives, regardless of whether she actually inspects it or not. Each  $\gamma_i$  is privately known to  $i$  and an i.i.d. draw from a commonly known distribution  $F(\cdot)$ . Consumers face a trade-off between enduring ads and forgiving consumption utility. We assume that consumers are boundedly rational in that they take into account their attention capacities when making the blocking decision and form rational expectations about their equilibrium consumption utilities. We impose the tie-breaking rule that whenever a consumer is indifferent, she will choose *not* to use the ad blocker. This conveniently allows us to ignore trivial equilibria where almost all consumers block, and both firms target a zero-measure set of consumers.

**Unlimited attention** We begin with the central observation that, without LA, only non-intrusive targeting profiles can be sustained in equilibrium, and ad blockers will not be used.

**Proposition 4** *Suppose that  $R_i > 1 \forall i \in [0, 1]$  and  $\bar{\gamma} \leq V - p - t/2$ . Then any equilibrium of the targeting-blocking game features non-intrusive targeting strategies, i.e.  $\lambda(\mathcal{I}_j \cap \mathcal{P}_{-j}) = 0$  and  $\lambda(\mathcal{I}_j \cap \mathcal{P}_j) = \lambda(\mathcal{P}_j) \forall j \in \{A, B\}$ , and no consumer blocks information.*

The parametric assumption  $\bar{\gamma} \leq V - p - t/2$  is with little loss of generality. It is imposed only to rule out that a fraction of consumers will always keep their ad blockers on unless they expect to receive no ad at all. As before, the fact that consumers have unbounded attention capacities disciplines firms from engaging into wasteful targeting activities. Put differently, with rational firms and fully attentive consumers the potential blocking threat is irrelevant because consumers will not be spammed in equilibrium. Rational consumers, anticipating that the usefulness of the messages outweighs their nuisance, therefore do not switch on their blockers. Proposition 4 resembles a result in Johnson (2013) who finds, in a different setting, that consumer blocking vanishes if the targeting abilities become sufficiently accurate.<sup>31</sup> In contrast, we next establish that with LA equilibrium blocking arises despite *perfect* marketing data.

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<sup>31</sup>Equilibrium blocking in his model is a consequence of imperfect marketing data, and reflects the fact that some consumers receive pure spam as a consequence of targeting inaccuracy. We could replicate this finding in the current model by using the modified setting of Section 4.



**Limited attention** We repeat the above analysis for the case of attention-constrained consumers, where  $R_i = 1 \ \forall i \in [0, 1]$ . We also assume, for the moment, that the perception probabilities are exogenous and equal for both firms ( $\pi_A = \pi_B = 1/2$ ). The intuition from the baseline model suggests that, with LA, firms may no longer coordinate on a non-overlapping targeting profile. Since a consumer may feel annoyed by a heap of incoming messages, even if these are not fully inspected or understood, information blocking is a relevant concern. A consumer with low nuisance tolerance would indeed choose to block information if she expects to receive ads from both firms. The incentive to use ad blockers is reinforced by the fact that an inattentive consumer correctly anticipates, in equilibrium, that if her blockers are off she might end up with consuming an inferior product. This threat of consumers to exit the market by blocking tends to reduce each firm's incentive to choose an overlapping targeting strategy. However, as the following proposition shows, with low information costs firms are locked in their roles as mass advertisers, despite substantial sale losses from blocking consumers:

**Proposition 5** *Suppose that  $R_i = 1 \ \forall i \in [0, 1]$  and  $c < \frac{pF(\gamma^*)}{2}$ , where  $\gamma^* = \frac{V-p-t/2}{2}$ . In any equilibrium of the targeting-blocking game both firms behave as mass-advertisers, i.e.  $\lambda(\mathcal{I}_A) = \lambda(\mathcal{I}_B) = 1$ , and a fraction  $1 - F(\gamma^*)$  of consumers blocks.*

Consumers with low nuisance costs ( $\gamma_i \leq \gamma^*$ ) will not mind receiving many ads and will never turn on their ad blockers. If providing information is cheap and attention is limited, a firm can always secure a positive profit from targeting these consumers, independent of their locations and the competing firm's targeting strategy. Consequently, no firm would ever refrain itself from flooding the market with its ads, which leads some annoyed consumers to turn on their ad blockers.

### 3.1 Ad Blocking and Salience Competition

We now generalize the targeting-blocking model from the last section to the case of endogenous salience competition. The idea is that, as in Section 2.2.2, firms can choose how intensely to compete for attention, but nuisance costs, and thus blocking probabilities, increase in the exposure of consumers to attention-seeking activities.

Formally, each firm  $j$  chooses which consumers to target ( $g_j$ ) at what salience levels ( $s_j$ ) similar to Section 2.2.2. The probability that  $j$  is perceived by a jointly targeted consumer  $i$

is given by (5). Given firms' targeting-salience decisions, the nuisance experienced by a non-blocking consumer  $i$  is  $\gamma_i S_i^\alpha$ , where  $S_i = \sum_j g_j(i) s_j(i)$  is  $i$ 's exposure to attention-seeking and  $\alpha \in (0, 1)$  is a parameter. For tractability reasons, we assume that the cost parameters  $\gamma_i$  are i.i.d. uniform on  $[0, \bar{\gamma}]$ . Simultaneous to the firms' choices, consumers decide on blocking based on the nuisance that they expect to experience if blockers are off. Firms face a strategic trade-off because higher own salience comes at the benefit of increased perception chances, but also at an explicit salience cost and at an implicit cost of increased ad blocking, where the strength of these effects depends on the competitor's salience level. As before we ignore price competition by assuming an exogenous price  $p \in (0, V - t]$ , and endogenize information costs by supposing that generating a message at a salience level  $s$  costs a firm  $h(s)$ . To obtain an explicit solution we impose the functional form  $h(s) = \kappa s^\eta$ , where  $\eta \geq 1$  and  $\kappa > 0$ . Note that if  $\alpha \rightarrow 0$  nuisance costs become insensitive to the salience levels, and we are back to the setting of Section 2.2.2.<sup>32</sup> Let  $\mu \equiv V - p - t/2$ . Assuming that information provision is not too costly for any given salience level (i.e.,  $\kappa$  is sufficiently small), we establish the following result.

