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Creating Attachment through Advertising: Loss Aversion and Pre-Purchase  
Information

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# Creating Attachment through Advertising: Loss Aversion and Pre–Purchase Information\*

Heiko Karle<sup>†</sup>

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## Abstract

Complementing the existing literature on anchoring effects and loss aversion, we analyze how firms can influence loss–averse consumers’ willingness to pay by product information in the form of informative advertising rather than by prices. We find that consumers’ willingness to pay is greatest when only partial information about the product—i.e. only a fraction of product attributes—is disclosed, and that partial information disclosure is the optimal mode of advertising for a monopolistic firm. This causes the consumers’ realized product valuation to diverge from their intrinsic product valuation, which leads to a reduction of consumer surplus. Consequently, transparency policies can help to protect consumers.

**Keywords:** Advertising, Loss Aversion, Information Disclosure

**JEL Classification:** D83, L41, M37

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# 1 Introduction

Advertisements for expensive durable goods, such as television advertisements or sales talks for cars, catalogs for furniture, or brochures advertising electronic devices from electrical stores or supermarkets, all provide a high information content about the characteristics of their products (Abernethy and Franke, 1996). For the retailers of these goods, it appears to be common advertising practice to disclose the product attributes which are the most favorable for potential buyers, such as, for example, the design and the horsepower rating of a BMW convertible. Product attributes which are possibly less favorable, at least for some intermediate- or high-valuation customers, are left to be discovered by potential buyers later during the purchasing process, for example, the fact that the convertible is only available with certain wheel sizes or certain colors for the interior decoration.

When consumers are not at an informational disadvantage at the moment of purchase because they can inspect products before purchase (Hirshleifer, 1973), the existence of such advertising practices cannot easily be explained by classical economic theory.<sup>1</sup> When, in addition, potential customers are experienced in buying products in the same product category and are willing to spend some time and effort to make the purchase decision (as is usually the case for expensive durable goods), explanations based on bounded rationality, such as limited attention, are not powerful.<sup>2,3</sup> In this paper, we provide a theoretical explanation for the partial disclosure of product attributes based on loss-averse preferences with rational expectations.

Our model incorporates the following consumer behavior: consumers are expectation-based loss averse following Kőszegi and Rabin (2006, 2007).<sup>4</sup> After receiving an advertisement for a good, consumers usually form expectations regarding the outcome of their purchase decision. With loss-averse preferences, these expectations yield a reference point with which consumers compare their actual transaction outcome. Deviations from the reference point lead to gains or losses which impact the consumers' utility. Consequently, by altering consumers' pre-purchase expectations via informative advertising, a firm can affect loss-averse

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<sup>1</sup>Anderson and Renault (2006) argue that consumers' transportation costs may render partial information disclosure optimal, but the authors cannot explain such advertising practices when consumers are already in the store talking to a salesperson, or in the case of (supermarket) shoppers.

<sup>2</sup>Considering naïve consumers who simply overvalue the importance of advertised product attributes, Zhou (2008) in a monopoly setup and Eliaz and Spiegel (2011) in a more general environment with competing firms, show that, by highlighting only favorable product attributes, firms can induce suboptimal product choices.

<sup>3</sup>When consumers are either not aware of adverse product effects or are uncertain about their magnitude, Li, Peitz, and Zhao (2010) predict harmful underprovision of product information by a monopolistic firm.

<sup>4</sup>Recent experimental work from the laboratory and in the field provides a large body of evidence that concludes that economic outcomes are well explained by this concept. These works consist of exchange and valuation experiments (see Ericson and Fuster, 2011), consumption-choice experiments with sandwiches (see Karle, Kirchsteiger, and Peitz, 2012), experiments in which participants are compensated for exerting effort in a tedious and repetitive task (see Abeler, Falk, Goette, and Huffman, 2011), and of sequential-move tournaments (see Gill and Prowse, 2012). There is also evidence that expectation-based reference dependence affects golf players' performance (see Pope and Schweitzer, 2011) and cabdrivers' labor supply decision (see Crawford and Meng, 2011).

consumers' willingness to pay.

Our setup builds on the monopoly advertising model of Anderson and Renault (2006), focusing on consumers who are expectation-based loss averse in the product valuation and price dimension (Kőszegi and Rabin, 2006, 2007, Heidhues and Kőszegi, 2008). Consumers are initially uncertain about their individual match value—i.e. their horizontal product valuation—but they do observe the price of the product. Consumers receive an advertising signal from the monopolist containing match value information and update their beliefs correspondingly. Following Anderson and Renault (2006), we assume that by disclosing product characteristics, the monopolist can reveal any amount of hard information about a consumer's match value to any consumer at zero cost. At the advertising stage, consumers also make a match value-dependent purchase plan, and form their probabilistic reference point distributions in the price and the match value dimension, where the former solely incorporates the uncertainty whether or not the product will be bought. Following Kőszegi and Rabin (2006, 2007), we assume that a consumer's purchase plan is self-fulfilling and constitutes a personal equilibrium. Before making their purchase decision, consumers become fully informed by their own inspection. A consumer then decides whether or not to buy the good: for each action, the consumer compares her resulting match value (resp. payment) to her expected outcome under her purchase plan and experiences gains or losses, accordingly.<sup>5</sup>

Considering consumer behavior at a given price, we find that an initial plan to buy with a high probability increases a consumer's loss in the match value dimension from not buying, and decreases her loss in the price dimension from buying, which unambiguously renders buying more attractive than with standard preferences. As a consequence, a high post-advertising probability of buying, which induces such a plan, increases a loss-averse consumer's willingness to pay, which is in line with recent experimental evidence.<sup>6</sup> Following Kőszegi and Rabin (2006), we call this effect *consumer attachment* which, in our setup, can be thought of as an expectation-based variant of the endowment effect first discussed by Thaler (1980) and documented, for example, by Kahneman, Knetsch, and Thaler (1990).

Our main result is that with loss-averse consumers, the monopolist optimally discloses a partial amount of match value information to consumers.<sup>7</sup> In our setup, optimal partial information disclosure means that the monopolist solely discloses to consumers whether or not their

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<sup>5</sup>In this paper, we do not consider loss aversion with respect to the update of prior beliefs to post-advertising beliefs, as suggested by Kőszegi and Rabin (2009). Yet, taking those comparisons into account would not affect our results since, in our setup, consumers do not undertake an action at the advertising stage. Alternatively, we could assume that consumers learn about the existence of the product only by the monopolist's advertising signal.

<sup>6</sup>In a simple exchange experiment, Ericson and Fuster (2011) find that participants are willing to pay 20–30% more for an object if they had expected to be able to get it with 80–90% probability rather than 10–20% probability. In a similar experiment, however, Smith (2008) does not find the same effect.

<sup>7</sup>Following Resnik and Stern (1977), the content analysis provides empirical evidence for positive but partial informative content of advertisements for many product categories such as cars, furniture, and electronics. For more details see Abernethy and Franke (1996), as discussed in Section 4.4.

intrinsic valuation lies above a certain threshold level which is lower than the purchase price.<sup>8</sup> We find that any consumer who receives a positive, optimal threshold signal buys the product even if her intrinsic valuation lies below the price. The intuition for the effectiveness of threshold advertising is as follows: the firm wants as many consumers as possible to have correct, high-end expectations about their product valuation. This leads to a high post-advertising probability of buying which, in turn, minimizes the consumers' loss in the price dimension from buying and maximizes their loss in the match value dimension (relative to zero) from not buying. As a result, even buying at a valuation slightly below the price becomes optimal *ex post*. The option of not buying and not receiving a match value of at least the threshold level is not credible after having received a positive, optimal threshold signal (contrary to the consumer's optimal plan after having received full information). If the threshold is set lower than the optimal level, consumers whose valuation is only slightly above the threshold will not buy, since their intrinsic valuation is too low relative to the price, and their loss in the match value dimension relative to all higher matches is too large. This implies that it is optimal for the monopolist to disappoint the marginal consumer to a certain extent relative to her expectations. The monopolist implements threshold match advertising by disclosing an intermediate fraction of product attributes, such that intermediate- and high-valuation consumers learn that their valuation is at least as high as the threshold but without fully observing their true valuation. At the same time, consumers with lower valuation learn that they won't buy the product *ex post*. We also find that the optimal advertising strategy leads to maximal prices set by the monopolist and to maximal overpay of the marginal consumer.

As an example of optimal threshold advertising, consider television advertisements or sales talks for cars which leave possibly unfavorable attributes (at least for some intermediate- or high-valuation customers) to be discovered by potential buyers later during the purchasing process. Here it is intended that customers become attached to buying the good before observing some possibly unfavorable attributes or facts. These facts may have otherwise deterred at least some of the buyers with the lowest valuation from buying at the given price if there had been no advertising.<sup>9</sup>

If partial information disclosure is not feasible, we show that the monopolist finds it optimal to disclose no match value information and to set a low price, for example, last-minute, discounted travel offers. Here, *ex-ante* uninformed consumers become partially attached by a low price offer, since low prices increase their post-advertising probability of buying the product. This leads to some excess demand which overcompensates the monopolist for set-

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<sup>8</sup>Threshold information can be released by the monopolist by disclosing a certain fraction of product attributes if the total number of product attributes is sufficiently large. Anderson and Renault (2006) provide a micro foundation for threshold advertising, which we discuss in Section 4.1.

<sup>9</sup>Note here that the creation of consumer attachment does not require the existence of unfavorable attributes to be unexpected. Conversely, unexpected losses in match value due to overly optimistic expectations can even decrease consumer attachment.

ting a low price. Full match value advertising is the least preferred mode of advertising with loss-averse consumers (at zero production cost), since it creates no consumer attachment at the initial stage when consumers make their purchase plan.

Because of consumer attachment, loss-averse consumers might accept higher prices or buy more often under partial or no match value advertising than under full match advertising (in which case they act like standard consumers). On the aggregate, we find that, under partial or no match value advertising, loss-averse consumers are worse off than under full match advertising. Furthermore, welfare is maximized under full match advertising. Optimal consumer protection policy should therefore highlight the importance of full information disclosure (mandatory disclosure rules or transparency policies) in advertising where applicable. For the interpretation of our welfare implications, it is also relevant that expectation-based loss-averse consumers are not boundedly rational but exhibit non-standard preferences. Preferences can be considered to be more persistent over time than behavior based on bounded rationality because of growing consumer sophistication about detrimental advertising practices in repeated play. Hence, our welfare implications are more conservative, yet more extensive, than those of advertising models based on boundedly rational behavior, such as limited attention (Zhou, 2008, Eliaz and Spiegler, 2011).

In economics and marketing, there is a large body of literature on anchoring effects, reference dependence and loss aversion, showing that firms can manipulate consumers' consumption behavior in their favor, for example, they can increase consumers' willingness to pay for a product.<sup>10</sup> Most of this literature focuses exclusively on prices as manipulation devices. In particular, it focuses on reference prices which might be temporal (past prices) or contextual (prices within the same product category). However, there also is evidence that the disclosure of product characteristics can have similar effects on the consumers' willingness to pay. For example, Ariely (2009) suggests that disclosing certain product attributes to consumers induces a perception of ownership for a good even before purchase takes place. This in turn increases the product valuation of potential buyers. Complementing the existing theoretical literature, our paper focuses on this latter aspect by providing a formal model of informative advertising when loss-averse consumers are initially uncertain about their horizontal valuation of a product.

Our contribution to the advertising literature is that we find that both aspects have an impact on the consumer's product valuation, that is, the moment at which information about the consumption value of a product reaches a consumer, as well as the amount of product information made available. This is orthogonal to Becker and Murphy (1993) who propose that

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<sup>10</sup>For example, see Adaval and Wyer (2011), Beggs and Graddy (2009), and Krishna, Wagner, Yoon, and Adaval (2006) for evidence on anchoring effects and Rajendran and Tellis (1994), Kalyanaram and Winer (1995), Genesove and Mayer (2001), Heidhues and Kőszegi (forthcoming), and Rosato (2012) for work on reference dependence and loss aversion.

advertising content must be complementary to the consumption of the advertised product in order to increase consumer's product valuation. In addition, our approach shows that the direct effect of advertising on utility (also called persuasive effect) and its effect through the information set are interlinked (see Bagwell, 2007 for a survey on the economics of advertising). In other words, presenting information in the right way can increase consumers' utility of buying since the outside option of not buying becomes less attractive. To the best of our knowledge, this is the first advertising paper to examine this point.<sup>11</sup>

In Section 2, we introduce our baseline advertising model and derive some benchmark results about consumer behavior under full, partial, and no information disclosure. We apply our baseline advertising model to analyze the monopolist's optimal advertising strategies and prices, and we derive welfare implications in Section 3. We discuss the use of more general marketing tools and consumer unawareness of loss-averse preferences in Section 4. We also consider the related literature on classical advertising and on consumer loss aversion. We conclude in Section 5. Where not indicated otherwise, proofs are relegated to Appendix A. In Appendix B, we analyze extensions of our baseline model such as in the case where the monopolist can choose whether or not to advertise the price, and in the case of positive search costs.

## 2 The Model

### 2.1 Setup

In this section, we introduce our basic model of informative advertising with loss-averse consumers. We build on the monopoly advertising model of Anderson and Renault (2006) who show that the transmission of various amounts of product information can be implemented by disclosing product characteristics to consumers. Our model is compatible with this interpretation.

In our setting, a monopolistic firm produces a single product at constant marginal costs normalized to zero. There is a continuum of consumers of mass one. Consumers' horizontal product valuation  $r$ —i.e. their match value of one unit of the product—is heterogeneous ex post. It is initially uncertain, with consumers holding identical priors  $F(r)$ , where  $F(r)$  is the cumulative distribution function of  $r$  with support  $[a, b] \subseteq \mathbb{R}_0^+$  and  $r$  is i.i.d. among consumers.<sup>12</sup> In period 0, the monopolist sets a deterministic price  $p$  which is observed by

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<sup>11</sup>Analyzing duopolistic competition when consumers are loss averse, Karle and Peitz (2012) discover the link between consumer information and loss aversion. In their setup, firms can either disclose full information or disclose no information at all. The authors show that disclosing full information makes loss-averse consumers behave like standard consumers, which can be optimal if price competition with loss-averse consumers is more fierce than with standard consumers as, for example, in strongly asymmetric markets.

<sup>12</sup>We assume that common product components such as quality are known by consumers from the outset. For



consumers and sends an advertising signal to any consumer by disclosing product attributes. This can transmit any amount of hard information concerning a consumer's match value of the product.<sup>13</sup> After receiving an advertising signal  $s$ , a consumer updates her beliefs about her expected match value of the product  $F(r|s)$ , makes a match value-dependent purchase plan, and forms stochastic beliefs regarding her consumption outcome. In period 1, a consumer inspects the good, observes her individual match value, and decides whether or not to buy a single unit of the good, choosing quantity  $q \in \{0, 1\}$ . For technical and expositional reasons, we assume that any indifference by the consumer in period 1 is broken in favor of buying.

