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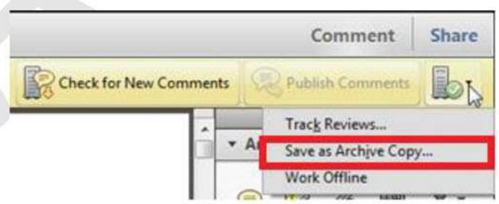

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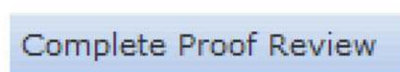

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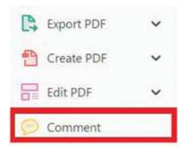

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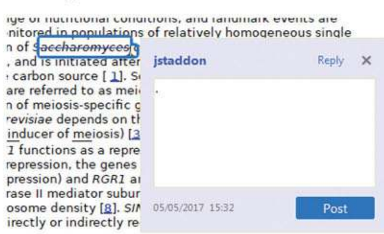

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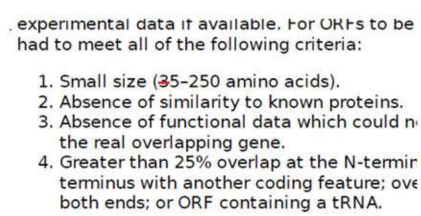

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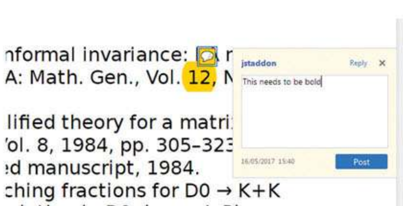

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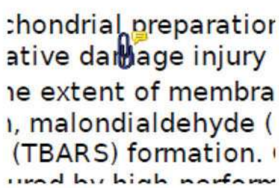

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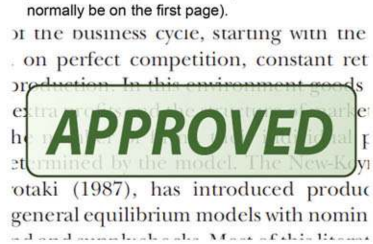

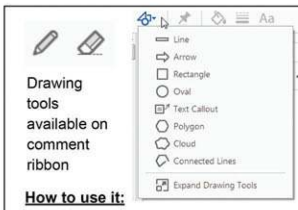

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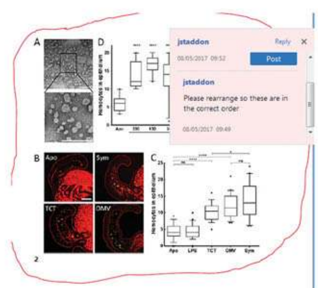

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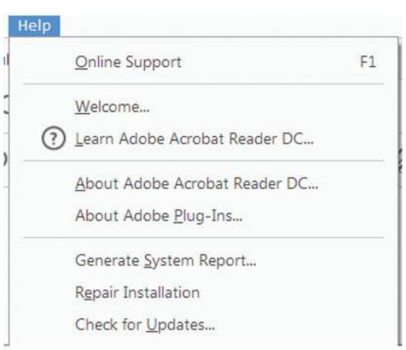

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RAND Journal of Economics
Vol. 00, No. 0, xxxx 2017
pp. 1–22

Advertising and attachment: exploiting loss aversion through prepurchase information

Q1 **Heiko Karle***

and

Heiner Schumacher**

We analyze a monopolist's optimal advertising strategy when consumers are expectation-based loss-averse and uncertain about their individual match value with the product. Advertising provides verifiable match value information. It modifies the consumers' reference point and hence their willingness to pay for the product. We show that the optimal advertising strategy pools different consumer types so that some consumers engage in ex ante *unfavorable trade. Incomplete informative advertising thus has a persuasive effect. This provides a rationale for policies that force the monopolist to disclose important product characteristics, not only at the point of sale, but also in all promotional materials.*

1. Introduction

■ The economic literature on advertising usually distinguishes between "informative" and "persuasive" advertising.[1] Informative advertising increases consumers' knowledge about a product's existence, characteristics, price, or quality. In contrast, persuasive advertising modifies consumers' preferences regarding the product in a way that increases their willingness to pay. Naturally, these two views on advertising have quite different policy implications. Informative

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A previous version of this article was circulated under the title "Creating attachment through advertising: loss aversion and prepurchase information." We are grateful to Kathryn Spier (the Editor), two anonymous referees, Malin Arve, Stefan Bechtold, Estelle Cantillon, Micael Castanheira, Dirk Engelmann, Jana Friedrichsen, Michael Grubb, Paul Heidhues, Martin Hellwig, Fabian Herweg, Claudio Karl, Georg Kirchsteiger, Sebastian Köhne, Botond Kőszegi, Patrick Legros, Vardges Levonyan, Luca Merlino, Wanda Mimra, Daniel Müller, Martin Peitz, Régis Renault, David Sauer, Nicolas Sahuguet, Martin Schonger, Christian Schulz, Michelle Sovinsky, Johannes Spinnewijn, Roberto Weber, and Jidong Zhou as well as various seminar audiences for their valuable comments and suggestions. Karle gratefully acknowledges Q2 financial support from the National Bank of Belgium (Research Grant, "The Impact of Consumer Loss Aversion on the Price Elasticity of Demand") and the ARC Grant, "Market Evolution, Competition and Policy: Theory and Evidence." The usual disclaimer applies.
[1] Bagwell (2007) uses this classification in his extensive overview of the economics of advertising. He also discusses a third type (advertising as a complement to the product), which is not relevant for this article.

advertising can be interpreted as the markets' welfare-enhancing response to asymmetric information problems between consumers and firms. In contrast, persuasive advertising is usually seen as welfare decreasing, as it drives a wedge between consumers' preferences and their intrinsic valuation of the product.