**Proposition 6** *There exists  $\hat{\kappa} > 0$  such that if  $\kappa \leq \hat{\kappa}$ , there exists an (essentially) unique equilibrium in which both firms behave as mass-advertisers, i.e.  $\lambda(\mathcal{I}_A) = \lambda(\mathcal{I}_B) = 1$ , and set the same salience level  $s^{**} > 0$  for all consumers, and a fraction  $\Lambda$  of consumers use ad blocking tools, where*

$$s^{**} = \left( \frac{(1 - \alpha)p\mu}{2^{2+\alpha}\bar{\gamma}\kappa\eta} \right)^{\frac{1}{\eta+\alpha}}, \quad \Lambda = 1 - \frac{\mu}{\bar{\gamma}(2s^{**})^\alpha}. \quad (8)$$

The equilibrium has the following comparative statics:

**Corollary 1** *Let  $\kappa \leq \hat{\kappa}$ . A decrease of  $\kappa$  or  $V$  and an increase of  $t$  or  $\bar{\gamma}$  increases the fraction of blocking consumers and decreases firm profits.*

The intuition for the result is as follows. A lower  $\kappa$  increases the intensity of salience competition, since the cost of making an advertisement of any given salience level is lower. Without the possibility of information blocking, this would not lead to a change in the firms' profit since the total expenditure in advertisement campaign would remain unchanged.<sup>33</sup> However,

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<sup>32</sup>On the other hand, the information blocking model without salience competition can be viewed as the limiting case  $\alpha \rightarrow 1$  of the current model, with the salience functions  $s_A(i) = s_B(i) = 1 \forall i \in [0, 1]$  being exogenously given.

<sup>33</sup>This can be seen by calculating analytically the equilibrium salience level  $s^*$  in Section 2.2.2 with the same salience cost function  $h(s) = \kappa s^\eta$ .

more intensive competition in advertising shrinks the actual size of the market by making more consumers block. In the strategic equilibrium, this loss of sales cannot be compensated by the potential gains of cheaper information costs. Next, an increase of  $\bar{\gamma}$  has a direct positive effect on the fraction of blocking consumers, reflecting that more consumers face higher nuisance cost and are inclined to block, and an indirect negative effect since firms save on costs and reduce their salience levels. Given that salience is decisive for attracting the attention of non-blocking consumers it is little surprising that the reduction in aggregate salience does not compensate for the increased propensity to block, leading to an increased equilibrium blocking fraction and lower profits. Finally, Corollary 1 suggests that ad blocking is particularly pronounced in markets with *low-involvement* products, where the general willingness-to-pay ( $V$ ) is low or the risk of possibly choosing a highly deceptive product is small ( $t$  is low). This follows because in both cases the opportunity costs of blocking are low, which reduces the intensity of salience competition and allows firms to save on information costs.

The general inefficiency that arises from blocking reflects that a scarce resource – attention – is over-utilized. An information gate, such as a platform, could reduce the welfare loss attributed to blocking by diminishing the information exposure of consumers. In our simple model, if all information is trafficked by a platform, which restricts the displayed information to a single firm for each consumer, consumers would have no need to block. In a sense a platform could work as a pricing device for the otherwise missing market for attention. This role of the platform as an attention gate does not require the platform to hold any additional information about consumers.<sup>34</sup> For example, the platform could decide which ad to display as an outcome of an all-pay auction. With symmetric firms this would result in equal perception chances ( $\pi_A = \pi_B = 1/2$ ) in the symmetric bidding equilibrium.

## 4 Imperfect Marketing Data

So far we have shown that with perfect information about consumers' preferences, firms' targeting decisions depend on the degree of consumer inattentiveness. In reality, firms may know less about the tastes of each individual consumer, and the precision of the targeting technology

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<sup>34</sup>This is different from the role of a platform as an information collector and broker that has been discussed recently in the literature (e.g., Bergemann and Bonatti, 2011; Eliaz and Spiegler, 2016)

hinges on the quality of the available marketing data.<sup>35</sup> This naturally raises the question of whether LA also has an impact on the information gathering process in the first place. To address this question we depart from the baseline model by allowing firms to have imperfect knowledge about consumers' preferences. The main insights from the baseline model carry through to this extension, and we find that the incentives for information acquisition of the firms depends crucially on consumer attention.

Formally, we consider a continuum of consumers indexed by  $i \in [0, 1]$  as in the baseline model. Each consumer has a strict preference  $\succ_i$  defined over two firms  $A$  and  $B$ , where  $A \succ_i B$  if  $i \in \mathcal{P}_A = [0, \theta]$  and  $B \succ_i A$  if  $i \in \mathcal{P}_B = (\theta, 1]$ ,  $\theta \in (0, 1)$ . Contrary to the baseline, each firm may have imperfect knowledge about consumer preferences depending on the marketing data that it collected. We assume that each firm's marketing data is (i) truthful, in thus that it qualitatively mirrors the true taste distribution, but its precision about preferences may be limited, and (ii) complete, in thus that it comprises all consumers.<sup>36</sup> Specifically, we suppose that firm  $j$  receives a binary signal  $z_{ji} \in \{0, 1\} \forall i \in [0, 1]$  by investigating its marketing data. These signals are independent across consumers and of a false-positive nature, which is common knowledge. If  $j \succ_i -j$ , then  $z_{ji} = 1$  with probability 1; if  $-j \succ_i j$ , then  $z_{ji} = 0$  with probability  $\alpha_j \in [0, 1]$ , and  $z_{ji} = 1$  with the remaining probability. While the marketing data includes a firm's prime consumers it may exacerbate the preferences for some consumers. It follows that whenever  $z_{ji} = 0$ ,  $j$  (correctly) infers that  $i \in \mathcal{P}_{-j}$  and accordingly  $z_{-ji} = 1$ . The parameter  $\alpha_j$  is a measure of the data quality in thus that firm  $j$  becomes more likely to correctly separate non-prime from prime consumers the larger  $\alpha_j$  is. Note that  $\alpha_j = 1$  corresponds to the perfect information case from the baseline, while  $\alpha_j = 0$  means that firm  $j$  has essentially no clue about consumer tastes.

Given its knowledge about consumer preferences, each firm decides which consumers to target ( $g_j$ ). The targeting profile  $(g_A, g_B)$  determines the consumers' information sets, and each consumer forms an attention set depending on her attention capacity, as in the baseline model. Each consumer  $i$  acquires her best perceived product, and each firm  $j$  earns an exogenous

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<sup>35</sup>In most cases, firms collect consumer data either from a direct firm-customer relationship ("First-Party" data) or by acquiring data from specialized companies ("Third-Party" data). Third-Party data usually is collected on the Internet using digital cookies, web beacons or e-tags without consumers being aware of them (see "Advertising and Technology", *The Economist*, Sep 2014, Special Report).

<sup>36</sup>To concentrate on how the potential of the marketing data to separate between prime and non-prime consumers affects each firm's targeting decision we ignore the possibility that the data may also be more or less informative about whether a consumer is in the market.

revenue  $p_j > 2c_j$  for each consumer that it successfully transects with.<sup>37</sup>

**Unlimited attention** We first study how marketing data affects the targeting equilibrium without LA. Let  $\mathcal{P}_j^* = \{i \in [0, 1] : z_{ji} = 1\}$  denote  $j$ 's prime segment as *indicated by the data*. Note that, by assumption,  $\mathcal{P}_j \subseteq \mathcal{P}_j^* \forall j \in \{A, B\}$  and  $\lambda(\mathcal{P}_A^* \cup \mathcal{P}_B^*) = 1$ . The following proposition characterizes the unique equilibrium outcome of the targeting game with imperfect marketing data and fully attentive consumers.