We next present the behavior of consumers in our model. Following Heidhues and Kőszegi (forthcoming), we apply the loss aversion concept of Kőszegi and Rabin (2006) to the purchase decision of a single good. A consumer's utility function has two components. First, her *intrinsic utility* is  $(r - p)q$  with  $q \in \{0, 1\}$  and reflects the standard part of the utility function. In addition, the consumer derives *gain-loss utility* from the comparison of her period-1 consumption outcomes to a reference point given by her period-0 expectations (probabilistic beliefs) about those outcomes. For a riskless intrinsic utility outcome  $(rq, pq)$  and riskless reference points  $(\tilde{r}, \tilde{p})$ , a consumer's total utility is given by

$$u[(rq, pq)|(\tilde{r}, \tilde{p})] = (r - p)q + \mu(\tilde{p} - pq) + \mu(rq - \tilde{r}) \quad (1)$$

with  $\mu$  being the gain-loss utility function. Following Kőszegi and Rabin (2006), we assume that  $\mu$  is piecewise linear with slope  $\eta > 0$  on gains and slope  $\eta\lambda > \eta$  on losses, where  $\eta > 0$  reflects the weight of the gain-loss utility compared to the intrinsic utility and  $\lambda$  the degree of loss aversion.<sup>14</sup> The specification in (1) also incorporates the assumption that consumers assess gains and losses over product and money dimensions separately.<sup>15</sup> Thus, for example, if a consumer believes that she will not receive the product and will not pay anything for it, then she evaluates receiving the product and paying for it as a gain in the product dimension and a loss in the price dimension. It is not considered to be a single gain or loss depending on the total consumption utility relative to the consumer's reference point.

Since we assume that consumers form rational expectations which might be stochastic,

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instance, consider third-party quality certification. These components solely shift the support of match values in this model.

<sup>13</sup>An information transmission mechanism induces a probability measure over the joint space of valuations and signals sent via advertising and enables the consumer to infer something about her valuation from the interpretation of the signal received. We provide a definition of the monopolist's information transmission mechanism at the beginning of Appendix A.2, see Definition 3.

<sup>14</sup>We assume in the baseline model that the degree of loss aversion  $\lambda$  is the same across dimensions. We discuss the effect of relaxing this assumption in Appendix B.1. As in Kőszegi and Rabin (2006), we do not consider *diminishing sensitivity* and *probability weighting* (the two remaining features of prospect theory; see Kahneman and Tversky 1979 and Tversky and Kahneman 1992).

<sup>15</sup>Note that this assumption is consistent with the experimental literature explaining the endowment effect, for example see Kahneman, Knetsch, and Thaler (1991) and is commonly made in the literature on consumer loss aversion, for example see Heidhues and Kőszegi (2008).

we follow Kőszegi and Rabin (2006) and extend the utility function in (1) to allow for the reference point to be a pair of probability distributions  $(G^r, G^p)$  over the two dimensions of intrinsic utility. Then, a consumer's total utility from an outcome  $(rq, pq)$  is equal to

$$U[(rq, pq)|(G^r, G^p)] = \underbrace{(r-p)q}_{\text{intrinsic u.}} + \underbrace{\int_{\tilde{p}} \mu(\tilde{p} - pq) dG^p(\tilde{p})}_{\text{gain-loss u. in price}} + \underbrace{\int_{\tilde{r}} \mu(rq - \tilde{r}) dG^r(\tilde{r})}_{\text{gain-loss u. in match value}}. \quad (2)$$

This implies that a consumer evaluating outcome  $(rq, pq)$  compares it to each possibility in the reference lottery. For example, if the consumer had been expecting to receive either a match value of 10 or 0, receiving a match value of 6 feels like a loss of 4 relative to the alternative of receiving 10 and like a gain of 6 relative to the alternative of receiving 0. Furthermore, this loss (resp. this gain) is weighted by the probability with which the consumer had been expecting to receive 10 (resp. 0).

To deal with the resulting interdependence between actual outcomes and expected outcomes, we apply the personal equilibrium concept of Kőszegi and Rabin (2006, 2007) which requires that reference points are given by rational (self-fulfilling) expectations about the purchase decision. Formally, notice that for any period-0 expectations held by the consumer, in period 1 she buys the product if her match value is at least as high as some cutoff level  $\hat{r}$ . This holds true since her total utility from buying ( $q = 1$ ) is strictly increasing in match value  $r$ , while that from not buying ( $q = 0$ ) is constant in  $r$ , and since we assumed that any indifference is broken in favor of buying. Thus, a consumer's period-0 plan whether or not to buy the product as a function of the period-1 match value  $r$  can be described by

$$\sigma(r) = \begin{cases} 0 & \text{if } r \in [a, \hat{r}[ \\ 1 & \text{if } r \in [\hat{r}, b]. \end{cases} \quad (3)$$

It follows that any self-fulfilling (or credible) plan must have such a cutoff structure. We next define when such a plan is credible. If a consumer holds post-advertising beliefs  $F(r|s)$  about her match value, such a plan induces an expectation  $G^p(F(\cdot|s), \hat{r})$  of paying price  $p$  with probability  $1 - F(\hat{r}|s)$ , and an expectation  $G^r(F(\cdot|s), \hat{r})$  of receiving a match value larger than  $r$ , given that  $r \geq \hat{r}$ , with probability  $1 - F(r|s)$  and receiving a match value of 0 with probability  $F(\hat{r}|s)$ . In that case, such a plan is credible if, given these expectations,  $\hat{r}$  is indeed a cutoff match value in period 1.

**Definition 1.** A cutoff match value  $\hat{r}$  constitutes a consumer's *personal equilibrium (PE)* given her post-advertising beliefs  $F(r|s)$  about her match value, if for the induced expectations  $G^r(F(\cdot|s), \hat{r})$  and  $G^p(F(\cdot|s), \hat{r})$ , it is true that

$$U[(\hat{r}, p)|(G^r, G^p)] = U[(0, 0)|(G^r, G^p)].$$

A consumer's preferred personal equilibrium is the PE that maximizes her initial utility.

**Definition 2.** A cutoff match value  $\hat{r}$ , constitutes a consumer's **preferred personal equilibrium (PPE)** given her post-advertising beliefs  $F(r|s)$  about her match value, if it is a PE and for any PE cutoff match value  $\hat{r}'$ ,

$$E_{r|s}[U[(r\sigma_{(r)}, p\sigma_{(r)})|(G^r, G^p)]] \geq E_{r|s}[U[(r\sigma'_{(r)}, p\sigma'_{(r)})|(G^{r'}, G^{p'})]],$$

where  $\sigma_{(r)}$  describes the consumer's purchase plan using cutoff  $\hat{r}$  as shown in (3).

We next characterize the monopolist's demand and profit function. For all advertising signals  $s$  in the monopolist's signal set  $S$ , let  $\hat{r}(p, s) \in [a, b]$  describe a consumer's cutoff match value between buying and not buying, given that she received advertising signal  $s$  and given price  $p \geq 0$ .<sup>16</sup> Let a consumer's post-advertising beliefs  $F(r|s)$  about her match value be defined on the domain  $[a, b]$ . Then, it holds that, for all  $s \in S$ , the demand conditional on receiving signal  $s$  is given by

$$D(p|s) = \int_{\hat{r}(p,s)}^b dF(r|s) = 1 - F(\hat{r}(p, s)|s). \quad (4)$$

Furthermore, for a given information transmission mechanism with signal set  $S$  (see Appendix A.2 for more details), the monopolist's total demand and profit functions are given by  $D(p) = E_{s \in S}[D(p|s)]$  and  $\pi(p) = p \cdot D(p)$ .

In order to ensure existence, we make the following, simplifying assumption.<sup>17</sup>

**Assumption 0.**

$F(r)$  is convex and twice continuously differentiable.

**Timing:**

1. **Advertising and price setting:** Firm sets price  $p$  and sends advertising signals  $s$  from a signal set  $S$ .
2. **Reference point formation:** The consumer observes price  $p$  and updates her belief  $F(r|s)$  corresponding to the match value  $r$ . In addition, she makes a match value-dependent purchase plan and forms a probabilistic reference point distribution in the price dimension (pay price  $p$  or pay zero), and in the match value dimension (receive a match value of  $r$ ,  $r \geq \hat{r}(p, s)$ , or receive match value of 0).

<sup>16</sup>For all  $s \in S$ , it holds that  $s$  is received by a set of consumers which constitutes an element of the partition of  $[a, b]$  induced by the information transmission mechanism of the monopolist.

<sup>17</sup>It is straightforward to check that, for instance, the uniform distribution satisfies this condition as a borderline case. This is a technical assumption which is not crucial for our results.

3. **Inspection and purchase:** The consumer inspects the product and observes her match value  $r$ : the consumer then undertakes a non–standard purchase decision, based on her utility that includes realized gains and losses relative to her reference point distribution.

The equilibrium concept is subgame perfect Nash with consumers playing a personal equilibrium.

## 2.2 Some Benchmark Results

In this section, we derive some benchmark results which characterize consumer behavior under full, partial, and no information disclosure. We show that consumer attachment does not arise under full information disclosure, while it exists in the two latter cases. In general, consumer attachment is increasing in the post–advertising probability of buying. Yet, for a purchase plan to satisfy the criterion of PPE, it must maximize the consumer’s expected utility at the initial stage.

### 2.2.1 Full Match Value Information

**No attachment on the equilibrium path:** first, we examine the case in which the monopolist advertises full match value information to any consumer ex ante (F). When price and match value are perfectly known after advertising, consumers do not experience uncertainty when reference points are formed (riskless choice). Kőszegi and Rabin (2006) show in Proposition 3 that, in this case, consumers will undertake a standard purchase decision—i.e. that they will maximize their intrinsic utility in PPE. The consumer’s intrinsic utility of buying the good is equal to  $r - p$ , while that of not buying is 0. Thus, the consumer’s cutoff match value between buying and not buying  $\hat{r}$  is equal to  $p$ . This means that a consumer whose product valuation is lower than the price does not buy the product, and therefore,  $\forall p \in [a, b]$ , the firm’s demand under full match value information equals

$$D(p) = 1 - F(p). \quad (5)$$

By assumption the monopolist’s profit function is twice continuous and globally quasi-concave (due to concavity of  $1 - F(p)$ ). Maximizing profits over  $p$  leads to the following first–order condition,

$$p = \frac{(1 - F(p))}{f(p)}. \quad (6)$$

**Example 1** (Uniform distribution). *If  $r$  is uniformly distributed on  $[0, 1]$ , the optimal price*

equals

$$p_F^* = \frac{1}{2}, \quad (7)$$

which describes the Nash equilibrium of the subgame with full information disclosure (F).

**Attachment ex post and the maximum level of attachment:** we show next that an outcome which differs from consumers' expectations, for example, an unexpected price increase, can create consumer attachment ex post. Note that, without a price commitment, this might indeed give an incentive to the monopolist to increase the price ex post but fails to satisfy the condition of rational expectations underlying the concept of PE.<sup>18</sup> Furthermore, we use this framework to characterize the maximum level of consumer attachment and show that it is reached when consumers expect to buy with probability one.

Consider a consumer located at  $r \in [a, b]$  when  $r$  is known ex ante. If, given  $(r, p)$ , the consumer initially expects to buy the good with probability one, her total utility from buying ex post is equal to

$$U[(r, p)|(r, p)] = r - p,$$

while her total utility from not buying ex post equals

$$U[(0, 0)|(r, p)] = 0 + \underbrace{\eta p}_{\text{gain}} - \underbrace{\eta \lambda r}_{\text{loss}}.$$

So given initial expectations of buying with probability one, if not buying ex post, the consumer experiences a gain in the price dimension and a loss in the match value dimension. Note that the consumer will buy the product ex post if  $\Delta U = U[(r, p)|(r, p)] - U[(0, 0)|(r, p)] \geq 0$  which is equivalent to

$$p \leq \frac{\eta \lambda + 1}{\eta + 1} r \equiv \bar{p}(r).$$

This means that, in a deterministic environment, initially expecting to buy the product with probability one causes the consumer at  $r$  to buy the product up to a price of  $\bar{p}(r)$  instead of  $r$ .<sup>19</sup> Note that this price exceeds the consumer's intrinsic valuation  $r$  as  $\lambda > 1$  and  $\eta > 0$ . For example, for  $\lambda = 2$  and  $\eta = 1$ ,  $\bar{p}(r)$  exceeds  $r$  by 50%. This confirms the importance

<sup>18</sup>We discuss this case in more detail in Appendix B.1.

<sup>19</sup>Equivalently, we can derive a lower bound  $\underline{r}$  on consumer's valuation for which she will purchase the good ex post given  $p$ ,

$$r \geq \frac{\eta + 1}{\eta \lambda + 1} p = \underline{r}(p).$$

of consumers' expectations for the prediction of their purchase behavior. The next lemma formalizes this insight.

**Lemma 1.** *The maximum level of consumer attachment is reached if a consumer expects to buy with probability one. Given price  $p \geq 0$ , such a consumer will buy the good if and only if her valuation  $r$  is not lower than  $\underline{r}(p) \equiv (\eta + 1)/(\eta\lambda + 1) \cdot p$ .*

Expecting to buy with probability one maximizes the loss in the match value dimension if not buying ( $\eta\lambda r$ ), and minimizes the loss in the price dimension if buying (0). Since match value (resp. price) enters the utility function with a positive (resp. negative) sign, both effects are in favor of buying the good. In fact, they maximize the distance between price and the cutoff match value between buying and not buying—i.e. they maximize consumer attachment. Note that expecting to buy with probability one might not be the PPE for consumers located between  $(\eta + 1)/(\eta\lambda + 1) \cdot p$  and  $p$ . In a deterministic environment, we therefore do not observe consumer attachment on the equilibrium path.<sup>20</sup>

### 2.2.2 Partial Match Value Information

Consider next that the monopolist discloses partial match value information ex ante. Let  $F(r|s)$  be a consumer's cumulated distribution function over match value after receiving a signal  $s$ , with domain  $[a, b]$  and support  $X(s) \subseteq [a, b]$ . For tractability reasons, we do not consider signals which induce atoms in  $F(r|s)$  in this paper, except for the case of full information disclosure, discussed in the previous subsection. Note that, in the case of full information disclosure, any consumer  $r$  receives a signal  $s(r) \in S_F$  which implies that  $F(r|s(r))$  has a single atom at  $r$ . Let  $S_F$  denote the corresponding signal set.

**Assumption 1.** *For all  $s \in S$  and for all  $S \neq S_F$ ,  $F(r|s)$  is continuous in  $r$ .*

For  $S \neq S_F$ , we next derive the consumer's cutoff match value,  $\hat{r}(p, s)$ , at which she will be indifferent between buying and not buying ex post for given price  $p$ . Given  $F(r|s)$  and  $p$ , a consumer makes a purchase plan involving a cutoff match value  $\hat{r}(p, s)$  and forms expectations about her induced purchase expenditure ( $p$  or 0) and her induced match value ( $r \in [\hat{r}(p, s), b]$  or  $r = 0$ ). Let  $(G^r, G^p)$  describe these expectations which the consumer uses as her joint reference point distribution in the price and the match value dimension.