In this article, we show that the distinction between informative and persuasive advertising may, in practice, be blurred. Incomplete product information may have a persuasive effect, and thus increase consumers' willingness to pay for a product. To illustrate this idea, consider the following example.[2] Imagine a potential car buyer who observes an advertisement that informs her about the design of a particular model. She likes the design and plans to buy the car. However, just before the purchase, she learns that the model's fuel efficiency is not great. Nevertheless, she follows her plan and buys the car, although she would not have made such a plan had she seen all the product details—including design and fuel efficiency—in the advertisement. The informative advertisement has a persuasive effect, as it shows the buyer something that she likes (design), thereby creating expectations of ownership[3] that alter her willingness to pay, while hiding other relevant aspects of the product (fuel efficiency).

To demonstrate that the intuition in this example is consistent with rational expectations, we examine a simple model of trade between a monopolist and expectation-based loss-averse consumers (Kőszegi and Rabin 2006, 2007).[4] When a consumer decides between buying or not buying, she compares the outcome of each decision to a reference point. This reference point is given by her expectations regarding product ownership and monetary expenses formed after observing the monopolist's advertisement. For example, if the consumer expects to buy the product, not buying creates a loss in the product dimension and a gain in the money dimension. Because losses loom larger than gains, the expectation of ownership renders buying more attractive, and therefore increases the consumer's willingness to pay. Conversely, if the consumer does not expect to buy the product, buying it creates a net loss through unexpected monetary expense, which in turn decreases her willingness to pay. Thus, the role of advertising in our model is to shift consumer expectations in favor of trade.

Our basic model of informative advertising is taken from Anderson and Renault (2006). Consumers differ in their match value with the monopolist's product (i.e., their utility from consuming the good). *Ex ante*, they do not know their individual match value, but they learn it by inspecting the product at the monopolist's store. Before inspecting the good, they see the monopolist's advertisement, which (potentially) provides information about individual match values. For example, the monopolist may provide full match information so that each consumer precisely knows her type, or incomplete information by sending the same signal to consumers with different match values. In contrast to Anderson and Renault (2006), we assume that there are no inspection costs. If consumers were not loss-averse, the monopolist's advertising content would not affect their decisions in our model: consumers would purchase the product if and only if their match value is (weakly) above the price.

[2] This example is borrowed from Ericson and Fuster's (2011) work on expectation-based loss aversion and extended to the advertising context.

[3] In this article, we use "expectations of ownership" and "attachment" synonymously.

[4] By now, there exists significant empirical evidence from the laboratory and the field that supports expectation-based reference points. Ericson and Fuster (2011) conduct a laboratory experiment in which they randomly vary the probability of ownership of an item. Subjects who anticipate a high probability of ownership have a higher valuation for the item than subjects exposed to a low probability of ownership. Abeler et al. (2011) and Gill and Prowse (2012) find similar evidence in real-effort experiments. There is also evidence that expectation-based reference points affect golf players' performance (Pope and Schweitzer, 2011) and New York cab drivers' labor supply (Crawford and Meng, 2011). Karle, Kirchsteiger, and Peitz (2015) show in a field-lab experiment that a reference point formed under uncertainty affects the consumption choice at a moment when uncertainty is fully resolved. In contrast, Smith (2012) and Heffetz and List (2014) find no significant relationship between expectations and the valuation for a good. One explanation for their negative results could be that the way how subjects form expectations varies with details of the experimental design (see Ericson and Fuster, 2013).

Our main result is that the monopolist maximizes its profit by publishing incomplete product information. In equilibrium, some consumers purchase the good, although their intrinsic valuation for the product is smaller than its price. As in the car purchase example, these consumers would not trade with the monopolist if they knew their true match value when making their purchase plan. We show that if the degree of loss aversion is not too large, then under the optimal advertising strategy, all consumers who purchase the good also expect to purchase it with certainty after observing the advertisement. This maximizes their willingness to pay after discovering their true match value. One advertising strategy that achieves this goal is "threshold match advertising," where all consumers whose match value is weakly above a certain threshold get a favorable signal (and end up purchasing the good), whereas all others get an unfavorable signal. If the threshold is chosen optimally, then consumers who get the favorable signal cannot credibly commit not to trade with the monopolist. This is true even if their true match value turns out to be close to the threshold: as they expect to get the good with high probability, not buying it creates net utility losses ("disappointment"), which make buying the product the preferred option.

Intuitively, threshold match advertising implies that the monopolist will provide information only on a limited set of product attributes, even if the product itself is complex and has many features (such as cars). Indeed, most car advertisements focus on a few positive attributes, which most potential customers would like, such as the particular design or the comfortable new touch screen of the board computer system. Attributes that some potential customers dislike are not mentioned (e.g., how the trade-off between fuel efficiency and engine power is resolved). In their meta-study on advertising content, Abernethy and Franke (1996) find that the medium number of "information cues" in advertising is 2.04, where only 58% have two or more cues (for car advertisements, the average is 2.97). More generally, advertising only a few strong product attributes is a well-documented practice for product introduction in the marketing literature, see Kotler and Armstrong (2010) . There may be alternative causes for limited information provision in advertising (such as limited attention or information processing capabilities). Our model provides a microfoundation for this practice that is purely rooted in consumer loss aversion.[5] Q3

The monopolist can exploit consumers' loss aversion even if the product is relatively simple, so that the set of available strategies is restricted to full match and no match advertising. We show that in this case, the monopolist may strictly prefer no match advertising (which informs consumers about the existence of the good, but leaves them uninformed about their individual match value). The intuition for this is as follows. If the majority of consumers purchase the good under full match advertising, then under no match value advertising, consumers expect to purchase the good with high probability. The monopolist can then exploit these expectations of ownership by charging a higher price or serving more consumers.