**Proposition 7** *Suppose that  $R_i > 1 \forall i \in [0, 1]$ . In any targeting equilibrium each firm only targets its indicated prime segment, i.e.  $\lambda(\mathcal{I}_j \cap \mathcal{P}_j^*) = \lambda(\mathcal{P}_j^*)$  and  $\lambda(\mathcal{I}_j \setminus \mathcal{P}_j^*) = 0$ , and equilibrium profits are  $\Pi_j = p_j \lambda(\mathcal{P}_j) - c_j \lambda(\mathcal{P}_j^*) \forall j \in \{A, B\}$ .*

In equilibrium, a firm will target a consumer if and only if its marketing data indicates that this consumer belongs to its prime segment. This follows because, given the complete and false-positive nature of the data,  $j$  infers that  $g_{-j}(i) = 1$  and  $i \notin \mathcal{P}_j$  for any consumer with  $z_{ji} = 0$ . Since all consumers are assumed to be attentive it is never profitable to send a message to such a consumer; likewise it is always a dominant action to inform any  $i$  with  $z_{ji} = 1$ .

Proposition 7 reveals that there can be overlapping equilibria in the targeting game with imperfect marketing data despite fully attentive consumers, in contrast to the baseline model. In equilibrium, each consumer  $i \in \mathcal{P}_{-j}$  will receive a message from firm  $j$  with probability  $1 - \alpha_j$  despite that she will always transact with firm  $-j$ . Hence, a fraction  $(1 - \alpha_A)(1 - \theta) + (1 - \alpha_B)\theta$  of consumers will be (inefficiently) informed by both firms. While any equilibrium with overlap is intrusive in the sense of Definition 1, this is entirely driven by incomplete information about the market and, importantly, *not* by the strategic desire to invade the competitor's prime segment. In fact, firm  $j$  does not send its messages to consumers in  $[0, 1] \setminus \mathcal{P}_j^*$ .

In the (essentially) unique targeting equilibrium, the number of jointly targeted consumers decrease as the quality of either firm's marketing data increases and gradually approaches a zero-measure set as  $\alpha_j \rightarrow 1 \forall j \in \{A, B\}$ . Similarly, each firm's expected profit is increasing in  $\alpha_j$  because  $\lambda(\mathcal{P}_j^*)$  decreases, where  $\lambda(\mathcal{P}_j^*)$  converges to  $\lambda(\mathcal{P}_j)$  as  $\alpha_j \rightarrow 1$ . This is independent of the marketing data owned by the other firm, which further implies that a firm could not be harmed by sharing its marketing data with its competitor, and each firm may have a positive

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<sup>37</sup>This parametric assumption implies that firm  $j$  will behave as a mass advertiser if its knowledge about any consumer's taste is no better than a random guess ( $\alpha_j = 0$ ).

willingness-to-pay for the other firm's marketing data. To see this in a simple case, suppose that  $\alpha_A < 1$  and  $\alpha_B = 1$ . By accessing firm  $B$ 's marketing data, firm  $A$  can completely avoid targeting consumers that it would have zero chance to win and save an expenditure of  $(1 - \alpha_A)(1 - \theta)c_A$  on its information costs. In fact, such sharing of marketing information could be even multilaterally beneficial in the presence of nuisance costs and the possibility of blocking for consumers as in Section 3, because it would reduce aggregate nuisance costs from mutually targeted consumers and therefore also the fraction of blocking consumers due to receiving multiple messages. In sum, under the standard assumption of unlimited attention capacities, firms would want better marketing data, consumers would be happy to give it to them, and the firm with better marketing data would be willing to share it with its competitor (possibly against a fee).

**Limited Attention** We now account for the possibility that consumers have LA. As in the baseline model, suppose that each consumer  $i$ 's attention capacity  $R_i$  is an i.i.d. binary draw. Given that the marketing data is only informative about  $\succ_i$  but not about  $R_i$ , the next result shows that the mass-advertising equilibrium persists, independent of the data quality, in presence of an arbitrarily small fraction of inattentive consumers provided that information costs are sufficiently low.<sup>38</sup>

**Proposition 8** *Suppose that  $\forall i \in [0, 1]$ ,  $R_i = 1$  with probability  $q \in [0, 1]$  and  $R_i = 2$  otherwise. If  $c_j < q\pi_j p_j \forall j \in \{A, B\}$ , then in any targeting equilibrium both firms mass-advertise, i.e.  $\lambda(\mathcal{I}_A) = (\mathcal{I}_A) = 1$ , and  $\Pi_j^* = p_j \lambda(\mathcal{P}_j) - c_j \forall j \in \{A, B\}$ .*

The intuition for the result is that the firms' concern about consumer preferences is strongly diluted by the presence of inattentive consumers. Provided that information costs are sufficiently low, each firm is incentivized to disregard its data and target the entire market if it is confident of capturing enough consumer attention. It follows that improved marketing data is ineffective in reducing the targeting overlap or in increasing profits. In contrast to the case of unlimited attention, this means that no firm has an incentive to acquire (or share) better

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<sup>38</sup>Van Zandt (2004) shows that if all firms possess a common marketing data of sufficiently high quality and all consumers are attention-constrained, a common increase in the information costs from zero to a small  $c > 0$  may benefit all firms. The reason is that, contrary to our setting, products are of a non-competitive nature in his models, where some consumers are completely uninterested in certain products. For such consumers, attracting attention never leads to a sale, and a firm would not send them any costly messages if it were informed about them. Therefore  $c > 0$  together with good data implies that consumers without interest in a certain product are not informed by the corresponding firm anymore.

marketing data, nor could consumers reduce a possible nuisance from receiving many ads (and possibly choosing the wrong alternative) by sharing their information with the firms.

## 5 Conclusion

In terms of advertising expenditures, the various forms of targeted advertising have been a key component in past years. The current paper highlights the limitations of targeting to businesses and welfare once the attention capacity constraints of consumers are taken into account. We found that the consequences of limited attention for equilibrium targeting strategies can be substantial. LA is a primary reason for why firms may have an incentive to target less precisely than they could. In our model firms may therefore even behave as mass advertisers despite the availability of perfect marketing data and targeting means. It follows that, with LA, the scope for targeting as an efficient marketing instrument can be severely reduced for *both* firms *and* consumers. In presence of inattentive consumers, the ability to attract attention detaches the resulting market shares from traditional fundamentals such as preferences or the degree of product differentiation – in a highly inattentive world salience becomes king even with sophisticated targeting abilities and perfect marketing data. Given the many consequences caused by LA, future empirical work may want to take into account sensible measures to control for inattention and salience effects when evaluating various information and advertising policies.