Given the consumer's expectations, her cutoff match value  $\hat{r}(p, s)$  can be derived as follows:

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<sup>20</sup>Analogously, it can be shown that negative attachment arises off-the-equilibrium-path, when consumers hold pessimistic expectations with respect to their purchase decision. Not buying ex post becomes credible if the price is sufficiently high

$$p > \frac{\eta + 1}{\eta\lambda + 1} r \equiv \underline{p}(r).$$

first note that, for all  $r \in [\hat{r}(p, s), b]$ , her total utility from buying ( $q = 1$ ) is given by

$$\begin{aligned}
U[(r, p)|(G^r, G^p)] &= (r - p) - \eta\lambda \cdot \int_0^p (p - \tilde{p})dG^p(\tilde{p}) + \eta \int_p^b (\tilde{p} - p)dG^p(\tilde{p}) \\
&\quad - \eta\lambda \cdot \int_r^b (\tilde{r} - r)dG^r(\tilde{r}) + \eta \int_0^r (r - \tilde{r})dG^r(\tilde{r}) \\
&= \underbrace{(r - p)}_{\text{intrinsic u.}} - \underbrace{\eta\lambda \cdot (p - 0)F(\hat{r}(p, s)|s)}_{\text{loss in price rel. to 0}} \\
&\quad - \underbrace{\eta\lambda \cdot \int_r^b (\tilde{r} - r)dF(\tilde{r}|s)}_{\text{loss in match value rel. to higher values}} + \underbrace{\eta \int_{\hat{r}(p, s)}^r (r - \tilde{r})dF(\tilde{r}|s) + \eta(r - 0)F(\hat{r}(p, s)|s)}_{\text{gain in match value rel. to lower values and 0}},
\end{aligned} \tag{8}$$

where we use that

$$g^p(\tilde{p}) = \begin{cases} F(\hat{r}(p, s)|s), & \text{if } \tilde{p} = 0; \\ 1 - F(\hat{r}(p, s)|s), & \text{if } \tilde{p} = p, \end{cases}$$

and

$$g^r(\tilde{r}) = \begin{cases} F(\hat{r}(p, s)|s), & \text{if } \tilde{r} = 0; \\ 0, & \text{if } \tilde{r} \in [a, \hat{r}(p, s)]; \\ f(\tilde{r}|s), & \text{if } \tilde{r} \in [\hat{r}(p, s), b]. \end{cases}$$

Focusing on the second part of the equation (8), the first term shows the consumer's intrinsic utility, while the remaining terms express her gain–loss utility in the price and the match value dimension. The second term reveals that the consumer experiences a loss in the price dimension from buying as  $p$  is larger than 0. This reflects that ex ante the consumer was expecting to pay the price  $p$  only with probability  $1 - F(\hat{r}(p, s)|s)$ , while she was expecting to pay 0 with probability  $F(\hat{r}(p, s)|s)$ . In addition, she experiences no gain in the price dimension. The consumer experiences a loss in the match value dimension if  $r$  is smaller than  $b$  (third term), a corresponding gain if  $r$  is larger than  $\hat{r}(p, s)$  (fourth term), and an additional gain of buying for all  $r$  above the cutoff  $\hat{r}(p, s)$  relative to  $r = 0$  when not buying (fifth term). Note that the gain–loss utility in the match value dimension is twofold: first, it matters whether the consumer buys or doesn't buy the product and, second, it matters how much the consumer likes the product should she buy.

For all  $r \in [a, b]$ , the consumer's total utility from not buying ( $q = 0$ ) equals

$$\begin{aligned}
 U[(0, 0)|(G^r, G^p)] &= 0 + \eta \int_0^b (\tilde{p} - 0) dG^p(\tilde{p}) - \eta\lambda \cdot \int_0^b (\tilde{r} - 0) dG^r(\tilde{r}) \\
 &= \underbrace{\eta(p - 0)(1 - F(\hat{r}(p, s)|s))}_{\text{gain in price rel. to } p} - \underbrace{\eta\lambda \cdot \int_{\hat{r}(p, s)}^b \tilde{r} dF(\tilde{r}|s)}_{\text{loss in match value rel. to values above } \hat{r}(p, s)}. \quad (9)
 \end{aligned}$$

The consumer's intrinsic utility is zero and she experiences a gain in the price dimension if  $p$  is larger than zero (first term in the second line). She also experiences a loss in the match value dimension from not buying (second term in the second line).

Now, we can evaluate the utility functions in (8) and (9) at  $r = \hat{r}$  and calculate the utility difference  $\Delta U = U[(r, p)|(G^r, G^p)] - U[(0, 0)|(G^r, G^p)]$ . After repeatedly simplifying, this leads to

$$\Delta U = (\eta + 1) \underbrace{(\hat{r} - p)}_{\text{net intrinsic u.}} + \underbrace{\eta(\lambda - 1)(1 - F(\hat{r}|s))\hat{r}}_{\text{net gain in match value}} - \underbrace{\eta(\lambda - 1)F(\hat{r}|s)p}_{\text{net loss in price}}. \quad (10)$$

This shows that loss aversion in the match value dimension has a purchase-enhancing effect which arises because not buying and receiving zero match value becomes less attractive when the consumer had been expecting to buy with a positive probability. The reverse holds true for loss aversion in the price dimension. Note that, for  $\lambda \rightarrow 1$  or  $\eta \rightarrow 0$ ,  $\Delta U = 0$  leads to  $\hat{r} = p$  which is the cutoff with standard consumers. From a technical perspective, it is worth noting that, although a consumer's total utility includes a reference comparison based on the post-advertising probability density function  $f(r|s)$ , the utility difference only depends on the post-advertising cumulated distribution function of match value  $F(r|s)$ . This strongly reduces the complexity of the underlying fixed point problem and allows for the application of a wide range of distribution functions.

In the next lemma, an implicit expression for the cutoff match value  $\hat{r}(p, s)$  is determined for all  $p \geq 0$ ,  $s \in S$ , and for any feasible signal set  $S$  (excluding the signal set for full information disclosure,  $S_F$ ) of an information transmission mechanism based on hard information.

**Lemma 2.** *For all  $s \in S$ , and for all feasible  $S \neq S_F$ , let  $F(r|s)$  be a consumer's distribution over match value after receiving a signal  $s$ , with domain  $[a, b]$  and support  $X(s) \subseteq [a, b]$ . Define  $\underline{x}(s) \equiv \inf X(s)$ ,  $\bar{x}(s) \equiv \sup X(s)$  and*

$$p_1(s) \equiv \frac{(\eta\lambda + 1)}{(\eta + 1)} \cdot \underline{x}(s), \quad p_2(s) \equiv \frac{(\eta + 1)}{(\eta\lambda + 1)} \cdot \bar{x}(s).$$

*Then, for given price  $p \geq 0$ , the cutoff match value  $\hat{r}(p, s)$  at which the consumer is in-*



different between buying and not buying after receiving a signal  $s$  is given by  $\underline{x}(s)$  if  $p < \min\{p_1(s), p_2(s)\}$  (**always buy**), by  $\bar{x}(s)$  if  $p > \max\{p_1(s), p_2(s)\}$  (**never buy**), and is implicitly defined by

$$p = \frac{(\eta + 1) + \eta(\lambda - 1)(1 - F(\hat{r}|s))}{(\eta + 1) + \eta(\lambda - 1)F(\hat{r}|s)} \cdot \hat{r}, \quad (11)$$

if  $p \in [\min\{p_1(s), p_2(s)\}, \max\{p_1(s), p_2(s)\}]$  (**interior solution**).

The characterization of  $\hat{r}(p, s)$  derived in this lemma can be applied to determine the probability of buying conditional on receiving signal  $s$ . For example, in the case of always buying (resp. never buying),  $1 - F(\hat{r}(p, s)|s) = 1$ , (resp.  $= 0$ ). Furthermore,  $\hat{r}(p, s)$  constitutes a consumer's PE.  $\hat{r}(p, s)$  constitutes a consumer's PPE if the interior solution of (11) is unique. If multiple interior cutoffs arise (which is possible off-the-equilibrium-path), we choose the lowest value which will be the most conservative value for the proof of the optimality of partial information disclosure in Lemma 4.

### 2.2.3 No Match Value Information

Suppose next that the monopolist does not disclose match value information ex ante (N). Initially, therefore, only price  $p$  is observed. In order to determine the monopolist's demand, we next derive the consumer's cutoff match value,  $\hat{r}_N(p)$ , at which the corresponding consumer will be indifferent between buying and not buying ex post for given price  $p$ .

Given that for all consumers the posterior cumulative distribution function is equal to the prior one, we find that the valuation of the indifferent consumer  $\hat{r}_N(p)$  is characterized by (11) in Lemma 2 with  $F(r|s) = F(r)$ . We next make the following assumptions on  $[a, b]$  and on  $\lambda$  and  $\eta$ .

#### Assumption 2.

- 1.)  $(\eta\lambda + 1)^2 / (\eta + 1)^2 \cdot a < b$ .
- 2.)  $\lambda \leq \lambda^c(\eta) \equiv \frac{1}{\eta} \left( (\eta + 1) \frac{1 + \sqrt{1 + 4b^2 f^2(b)}}{2bf(b)} - 1 \right)$  with  $\lambda^c(\eta) > 1, \forall \eta > 0$ .

By assuming that the distance between  $a$  and  $b$  is sufficiently large, we ensure that  $\hat{r}_N(p)$  is interior at least for some non-empty price range. By imposing an upper bound on degree of loss aversion  $\lambda$  for all  $\eta > 0$ , we assure that, for interior values of  $\hat{r}_N(p)$ , the demand implied by  $\hat{r}_N(p)$  satisfies the law of demand. Furthermore, the second part of the assumption together with convexity of  $F$  is a sufficient condition for equilibrium existence in our model as shown in Proposition 1 and 2. Intuitively, it is required that, for a given distribution function  $F(r)$  with support on  $[a, b]$ , the degree of loss aversion is sufficiently low such that  $\hat{r}_N(p)$  does not become too convex and, therefore,  $1 - F(\hat{r}_N(p))$  does not become too convex.

The next lemma shows that under our assumptions such a cutoff  $\hat{r}_N(p)$  indeed exists and that it is unique.

**Lemma 3.** *Suppose consumers initially observe prices but no match value information. Then, for all  $p \geq 0$ , there exists a unique cutoff  $\hat{r}_N(p)$  characterized by (11) with  $F(r|s) = F(r)$  which satisfies  $\hat{r}'_N(p) > 0$  for  $p \in [p_{1,N}, p_{2,N}]$ , where  $p_{1,N} = (\eta\lambda + 1)/(\eta + 1) \cdot a$  and  $p_{2,N} = (\eta + 1)/(\eta\lambda + 1) \cdot b$  if and only if*

$$\lambda \leq \lambda^c(\eta) \quad \text{defined by Assumption 2.2 with } \lambda^c(\eta) > 1, \forall \eta > 0. \quad (12)$$

For  $p < p_{1,N}$ ,  $\hat{r}_N(p) \equiv a$ , while, for  $p > p_{2,N}$ ,  $\hat{r}_N(p) \equiv b$ .

Note that by implying strict monotonicity of  $\hat{r}_N(p)$  in  $p$ , the law of demand ensures the existence of the inverse cutoff function  $\hat{r}_N^{-1}(p) = p_N(\hat{r})$  with domain  $[a, b]$  and codomain  $[p_{1,N}, p_{2,N}]$ . Furthermore,  $\hat{r}_N(p)$  constitutes a consumer's PPE after receiving no match value information.

**Example 1 (cont'd)** (Uniform distribution). *Consider  $[a, b] = [0, 1]$ ,  $F$  being the uniform cdf, and  $\eta = 1$ . Then,  $F(\hat{r}_N) = \hat{r}_N$  and (11) can be transformed to a quadratic equation in  $\hat{r}_N$ . Solving for  $\hat{r}_N$  yields the cutoff match value function*

$$\hat{r}_N(p) = \frac{(\lambda + 1)}{2(\lambda - 1)} - \frac{p}{2} - \sqrt{\frac{p^2}{4} - \frac{(\lambda + 5)p}{2(\lambda - 1)} + \frac{(\lambda + 1)^2}{4(\lambda - 1)^2}}$$

subject to  $\lambda > 1$  and  $p$  being sufficiently small such that  $\hat{r}_N \in [0, 1]$ . The second solution to the quadratic equation can be ruled out since it does not satisfy the law of demand. The square root is defined for  $p \leq \tilde{p}(\lambda)$  with  $\tilde{p}(\lambda) = (\lambda + 5 - 2\sqrt{2}\sqrt{\lambda + 3})/(\lambda - 1)$ . Hence,  $p_N(b) \leq \tilde{p}(\lambda)$  determines the upper bound on  $\lambda$ ,  $\lambda^c(\eta = 1) \equiv \sqrt{5} \approx 2.24$ . Analogously,  $\lambda^c(\eta = 1)$  can be derived from (12).

Figure 2 in Section 3.2 illustrates that the demand in the case of no match value disclosure,  $D(p) = 1 - F(\hat{r}_N(p))$ , (dotted line) is more concave than that of full match value disclosure,  $D(p) = 1 - F(p)$ , (dashed line).<sup>21</sup> Moreover, for  $p < \text{Median}(r)$  demand with ex-ante uninformed consumers is higher than demand with fully informed consumers (standard demand). This means that a low price attracts more initially uninformed consumers than fully informed consumers (or consumers with standard preferences). This is due to the fact that a low price increases the initial probability of buying the good which leads to an overall net loss when the product is not bought ex post. Thus, low prices can be used to attach uninformed consumers to some extent: the marginal consumer accepts prices which are above her intrinsic valuation  $\hat{r}_N$ —i.e.  $\hat{r}_N < p_N(\hat{r}_N)$  which follows from (11) for  $\hat{r}_N \in [a, \text{Median}(r)]$ .

<sup>21</sup>As in Johnson and Myatt (2006), p.762, 766, informative advertising leads to a counter-clockwise rotation of the demand function.

**Remark 1.** *Advertising a relatively low price to consumers who are initially uninformed about match value induces the marginal consumer to accept prices above her intrinsic valuation.*

### 3 Optimal Advertising and Prices

#### 3.1 Unconstrained Information Disclosure

In this subsection, we derive the optimal mode of advertising when the monopolist can choose any information transmission mechanism providing hard information, satisfying Assumption 1. We indicate that the monopolist can indeed attach consumers more by informative advertising than by solely setting a low price. We show that the optimal mode of advertising for the monopolist is to inform consumers whether or not their match value lies above a certain threshold.<sup>22</sup> This holds true because consumers, together with a positive signal, do not receive any further information about their match value—as, for example, whether their valuation is of low or high type in the interval above the threshold—which could reduce their attachment. The next lemma derives the optimality of threshold advertising.