When consumers are expectation-based loss-averse, incomplete product information strictly lowers their surplus as compared to the full information case. The reduction comes from two sources: first, the negative gain-loss utility that is due to uncertainty about the true match value (the threat of disappointment); and second, the economic costs from purchasing a product that does not fit the needs of some of its buyers. Thus, disclosure policies that force firms to reveal all important product characteristics *before* customers make purchasing plans may increase consumer surplus. Indeed, such policies are implemented in a number of markets. For example, in the European Union, automobile manufacturers are required to inform customers about the fuel economy and CO_2 emissions of their products, not only at the point of sale, but also in all promotional materials (Directive 1999/94/EC).

Our model provides a new rationale for this policy. It prevents customers who care about the environment—like the one in our example—from becoming too attached to the product when they

[5] There are other advertising practices that resemble threshold match advertising, for example, targeted advertising that only sends information to high-match types or advertising that highlights the similarity between previous and potential customers.

encounter product information at the planning stage. The conventional economic justification of mandatory information disclosure (e.g., the disclosure of commissions in financial products) is that it reduces problems of asymmetric information between naive consumers and firms.[6] In our case, the regulation of content in promotional materials helps consumers to make better plans, or, more precisely, to form expectations that lead to more beneficial outcomes. As we show in our model, this regulation can increase consumer surplus even if there is no asymmetric information between consumers and firms at the contracting stage.

The rest of the article is organized as follows. In Section 2, we relate our contribution to the previous literature. Section 3 describes our model. In Section 4, we derive the monopolist's advertising strategy and its implications for consumer surplus. Section 5 offers several robustness checks and extensions. Section 6 concludes. All proofs are relegated to the Appendix.

2. Related literature

■ Our article is closely related to Anderson and Renault's (2006) model of informative advertising. They assume risk-neutral consumers who have to pay inspection costs to learn their true match value (e.g., the inconvenience of going to the monopolist's store). If these costs are sufficiently large, the monopolist has to inform consumers for which groups it pays off (on average) to inspect the good; otherwise, no consumer would visit its store. Threshold match advertising is then optimal for the monopolist, because it makes some consumers purchase the product whose type is smaller than the sum of price and inspection costs. Our analysis differs from that of Anderson and Renault (2006) in two important aspects. First, there is no persuasion in their model. The monopolist does not benefit from inspection costs (they are simply a hurdle to trade that lowers its profit). In our model, the monopolist strictly benefits from consumers' loss aversion by exploiting the persuasive effect of incomplete product information. We further illustrate this difference in Section 5, when we discuss the effect of consumer information on market outcomes. Second, the driver of our results is consumers' expectation-based loss aversion, as opposed to physical inspection costs. Therefore, the model is a better fit for online commerce that frequently offers both free delivery and free return. It is also better suited for shopping in locations that consumers visit on a regular basis (supermarkets, shopping malls) so that no additional inspection costs occur; and for expensive durables (such as cars) where inspection costs are small relative to the value of the product.

This article contributes to a recent literature that analyzes the implications of expectation-based loss aversion for trade between consumers and firms. The two closest articles to ours are Heidhues and Kőszegi (2014) and Rosato (2016). They also study how a monopolist can exploit consumers' loss aversion through marketing strategies. However, the marketing instrument in their models is the price of the good, rather than advertising content. In Heidhues and Kőszegi (2014), the monopolist creates an attachment effect by committing to a price distribution that puts a positive weight on both regular prices above the consumers' intrinsic valuation and sales prices. In a related sense, Rosato (2016) demonstrates that a retailer selling close substitutes maximizes its profit by offering one good on a limited supply at sales prices, and another good on unlimited supply at exploitative prices. There is one important difference in the modelling strategy between these two articles and ours. Both Heidhues and Kőszegi (2014) and Rosato (2016) assume that consumers are forced to inspect the good. The monopolist's exploitative strategy then implies that consumers experience negative expected utility. In our framework, we do not assume forced inspection. Consumers can choose not to inspect the good, which limits the monopolist's ability to extract their surplus. In Section 5, we explain in detail why we can avoid the assumption of forced inspection.

Our article is also related to Heidhues and Kőszegi (2008) and Karle and Peitz (2014), who study imperfect competition with expectation-based loss-averse consumers. In Heidhues and

[6] See Inderst and Ottaviani (2012) for an example in the context of retail finance.

Kőszegi (2008), consumers initially are uncertain about both prices and match values. Consumer loss aversion then may eliminate price variations in the market, even if firms exhibit varying production costs. Karle and Peitz (2014) consider a similar setup in which firms post their prices upfront and consumers are either informed or uninformed about their match value. They show that if firms differ in their production costs, the presence of uninformed loss-averse consumers leads to more competition and lower prices. In this case, firms may benefit from disclosing full match information *ex ante*. However, none of these two articles considers content advertising that allows for partial information disclosure, as we do in this article.[7]

On a more general level, our article is related to the recent literature on "Bayesian persuasion," initiated by Kamenica and Gentzkow (2011). In these models, the sender commits to a signal mechanism that makes the receiver more likely to choose the sender's preferred action. When the receiver chooses her action, she knows the mechanism and the signal it has generated, but she is still uncertain about the true state of the world. In our model, the receiver knows the true state of the world at the decision stage. Nevertheless, the sender's mechanism and its signal matter, as they alter the receiver's expectations and therefore preferences. In terms of advertising, Bayesian persuasion with standard preferences works only for experience goods, but does not work for inspection goods (where the receiver has full match information when she takes her decision). Our results imply that Bayesian persuasion with expectation-based loss-averse receivers may also work for inspection goods.