## Appendix

**Proof of Theorem 1** Note that leaving a non-zero measure set of consumers in its prime segment uninformed about its product (i.e.,  $\lambda(\mathcal{I}_j \cap \mathcal{P}_j) < \lambda(\mathcal{P}_j)$ ) is never optimal for firm  $j$  if  $c_j < q\pi_j p_j + (1 - q)p_j$ , since by covering these consumers firm  $j$  can always secure a positive expected payoff. But then, given that firms will fully cover their respective prime segments, there is no point for any firm  $j$  to penetrate its competitor's prime segment (i.e.,  $\lambda(\mathcal{I}_j \cap \mathcal{P}_{-j}) > 0$ ) if  $c_j > q\pi_j p_j$ , since the expected profit from doing so is negative. Thus, (i) immediately follows.

If  $c_j < q\pi_j p_j$ , then leaving a non-zero measure set of consumers uninformed about its product (i.e.,  $\lambda(\mathcal{I}_j) < 1$ ) would never be optimal for firm  $j$ , since by covering these consumers firm  $j$  can always secure a positive expected profit. Hence, (ii) is a direct consequence of dominance

Given  $c_j > q\pi_j p_j$  and the full-coverage assumption  $p_j \in (c_j, V_j - t] \forall j \in \{A, B\}$ , targeting any non-trivial set of consumers in  $\mathcal{P}_{-j}$  will be profitable for firm  $j$  if and only if they are not targeted by firm  $-j$ . This implies the first part of (iii), i.e., if  $c_j > q\pi_j p_j \forall j \in \{A, B\}$ , the equilibrium targeting profile cannot be overlapping. Additionally, if  $c_j > q\pi_j p_j + (1 - q)p_j$ , then firm  $j$  will only find it profitable to target the consumers that are not targeted by firm  $-j$ , regardless of whether they are located in  $\mathcal{P}_j$  or  $\mathcal{P}_{-j}$ . Clearly, it follows that any non-overlapping targeting profile that satisfies  $\lambda(\mathcal{I}_A) + \lambda(\mathcal{I}_B) = 1$  constitutes an equilibrium if  $c_j > q\pi_j p_j + (1 - q)p_j \forall j \in \{A, B\}$ . This concludes the proof of (iii).

Finally, for (iv), since as a dominant strategy firm  $j$  will target essentially the entire market if  $c_j < q\pi_j p_j$ , targeting consumers located in  $\mathcal{P}_j$  will never be profitable for firm  $-j$  given  $c_{-j} > q\pi_{-j} p_{-j}$ . If, in addition,  $c_{-j} > q\pi_{-j} p_{-j} + (1 - q)p_{-j}$ , then even targeting a consumer located in  $\mathcal{P}_{-j}$  will not be profitable for firm  $-j$ . Hence, given firm  $j$ 's dominant strategy, it is a best response for firm  $-j$  to target only the consumers located in  $\mathcal{P}_{-j}$  if  $c_{-j} \in (q\pi_{-j} p_{-j}, q\pi_{-j} p_{-j} + (1 - q)p_{-j})$ , and it will optimally choose to shut down if  $c_{-j} > q\pi_{-j} p_{-j} + (1 - q)p_{-j}$ . ■

**Proof of Proposition 1** Let  $\tilde{\mathcal{P}}_A = [0, i_0]$  and  $\tilde{\mathcal{P}}_B = [i_0, 1]$ , where

$$i_0 = \max \left\{ \min \left\{ \frac{x_A + x_B}{2} + \frac{p_B - p_A}{2t}, 1 \right\}, 0 \right\}.$$

For a given pair of prices  $(p_A, p_B)$ , it is straightforward to verify that the equilibrium targeting strategy of firm  $j$  in the targeting subgames must take on the following form. If  $p_j < c$ , then



$g_j(i) = 0 \forall i \in [0, 1]$ ; If  $p_j = c$ , then  $g_j(i) \in \{0, 1\}$  if either  $g_{-j}(i) = 0$  or  $i \in \tilde{\mathcal{P}}_j$  and  $g_j(i) = 0$  otherwise; If  $p_j > c$ , then  $g_j(i) = 1$  if  $p_j \leq V - |i - x_j|t$  and either  $g_{-j}(i) = 0$  or  $i \in \tilde{\mathcal{P}}_j$ . Note that we need not worry about the tie-breaking rule for the marginal consumer  $i_0$  because she has zero mass.

**Lemma A1** In any SPE,  $p_j > c \forall j \in \{A, B\}$ .

Proof: Consider any  $(p_A, p_B)$  such that  $p_A \leq c$ , and hence  $\Pi_A \leq 0$ . If  $p_B < c$ , then  $g_B(i) = 0 \forall i \in [0, 1]$ , and  $A$  could secure a positive profit by deviating to  $\tilde{p}_A = V - t$  and setting  $g_A(i) = 1 \forall i \in [0, 1]$ . If  $p_B \geq c$ , then by deviating to  $\tilde{p}_A = c + \varepsilon$  for sufficiently small  $\varepsilon > 0$ , firm  $A$  can make a positive profit by targeting a fraction  $i_0 > 0$  of consumers in the second stage. Hence, for  $(p_A, p_B)$  to be part of a SPE we must have  $p_A > c$ . The proof for  $p_B > c$  is analogous. ■

**Lemma A2** In any SPE,  $t(x_A + x_B) - 2t < p_A - p_B < t(x_A + x_B)$ .

Proof: If  $p_A - p_B \geq t(x_A + x_B)$  then  $i_0 = 0$  and  $g_A(i) = 0 \forall i \in [0, 1]$ , since all consumers would find  $B$  the optimal choice and it is also optimal for firm  $B$  to set  $g_B(i) = 1 \forall i \in [0, 1]$  given  $p_B > c$ . Hence  $\Pi(A) = 0$ . But then, given  $p_B > c$  in any SPE, firm  $A$  can profitably deviate to  $p_A = c + \varepsilon < p_B$  for some  $\varepsilon > 0$ , because there then is a positive interval of consumers located around  $x_A$  that now find  $A$  to be the best choice. Hence, for  $(p_A, p_B)$  to be part of a SPE we must have  $p_A - p_B < t(x_A + x_B)$ . The proof for  $p_A - p_B > 2t - t(x_A + x_B)$  is analogous. ■

**Lemma A3** In any SPE,  $p_A \leq V - t \max\{x_A, |i_0 - x_A|\}$ , and  $p_B \leq V - t \max\{(1 - x_B), |i_0 - x_B|\}$ .