**Lemma 4.** *Suppose consumers observe price  $p$ . Then, for all  $p \in [0, b]$ , the monopolist cannot do better than informing consumers whether or not their individual match value lies above some critical threshold  $t \in [a, \underline{r}(p)]$  if  $\underline{r}(p) > a$  and  $t = a$  otherwise, where  $\underline{r}(p) \equiv (\eta + 1)/(\eta\lambda + 1) \cdot p$ .*

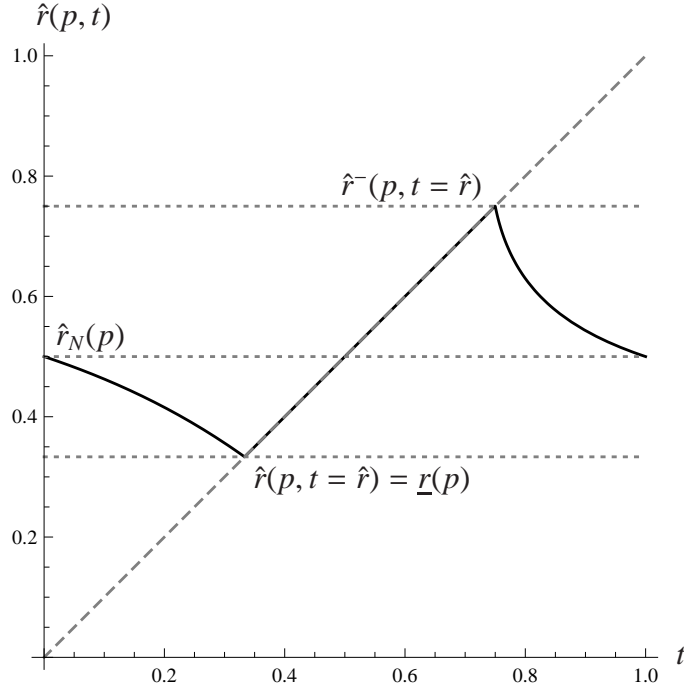
For given price  $p$ , the optimal threshold level can be derived by minimizing the cutoff match value  $\hat{r}(p, t)$  over the threshold level  $t \in [a, \underline{r}(p)]$ . Consider Figure 1 as an illustration. Note that  $t = a$  is equal to the case of no match value disclosure. The next lemma characterizes the optimal threshold level the monopolist can choose for a given price.

**Lemma 5.** *For all  $p \in [0, b]$ , the monopolist optimally sets a threshold level of  $t^* = \underline{r}(p) = (\eta + 1)/(\eta\lambda + 1) \cdot p$  if  $\underline{r}(p) > a$  and  $t^* = a$  otherwise; with the optimal threshold level also being the cutoff match value, i.e.  $\hat{r}(p, t = \hat{r}) = \underline{r}(p)$ .*

For simplicity reasons, we refer to  $\hat{r}(p, t = \hat{r})$  as  $\hat{r}(p, t^*)$  in the following.  $\hat{r}(p, t^*)$  constitutes a consumer's PPE after receiving a positive, optimal threshold signal. By Lemma 1,  $\hat{r}(p, t^*) = \underline{r}(p)$  implies that the marginal consumer becomes fully attached by optimal threshold advertising. Note that, although the optimal threshold lies below the price, loss-averse consumers who receive a positive threshold signal will buy the product ex post. This is because they would perceive a large loss in the match value dimension if they didn't buy ex post. Even buying the product at the lowest valuation above the threshold  $\underline{r}(p)$  leads only to some loss in

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<sup>22</sup>We discuss the foundation of threshold match advertising in more detail in Section 4.1.



Cutoff match value between buying and not buying  $\hat{r}(p, t)$  as function of the threshold  $t$  for given price  $p = 0.5$  and for  $\lambda = 2$  and  $\eta = 1$ ; match values are uniformly distributed on  $[a, b] = [0, 1]$ .

Figure 1: Cutoff Match Value for Threshold  $t$

match value with respect to valuations above  $\underline{r}(p)$  but also to a gain in match value with respect to not buying. Overall, this leads to a net gain in the match value dimension from buying, relative to not buying, which can be observed from the indifferent consumer's net utility after receiving a positive, optimal threshold signal,

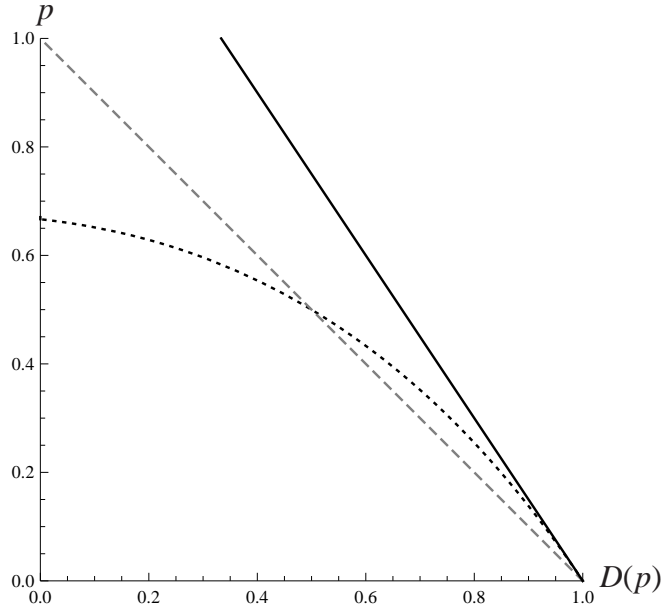
$$\Delta U = \underbrace{(\eta + 1)(\hat{r} - p)}_{\text{net intrinsic u.}} + \underbrace{\eta(\lambda - 1)\hat{r}}_{\text{net gain in match value}} - \underbrace{0 \cdot p}_{\text{net loss in price}}. \quad (13)$$

This equation also illustrates that consumers who receive a positive, optimal threshold signal do not experience a loss in the price dimension because they already expected to be paying the purchase price with probability one.

Having analyzed optimal advertising for a given price, we now turn toward firm's joint advertising and price setting decision. The next proposition characterizes the subgame perfect Nash equilibrium under unconstrained advertising which we denote by T.

**Proposition 1.** *Suppose match value advertising is unconstrained. Then, the monopolist prefers advertising optimal threshold match information with  $t^* = (\eta + 1)/(\eta\lambda + 1) \cdot p_T^*$  over any other mode of advertising. The equilibrium price is given by,*

$$p_T^* = \frac{(\eta\lambda + 1)}{\eta + 1} \cdot p_F^*, \quad (14)$$



Inverse demand functions for  $\lambda = 2$  and  $\eta = 1$ , solid: *optimal threshold advertising*, dotted: *no match value advertising* and dashed: *full match value advertising*; match values are uniformly distributed on  $[a, b] = [0, 1]$ .

Figure 2: Inverse Demand Functions

where  $p_F^*$  is the equilibrium price under full match advertising (or when consumers show standard preferences), see (6). Equilibrium always exists.

Note that the equilibrium price exceeds the one in the case of full match advertising (or when consumers show standard preferences) by factor  $(\eta\lambda + 1)/(\eta + 1)$ .<sup>23</sup>

Johnson and Myatt (2006) indicate that demand curve shifts can be attributed to the persuasive effect of advertising, while demand curve rotations (around the median) can be attributed to the informative effect. Figure 2 illustrates that, with loss-averse consumers, the inverse demand curve under optimal threshold advertising (solid line) can be attained by a combination of a clockwise rotation around  $(D = 0.5, p = 0.5)$  and an outward shift of the inverse demand curve under no match value advertising (dotted line). In contrast, the inverse demand curve under full match value advertising (dashed line) is attained by a clockwise rotation of the latter around  $(D = 0.5, p = 0.5)$  only. This illustrates that, with loss-averse consumers, purely informative advertising has a persuasive effect which is inversely U-shaped in the information content of advertising.

### 3.2 Constrained Information Disclosure

In this subsection, we consider the case in which match value must be either fully revealed via advertising or is not revealed at all. This refers to markets of products which show only

<sup>23</sup>Numerical results for prices, demand, and profit are presented in Table 1.

a small number of attributes such that threshold advertising is not feasible. We combine our benchmark results from Section 2.2, where it was shown that uninformed, loss-averse consumers are more easily attracted by lower prices than fully informed or standard consumers, as is illustrated in Figure 2 for  $p < 0.5$ .

The next proposition describes the subgame perfect Nash equilibrium when advertising is constrained to full or no match information.

**Proposition 2.** *Suppose that only full or no match information can be released. Then, the monopolist refers to disclose no match value information in equilibrium. The equilibrium price  $p_N^*$  is characterized by*

$$p_N = \frac{1 - F(\hat{r}_N(p_N))}{f(\hat{r}_N(p_N))\hat{r}'_N(p_N)}, \quad (15)$$

where  $\hat{r}_N(\cdot)$  is implicitly determined by (11) with  $F(r|s) = F(r)$ . Equilibrium always exists.

This proposition shows that full information disclosure is never implemented even for products with a small number of product attributes. In the next section, we present equilibrium prices, demand, and profit for full, optimal threshold, and no information disclosure in a numerical example, see Table 1. We also derive consumer surplus and welfare and discuss policy implications.

### 3.3 Consumer Surplus and Welfare

In this subsection, we show that full information disclosure leads to the highest level of consumer surplus and welfare. Optimal threshold information disclosure leads to the second highest level of consumer surplus and welfare, while no match value disclosure yields the lowest level of both.

Consumer surplus is determined by the aggregate indirect utility of consumers given information disclosure mode  $i$  and equilibrium price  $p_i^*$ ,

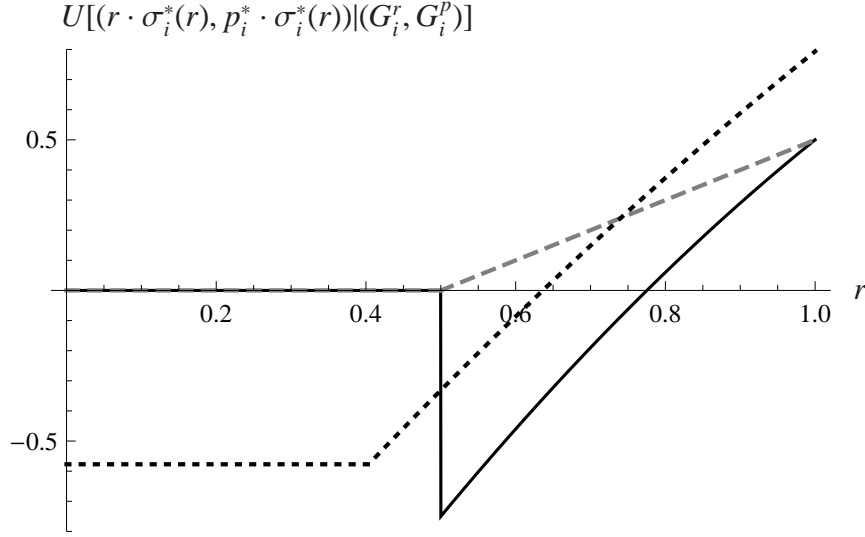
$$CS_i(p_i^*) = \int_a^{\hat{r}_i(p_i^*)} U[(0, 0)|(G_i^r, G_i^p)]dF(r) + \int_{\hat{r}_i(p_i^*)}^b U[(r, p_i^*)|(G_i^r, G_i^p)]dF(r), \quad (16)$$

with  $i = \{\mathbf{F}, \mathbf{N}, \mathbf{T}\}$  and (F) for full match information disclosure, (N) for no match information disclosure and (T) for optimal threshold information disclosure.<sup>24</sup>

Under **full match advertising** ( $i = \mathbf{F}$ ), a consumer's indirect utility is equal to her intrinsic

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<sup>24</sup>In the expression in (16), we make use of the fact that, for any  $i = \{\mathbf{F}, \mathbf{N}, \mathbf{T}\}$ , there only exists a unique cutoff match value  $\hat{r}_i(p_i^*)$ , respectively.



Consumer's indirect utility in equilibrium in the three subgames ( $i = \{F, T, N\}$ ) as function of her realized match value  $r$  for given equilibrium prices  $p_i^*$  and for  $\lambda = 2$ ; solid: *optimal threshold advertising*, dotted: *no match value advertising* and dashed: *full match value advertising*; match values are uniformly distributed on  $[a, b] = [0, 1]$ .

Figure 3: Indirect Utility under Full, Optimal Threshold, and No Match Information

utility, which is zero below the cutoff of buying and positive thereafter.

$$CS_F(p_F^*) = \int_{p_F^*}^b (r - p_F^*) dF(r) \quad (17)$$

Under **optimal threshold match advertising** ( $i = T$ ), the indirect utility of consumers who received a negative signal is also zero, while the indirect utility of consumers who received a positive signal can be negative or positive depending on the realization of their match value  $r$ .

$$CS_T(p_T^*) = \int_{\hat{r}(p_T^*)}^b \left[ (r - p_T^*) - \lambda \cdot \int_r^b \frac{(\tilde{r} - r)}{1 - F(\hat{r})} dF(\tilde{r}) + \int_{\hat{r}}^r \frac{(r - \tilde{r})}{1 - F(\hat{r})} dF(\tilde{r}) \right] dF(r) \quad (18)$$

Both components of indirect utility, the intrinsic and the gain–loss one can be negative or positive; the former since  $\hat{r}(p_T^*) < p_T^*$ , and the latter due to a net loss in match value for  $r$  close to  $\hat{r}(p_T^*)$ .

Under **no match advertising** ( $i = N$ ), consumers additionally experience gain–loss utility when not buying ( $r < \hat{r}(p_N^*)$ ) which is negative since  $p_N^*(1 - F(\hat{r})) < \int_{\hat{r}}^b \tilde{r} dF(\tilde{r})$ , see first term in (19). Consumers also experience negative or positive intrinsic and gain–loss utility when they buy the product.

$$CS_N(p_N^*) = F(\hat{r}) \left[ p_N^*(1 - F(\hat{r})) - \lambda \int_{\hat{r}}^b \tilde{r} dF(\tilde{r}) \right] + \int_{\hat{r}(p_N^*)}^b \left[ (r - p_N^*) - \lambda p_N^* F(\hat{r}) - \lambda \cdot \int_r^b (\tilde{r} - r) dF(\tilde{r}) + \int_{\hat{r}}^r (r - \tilde{r}) dF(\tilde{r}) + rF(\hat{r}) \right] dF(r) \quad (19)$$

Figure 3 illustrates consumer's indirect utility in the three subgames. It is shown that, except for consumers with match value close to  $b$ , consumers under no or optimal threshold match advertising are weakly worse off than under full match advertising.

On the aggregate level, consumer surplus is also highest under full match advertising as is highlighted in the next proposition.

**Proposition 3.** *Consumer surplus is highest under full information disclosure.*

Table 1: Consumer Surplus and Welfare

	$p_i^*$	$D_i$	$CS_i$	$\Pi_i$	$W_i$
$i = F$	0.5	0.5	0.125	0.25	0.375
$i = T$	0.75	0.5	-0.042	0.3125	0.354
$i = N$	0.436	0.596	-0.151	0.260	0.109

For  $\lambda = 2$ ,  $\eta = 1$  and match values are uniformly distributed on  $[a, b] = [0, 1]$ .