3. The model

■ We analyze trade between a monopolist and a continuum of consumers. In period 0, the monopolist chooses a price for its good and an advertising strategy. Consumers then observe price, advertising strategy, and a signal that depends both on the advertisement and their individual match value. In period 1, they either inspect the good or not. If a consumer inspects the good, she learns her true match value, and decides whether to purchase one unit of the good. Otherwise, no trade occurs. The production costs of the good are normalized to zero.

□ **Match values and advertising strategy.** A consumer's match value is denoted by r. Initially, consumers do not know their match value; they only know that match values are distributed according to the distribution function $F(r)$ with support $[a, b] \subseteq \mathbb{R}_0^+$. We assume that F is continuously differentiable, strictly increasing on $[a, b]$, and that $[1 - F(r)]r$ has a unique maximum.[8] The monopolist cannot distinguish between different consumer types,[9] but it may provide match value information by revealing product characteristics through advertising. We follow Anderson and Renault (2006), and model advertising as an "information transmission mechanism," henceforth, ITM. An ITM Θ is a set of signals S_Θ and a probability distribution that determines the chance with which certain consumer types observe a signal $s \in S_\Theta$ (see the Appendix for the complete formal definition). Consumers fully understand the ITM, and can update the belief about their match value based on the observed signal. To follow is a simple example that we will use in the subsequent analysis. Consider the ITM Θ^x with $S_{\Theta^x} = \{s_L, s_H\}$, which specifies that consumers with match values $r \in [a, x)$ observe signal s_L (the "bad" signal), whereas consumers with match values $r \in [x, b]$ observe signal s_H (the "good" signal). This ITM informs consumers as to whether their match value is

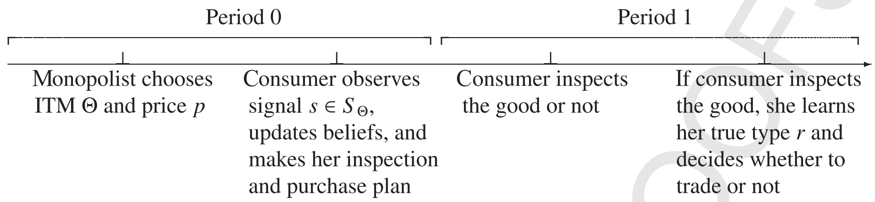
[7] Other applications of expectation-based loss aversion include Herweg and Mierendorff (2013), Hahn et al. (forthcoming), and Carbajal and Ely (2016) on monopolistic screening; Herweg, Müller, and Weinschenk (2010) on principal-agent contracts; Gill and Stone (2010), Lange and Ratan (2010), and Dato, Grunewald, and Müller (2015) on auctions; and Daido and Murooka (forthcoming) on team incentives.

[8] The last assumption is not essential and only made to simplify the exposition of our results.

[9] Throughout the article, we use the terms "match value" and "type" as synonyms.

FIGURE 1

TIMELINE



above or below threshold x. Depending on the signal, consumers update the belief about their type to

$$F(r|\Theta^x, s_L) = \begin{cases} \frac{F(r)}{F(x)} & \text{for } r \in [a, x) \\ 1 & \text{for } r \in [x, b] \end{cases} \quad \text{or} \quad F(r|\Theta^x, s_H) = \begin{cases} 0 & \text{for } r \in [a, x) \\ \frac{F(r)-F(x)}{1-F(x)} & \text{for } r \in [x, b] \end{cases}. \tag{1}$$

Of course, the monopolist can also choose much more complex ITMs. These could be, for example, an ITM that groups consumers into more than two intervals, an ITM where each consumer type observes a different signal so that all consumers learn their match value, or an ITM where all consumers observe the same signal so that no information is provided. Figure 1 shows a timeline of all events.

□ **Consumer preferences.** We follow Kőszegi and Rabin (2006, 2007) to model consumers' expectation-based loss aversion. Denote by p the price of the good. Consider a consumer with type r. Her utility consists of two components: first, her "consumption utility" when she purchases the good, $r - p$; and second, her "gain-loss utility" from comparisons of the actual outcome to a reference-point given by her period-0 expectations. Consumers assess gains and losses over product and money dimensions separately. Suppose a consumer expects that she purchases the good with certainty, her match value is $\tilde{r}$, and her monetary expense is $\tilde{p}$. If the true match value is r and the price is p, her utility from buying equals

$$u(r, p|\tilde{r}, \tilde{p}) = r - p + \mu(r - \tilde{r}) + \mu(-p + \tilde{p}), \tag{2}$$

and her utility from not buying after inspection is $u(0, 0|\tilde{r}, \tilde{p})$. The function μ captures gain-loss utility. We assume that μ is piecewise linear with slope η for gains and slope $\eta\lambda$ for losses, $\eta > 0$ is the weight of gain-loss utility relative to consumption utility, and $\lambda > 1$ is the degree of loss aversion. The consumers' utility from not inspecting the good is zero.

A consumer may have stochastic expectations about the final outcome, for example, she may expect that her true match value is drawn according to some distribution and that her monetary expense is p or zero, each with some positive probability. The reference point reflects this uncertainty. Let the distribution function G^r be the consumer's expectation regarding her utility in the product dimension and G^p her expectation regarding her monetary expenses. Her utility from the realized outcome (r, p) after inspection then is

$$u(r, p|G^r, G^p) = r - p + \int \mu(r - \tilde{r})dG^r(\tilde{r}) + \int \mu(-p + \tilde{p})dG^p(\tilde{p}). \tag{3}$$

Thus, gains and losses are weighted by the probability with which the consumer expects them to occur. This preference model captures the following intuition. If a consumer expects to win either 0 or 10 units, each with probability 50%, then an outcome of six units feels like a gain of six units weighted with 50% probability, and a loss of four units also weighted with 50% probability.