Proof: By Lemma A2, we have  $i_0 \in (0, 1)$  in any SPE. Now suppose, in contradiction, that  $p_A > V - t \max\{x_A, |i_0 - x_A|\}$  in some SPE. Then there must be a non-trivial interval of consumers in  $[0, i_0]$  remain untargeted by firm  $A$ ; otherwise the firm would incur a loss because all these consumers strictly prefer the outside option. However, because  $i_0 \in (0, 1)$  and all consumers with  $i \leq i_0$  are  $A$ -captive once  $g_A(i) = 1$ , firm  $A$  is like a monopolist on  $[0, i_0]$ . But then, it follows from the assumption  $V \geq c + 2t$  that firm  $A$  would always want to lower its price in the first stage and then serve all these consumers, regardless of firm  $B$ 's corresponding targeting strategy. Therefore, we must have  $p_A \leq V - t \max\{x_A, |i_0 - x_A|\}$  in any SPE. The proof for  $p_B \leq V - t \max\{(1 - x_B), |i_0 - x_B|\}$  is analogous. ■

Given the characterization of the firms' targeting strategies in the second stage, the equilibrium prices can be found as a Nash equilibrium to the pure pricing game where each firm's

demand is determined by the marginal consumer  $i_0$  and payoffs are

$$\Pi_A = (p_A - c) \left( \frac{x_A + x_B}{2} + \frac{p_B - p_A}{2t} \right), \quad \Pi_B = (p_B - c) \left( 1 - \frac{x_A + x_B}{2} - \frac{p_B - p_A}{2t} \right), \quad (9)$$

subject to the restrictions on  $(p_A, p_B)$  imposed by the previous lemmata. It is straightforward to verify that this pricing game has a unique interior Nash equilibrium given by  $p_A^*$  and  $p_B^*$  as quoted by the proposition, which also satisfy lemmata A1-A3. We can thus conclude that  $(p_A^*, p_B^*)$  is the unique SPE price, and the market is segmented at the marginal consumer  $i_0 = \frac{1}{3} + \frac{x_A + x_B}{6}$ . The equilibrium profits can be obtained via plugging  $p_A^*$  and  $p_B^*$  into (9). ■

**Proof of Proposition 2** Let  $p_j^M = V - t \max\{x_j, 1 - x_j\}$  denote the hypothetical monopoly price each firm would set conditional on being a monopolist in the market facing a information cost of  $c$ . Denote  $\mathcal{O}_j(p_j) = \{i \in [0, 1] \mid V - p_j - t|i - x_j| \geq 0\}$ . Note that any consumer  $i \notin \mathcal{O}_j(p_j)$  will strictly prefer the outside option to the product offered by firm  $j$ .

- (i) Suppose firm  $A$  sets  $p_A = p_A^M$ . Subsequently, it is a dominant strategy for firm  $A$  to target the entire market. Since in this case firm  $A$ 's targeting decision will not be affected by firm  $B$ 's price, it is clear that firm  $B$ 's best response involves  $p_B \in [p_B^M, V]$ , which implies that the subsequent targeting decision of firm  $B$  is also pinned down by its choice of  $p_B$ . More specifically, firm  $B$  will optimally choose to target and only target the consumers located in  $\mathcal{O}_B(p_B)$ , and its expected payoff is given by  $\Pi_B = \lambda(\mathcal{O}_B(p_B))(\pi_B p_B - c)$ . Therefore, firm  $B$ 's optimal choice of  $p_B$  requires it to solve a standard monopoly pricing problem, given its location  $x_B$  and the fact that any price it chooses will be discounted by  $\pi_B$ . It is then straightforward to verify that given  $\pi_B(V - t(1 + \max\{x_B, 1 - x_B\})) > c$ , the unique best response for firm  $B$  is to set  $p_B^M$  and also target the entire market subsequently. Applying the same argument to  $A$  given  $p_B = p_B^M$  shows that indeed the strategy profile specified in (i) is part of a SPE. We now establish the uniqueness of the SPE outcome by a series of lemmas.

**Lemma A4** In any SPE,  $\pi_j p_j > c \forall j \in \{A, B\}$ .

Proof: First, consider a pair of prices  $(p_j, p_{-j})$  such that  $\pi_j p_j \leq c$  and  $\pi_{-j} p_{-j} > c$ . With such prices, setting  $g_{-j}(i) = 1 \forall i \in [0, 1]$  is a dominant strategy for firm  $-j$  in the targeting stage, and then  $\Pi_j \leq 0$ . As a best response, firm  $j$  will shut down and

earn a payoff of zero in the corresponding targeting subgames. But then deviating to the monopoly price  $p_j^M$  together with  $g_j(i) = 1 \forall i \in [0, 1]$  is profitable for firm  $j$ , since by doing so it can earn at least an expected payoff of  $\pi_j p_j^M - c > 0$ . Hence, any prices  $(p_j, p_{-j})$  such that  $\pi_j p_j \leq c$  and  $\pi_{-j} p_{-j} > c$  cannot be part of a SPE.

Next, consider any prices  $(p_j, p_{-j})$  such that  $\pi_j p_j < c$  and  $\pi_{-j} p_{-j} \leq c$ . Since  $\pi_j p_j < c$ , any equilibrium in the corresponding targeting subgames must be non-overlapping. Thus, with such prices, firm  $-j$  earns  $\Pi_{-j} \leq p_{-j} - c$ . But then by unilaterally deviating to  $p_{-j}^M$  in the pricing stage, firm  $-j$  will optimally target the entire market in the targeting stage and force firm  $j$  to shut down. This is a profitable deviation for firm  $-j$ , since  $p_{-j}^M - c > p_{-j} - c$  according to the parametric assumption in (i). As a result, any prices  $(p_j, p_{-j})$  such that  $\pi_j p_j < c$  and  $\pi_{-j} p_{-j} \leq c$  cannot be part of a SPE.

Finally, the price pair  $(p_A, p_B)$  such that  $\pi_j p_j = c \forall j \in \{A, B\}$  cannot be part of a SPE either. With such prices, given our tie-breaking assumption there is a unique equilibrium in the targeting subgame, in which  $g_j(i) = 1 \forall i \in [0, 1]$  and  $j \in \{A, B\}$ , i.e., both firms will target the entire market. In this case, the expected payoffs are zero for both firms. But then, an unilateral deviation of, say, firm  $A$  to setting  $p_A = p_A^M$  together with  $g_A(i) = 1 \forall i \in [0, 1]$  will yield at least an expected payoff of  $\pi_A p_A^M - c > 0$  for firm  $A$ . ■

**Lemma A5** In any SPE,  $p_j \in [p_j^M, V] \forall j \in \{A, B\}$ .

Proof: By Lemma A4, we can restrict our attention the price pairs  $(p_A, p_B)$  such that  $p_j > c/\pi_j$  for all  $j \in \{A, B\}$ . Note that conditional on  $p_j > c/\pi_j$ , firm  $j$ 's targeting decision is completely pinned down by its own price  $p_j$ : in the targeting stage it is a dominant strategy for firm  $j$  to target (and only target) the consumers in  $\mathcal{O}_j(p_j)$ . But then, it is clear that any price  $p_j \in (c/\pi_j, p_j^M)$  is dominated by  $p_j^M$ . ■

**Lemma A6** In any SPE, all consumers in  $[0, \min\{2x_A, 1\}]$  are targeted by firm  $A$ , and all consumers in  $[\max\{0, 2x_B - 1\}, 1]$  are targeted by firm  $B$ .