In order to compare consumer surplus and welfare across the different subgames, we next make the assumption that match value is uniformly distributed on  $[0, 1]$ . We find that consumer surplus is higher under optimal threshold advertising than under no match advertising. We also find the same ordering for welfare, with the welfare level under full match advertising being the highest (cf. Table 1).<sup>25</sup>

Table 1 shows that consumers' expected indirect utility under optimal threshold advertising or no match value advertising can be negative. Note, however, that in this case, never buying is not a PE since after receiving a positive optimal threshold signal or a low price quote, never buying is not credible, i.e. the unique cutoff match value is interior. Therefore, buying for all match value levels above the cutoff match value  $\hat{r}_T$  (resp.  $\hat{r}_N$ ) constitutes the PPE. In our setup, only not receiving an advertisement and not learning about the product's existence at all would lead to zero utility.

Overall, the implications for consumer policy and welfare are aligned: transparency policies which require the disclosure of full information in advertising are favorable.

## 4 Discussion

### 4.1 Foundation of Threshold Match Advertising

Threshold match advertising requires that the monopolist discloses a sufficient level of product features to inform intermediate- and high-valuation consumers that their match value lies above the threshold, but without revealing any further information. Anderson and Renault

<sup>25</sup>Note that, although this result holds more generally, the comparison of consumer surplus and welfare levels requires functional form assumptions with respect to  $F(r)$ .



(2006) show that disclosing certain product attributes is equivalent to specifying a subset of products to which the advertised product belongs. For instance, revealing a high horsepower rating could be a threshold strategy for a monopolist selling a sports car if the set of potential new products contains sports cars, SUVs and subcompact cars. A high horsepower rating would then signal that the advertised product must be a sports car or a SUV without disclosing the exact product category. Consumer who have a high (resp. medium) valuation for sports cars and a medium (resp. high) valuation for SUVs would infer from the announcement that their match value is at least at a medium level, while the consumers who only prefer subcompact cars would expect a low valuation.

The two main requirements for threshold match advertising are *technological feasibility* and *message credibility*. Technological feasibility means that the number of potential products (i.e. product characteristics) must be sufficiently large relative to the number of consumer types. Yet potential products do not have to contain any attribute, and consumer types do not necessarily value any attribute. Message credibility requires that any disclosure strategy must be an equilibrium strategy for all potential product types, i.e. all product types must play a pooling strategy in a Perfect Bayesian Equilibrium. Given that these requirements are met, threshold information with respect to the same threshold can be transmitted to any consumer with a unique message. In this paper, we refer to products which satisfy this condition as sufficiently complex products. Since, in our model, loss-averse consumers have a fixed, intrinsic product valuation about which they become informed by advertising and inspection, we can apply the concept of threshold match advertising without further adjustments.

A second interpretation of threshold match advertising is compatible with our main result: if consumers below the threshold learn their full match valuation of the good instead of receiving only a negative threshold signal,  $\hat{r}(p, t)$  remains unchanged up to  $t = p$ . This holds true since consumers below the threshold never buy in this region (cf. Figure 1, where  $p = \hat{r}_N(p)$ ). Only for  $t > p$ ,  $\hat{r}(p, t)$  is altered and equal to  $p$  since any consumer with valuation above  $p$  buys ex post after receiving either a positive threshold signal or her full match valuation. Since  $\hat{r}(p, t) = p$  is dominated by  $\hat{r}(p, t) = \underline{r}(p) < p$ , the optimal threshold level remains  $t^* = \underline{r}(p)$ . This second interpretation of threshold match advertising is related to products for which intermediate- and high-type consumers value more product attributes than lower types. Therefore, revealing an intermediate amount of attributes can inform low types perfectly, while intermediate and high types still experience a residual uncertainty conditional on their valuation being above the threshold (for example, sports cars with fancy extra equipment). In this case,  $t = b$  reflects full information disclosure and  $t$  can be interpreted as being monotonically increasing in the amount of revealed product attributes.

## 4.2 More General Marketing Practices

In this subsection, we indicate that, by slightly modifying the assumptions of our baseline model, we can explain more general marketing practices which are commonly observed. First, if firms are able to alter the initial value or price of a product ex post, attached consumers whose attachment is not fully skimmed off by the initial price quote—as, for example, fully informed consumers with high valuations—can be fully exploited. For instance, salespeople who only have a short-term perspective frequently offer product **add-ons** ex post—as, for example, extra insurances for cars. They may also guide consumers towards a more expensive product version, or ask for a higher price than initially anticipated by consumers. Second, using data on the consumers' purchase histories, firms have the ability to distinguish amongst consumers. In this case, optimal threshold advertising can be implemented by **targeting** only those consumers above the threshold; see, for example, the targeted advertising newsletters of Amazon. Third, **money-back guarantees** are frequently offered in addition to informative advertising. In this case, our results also extend to experience goods—i.e. to products whose match value cannot be fully accessed by consumers at the moment of purchase. Together with optimal threshold advertising, we predict that there is no product return.

## 4.3 Time-Inconsistent Behavior and Unawareness of Loss-Averse Preferences

In this subsection, we discuss the time consistency of consumer behavior in the baseline model and the case when consumers are unaware of loss-averse preferences.

Although we assume that loss-averse consumers form rational expectations, in our setup, loss-averse consumers behave time inconsistently in the sense that they potentially buy products whose price exceeds their initial valuation. For example, compare the classical models of hyperbolic discounting by Loewenstein and Prelec, 1992, Laibson, 1997, and O'Donoghue and Rabin, 1999. In our setup, the only way how a consumer can overcome this time-inconsistent behavior if there are no transparency policies, is to not receive an advertisement and to not learn about the product's existence at all.

If we allow for loss-averse consumers who are unaware of their loss-averse preferences, we make the following prediction: consumers do not incorporate the gain-loss comparison when making their purchase plan (this is, they do not play a PE strategy). Yet, if a consumer's post-advertising probability of buying is sufficiently high, she will feel attached to buying the good ex post due to unexpected losses in the match value dimension from not buying.

## 4.4 Related Literature

In this subsection we compare our results to those of the classical advertising literature and the literature on consumer loss aversion.

**Loss aversion:** the model closest to ours is that of Heidhues and Kőszegi (forthcoming) who examine a monopolist's optimal pricing strategy when expectation-based, loss-averse consumers decide upon buying one unit of a product with known, common valuation as, for example, groceries. The authors show that the monopolist committing to a price distribution *ex ante* can create consumer attachment by infrequently offering variable sales prices for which not buying the good is not a credible equilibrium strategy for consumers. By doing so, the consumers' reference point is shifted in favor of buying the good such that buying at the regular price also becomes more attractive. This can be exploited by the monopolist by setting a regular price above the consumer's intrinsic valuation. In our setup, prices are uniform but, by keeping some residual uncertainty about consumers' product valuation above the threshold, the monopolist can increase consumer attachment. In contrast to Heidhues and Kőszegi (forthcoming), we receive full attachment of the marginal consumer and can quantify the resulting markup above the optimal price with standard consumers as a function of the degree of loss aversion.

In a different application, Rosato (2012) shows that a retailer selling two substitute goods can attach expectation-based, loss-averse consumers by a tempting discount on a good available only on limited supply. The retailer then cashes in with a high price on the substitute good available on full supply. In contrast to our paper, the disclosure of product information does not play a role in attaching consumers to the product.

The concept of expectation-based reference points utilized in this paper was introduced by Kőszegi and Rabin (2006, 2007).<sup>26</sup> Heidhues and Kőszegi (2008) and Karle and Peitz (2012) apply this concept to model consumer behavior in oligopolistic product markets. Heidhues and Kőszegi (2008) predict less price variation across products (focal prices) and over time (sticky prices) when consumers are expectation-based loss averse. Conversely, in a related setup in which consumers incorporate information about price levels into their reference points, Karle and Peitz (2012) find a price variation-increasing, pro-competitive effect of consumer loss aversion. Zhou (2011) and Spiegler (2011b) consider consumers with history-based and sampling-based reference points in an oligopolistic and a monopolistic setting, and partly confirm the results of the two former papers. In a setup with monopolistic screening, Carbajal and Ely (2011), Hahn, Kim, Kim, and Lee (2012) and Herweg and Mierendorff (forthcoming) analyze the implications of expectation-based loss aversion for the design of profit-maximizing menus and tariffs.<sup>27</sup>

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<sup>26</sup>Kőszegi and Rabin (2009) extend their previous model to intertemporal decisions.

<sup>27</sup>Other applications of the expectation-based loss aversion concept of Kőszegi and Rabin (2006, 2007) include Macera (2009) and Herweg, Mueller, and Weinschenk (2010) on agency contracts, Lange and Ratan (2010) and

Related to our work, Malmendier and Szeidl (2008) provide evidence from laboratory and field experiments that, in online auctions such as those on eBay, certain bidders tend to overbid. As one potential explanation, the authors mention loss aversion with respect to not receiving the good.<sup>28</sup> More broadly, our paper contributes to the analysis of behavioral biases in market settings, as in DellaVigna and Malmendier (2004), Eliaz and Spiegler (2006), Gabaix and Laibson (2006), and Grubb (2009).<sup>29</sup>

**Classical advertising:** a large part of the economic literature on advertising focuses on the role of advertising in shifting the (inverse) demand curve outward; for example, directly persuasive advertising, advertising as a signaling device for product quality, or advertising as a means to inform consumers about product existence (see Bagwell, 2007). In this paper, we draw attention to the informative content of advertising which reveals horizontal product information to consumers who are already aware of the product's existence. As indicated by Johnson and Myatt (2006), this form of advertising rotates the inverse demand curve with standard consumers clockwise instead of shifting it. Johnson and Myatt (2006) in line with Lewis and Sappington (1994) find that a monopolist undertaking informative advertising prefers one of two extremes: either no information disclosure if consumers' taste heterogeneity and marginal costs are small (as in the case of mass products), or perfect information disclosure if consumers' taste heterogeneity and marginal costs are sufficiently large (as in the case of niche products). In contrast to their result, in this paper we argue that, with loss-averse consumers, the optimal level of information disclosure is always partial. This resembles a simultaneous outward shift and clockwise rotation of the inverse demand curve up to the optimal level of information content and a move backward thereafter. In our model, if the degree of loss aversion becomes negligible, the demand function will be independent of the information content of advertising since we consider inspection goods. In this case, the monopolist will be indifferent between full, partial and no information disclosure.

The advertising paper closest to ours is that of Anderson and Renault (2006). In an advertising model with standard consumers, they also find that partial information disclosure can be optimal if consumers are discouraged from learning their intrinsic product valuation for an inspection good, for instance through high search or transportation costs. In contrast to their result, we find that disclosing partial information about products is optimal even if search costs do not affect consumers' purchase decisions. The reason for this result is that our model incorporates the additional, persuasive effect of information disclosure when consumers are expectation-based loss averse. Our policy implications also differ from Anderson and Renault: while, in our model, transparency policies reduce prices and increase consumer surplus,

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Eisenhuth and Ewers (2012) on sealed-bid auctions, and Daido and Murooka (2012) on team incentives.

<sup>28</sup>See also Heyman, Orhun, and Ariely (2004) and Ariely (2009, Ch.8). Other explanations for overbidding reported in this literature are bidding fever and joy of playing.

<sup>29</sup>For overviews, see Ellison (2006), DellaVigna (2009), and Spiegler (2011a).

in their model, they reduce sales volume and hurt firms and consumers.

There is a large body of theoretical and empirical literature following Nelson (1974) on advertising as a signaling device. In this literature, firms may provide information about their product attributes indirectly through their advertising expenditures rather than directly through advertising content, as in our paper.<sup>30</sup> Other papers consider advertising when the consumer experiences a positive consumption externality from buying the same good (social goods).<sup>31</sup> Following Chwe (2001), this literature highlights the idea that a firm's advertising expenditures can serve as a coordination device for consumers who benefit from consuming a social good. In contrast to our paper, this literature focuses exclusively on the signaling interpretation of advertising instead of on its information content.

Following the seminal paper of Resnik and Stern (1977), the marketing literature has provided a large number of studies which analyze the informative content of advertising in all media channels, across countries and product categories, and over time. In a meta-analysis, Abernethy and Franke (1996) find that 84% of 91,438 advertisements show at least one cue, 58% show at least two cues, while 33% show at least three. The product categories with the highest information content are cars, furniture and electronics (with an average above 2.7 cues). This is in line with our theoretical prediction that the informative content of advertising for expensive durable goods should be high yet partial to create consumer attachment.

## 5 Conclusion

This paper has examined informative advertising when consumers are loss averse and form expectation-based reference points about their purchase expenditure and product valuation after receiving an advertisement. For this purpose, we embedded rational consumers with loss-averse preferences, à la Kőszegi and Rabin (2006), into an advertising model based on Anderson and Renault (2006). In a monopolistic setup, we analyze the optimal advertising content for inspection goods.

We find that optimal informative advertising neglects certain product attributes which are less favorable, at least for some medium- and high-valuation consumers. Those attributes are left to be discovered by potential buyers later during the purchase process, after they have made the plan to buy the good. In contrast to Anderson and Renault (2006), we predict that optimal informative advertising increases the consumers' willingness to pay—i.e. has a persuasive effect. We also show that no information disclosure, together with a low price, increases consumers' willingness to pay to some extent, while full information disclosure does not have such an effect. Consumer surplus and welfare are greatest under full information disclosure,

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<sup>30</sup>For example, see Kraehmer (2006), Anand and Shachar (2009), Bar-Isaac, Caruana, and Cunat (2010), Mayzlin and Shin (2011) and Sun (2011).

<sup>31</sup>See among others Chwe (2001), Pastine and Pastine (2002), Clark and Horstmann (2005), Sahuguet (2011).

followed by partial information disclosure. Consequently, optimal consumer protection policies should highlight the importance of transparency policies, if applicable. Otherwise partial information disclosure is preferable to no information disclosure.

Since our model is based on rational expectations, our analysis could not incorporate the possibility that consumers could be unaware of unfavorable product attributes, or that advertising firms might exaggerate the valuation of their product. Yet, it seems that it cannot be in a firm's best interest that loss-averse consumers hold unrealistically high expectations towards their product valuation for an inspection good, since this would cause extraordinary losses in the match value dimension when consumers inspect the product before purchase. These losses could reduce consumer attachment rather than increasing it.

Focusing on a monopolistic setup, we have not explored the impact of detrimental or comparative advertising practices which may cause negative attachment for loss-averse consumers. Yet, as an agenda for future research, it may be fruitful to shed light on optimal advertising content under firm competition when consumers are loss averse.