□ **Inspection and purchase plans.** After observing the monopolist's ITM Θ and signal $s \in S_\Theta$, a consumer updates the belief about her type to $F(r|\Theta, s)$ and makes a plan regarding the inspection and purchase decision. This plan is captured by a function $\hat{r}(\Theta, s, p) \in \{N\} \cup \mathbb{R}_0^+$. Value N means that the consumer does not inspect the good, so that there is no purchase decision. A value in $\mathbb{R}_0^+$ indicates that the consumer inspects the good and executes a purchase plan. This plan must be credible. Given the expectations G^r, G^p, it generates, it must be rational for the consumer to follow it through. Formally, a credible purchase plan must form a personal equilibrium (Kőszegi and Rabin, 2010). Note from equation (3) that for given price p and expectations G^r, G^p, the consumer's utility, strictly increases in her match value r. Hence, every credible purchase plan must have a cutoff structure. This means that when the consumer inspects the good, she purchases the good if $r \geq \hat{r}(\Theta, s, p)$, and otherwise refrains from trading.[10] Ties are broken in favor of trading. ITM, signal, price, and plan define a consumer's expectations regarding her utility in the product dimension, denoted by $G^r(\tilde{r}|\Theta, s, p, \hat{r}(\Theta, s, p))$, and her expectations about monetary expenses, denoted by $G^p(\tilde{p}|\Theta, s, p, \hat{r}(\Theta, s, p))$. A plan is a personal equilibrium if the consumer does not inspect the good or, when inspecting the good, she is indifferent between trading or not if her true type equals the cutoff value $\hat{r}(\Theta, s, p)$.

Definition 1. A plan $\hat{r}(\Theta, s, p)$ is a personal equilibrium (PE) if for any feasible ITM Θ, signal $s \in S_\Theta$, and price p with $\hat{r}(\Theta, s, p) \neq N$, we have

$$u(\hat{r}(\Theta, s, p), p|G^r, G^p) = u(0, 0|G^r, G^p),$$

where $G^r = G^r(\tilde{r}|\Theta, s, p, \hat{r}(\Theta, s, p))$ and $G^p = G^p(\tilde{p}|\Theta, s, p, \hat{r}(\Theta, s, p))$.

The consumer's preferred personal equilibrium is the PE that maximizes her utility for any given ITM, signal, and price. Define the indicator function $\sigma(r, \hat{r})$ as $\sigma(r, \hat{r}) = 1$ if $r \geq \hat{r}$ and $\sigma(r, \hat{r}) = \sigma(r, N) = 0$ otherwise.

Definition 2. A plan $\hat{r}(\Theta, s, p)$ is a preferred personal equilibrium (PPE) if for any feasible ITM Θ, signal $s \in S_\Theta$, price p, and any alternative personal equilibrium $\bar{r}(\Theta, s, p)$, we have

$$\begin{aligned} &E\left[u(r\sigma(r, \hat{r}), p\sigma(r, \hat{r}))|G^r(\tilde{r}|\Theta, s, p, \hat{r}), G^p(\tilde{p}|\Theta, s, p, \hat{r})\right] \\ &\geq E\left[u(r\sigma(r, \bar{r}), p\sigma(r, \bar{r}))|G^r(\tilde{r}|\Theta, s, p, \bar{r}), G^p(\tilde{p}|\Theta, s, p, \bar{r})\right], \end{aligned}$$

where $\hat{r} = \hat{r}(\Theta, s, p)$, $\bar{r} = \bar{r}(\Theta, s, p)$, and expectations are taken with respect to $F(r|\Theta, s)$.

An equilibrium of this game consists of a PPE $\hat{r}(\Theta, s, p)$, an ITM Θ^*, and a price p^* so that Θ^*, p^* maximize the monopolist's profit when consumers act according to $\hat{r}(\Theta, s, p)$. For convenience, we assume that the PPE is such that whenever consumers are indifferent between two different PE cutoff values $\hat{r}$ and $\bar{r}$, they choose the smaller one.

4. Optimal advertising

■ Consider as a benchmark the case when consumers are not loss-averse, $\eta = 0$. Inspecting the good is then costless for them. If the monopolist charges the price p, they purchase the good if and only if their match value r weakly exceeds p. The monopolist's profit as a function of the marginal consumer $\hat{r}$ is then given by

$$\pi_f(\hat{r}) = [1 - F(\hat{r})]\hat{r}. \tag{4}$$

By assumption, there is a unique optimal marginal consumer $\hat{r}_f^*$, which is either given by the cornersolution $\hat{r}_f^* = a$, or characterized by the first-order condition

$$\frac{d\pi_f(\hat{r})}{d\hat{r}} = 1 - F(\hat{r}) - f(\hat{r})\hat{r} = 0. \tag{5}$$

[10] If $\hat{r}(\Theta, s, p)$ weakly exceeds b, this means "inspect the good, but never buy it." If $\hat{r}(\Theta, s, p)$ is weakly below a, this means "inspect the good and always buy it."

The monopolist's optimal price is $p_f^* = \hat{r}_f^*$. The details of its advertising strategy are not important. Some advertising may be needed in order to inform consumers of the existence of the product, but the informational content does not affect demand.

Next, assume that consumers are loss-averse, $\eta > 0$. By fully revealing all relevant details of the product, the monopolist can generate the same demand as in the case of no loss aversion. Formally, this is possible by choosing an ITM Θ with signal set $S_\Theta = [a, b]$ and specifying that a consumer with type r observes signal $s = r$. If each consumer exactly knows her match value r, the preference model collapses to a standard risk-neutral utility framework. Consumers then purchase the good if and only if $r \geq p$, so that the monopolist's profit is again given by $\pi_f(\hat{r})$. The subscript "f" thus denotes full match information. The monopolist, however, can potentially increase its profit above $\pi_f(\hat{r}_f^*)$ by not revealing all information and charging a different price. We show that this is the case in two different scenarios. First, we consider the case when the monopolist can choose any degree of information transmission (any ITM is feasible). Second, we assume that the monopolist can only choose between full match information and no information at all.