Proof: By Lemmas A5 and A6, we can restrict attention to the cases where  $p_j \in [p_j^M, V] \forall j \in \{A, B\}$ . Geometrically, this implies that in equilibrium,  $\mathcal{O}_j(p_j)$  is an interval around  $x_j$ . Also note that there cannot be a non-zero measure set of consumers that are untargeted by any firm in equilibrium, since in this case some firm  $j$  will get an additional

consumer for sure by marginally lowering its price and then targeting further in the second stage. This is profitable for firm  $j$  since  $p_j^M \geq V - t \geq t + c > \pi_B \lambda(\mathcal{I}_B(p_B))t + c$ .

Now suppose, in contradiction, that there exists  $\varepsilon > 0$  such that the consumers located in  $[1 - \varepsilon, 1] \subseteq [x_B, 1]$  are targeted by firm  $A$  but not by firm  $B$ . Since  $x_A < x_B$ , this would imply that firm  $A$  are charging  $p_A = p_A^M$  and targeting the entire market. But then, the unique best response of firm  $B$  would be to choose  $p_B = p_B^M$  and target the entire market as well. Thus, in any SPE firm  $B$  must target all consumers in  $[x_B, 1]$ . By symmetry, consumers located in  $[\max\{0, 2x_B - 1\}, x_B]$  will also get a positive payoff by transacting with firm  $B$  and, hence, they will be targeted by firm  $B$  as well. Proving that in any SPE firm  $A$  must target all consumers in  $[0, \min\{2x_A, 1\}]$  is analogous. ■

Now suppose, without loss of generality, that in equilibrium firm  $A$  charges  $p_A \in [p_A^M, V]$  and targets the consumers in  $[0, \lambda_A]$ , while firm  $B$  charges  $p_B \in [p_B^M, V]$  and targets the consumers in  $[1 - \lambda_B, 1]$ , where  $\lambda_A, \lambda_B \geq 0$ . As argued, there cannot be a non-zero measure set of consumers that are untargeted by any firm in equilibrium, thus  $\lambda_A + \lambda_B \geq 1$ . Suppose further that both  $\lambda_A$  and  $\lambda_B$  are strictly less than one or, equivalently, that  $p_j \in (p_j^M, V) \forall j \in \{A, B\}$ . By marginally lower its price and target further, firm  $j$ 's marginal revenue is *at least*  $\pi_j p_j^M$ , while its marginal (opportunity) cost is given by  $(\lambda_A + \lambda_B - 1)\pi_j t + (1 - \lambda_{-j})t + c$ . Hence, a necessary condition to have  $p_j \in (p_j^M, V]$  in equilibrium is

$$\pi_j p_j^M < (\lambda_A + \lambda_B - 1)\pi_j t + (1 - \lambda_{-j})t + c \quad \forall j \in \{A, B\},$$

which further implies  $\pi_A p_A^M + \pi_B p_B^M < t + 2c$ . However, this inequality can never hold, since the parametric assumption in (i) asserts that  $\pi_j p_j^M > \pi_j t + 2c \forall j \in \{A, B\}$ . ■

- (ii) Suppose that for given prices  $(p_A, p_B)$  firm  $A$  targets the a set  $\mathcal{I}_A \subset [0, 1]$  of consumers in the second stage. Because  $\pi_B V < c$  it cannot be profitable for  $B$  to target any subset of consumers in  $\mathcal{I}_A$  of positive measure. Therefore, there cannot be overlap in any SPE, and it immediately follows that any targeting profile that is part of a SPE must be essentially of the form that  $A$  targets a subset  $\mathcal{I}_A \subset [0, 1]$  and  $B$  targets the subset  $\mathcal{I}_A^C$ . Knowing that it will be the monopolist in its respective segment, each firm then sets the monopoly

price  $p_j^*$  corresponding to its anticipated targeting subset. Given that the subset  $\mathcal{I}_A$  in the above discussion is arbitrary, we can also conclude that any non-overlapping targeting profile that partitions the unit interval together with the prices  $p_j^* = \inf_{i \in \mathcal{I}_j} \{V - t|i - x_j|\}$  can be sustained as a SPE outcome. ■

- (iii) Without loss of generality, let  $j = A$  and  $-j = B$ . Since  $c > \pi_B V$ ,  $B$  would be only interested in targeting  $i$  if  $g_A(i) = 0$ . Moreover, because  $c < \pi_A(V - t \max\{x_A, 1 - x_A\})$  it is a dominant strategy for  $A$  to set  $p_A = p_A^M$  and to target the entire market in the second stage. Hence, the unique SPE outcome is as stated in (iii). ■

**Remark on tie-breaking rule** We now show that result (i) of Proposition 2 remains valid for any arbitrary tie-braking rule given the additional assumption that  $c \leq t$ . With respect to the above proof of (i) we only need to show that  $p_j = c/\pi_j$ ,  $\forall j \in \{A, B\}$  cannot be part of a SPE. Suppose, in contradiction, that  $p_j = c/\pi_j$ ,  $\forall j \in \{A, B\}$  in some SPE. Note that by the parametric assumptions in (i) we have  $c/\pi_j < V - 2t$ , thus  $p_j = V - 2t - \varepsilon_j$  for some unique  $\varepsilon_j > 0$ . Without imposing a specific tie-braking rule, any targeting profile  $(g_A, g_B)$  such that partitions the unit interval constitute a targeting equilibrium in the second stage. Now consider a deviation to  $\hat{p}_j^M > c/\pi_j$ . With such a price,  $g_j(i) = 1 \forall i \in [0, 1]$  becomes a dominant strategy in the subsequent targeting subgame. Hence, firm  $j$  can secure itself a deviation payoff of  $\Pi_j^D \geq \pi_j \hat{p}_j^M - c \geq \pi_j(V - t) - c$ . Therefore, for  $p_j = c/\pi_j$  to be part of a SPE it is necessary that such a deviation is not profitable. This requires that  $\hat{\Pi}_j \geq \Pi_j^D$ , where  $\hat{\Pi}_j$  is the payoff received in the equilibrium of the targeting subgame following both firms choosing  $p_j = c/\pi_j$ . Since the equilibrium of the targeting subgame cannot be overlapping given  $p_j = c/\pi_j \forall j \in \{A, B\}$ , we have  $\hat{\Pi}_A = \lambda(V - 2t - \varepsilon_A - c)$  and  $\hat{\Pi}_B = (1 - \lambda)(V - 2t - \varepsilon_B - c)$ , where  $\lambda \in [0, 1]$  is the measure of consumers targeted by  $A$ . However, the inequalities  $\hat{\Pi}_j \geq \Pi_j^D \forall j \in \{A, B\}$  together imply that  $V - 2t - c - \lambda\varepsilon_A - (1 - \lambda)\varepsilon_B \geq V - t - 2c$  or equivalently that  $c \geq t + \lambda\varepsilon_A + (1 - \lambda)\varepsilon_B$ , contradicting the assumption that  $c \leq t$ . ■