## Appendix

### A Relegated Proofs

#### A.1 Relegated proof of Section 2

*Proof of Lemma 1.* Suppose, for given price  $p \geq 0$ , a consumer located at  $r$  expects to buy with probability  $\sigma'$ ,  $\sigma' \in [0, 1]$ . Then, her utility of buying ex post equals

$$U[(r, p)|(\sigma', \sigma')] = r - p - \underbrace{\eta\lambda(1 - \sigma')p}_{\text{loss in } p} + \underbrace{\eta(1 - \sigma')r}_{\text{gain in } r},$$

where the probability of the complementary event “not buying” ( $1 - \sigma'$ ) affects the size of gains and losses. Her utility of not buying ex post can be expressed as

$$U[(0, 0)|(\sigma', \sigma')] = 0 + \underbrace{\eta\sigma'p}_{\text{gain in } p} - \underbrace{\eta\lambda\sigma'r}_{\text{loss in } r}.$$

The consumer will buy the product ex post if  $\Delta U = U[(r, p)|(\sigma', \sigma')] - U[(0, 0)|(\sigma', \sigma')] \geq 0$  which is equivalent to

$$r \geq \frac{(\eta + 1) + \eta(\lambda - 1)(1 - \sigma')}{(\eta + 1) + \eta(\lambda - 1)\sigma'}p \equiv \underline{r}(p, \sigma').$$

Note that the gap between  $p$  and  $\underline{r}(p, \sigma')$  is maximized if  $\underline{r}(p, \sigma')$  is minimized. Since  $\underline{r}(p, \sigma')$  is strictly decreasing in  $\sigma'$ ,  $\sigma' = 1$  is the required minimizer.  $\square$

*Proof of Lemma 2.* Setting  $\Delta U$  in (10) equal to zero yields equation (11) which implicitly defines  $\hat{r}(p, s)$ . For  $\hat{r}(p, s) \in [\underline{x}(s), \bar{x}(s)]$ ,  $F(\hat{r}|s) \in [0, 1]$  and  $F(\hat{r}|s)$  is non-decreasing in  $\hat{r}$ .  $F(\hat{r}|s)$  is also continuous in  $\hat{r}$  by Assumption 1. Hence, there exists an interior solution for  $p \in [\min\{p_1(s), p_2(s)\}, \max\{p_1(s), p_2(s)\}]$ , where  $p_1(s)$  and  $p_2(s)$  are derived from the RHS of (11) at  $\hat{r} = \underline{x}(s)$  and  $\hat{r} = \bar{x}(s)$ . If multiple interior cutoffs arise, we choose the lowest value which will be the most conservative value for the prove of the optimality of threshold advertising in Lemma 4. For corner solutions,  $\hat{r}(p, s)$  can be defined as shown in the lemma.  $\square$

*Proof of Lemma 3.* Given the analysis provided in the main text, it is left to derive the critical degree of loss aversion  $\lambda^c$  such that the law of demand is satisfied for  $\lambda \leq \lambda^c$ . Let be the inverse function of  $\hat{r}(p)$ .  $p_N(\hat{r})$  is defined by the RHS of (11) for  $F(\hat{r}|s) = F(\hat{r})$ , with domain  $[a, b]$  and codomain  $[p_{1,N}, p_{2,N}]$ .  $p_N(\hat{r})$  is equal to

$$p_N(\hat{r}) = \frac{A(\hat{r}) \cdot \hat{r}}{B(\hat{r})}, \quad (20)$$

where  $A(\hat{r}) \equiv (\eta + 1) + \eta(\lambda - 1)(1 - F(\hat{r}))$  and  $B(\hat{r}) \equiv (\eta + 1) + \eta(\lambda - 1)F(\hat{r})$ . For reasons of brevity, we skip the index  $\hat{r}$  in the following where it is unambiguous. The first derivative of  $p_N(\hat{r})$  with respect to  $\hat{r}$  is equal to

$$p'_N(\hat{r}) = \frac{(\eta\lambda + 1)(\eta + 1) + \eta^2(\lambda - 1)^2(1 - F)F - [(\eta\lambda + 1)^2 - (\eta + 1)^2]f \cdot \hat{r}}{B^2}. \quad (21)$$

Defining  $C \equiv \eta^2(\lambda - 1)^2(1 - F)F > 0$  and  $D \equiv ((\eta\lambda + 1)^2 - (\eta + 1)^2)f\hat{r} > 0$ ,  $p'(\hat{r})$  can be expressed as

$$p'_N(\hat{r}) = \frac{(\eta\lambda + 1)(\eta + 1) + C - D}{B^2}.$$

Since, for  $\lambda \rightarrow 1$ ,  $C$  and  $D$  approach zero, we can always find  $\lambda$ 's sufficiently low but  $\lambda > 1$  such that  $p'_N(\hat{r}) > 0 \forall \hat{r} \in [a, b]$ . Denote the critical  $\lambda$  (for given  $\eta$ ) such that  $p'_N(\hat{r}) \geq 0 \forall \hat{r} \in [a, b]$  as  $\lambda^c(\eta)$ .

The second derivative of  $p_N(\hat{r})$  with respect to  $\hat{r}$  equals

$$p''_N(\hat{r}) = \frac{B[C' - D'] - 2(\eta\lambda - 1)f \cdot N}{B^3}, \quad (22)$$

where  $N \equiv (\eta\lambda + 1)(\eta + 1) + C - D$  is the numerator of  $p'_N(\hat{r})$  and

$$C' - D' = -\eta(\lambda - 1) \left( [2(\eta + 1) + 2\eta(\lambda - 1)F]f + [\eta(\lambda - 1) + 2]f'\hat{r} \right). \quad (23)$$

Since by convexity of  $F$ ,  $f' \geq 0$ , we receive that  $C' - D' < 0$ . Since  $C' - D' < 0$ ,  $B > 0$  and, for  $\lambda \in (1, \lambda^c(\eta)]$ ,  $p'_N(\hat{r}) \geq 0$ , it holds that  $p''_N(\hat{r}) < 0$  for  $\lambda \in (1, \lambda^c(\eta)]$ . Since  $p''_N(\hat{r}) < 0$  for  $\lambda \in (1, \lambda^c(\eta)]$ ,  $p'_N(\hat{r}) \geq 0 \forall \hat{r} \in [a, b]$  if  $p'_N(b) \geq 0$ —i.e. it suffices to focus on the highest value of  $\hat{r}$ ,  $\hat{r} = b$ . Thus, from  $p'_N(b) \geq 0$  we can derive  $\lambda^c$ .

$$\begin{aligned} p'_N(b) &\geq 0 \\ bf(b) \cdot \Lambda^2 - (\eta + 1) \cdot \Lambda - (\eta + 1)^2 bf(b) &< 0, \end{aligned}$$

where  $\Lambda = \eta\lambda + 1$ . The two square roots of this quadratic equation are described by

$$\Lambda_{1/2} = \frac{(\eta + 1) \pm \sqrt{(\eta + 1)^2 + 4(\eta + 1)^2 bf^2(b)}}{2bf(b)}.$$

Choosing the root which is consistent with  $\lambda > 1$  leads to

$$\lambda^c(\eta) = \frac{1}{\eta} \left( (\eta + 1) \frac{1 + \sqrt{1 + 4bf^2(b)}}{2bf(b)} - 1 \right),$$

where  $\lambda^c(\eta) > 1$ ,  $\forall \eta > 0$  since, for  $F$  being convex,  $bf(b) \geq 1$  and,  $\forall \eta > 0$ ,  $\lambda^c(\cdot, \eta)$  as a



function of  $bf(b)$  is larger than 1 at  $bf(b) = 1$ , strictly decreasing in  $bf(b)$  and, for  $bf(b) \rightarrow \infty$ ,  $\lambda^c(\cdot, \eta) \rightarrow 1$  from above.  $\square$

## A.2 Relegated proof of Section 3

*Proof of Lemma 4.* This proof uses the definition of an information transmission mechanism (henceforth ITM) as in the proof of Lemma 1 of Anderson and Renault (2006), see Definition 3 below. The main insight of our proof is twofold. First, for any ITM, we can replicate the maximum attachment level induced by one of its signals (see  $\hat{r}(p, s_{\text{inf}}) \equiv \inf_{s \in S} \{\hat{r}(p, s) | P(r \geq \hat{r}(p, s) | s) > 0\}$  below) by an ITM which relies only on a positive and a negative threshold signal with threshold level  $t$ , and second, (including also the remaining signals) the probability of buying in the latter ITM will be at least as large as that in the former ITM. The intuition for these results is that a positive threshold signal allows for posterior product valuations up to the maximum level of  $b$  for any consumer above the threshold. Giving any additional information to some consumers above the threshold reduces overall consumer attachment, in particular the attachment of consumers whose valuation is close to the threshold. Therefore the probability of buying decreases.

We define an information transmission mechanism in the following way.

**Definition 3.** *An ITM induces a probability measure over the joint space of valuations and signals sent via advertising and enables the consumer to infer something about her valuation from the interpretation of the signal received. Hence, an ITM is a probability space  $([a, b] \times S, \beta([a, b]) \times H, P)$  with  $\beta([a, b])$  denotes the  $\sigma$ -field of Borel sets in  $[a, b]$ ,  $S$  is a set of signals,  $H$  is a  $\sigma$ -field of subsets of  $S$ , and  $P$  is a probability measure over  $[a, b] \times S$  that satisfies  $P(r \leq \tilde{r}) = F(\tilde{r})$  for all  $\tilde{r} \in [a, b]$ .*

For each ITM and for a price  $p$ , the probability of buying is determined by,

$$E_{s \in S} [P(r \geq \hat{r}(p, s) | s)], \quad (24)$$

where  $\hat{r}(p, s)$  is the (lowest) cutoff between buying and not buying after receiving signal  $s \in S$  derived by Lemma 2 with  $P(r > \hat{r}(p, s) | s) = 1 - F(\hat{r}(p, s) | s)$ . Alternatively,  $\hat{r}(p, s) = p$  in the case of full information disclosure, where any consumer receives an individual signal which induces an atom in her post-advertising cumulative distribution function at her true match value level. This lemma is proved by proving the following claim.

**Claim 1.** *Consider an ITM  $([a, b] \times S, \beta([a, b]) \times H, P)$ . For any price  $p$ , there exists another ITM' with signal set  $S'$  and probability  $P'$  such that for some  $s^* \in S'$  and some  $t \in [a, \underline{r}(p)]$ ,*

1.  $P'(s = s^* | r \geq t) = 1$  and  $P'(s = s^* | r < t) = 0$ ;

2.  $E_{s' \in S'}[P'(r \geq \hat{r}(p, s')|s')] \geq E_{s \in S}[P(r \geq \hat{r}(p, s)|s)]$ , i.e. the probability of buying in ITM' is at least as large as in ITM.

*Proof.* Let  $\hat{r}_N(p)$  be the cutoff between buying and not buying if no match value information is released (see Lemma 3). Now, for any given ITM and for all signals  $s \in S$ , we define the lowest cutoff match value subject to the probability of buying after receiving signal  $s$  being positive,  $\inf_{s \in S}\{\hat{r}(p, s)|P(r \geq \hat{r}(p, s)|s) > 0\}$ , and denote it by  $\hat{r}(p, s_{\text{inf}})$ . Then, if  $\hat{r}(p, s_{\text{inf}}) \geq \hat{r}_N(p)$  (signals without information content or with attachment-reducing information content or sufficiently low price such that always buying is optimal even without further information), the claim is trivially satisfied for  $t = a$ . We now assume that  $\hat{r}(p, s_{\text{inf}}) < \hat{r}_N(p)$ . Then, by Lemma 1, it holds that  $\hat{r}(p, s_{\text{inf}}) \in [\underline{r}(p), \hat{r}_N(p)[$  and that  $\hat{r}_N(p) > a$  and  $\hat{r}(p, s_{\text{inf}}) \geq a$ .

Let  $s' \in \{s^-, s^*\}$  and define  $P'$  as follows. Let  $P'(r \leq \tilde{r}) = F(\tilde{r})$  for all  $\tilde{r} \in [a, b]$ ,  $P'(s = s^*|r) = 1$  if  $r \geq t$  and  $P'(s = s^-|r) = 1$  if  $r < t$ . Hence,  $P'(s = s^*) = 1 - F(t)$ . Now, let  $\hat{r}(p, s^*) = \hat{r}(p, s_{\text{inf}})$  and  $\hat{r}(p, s^*)$  be the cutoff between buying and not buying after receiving signal  $s^*$  which, by construction, is identical for all  $r \geq t$ . For  $t \leq \hat{r}(p, s^*)$ , the probability of buying after receiving  $s^*$ ,  $P'(r \geq \hat{r}(p, s^*)|s^*)$ , is equal to  $P'(r \geq \hat{r}(p, s^*)) \cdot P'(s' = s^*|r \geq \hat{r}(p, s^*)) / P'(s' = s^*) = (1 - F(\hat{r}(p, s^*)) / (1 - F(t)))$  (since  $P'(s = s^*|r \geq \hat{r}(p, s^*)) = 1$  for  $t \leq \hat{r}(p, s^*)$ ). Note that, for  $\hat{r}(p, s_{\text{inf}}) = \hat{r}(p, s^*)$ , by Lemma 2 it must hold that  $P(r \geq \hat{r}(p, s_{\text{inf}})|s_{\text{inf}}) = P'(r \geq \hat{r}(p, s^*)|s^*)$ . Thus, by Lemma 2 with  $P'(r \geq \hat{r}(p, s^*)|s^*) = (1 - F(\hat{r}(p, s^*)) / (1 - F(t)))$ , we can next define  $t$  implicitly by

$$p = \frac{(\eta + 1) + \eta(\lambda - 1) \frac{1-F(\hat{r})}{1-F(t)}}{(\eta + 1) + \eta(\lambda - 1) \frac{F(\hat{r})-F(t)}{1-F(t)}} \cdot \hat{r}, \quad (25)$$

where  $\hat{r} = \hat{r}(p, s^*) = \hat{r}(p, s_{\text{inf}}) \in [\underline{r}(p), \hat{r}_N(p)[$ . We denote  $\hat{r}(p, s^*)$  by  $\hat{r}(p, t)$  from now on. We receive from (25) that  $t \in ]a, \underline{r}(p)[$  with  $\hat{r}(p, t)$  being decreasing in  $t$  (see the proof of Lemma 5 for more details). This implies the uniqueness of  $t$ . For  $t > \underline{r}(p)$ ,  $t$  could be decreased to  $\underline{r}(p)$  and the prior probability of buying would be  $1 - F(\underline{r}(p))$ , which is an upper bound for given price  $p$  by Lemma 1. Thus,  $t \leq \hat{r}(p, t)$  is satisfied.

Now, first, by construction,  $([a, b] \times S', \beta([a, b]) \times H', P')$  is an ITM which satisfies (1.), where  $H'$  is comprised of all subsets of  $S'$ . Second, the probability of buying in  $([a, b] \times S', \beta([a, b]) \times H', P')$  is at least as large as in the initial ITM, since  $E_{s' \in S'}[P'(r \geq \hat{r}(p, s')|s')] = P'(s' = s^*)P'(r \geq \hat{r}(p, s^*)|s^*) = P'(r \geq \hat{r}(p, s^*)) = 1 - F(\hat{r}(p, s^*)) = 1 - F(\hat{r}(p, s_{\text{inf}})) = P(r \geq \hat{r}(p, s_{\text{inf}})) \geq E_{s \in S}[P(r \geq \hat{r}(p, s)|s)] \geq E_{s \in S}[P(r \geq \hat{r}(p, s)|s)]$ .  $\square$

This proves the lemma.  $\square$

*Proof of Lemma 5.* We have to derive the optimal threshold  $t^*$  that the monopolist can choose. By Lemma 4, it holds that, for all  $p \in [0, b]$ ,  $t^* \in [a, \underline{r}(p)]$  if  $\underline{r}(p) > a$ . If  $\underline{r}(p) \leq a$ , then it trivially holds that  $t^* = a$ . We next focus on the former case. Note that it follows from the

proof of Lemma 4, in particular by (25) that, for  $t \in [a, \underline{r}(p)]$ ,  $\hat{r}(p, t) \in [\underline{r}(p), \hat{r}_N(p)]$  with  $\underline{r}(p)$  being the lowest cutoff for a given price  $p$  by Lemma 1 which leads to the highest demand for given price  $p$  and, thus, is the most profitable for the monopolist. Furthermore, it follows from (25) that  $\hat{r}(p, t) = \hat{r}_N(p)$  for  $t = a$  and  $\hat{r}(p, t) = \underline{r}(p)$  for  $t = \hat{r}(p, t)$ .