□ **Unconstrained information disclosure.** If the monopolist does not fully disclose all product characteristics, consumers experience uncertainty regarding their true match value. In this case, inspecting the good is no longer costless for expectation-based loss-averse individuals. A consumer who expects both trade and a large match value may be disappointed if she finds out that her true match value is relatively small. She would then experience a loss in the product dimension. A consumer who initially expected trade only with small probability may find out that her true match value is relatively large, so that she purchases the good. She then experiences a loss in the money dimension and a gain in the product dimension. Because losses are weighted heavier than gains, uncertainty always reduces the expected utility from inspecting the good.

If a consumer inspects the good, her plan must satisfy two conditions. First, it must be rational to follow it through in period 1 after learning the true match value. Second, in period 0, the consumer's expected utility from executing the plan must be nonnegative; otherwise, the only rational action would be not to inspect the good. In the following, we examine the structure of credible plans and under what circumstances inspection is individually rational.

Suppose that the monopolist has chosen ITM Θ and price p. Consider a consumer who observes signal $s \in S_\Theta$. She updates the belief about her type to $F(r|\Theta, s)$. Let $\underline{x}$ ($\overline{x}$) be the lower (upper) bound of the support of this distribution. Assume that the consumer's plan is to inspect the good and to purchase it with positive probability so that $\hat{r}(\Theta, s, p) < \overline{x}$. Abbreviate $\hat{r} = \hat{r}(\Theta, s, p)$. This plan is credible if and only if the consumer is indifferent between trading or not when she learns that her true type is indeed given by $\hat{r}$. Her utility in period 1 from purchasing the good at match value $\hat{r}$ is

$$\hat{r} - p - \eta\lambda F(\hat{r}|\Theta, s)p + \eta F(\hat{r}|\Theta, s)\hat{r} - \eta\lambda \int_{\hat{r}}^{\overline{x}} (r - \hat{r})dF(r|\Theta, s). \tag{6}$$

The first two terms capture consumption utility; the third term is a loss in the money dimension due to the fact that the consumer expected to pay nothing with probability $F(\hat{r}|\Theta, s)$; the fourth term is a gain in the product dimension due to the fact that the consumer expected to consume nothing with probability $F(\hat{r}|\Theta, s)$; and the fifth term is a loss in the product dimension, which is due to the fact that the consumer expected match value $r > \hat{r}$ with density $f(r|\Theta, s)$. Her utility in period 1 from not purchasing the good at match value $\hat{r}$ is

$$\eta[1 - F(\hat{r}|\Theta, s)]p - \eta\lambda \int_{\hat{r}}^{\overline{x}} rdF(r|\Theta, s). \tag{7}$$

Consumption utility now equals zero. The first term is a gain in the money dimension, and the second term is a loss in the product dimension. Equating (6) and (7) yields us a condition for the credibility of a plan. The consumer has to choose the cutoff $\hat{r}$ so that

$$p = \frac{1 + \eta\lambda - \eta(\lambda - 1)F(\hat{r}|\Theta, s)}{1 + \eta + \eta(\lambda - 1)F(\hat{r}|\Theta, s)}\hat{r} \equiv p(\hat{r}|\Theta, s). \tag{8}$$

This equality is a necessary, but not a sufficient condition for a PPE cutoff value at $\hat{r}$. The inverse cutoff function $p(\hat{r}|\Theta, s)$ indicates the price the monopolist has to charge so that a consumer who observes ITM Θ and signal $s \in S_\Theta$ has a PE cutoff value at $\hat{r}$. We will frequently refer to this function. If $p(\hat{r}|\Theta, s) > p$, a cutoff at $\hat{r}$ is not credible, as the consumer strictly prefers trading over not trading whenever the true match value r is sufficiently close to $\hat{r}$. Intuitively, the inequality $p(\hat{r}|\Theta, s) > p$ indicates that the good is too cheap (trading is too attractive) for a cutoff at $\hat{r}$: if the true match value is $\hat{r} - \varepsilon$ for sufficiently small $\varepsilon > 0$, the gains in consumption utility and the product dimension outweigh the loss in the money dimension. Likewise, if $p(\hat{r}|\Theta, s) < p$, a cutoff at $\hat{r}$ is not credible, because for match values sufficiently close to $\hat{r}$, the consumer strictly prefers not trading over trading.

Under what circumstances is it rational to inspect the good? Consider again the consumer who observes signal $s \in S_\Theta$ and price p. If she executes a plan with cutoff at $\hat{r} \in [\underline{x}, \overline{x})$, her expected utility consists of both consumption and gain-loss utility. The latter component is strictly negative and its size depends on the degree of loss aversion λ. For $\lambda = 1$, gains and losses are weighted equally so that the expected gain-loss utility equals zero. Thus, if expected consumption utility is strictly positive and the degree of loss aversion is not too large, it is rational to inspect the good. At a later stage, we will examine a numerical example to see what "too large" means.

How should the monopolist inform consumers about their match value in order to maximize its revenue? As long as λ is not too large, the answer is surprisingly simple. Note from (8) that it is rational for the consumer to trade at the cutoff value $\hat{r}$ only if

$$\hat{r} \geq \frac{1 + \eta + \eta(\lambda - 1)F(\hat{r}|\Theta, s)}{1 + \eta\lambda - \eta(\lambda - 1)F(\hat{r}|\Theta, s)}p. \tag{9}$$

The right-hand side of this expression strictly increases in $F(\hat{r}|\Theta, s)$. If we set $F(\hat{r}|\Theta, s) = 0$, we obtain a lower bound on the smallest credible cutoff value, $\hat{r} = \frac{1+\eta}{1+\eta\lambda}p$. When the monopolist charges p, it will at most serve consumers with match values in the interval $[\frac{1+\eta}{1+\eta\lambda}p, b]$.