**Proof of Proposition 3** Given the arguments in text we only need to show that no asymmetric equilibria exists. First, consider a jointly targeted consumer  $i \in \mathcal{I}_A \cap \mathcal{I}_B$ . Then, there cannot be an equilibrium where  $s_A^*(i) \neq s_B^*(i)$ . This follows from a corollary (of Proposition 4) on symmetric contests in Hefti (2016), stating that best-reply maps associated with an equation like (6) can never possess asymmetric fix points. Because we take (6) to hold for any

mutually targeted consumer it follows therefore that  $s_A^*(i) = s_B^*(i) = s^*$  on any  $\mathcal{I}_A \cap \mathcal{I}_B \neq \emptyset$  in equilibrium.  $\blacksquare$

**Proof of Proposition 4** Clearly, in any equilibrium  $\lambda(\mathcal{I}_j \cap \mathcal{I}_{-j} \cap \mathcal{P}_j) = 0 \ \forall j \in \{A, B\}$ , since targeting is costly and firm  $-j$  can never win any consumer that is located in  $\mathcal{P}_j$  and is also targeted by firm  $j$ . This implies that the targeting profile must be non-overlapping in any equilibrium, and therefore each consumer will be targeted by at most one ad. Next, suppose a consumer  $i \in \mathcal{P}_j$  is targeted by firm  $-j$ . This would be profitable for firm  $-j$  if and only if this consumer is not targeted by firm  $j$  and the probability that she will use the ad blocker is sufficiently low. But then, it would also be profitable for firm  $j$  to target this consumer, since in that case it will be the chosen firm if that consumer indeed does not use the ad blocker. Hence, in equilibrium there cannot be a non-zero measure set of consumers in  $\mathcal{P}_j$  being targeted by firm  $-j$  only. Thus, in any equilibrium the targeting profile must be non-intrusive, and any consumer with rational expectation would not choose to use the ad blocker given the assumptions that  $x_A = 0$ ,  $x_B = 1$  and  $\bar{\gamma} \leq V - p - t/2$ , because in this case

$$EU_i(b_i = 0 | \gamma_i) = V - p - \min\{i, 1 - i\}t - \gamma_i \geq V - p - t/2 - \bar{\gamma} \geq 0.$$

This in turns implies that in any equilibrium, each firm  $j$  will target and only target consumers located in  $\mathcal{P}_j$  (up to zero-measure sets).  $\blacksquare$

**Proof of Proposition 5** First, note that if a consumer with  $\gamma_i \leq \gamma^*$  would not use the ad blocker even if she expects to be spammed by both firms, since:

$$EU_i(b_i = 0 | \gamma_i) = V - p - \left(\frac{i}{2} - \frac{1-i}{2}\right)t - 2\gamma_i \geq V - p - \frac{t}{2} - 2\gamma^* = 0.$$

As a result, any firm can secure an expected revenue of  $\frac{pF(\gamma^*)}{2}$  by targeting an arbitrary consumer, independent of the competing firm's targeting strategy. Hence if  $c < \frac{pF(\gamma^*)}{2}$  holds, leaving a non-zero measure set of consumers untargeted would never be optimal for any firm, and we thus have  $\lambda(\mathcal{I}_A) = \lambda(\mathcal{I}_B) = 1$  in any equilibrium. Consequently, in equilibrium every consumer rationally expects to receive ads from both firm and pay a transportation cost of  $t/2$  if she does not switch on the ad blocker. It then follows that in any equilibrium, almost every

consumer with  $\gamma_i > \gamma^*$  will choose to use the ad blocker, while the remaining ones will not. ■

**Proof of Proposition 6** First, there cannot be an equilibrium in which a non-zero set of consumers remains completely uninformed because consumers located in this set will not block and therefore any firm could capture these consumers by sending them a message at zero salience costs. Second, there cannot be any equilibrium in which a non-zero set of consumers is targeted by one firm only. This is because in such an equilibrium optimality requires the salience level of the messages received by such consumers to be zero, giving the competitor an incentive to steal away these consumers by sending them a message with an arbitrarily low salience level. It follows that the only type of equilibrium candidate is where  $\lambda(\mathcal{I}_A) = \lambda(\mathcal{I}_B) = 1$ . Consider a consumer  $i \in [0, 1]$  who is aware of her LA and expects to receive messages from both firms at an aggregate salience level  $S > 0$ . This consumer's expected consumption utility, conditional on not blocking, is  $V - p - t/2$ . Thus, with rational expectations, the chance that  $i$  chooses to block is

$$\Pr(b_i = 1|S) = 1 - \Pr\left(\gamma_i \leq \frac{V - p - \frac{t}{2}}{S^\alpha}\right) = \begin{cases} 1 - \frac{\mu}{\bar{\gamma}S^\alpha} & S^\alpha > \frac{\mu}{\bar{\gamma}}, \\ 0 & \text{otherwise.} \end{cases}$$

With salience levels  $s_A(i), s_B(i)$  such that  $S^\alpha > \frac{\mu}{\bar{\gamma}}$ , firm  $j$ 's expected profit from  $i$  is

$$\Pi_j(i) = \frac{p\mu}{\bar{\gamma}(s_j(i) + s_{-j}(i))^\alpha} \cdot \frac{s_j(i)}{s_j(i) + s_{-j}(i)} - \kappa s_j(i)^\eta, \quad (10)$$

with first-order conditions given by

$$\frac{p\mu(s_{-j}(i) - \alpha s_j(i))}{\bar{\gamma}(s_j(i) + s_{-j}(i))^{2+\alpha}} = \kappa s_j(i)^{\eta-1}\eta. \quad (11)$$

The single symmetric solution to the first-order conditions of the two firms is  $s_A(i) = s_B(i) = s^{**}$ , where  $s^{**}$  is given by (8). To show that both firms sending their messages at the uniform salience level  $s^{**}$  to the entire market is an equilibrium it remains to verify that indeed  $\mu/(\bar{\gamma}(2s^{**})^\alpha) \leq 1$  and firms make a positive expected profit from each mutually targeted consumer. Using (8) the first inequality becomes

$$\left(\frac{(1-\alpha)p}{2^{1+\alpha}\kappa\eta}\right)^\alpha \geq \left(\frac{\mu}{\bar{\gamma}}\right)^\eta \Leftrightarrow \kappa \leq \hat{\kappa} \equiv \left(\frac{\mu}{\bar{\gamma}}\right)^{\alpha/\eta} \frac{(1-\alpha)p}{2^{1+\alpha}\eta}.$$