We next show that  $\hat{r}(p, t)$  is strictly decreasing in  $t$  for  $t \in [a, \underline{r}(p)]$  which implies that  $t^* = \underline{r}(p)$  is the unique, optimal threshold in the case in which  $\underline{r}(p) > a$ . Replacing  $\hat{r}$  by  $\hat{r}(p, t)$  in (25) and applying the implicit function theorem to this expression yields

$$\frac{d\hat{r}(p, t)}{dt} = -\left(\frac{\partial p}{\partial \hat{r}}\right)^{-1} \frac{\partial p}{\partial t}, \quad (26)$$

where, for  $t = a$ ,  $\partial p / \partial \hat{r}$  is given in (21) which is strictly positive under our assumption that  $\lambda \leq \lambda^c(\eta)$ . Adjusting for  $t \geq a$  leads to

$$\frac{\partial p}{\partial \hat{r}} = \frac{(\eta\lambda + 1)(\eta + 1) + \eta^2(\lambda - 1)^2(1 - F(\hat{r}))\frac{F(\hat{r}) - F(t)}{(1 - F(t))^2} - [(\eta\lambda + 1)^2 - (\eta + 1)^2]\frac{f(\hat{r}) \cdot \hat{r}}{1 - F(t)}}{((\eta + 1) + \eta(\lambda - 1)\frac{F(\hat{r}) - F(t)}{1 - F(t)})^2},$$

which also is strictly positive for all feasible pairs of  $(\eta, \lambda)$  since the denominator of  $\partial p / \partial \hat{r}$  decreases more in  $t$  than its numerator. Second,

$$\frac{\partial p}{\partial t} = \frac{\eta^2(\lambda - 1)^2(1 - F(\hat{r}))f(\hat{r})\left((1 - F(\hat{r})) - (F(\hat{r}) - F(t))\right) \cdot \hat{r}}{((\eta + 1) + \eta(\lambda - 1)\frac{F(\hat{r}) - F(t)}{1 - F(t)})^2(1 - F(t))^3} > 0,$$

since  $(1 - F(\hat{r})) - (F(\hat{r}) - F(t)) > 0$  for  $t < \hat{r}$  which holds true by (25). Thus,  $d\hat{r}(p, t)/dt < 0$  for  $t \leq \hat{r}(p, t) = \underline{r}(p)$  which implies that  $t^* = \underline{r}(p)$  is the unique optimum in the case in which  $\underline{r}(p) > a$ .  $\square$

*Proof of Proposition 1.* The proof combines the results of Section 2 and 3 and derives the optimal threshold and price set by the monopolist. We also show that an equilibrium always exists.

First, it follows from Lemma 5 that, for any price  $p \in [0, b]$ , sending a threshold signal with  $t^* = \max\{\underline{r}(p), a\}$  is the optimal advertising strategy since it minimizes the cutoff between buying and not buying of the indifferent consumer, and therefore maximizes demand. Hence, the profit under optimal threshold advertising is largest for any price  $p \in [0, b]$ . Thus, by a reveal preference argument, the equilibrium profit under optimal threshold advertising must be maximal.

It is left to show that the optimal price under optimal threshold advertising is  $(\eta\lambda + 1)/(\eta + 1)$ -times larger than that under full match advertising, i.e.  $p_T^* = (\eta\lambda + 1)/(\eta + 1) \cdot p_F^*$ . This follows directly from the first-order conditions. Given that  $\hat{r}_T(p) = (\eta + 1)/(\eta\lambda + 1) \cdot p$ , the

first-order condition under optimal threshold advertising is equivalent to

$$p_T^* = \frac{1 - F\left(\frac{\eta+1}{(\eta\lambda+1)} \cdot p_T^*\right)}{f\left(\frac{\eta+1}{(\eta\lambda+1)} \cdot p_T^*\right) \cdot \frac{\eta+1}{(\eta\lambda+1)}}.$$

Next, multiplying by  $(\eta + 1)/(\eta\lambda + 1)$  and substituting  $(\eta + 1)/(\eta\lambda + 1) \cdot p_T^*$  by  $p_F^*$  leads to the first-order condition under no match value advertising. Hence,  $p_F^*$  must be equal to  $(\eta + 1)/(\eta\lambda + 1) \cdot p_T^*$ .

Second, we consider equilibrium existence. An existence proof for the case of full and no match information is provided in the first part of the proof of Proposition 2. Concerning existence in the subgame with threshold match advertising when  $t \in [a, \hat{r}(p, t^*)]$ , note that no match advertising is simply a special case of this subgame when the threshold  $t$  is equal to  $a$ . It can be shown that existence for  $t = a$  carries over for all  $t \in [a, \hat{r}(p, t^*)]$  since  $\hat{r}(p, t)$  implicitly defined in (25) becomes less convex in  $p$  when  $t$  increases in the interval  $[a, \hat{r}(p, t^*)]$ . For  $t = \hat{r}(p, t^*)$ ,  $\hat{r}(p, t)$  becomes even linear in  $p$ . Therefore, convexity of  $F$  and  $\lambda \in (1, \lambda^c(\eta))$  ensure equilibrium existence for any threshold advertising strategy.  $\square$

*Proof of Proposition 2.* In this proof, we use the cutoff levels under full and no match advertising derived in Section 2 and show that the monopolist prefers no match value advertising to full match advertising. Furthermore, we prove equilibrium existence in both subgames.

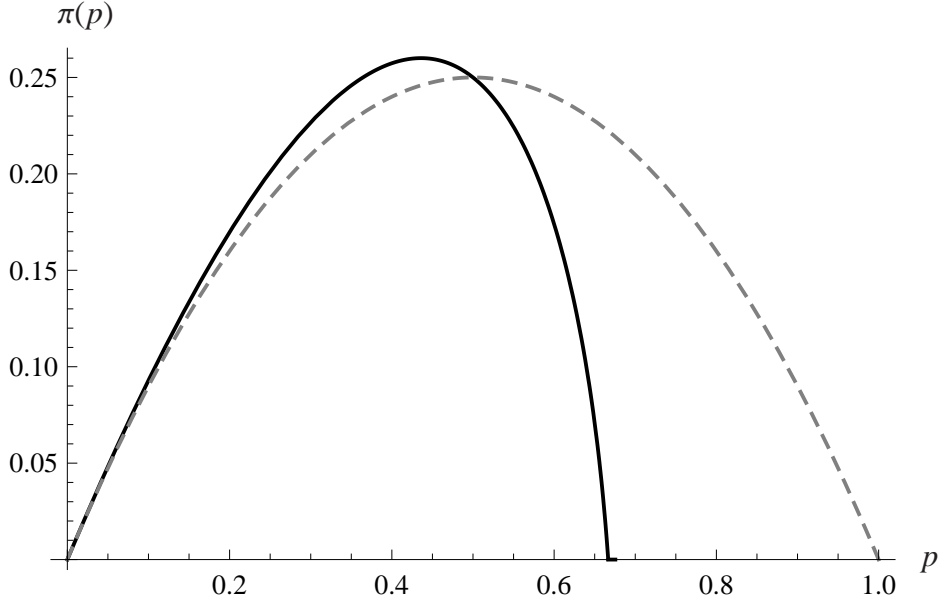
We first prove existence. Given that marginal costs are zero, the monopolist's profit function is equal to  $\pi_i(p) = p[1 - F(\hat{r}_i(p))]$  with  $i \in \{N, F\}$ . Using that, for  $\lambda \in (1, \lambda^c(\eta))$ ,  $\hat{r}_i(p)$  is strictly increasing in the relevant range for both modes of advertising (see Lemma 3 for no match advertising and note that  $\hat{r}_F(p) = p$  for full match advertising), the profit function can also be expressed as a function of  $\hat{r}$ — $\pi_i(\hat{r}) = p_i(\hat{r})[1 - F(\hat{r})]$ —and be maximized over  $\hat{r}$ . This yields

$$\pi_i'(\hat{r}) = p_i'(\hat{r})(1 - F(\hat{r})) - p_i(\hat{r})f(\hat{r}) \quad (27)$$

and

$$\pi_i''(\hat{r}) = p_i''(\hat{r})(1 - F(\hat{r})) - 2p_i'(\hat{r})f(\hat{r}) - p_i(\hat{r})f'(\hat{r}). \quad (28)$$

We next show that, for  $\lambda \in (1, \lambda^c(\eta))$ , the second-order condition is always satisfied. First note that the last term of (28) is negative since  $F$  is convex and hence  $f'(\hat{r}) \geq 0$ . In the subgame with full match value disclosure,  $p_N(\hat{r}) = \hat{r}$  which implies that the second-order condition is satisfied. Thus, an equilibrium always exists in this subgame. In the subgame with no match information disclosure, for  $\lambda \in (1, \lambda^c(\eta))$ , it holds that  $p_N'(\hat{r}) > 0$  and  $p_N''(\hat{r}) < 0$  where  $p_N(\hat{r})$  is given by (11) in Lemma 2 with  $F(r|s) = F(r)$ . Therefore  $\lambda \in (1, \lambda^c(\eta))$  is a sufficient condition for equilibrium existence in this subgame. Figure 4 illustrates the monopolist's profit function



Profit functions for  $\lambda = 2$ , solid: *no match value advertising* and dashed: *full match value advertising*; match values are uniformly distributed on  $[a, b] = [0, 1]$  and marginal costs are  $c = 0$ . The optimal price in the case of no match value advertising is  $p_N^* = 0.4360$  and the optimal price in the case of full-disclosure is  $p_F^* = 0.5$ .

Figure 4: Constrained Advertising: Profit Functions

in the two subgames.

Since, for  $\lambda \rightarrow 1$ , the equilibrium profit in the subgame with no match information disclosure (N) approaches that with full match information disclosure (F), it suffices to show that, for  $\lambda \in (1, \lambda^c(\eta)]$ ,

$$\frac{d\pi_N(\hat{r})}{d\lambda} > 0.$$

Note that  $\pi_N(\hat{r}(\lambda), \lambda) = p_N(\hat{r}(\lambda), \lambda)(1 - F(\hat{r}(\lambda)))$ , where  $\hat{r}$  in equilibrium is given by the first-order condition of  $\pi_N(\hat{r})$  with respect to  $\hat{r}$  and  $p_N(\hat{r})$  by the RHS of (11). By the envelope theorem, we receive that the sign of the equilibrium profit depends only on the sign of the equilibrium price as a function of  $\hat{r}$ ,

$$\frac{d\pi_N(\hat{r})}{d\lambda} = \frac{\partial p_N(\hat{r})}{\partial \lambda} (1 - F(\hat{r})).$$

Furthermore, it holds that

$$\frac{\partial p_N(\hat{r})}{\partial \lambda} = \frac{(\eta + 1)\eta(1 - 2F)}{((\eta + 1) + \eta(\lambda - 1)F)^2} \begin{cases} > 0, & \text{if } \hat{r} < \text{Median}(r); \\ \leq 0, & \text{if } \hat{r} \geq \text{Median}(r). \end{cases} \quad (29)$$

Note that this is in line with our observation made in Section 2.2.3 that consumers become attached without match information disclosure if prices are sufficiently low—or equivalently

if  $\hat{r}$  is sufficiently low.

We next show that convexity of  $F$  implies that, for  $\lambda \in (1, \lambda^c(\eta)]$ ,  $\hat{r} < \text{Median}(r)$ . First note that, for  $\lambda = 1$ , convexity of  $F$  implies that  $\text{Median}(r) \geq (b-a)/2$  and  $f(\text{Median}(r)) \geq 1/(b-a)$ . Now, by contradiction assume that, for  $\lambda = 1$ ,  $\hat{r} > \text{Median}(r)$ . Then,  $F(\hat{r}) > 1/2$  and from the first-order condition it follows that  $1 - F(\hat{r}) - \hat{r}f(\hat{r}) = 0$ . Therefore, it must hold that  $\hat{r}f(\hat{r}) < 1/2$  which states a contradiction to  $\hat{r}f(\hat{r}) > \text{Median}(r)f(\text{Median}(r)) \geq (b-a)/(2(b-a)) = 1/2$ . Hence, for  $\lambda = 1$ ,  $\hat{r} \leq \text{Median}(r)$  must hold. This property carries over with strict inequality to the case of  $\lambda \in (1, \lambda^c(\eta)]$  if  $d\hat{r}_N/d\lambda < 0$ . Applying the implicit function theorem to the first-order condition of  $\pi_N(\hat{r})$  with respect to  $\hat{r}$ , we receive,

$$\frac{d\hat{r}_N}{d\lambda} = - \left[ \frac{(p'_N)^2 - p''_N p_N}{(p'_N)^2} - \frac{-f^2 - f'(1-F)}{f^2} \right]^{-1} \cdot \frac{p'_N \partial p_N / \partial \lambda - p_N \partial p'_N / \partial \lambda}{(p'_N)^2}. \quad (30)$$

The first term in square brackets is positive since, for  $\lambda \in (1, \lambda^c(\eta)]$ ,  $p''_N \leq 0$ . The second term in square brackets is also positive due to  $f' \geq 0$ . Since, for  $\lambda \in (1, \lambda^c(\eta)]$ ,  $p'_N > 0$  and  $\partial p_N / \partial \lambda > 0$ , the third term is positive if  $\partial p'_N / \partial \lambda$  is sufficiently low with

$$\partial p'_N / \partial \lambda = \frac{(\eta + 1)(1 - 2F)((\eta + 1) + \eta(\lambda - 1)F) - (\eta + 1)^2[(\eta\lambda + 1) - \eta(\lambda - 1)F]\hat{r}f}{((\eta + 1) + \eta(\lambda - 1)F)^3} \leq 0.$$

We can show that this is the case by simplifying the the numerator of the third term of (30). This yields

$$p'_N \partial p_N / \partial \lambda - p_N \partial p'_N / \partial \lambda = \frac{\eta(\eta + 1)\hat{r}^2 \left( 2 + \eta[(\eta + 2) + \lambda(\eta\lambda + 2)] - 2\eta^2(\lambda - 1)^2(1 - F)F \right) f}{((\eta + 1) + \eta(\lambda - 1)F)^4},$$

which is always positive since  $(1 - F)F$  is bound above by  $1/4$ . Hence,  $d\hat{r}_N/d\lambda < 0$  which implies that  $d\pi_N/d\lambda > 0$ . Thus, for  $\lambda \in (1, \lambda^c(\eta)]$ ,  $\pi_N(p_N) > \pi_N(p_N)|_{\lambda=1} = \pi^F(p^F)$  which completes the proof.  $\square$

*Proof of Proposition 3.* We have to show that  $CS_F \geq \max\{CS_N, CS_T\}$ . We start with  $CS_F \geq CS_T$ . From Proposition 1 it follows that  $p_T > p_F$  but  $\hat{r}_T = \hat{r}_F$ . Therefore the intrinsic utility of buying is lower under  $T$  than under  $F$ . Thus, the intrinsic component of consumer surplus is lower under  $T$  than under  $F$ . The component of consumer surplus influenced by gains and losses is zero under  $F$  and negative under  $T$  since it is equal to the expected value of the reference comparison with weight  $\lambda > 1$  on losses and weight one on gains. Hence, it holds that  $CS_F \geq CS_T$ .