We now find an ITM that maximizes demand for the monopolist's good at a given price p. Recall the threshold ITM Θ^x from the last section, which sends signal s_L to all consumers with type $r < x$ and signal s_H to all consumers with type $r \geq x$. We choose the threshold equal to the smallest possible cutoff at price p, $x = \frac{1+\eta}{1+\eta\lambda}p$. Then, it is a personal equilibrium for a consumer to always purchase the good after observing signal s_H and never to purchase the good after observing s_L. To see the first claim, note that we have $F(x|\Theta^x, s_H) = 0$ and therefore $p(x|\Theta^x, s_H) = p$. We only have to make sure that this is also the consumers' preferred credible plan. Indeed, we can show that there is no other credible plan that specifies a cutoff value above x if λ is not too large. Formally, we have $p(\hat{r}|\Theta^x, s_H) > p$ for all $\hat{r} \in (x, b]$ in this case. The value x is then the unique PE cutoff value and hence also the PPE cutoff value. Consequently, the threshold ITM Θ^x with $x = \frac{1+\eta}{1+\eta\lambda}p$ maximizes demand for given price p. If λ is not too large,[11] there is no ITM that creates even higher demand for the monopolist's good.

Lemma 1. Let the price $p < b$ be given. If λ is not too large, the ITM Θ^x that informs consumers whether or not their match value lies below or weakly above $x = \frac{1+\eta}{1+\eta\lambda}p$ maximizes the

[11] Note that there are two reasons why λ must not be too large (it must be rational for the consumer to inspect the good and there must not be a PE cutoff value above x). The upper bound on λ depends on η and the distribution function F, see the proof of Lemma 1 for details. Below, we examine a numerical example for which we can explicitly derive the upper bound on λ.

monopolist's profit. After observing this ITM, the consumers' PPE then specifies to always purchase the good if the match value is weakly above $\frac{1+\eta}{1+\eta\lambda}p$, and not to purchase it otherwise.

With this result, we can characterize the monopolist's optimal price and advertising strategy. If it charges the price p and chooses an ITM that maximizes revenues, it serves all consumers with types weakly above $\frac{1+\eta}{1+\eta\lambda}p$ or, in case of a corner solution, all consumers. The monopolist's profit as a function of the marginal consumer $\hat{r}$ therefore is

$$\pi_t(\hat{r}) = \frac{1+\eta\lambda}{1+\eta}[1 - F(\hat{r})]\hat{r} = \frac{1+\eta\lambda}{1+\eta}\pi_f(\hat{r}). \tag{10}$$

The subscript "t" denotes optimal threshold match information. Compared to the monopolist's full information profit, its profit under optimal treshold advertising is scaled up by the factor $\frac{1+\eta\lambda}{1+\eta}$. Thus, the monopolist serves the same consumers as under full match advertising, but charges a strictly higher price, that is, $p_t^* = \frac{1+\eta\lambda}{1+\eta}p_f^*$. This is our main result.

Proposition 1. Let η be given. If λ is not too large, the monopolist charges the price $\frac{1+\eta\lambda}{1+\eta}p_f^*$ and chooses an ITM so that all consumers with match value $r \geq \hat{r}_f^*$ purchase the good, whereas all other consumers do not. Its profit then exceeds the full match advertising profit $\pi_f(\hat{r}_f^*)$.

Lemma 1 and Proposition 1 show that by providing threshold match value information, the monopolist can increase its profit above the full match advertising profit $\pi_f(\hat{r}_f^*)$. The ITM updates the consumers' expectations in a way so that the monopolist sells to consumer types who would not purchase the good if they knew their true match value before inspection. To see this, recall that under full match information, all consumers with type $r \geq p$ purchase the good, whereas all others do not. Consider a consumer whose type r' is slightly smaller than p. This consumer would not purchase the good under full match information. Suppose now that she mistakenly believes that her true type is $r > p$, and that she expects to trade with probability one. Then, after finding out her true match value, she has to weigh negative consumption utility from trading, $r' - p$, against the net loss in gain-loss utility from not trading, $-\eta\lambda r' + \eta p$. If r' is close enough to p, trading is the lesser of two evils for this consumer.

Under optimal threshold match advertising, consumers face substantial uncertainty regarding their match value. It can be any value from the interval $[\hat{r}_f^*, b]$, which creates scope for disappointments (when a small match value close to $\hat{r}_f^*$ is realized, the comparison to all the larger match values hurts). Formally, after observing the good signal, consumers' expected utility from always purchasing the good equals

$$\int_{\hat{r}_f^*}^{b} r\,dF(r|\Theta^x, s_H) - \frac{1+\eta\lambda}{1+\eta}p_f^* - \eta(\lambda-1)\int_{\hat{r}_f^*}^{b}\int_{r}^{b}(\tilde{r}-r)dF(\tilde{r}|\Theta^x, s_H)dF(r|\Theta^x, s_H). \tag{11}$$

The first two terms capture consumption utility and the third term captures the potential for disappointments through gains-loss utility. Note that this term increases in η and λ. If η, λ are large enough, the expected utility from any credible plan that involves trade with some probability is negative, even if the monopolist only charges the full information price p_f^*. It is then no longer rational for the consumer to inspect the good; and the threshold ITM Θ^x with $x = \hat{r}_f^*$ is no longer optimal for the monopolist.