Thus, given that  $\kappa \leq \hat{\kappa}$  and both firms target consumer  $i$  with the salience level  $s^{**}$ , the expected profit of  $j$  is

$$\Pi_j(i) = \frac{p}{2} \frac{\mu}{\bar{\gamma}(2s^{**})^\alpha} - \kappa(s^{**})^\eta.$$

It is straightforward to verify that  $\Pi_j(i) > 0 \Leftrightarrow 2\eta > 1 - \alpha$ , where the last inequality holds since  $\eta \geq 1$  and  $\alpha > 0$ . Therefore, it is indeed an equilibrium for both firms to target the entire market at  $s^{**}$ , provided that  $\kappa \leq \hat{\kappa}$ , and a fraction  $\Lambda = 1 - \omega/(\bar{\gamma}(2s^{**})^\alpha)$  of consumers (i.e., the ones with low nuisance tolerance) uses the blocking tools.

For uniqueness, it suffices to show that the best-reply function  $s_j(s_{-j})$ , implicitly defined by (11), and its counterpart  $s_{-j}(s_j)$  do not have any asymmetric fixed points.<sup>39</sup> To prove this we make use of Theorem 2 in Hefti (2016), stating that if  $s'_j(s_{-j}) > -1 \forall s_{-j} > 0$  then there cannot be such asymmetric fixed points. Let  $j = A$  and  $-j = B$ . Note first that for any given  $s_B > 0$ , a solution  $s_A(s_B)$  to the equation (11) always exists. Moreover, this solution must satisfy  $0 < \alpha s_A(s_B) < s_B$  and must be unique because the LHS of (11) is decreasing in  $s_A$  whenever  $s_B \geq \alpha s_A$ . Now let

$$\phi(s_A, s_B) \equiv p \frac{\mu(s_B - s_A \alpha)}{\bar{\gamma}(s_A + s_B)^{2+\alpha}} - \kappa s_A^{\eta-1} \eta.$$

It follows that  $\phi'_{s_A}(s_A(s_B), s_B) < 0$ .<sup>40</sup> An application of the Implicit Function Theorem then yields that for given  $s_B > 0$ ,

$$s'_A(s_B) = -\frac{\phi'_{s_B}(s_A(s_B), s_B)}{\phi'_{s_A}(s_A(s_B), s_B)} = \frac{(1 + \alpha)s_A(s_A(1 + \alpha) - s_B)}{(\eta - 1)(s_A + s_B)(s_B - \alpha s_A) - (1 + \alpha)s_A(\alpha s_A - 2s_B)},$$

where the denominator is strictly positive (a consequence of  $\phi'_{s_A}(s_A(s_B), s_B) < 0$ ). The condition  $s'_A(s_B) > -1$  then can be reduced to  $(1 + \alpha)s_A > (\eta - 1)(\alpha s_A - s_B)$ , which is satisfied as  $s_A > 0$  and  $s_B > \alpha s_A$ . ■

<sup>39</sup>Note that the  $j$ 's best-reply function  $s_j(s_{-j})$  is defined by (11) only if  $(s_j(s_{-j}) + s_{-j})^\alpha \geq \mu/\bar{\gamma}$ . If this inequality is violated, consumer  $i$  does not block for sure and the profit function is  $\Pi_j(i) = p \frac{s_j(i)}{s_j(i) + s_{-j}(i)} - \kappa s_j(i)^\eta$ , with associated first-order condition of the form (6). We already know from the proof of Proposition 3 that the corresponding best-reply map cannot have any asymmetric fixed point, and the fact that there is possibly an isolated non-differentiability of  $s_j(i)(s_{-j}(i))$  at the switching point is irrelevant in order to exclude asymmetric fixed points by the result in Hefti (2016).

<sup>40</sup>Meaning: The partial derivative of  $\phi(s_A, s_B)$  with respect to  $s_A$ , evaluated at  $s_A = s_A(s_B)$ . Note that  $\phi'_{s_A}(s_A(s_B), s_B) < 0$  also assures that the underlying objective function is strongly quasiconcave in  $s_A$ .



**Proof of Corollary 1** Using  $s_A = s_B = s^{**}$  from (8) in (10) and rearranging gives

$$\Pi = \kappa^{\frac{\alpha}{\eta+\alpha}} \left( \frac{2\eta}{1-\alpha} - 1 \right) \left( \frac{(1-\alpha)p\mu}{2^{2+\alpha}\bar{\gamma}\eta} \right)^{\frac{\eta}{\eta+\alpha}}.$$

Hence  $\frac{\partial \Pi}{\partial \mu} > 0$  and  $\frac{\partial \Pi}{\partial \bar{\gamma}} < 0$  both because  $\frac{2\eta}{1-\alpha} - 1 > 0$ , and  $\frac{\partial \Pi}{\partial \kappa} > 0$  is obvious. Further, we have

$$\Lambda = 1 - \frac{1}{2^\alpha} \left( \frac{2^{2+\alpha}\kappa\eta}{p(1-\alpha)} \right)^{\frac{\alpha}{\eta+\alpha}} \left( \frac{\mu}{\bar{\gamma}} \right)^{\frac{\eta}{\eta+\alpha}}$$

from which  $\frac{\partial \Lambda}{\partial \mu} < 0$ ,  $\frac{\partial \Lambda}{\partial \bar{\gamma}} > 0$  and  $\frac{\partial \Lambda}{\partial \kappa} < 0$  follow. ■

**Proof of Proposition 7** Conditional on  $z_{ji} = 1$ , by Bayes rule the probability that  $j \succ_i -j$  is given by  $1/(1 + \alpha_j) \geq 1/2$ . Since  $p_j > 2c_j$ , firm  $j$ 's expected profit from targeting such a consumer is at least  $p_j/(1 + \alpha_j) - c_j > 0$ . Hence, in any targeting equilibrium,  $z_{ji} = 1 \implies g_j(i) = 1$  for almost every  $i \in [0, 1]$ . Now suppose  $z_{ji} = 0$ . In this case, firm  $j$  knows for sure that  $-j \succ_i j$ . But then, firm  $j$  also knows that  $z_{-ji} = 1$  with probability one and, hence, this consumer will be targeted by firm  $-j$  for sure. Given that consumers' attention is unconstrained, firm  $j$  can never gain anything by targeting such consumers. As a result, we have that in any targeting equilibrium,  $z_{ji} = 0 \implies g_j(i) = 0$  for almost every  $i \in [0, 1]$ . ■

**Proof of Proposition 8** Identical to the proof of case (ii) of Theorem 1. ■

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