Second, we show that  $CS_F \geq CS_N$  using an argument similar to the one used in the proof of Proposition 2. Note that, for  $\lambda \rightarrow 1$ ,  $CS_N(p_N(\lambda), \lambda) = CS_F(p_F)$  with  $p_N(\lambda) = p_F$  or, equivalently maximizing over  $\hat{r}_i$  instead of  $p_i$ ,  $CS_N(\hat{r}_N(\lambda), \lambda) = CS_F(\hat{r}_F)$  with  $\hat{r}_N(\lambda) = \hat{r}_F$ . It suffices to show that  $\partial CS_N / \partial \lambda < 0$  for all feasible  $\lambda$  and  $\hat{r}_N(\lambda)$  since by the envelop theorem

$$dCS_N/d\lambda = \partial CS_N/\partial\lambda,$$

$$\begin{aligned} \frac{\partial CS_N}{\partial\lambda} = & - \int_{\hat{r}_N}^b \left( \frac{\partial p_N(\hat{r}_N, \lambda)}{\partial\lambda} \right) dF(r) - [p_N(\hat{r}_N, \lambda) + (\lambda - 1) \frac{\partial p_N(\hat{r}_N, \lambda)}{\partial\lambda}] F(\hat{r}_N)(1 - F(\hat{r}_N)) \\ & - \int_{\hat{r}_N}^b s dF(s) F(\hat{r}_N) - \int_{\hat{r}_N}^b \left[ \int_r^b (s - r) dF(s) \right] dF(r), \end{aligned}$$

where  $p_N(\hat{r}_N, \lambda)$  is given by the RHS of (11) with  $F(r|s) = F(r)$  and  $\partial p_N(\hat{r}_N, \lambda)/\partial\lambda > 0$ . Hence, all terms of the previous equation are negative and  $\partial CS_N/\partial\lambda < 0$  for all  $\lambda \leq \lambda^c$  and  $\hat{r}_N(\lambda)$ .  $\square$

## B Extensions

### B.1 No Price Advertising

In this extension, we discuss the consequences of relaxing the assumption that price is observable to consumers ex ante. We show that, in contrast to classical models of consumer search, non-observability of prices can lead to equilibrium non-existence when there is a continuum of expectation-based loss-averse consumers. We then present additional assumptions under which an equilibrium exists in this case nevertheless. Under any of these assumptions, the monopolist is essentially indifferent between advertising prices or not.

In the classical model of Anderson and Renault (2006), consumers have positive search costs and the monopolist has an incentive to advertise price information together with full match information. This is due to a hold-up problem which resembles the Diamond paradox (Diamond, 1971). Without being committed to a certain price level, the monopolist always finds it profitable to set a price higher than expected by consumers after search costs are sunk. Anticipating such a price increase, consumers would decide not to search and would not buy the product.

In our model, we deal with a similar, yet more intense, problem with respect to price deviations ex post, which compromises equilibrium existence. In our model, this is due to imperfect consumer attachment ex ante as, for example, in the case of full match advertising. If future attachment is not incorporated into the consumers' initial willingness to pay, the monopolist might prefer to deviate from the consumer's expected price level ex post. However, in contrast to Anderson and Renault (2006), such a price increase ex post can lead to non-existence in our model since consumers always visit the shop ex post, and the price set by the monopolist might not meet consumers' expectations. We provide a formal proof of this claim in the Web Appendix. We next discuss assumptions which ensure equilibrium existence even if price is not advertised ex ante.

**Different weights of the two dimensions of loss aversion:** consider a consumer who shows a different parameter of loss aversion for each dimension—i.e.  $\lambda_r \neq \lambda_p$  and  $\lambda_r, \lambda_p \geq 1$ .

Analogously to (10), if no match value information is disclosed, the consumer's net utility from buying is equal to

$$\Delta U = (\eta + 1) \underbrace{(\hat{r} - p)}_{\text{net intrinsic u.}} + \underbrace{\eta(\lambda_r - 1)(1 - F(\hat{r}))\hat{r}}_{\text{net loss in match value}} - \underbrace{\eta(\lambda_p - 1)F(\hat{r})p}_{\text{net loss in price}}. \quad (31)$$

The consumer's attachment is largest if the consumer perceives only loss aversion in the match value dimension, i.e. if  $\lambda_r > \lambda_p = 1$ ,

$$p = \frac{(\eta + 1) + \eta(\lambda_r - 1)(1 - F(\hat{r}))}{(\eta + 1)} \hat{r} > \hat{r},$$

while her attachment is lowest and even negative if the consumer only experiences loss aversion in the price dimension, i.e. if  $1 = \lambda_r < \lambda_p$ ,

$$p = \frac{(\eta + 1)}{(\eta + 1) + \eta(\lambda_p - 1)F(\hat{r})} \hat{r} < \hat{r}.$$

This indicates that loss aversion in the price dimension decreases consumer attachment, whereas loss aversion in the match value dimension has the opposite effect. Furthermore, for  $\lambda_r < \lambda_p$ , the monopolist has less incentives to deviate from the price expected by the consumer if the price is not be observable ex ante. This is due to the fact that the relatively large weight on loss aversion in the price dimension increases consumers' losses from an unexpected price rise and decreases the monopolist's deviation demand and deviation profit.

**Informed consumers:** A sufficiently large share of fully informed consumers who also know the price ex ante prevents the monopolist from deviating from uninformed consumers' expectations.

**Utility shock:** Another way to depart from price observability ex ante may be the introduction of an ex post utility shock for which consumers do not experience gain–loss utility (see Heidhues and Köszegi, 2005). Such a shock reduces consumer attachment ex post which could create a profitable price deviation otherwise.

Note also that under optimal threshold match advertising, the price consumers would anticipate without price observability ex ante is equal to the optimal price the monopolist can achieve. Therefore, the monopolist would not have an incentive to deviate from consumers' expectations if price was not observable ex ante. Furthermore, we could consider niche products which are only bought by consumers who have a very high valuation for the product and this fact is known ex ante. In our model, this can be represented by consumers whose valuation shows a very high lower bound  $a$ . If  $a \geq \underline{r}(p) = (\eta + 1)/(\eta\lambda + 1) \cdot p$ , buying for sure is a PPE (see Section 2.2). If, for sufficiently high  $a$ , the price for niche consumers reaches that of fully attached consumers, the monopolist does not have an incentive to deviate from consumers' price expectations, and thus price advertising is not required for an equilibrium to exist.



## B.2 Positive Search Costs and the Option Not To Search

In this extension, we allow consumers to choose whether or not they want to inspect the good ex post and learn their true match value  $r$  with positive search costs,  $z > 0$ . Suppose that the price is observable ex ante. A first observation is that our results will not be affected if all consumers search, even if no match information is advertised. Note that any consumer will search to observe her match value ex post if expecting not to search (and not to buy) is not credible (is not a PE). In contrast, suppose that a consumer expects not to search with probability one. Her utility of not searching (and not buying) is zero. Now, consider the consumer's utility from searching and buying if she deviates from her initial plan and if she turns out to be of high type  $r \geq \hat{r}_1$  and therefore buys (which happens with probability  $(1 - F(\hat{r}_1))$ ),

$$U[(r, p)|(0, 0)] = \left( r - p - \underbrace{\lambda p}_{\text{loss in price}} + \underbrace{r}_{\text{gain in match}} \right) (1 - F(\hat{r}_1)) - z - \underbrace{\lambda z}_{\text{loss in search costs}} \quad (32)$$

$\Delta U \geq 0$  for the indifferent consumer at  $\hat{r}_1$  is equivalent to

$$\left( \frac{\eta + 1}{(\eta\lambda + 1)} \hat{r}_1 - p \right) (1 - F(\hat{r}_1)) \geq z. \quad (33)$$

For  $z$  sufficiently low, (33) is satisfied if the price is not too high, i.e.  $(\eta + 1)/(\eta\lambda + 1)b > p$ . In this case, not searching is not credible (this is, is not a PE). Therefore, if (33) is satisfied, consumers search with probability one and experience no net loss in the search costs dimension. Moreover, search costs are irrelevant for the valuation of the indifferent consumer between buying and not buying. Hence, our results are robust to search costs up to the limit specified by (33). With optimal threshold advertising, the critical level of search costs is higher than the one specified in (33) since the expected surplus from searching is multiplied by  $1/(1 - F(\underline{r}(p)))$  which is larger than one,

$$\left( \frac{\eta + 1}{(\eta\lambda + 1)} \hat{r}_2 - p \right) \frac{1 - F(\hat{r}_2)}{1 - F(\underline{r}(p))} \geq z. \quad (34)$$

For larger search costs, not searching becomes the consumer's PE and also her PPE if the expected utility of not searching is larger than that under searching (which depends on  $z$  and  $\lambda$ ). Then, consumers would not search (or visit the firm) without receiving a lower price or further match value information by the monopolist's advertising signal. Additionally, this means that the monopolist would have an informative motive for match value disclosure but the persuasive motive would still be present and influence the optimal threshold and price set by the monopolist.

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## Web Appendix: No Price Advertising

We next consider a setup in which the monopolist is not required to advertise price information. We focus on the most critical case for equilibrium existence—the case in which the monopolist discloses full match value but no price information—and show that, due to consumer loss aversion together with consumers having heterogenous product valuations, the monopolist always has an incentive to deviate from the consumer’s expected price. To formalize this argument, the next lemma shows that, in this case, the firm’s demand is not price sensitive around consumer’s expected price  $p'$ .

**Lemma 6.** *Suppose consumers observe their match value ex ante but observe prices only ex post. Let  $\eta$  be equal to 1. If consumers expect  $p' \geq 0$  to be the equilibrium price, then,  $\forall p \geq 0$ , firm’s demand function is equal to*

$$D(p|p') = \begin{cases} 1 - F(\max\{\min\{\frac{\lambda+1}{2}p, b\}, a\}), & \text{if } p < \frac{2}{\lambda+1}p'; \\ 1 - F(\max\{\min\{p', b\}, a\}), & \text{if } p \in [\frac{2}{\lambda+1}p', \frac{2\lambda}{\lambda+1}p']; \\ 1 - F(\max\{\min\{p - \frac{\lambda-1}{\lambda+1}p', b\}, a\}), & \text{if } p > \frac{2\lambda}{\lambda+1}p'. \end{cases}$$

The proof of the lemma is provided below. Note that firm’s demand has slope zero for  $p \in [2/(\lambda+1)p', 2\lambda/(\lambda+1)p']$  which means that deviating from the consumer’s expected price  $p'$  to a higher price  $p$  up to  $2\lambda/(\lambda+1)p'$  is profitable for the firm if  $1 - F(\max\{\min\{p', b\}, a\})$  is positive, since such a deviation increases the firm’s markup without reducing its demand. On the other hand, if consumers expect a very high price such that  $1 - F(\max\{\min\{p', b\}, a\})$  is zero, then the firm always prefers to set a low price level (below  $2/(\lambda+1)b$ ) which yields positive demand (and markup). Thus, there cannot exist an equilibrium in which the firm advertises only full match value information but no price information. This result suggests that, although consumers are willing to buy the good at a higher price ex post, the firm cannot exploit this in equilibrium. This means that our equilibrium concept selects equilibria in which producers do not engage in short-term deception. Hence, the game we consider in this paper can be interpreted as a static reduced form of a dynamic game with brand reputation (compare Heidhues and Kőszegi (forthcoming) who use a similar interpretation). In Appendix B.1, we present assumptions which ensure existence even if the monopolist is not required to disclose price information.

*Proof of Lemma 6.* Let  $p'$  be the price expected by consumers. So all consumers with  $r \geq p'$  anticipate that they will buy the product, while other consumers with  $r < p'$  will not.

1. Suppose the firm deviates to  $p > p'$ . Consider first a consumer with  $r \geq p'$ . If she chooses to buy, her indirect utility will be

$$U[(r, p)|(r, p')] = r - p - \lambda(p - p'),$$

whereas her indirect utility of not buying ex post equals

$$U[(0, 0)|(r, p')] = 0 + p' - \lambda r.$$

Then,

$$U[(r, p)|(r, p')] - U[(0, 0)|(r, p')] \geq 0 \Leftrightarrow r \geq p - \frac{\lambda - 1}{\lambda + 1} p'.$$

If  $p$  is close to  $p'$  such that  $p - \frac{\lambda - 1}{\lambda + 1} p' \Leftrightarrow p < \frac{2\lambda}{\lambda + 1} p'$ , then all such consumers will buy; while if  $p$  is relatively high such that the opposite condition holds, then some consumers will be induced to leave the market without buying the product and only those with  $r \geq p - \frac{\lambda - 1}{\lambda + 1} p'$  will buy.

Next consider a consumer with  $r < p'$ . If she chooses to buy, her indirect utility will be

$$U[(r, p)|(0, 0)] = r - p - \lambda p + r = 2r - (\lambda + 1)p,$$

while her indirect utility of not buying ex post equals

$$U[(0, 0)|(0, 0)] = 0.$$

As  $U[(r, p)|(0, 0)] < 0$  no such consumer will buy.

2. Suppose now the firm deviates to a price  $p < p'$ . Consider first a consumer with  $r \geq p'$ . If she chooses to buy, her indirect utility will be

$$U[(r, p)|(r, p')] = r - p + (p' - p) > 0,$$

whereas her indirect utility of not buying ex post equals

$$U[(0, 0)|(r, p')] = p' - \lambda r < 0.$$

Thus, all such consumers will buy.

Consider now a consumer with  $r < p'$ . If she chooses to buy, her utility will be

$$U[(r, p)|(0, 0)] = r - p - \lambda p + r > 0,$$

while her indirect utility of not buying ex post is equal to

$$U[(0, 0)|(0, 0)] = 0.$$

Then,

$$U[(r, p)|(0, 0)] - U[(0, 0)|(0, 0)] \geq 0 \Leftrightarrow r \geq \frac{\lambda + 1}{2}p.$$

So, if  $p$  is close to  $p'$  such that  $\frac{\lambda+1}{2}p \geq p'$ , then no such consumers will buy; while if  $p$  is low enough such that the opposite condition holds, then those consumers with  $r \in [\frac{\lambda+1}{2}p, p')$  will be induced to reverse their initial decisions and buy the good.

Combining the demand of part one and two leads to the demand in the lemma. □



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