Nevertheless, the monopolist can exploit the consumers' loss aversion for all values of η and λ. To see this, suppose that it chooses the price p_f^* and an ITM that sends the same signal s_H to two disjoint sets of consumers: large types with match values in $[b-\varepsilon, b]$ and, with probability Δ, intermediate types with match values in $[\hat{r}_f^* - \varepsilon, \hat{r}_f^*)$. Note that the latter group of consumers would not trade with the monopolist under full match information. Now observe that if Δ and ε are small, a consumer who observes signal s_H knows that with high probability, she has a type close to the maximum. This limits the scope for disappointments. We can show that for any values η, λ one can choose ε, Δ so that the consumer always purchases the good after observing signal

s_H. Thus, the monopolist can achieve profits above $\pi_f(\hat{r}_f^*)$ by providing partial match information, regardless of the consumers' degree of loss aversion.

Proposition 2. For any values of the loss aversion parameters $\eta > 0$ and $\lambda > 1$, the monopolist chooses a price and an ITM that provides partial match information so that its profit exceeds the full match advertising profit $\pi_f(\hat{r}_f^*)$.

□ **Constrained information disclosure.** Suppose the monopolist's options to communicate different match information to different consumers are limited, so that it can only choose between full or no match advertising. For example, this could be the case when the product is so simple that advertising is either completely uninformative (it only mentions the existence of the product) or it contains all relevant details.[12] The question then is whether or not the monopolist can benefit from keeping consumers uninformed.

Denote by ITM Θ^n an advertising strategy that sends the same signal s_n to all consumers. The subscript "n" denotes no match information. The consumers' belief about their type after observing this advertising strategy is then given by the original distribution, that is, $F(r|\Theta^n, s_n) = F(r)$. If the monopolist chooses this ITM, it does not serve all consumers unless it charges a relatively small price. For higher prices, consumers plan to purchase the good if and only if their true match value exceeds a cutoff value that is strictly larger than a. This cutoff value is given by $\hat{r}(\Theta^n, s_n, p) = \hat{r}_n$. Note that this differs from optimal threshold match advertising, where consumers always trade after observing the good signal.

The location of $\hat{r}_n$ determines the consumers' attachment to the product: if $\hat{r}_n$ is relatively close to a, they expect to trade with high probability. Not purchasing the good then creates a large loss in the product dimension, whereas purchasing only creates a small loss in the money dimension. To avoid the large loss in the product dimension, consumers are willing to pay more for the good than if they were perfectly informed about their match value. Conversely, if $\hat{r}_n$ is relatively close to b, not purchasing the good creates only a small loss in the product dimension, whereas trade creates a large loss in the money dimension. Consumers are then less willing to pay for the good than in the case of full match information.

We capture this intuition graphically in Figure 2. It shows for both the full information ITM Θ^f and the no information ITM Θ^n, the price that the monopolist has to charge in order to have the marginal consumer at $\hat{r}$. Under full match advertising, this price linearly increases in the cutoff level and is given by $p_f(\hat{r}) = \hat{r}$. Under no match advertising, to get PE cutoff level $\hat{r}$, the price must be chosen so that

$$p = \frac{1 + \eta\lambda - \eta(\lambda - 1)F(\hat{r})}{1 + \eta + \eta(\lambda - 1)F(\hat{r})}\hat{r} = p(\hat{r}|\Theta^n, s_n). \tag{12}$$

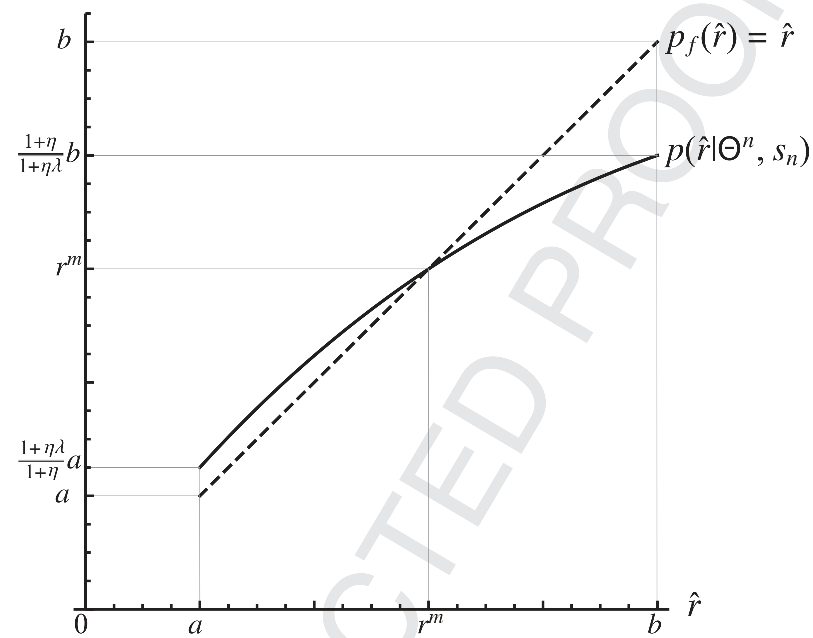
We can show that if λ is not too large, this function is concave and has a unique intersection with $p_f(\hat{r})$ at the median r^m. Observe that if $\hat{r}$ is smaller than the median r^m, consumers expect to purchase the good with more than 50% probability. The monopolist then can charge a higher price under no information than under full information ($p > \hat{r}$). However, if $\hat{r}$ exceeds the median r^m, consumers expect to trade with less than 50% probability, so that the monopolist has to charge a price that is smaller than under full information ($p < \hat{r}$).

We now can show that the monopolist strictly gains from providing no information if $\hat{r}_f^* \leq r^m$. Assume that under full information, it serves strictly more than one half of the consumer population, $\hat{r}_f^* < r^m$. Then, by providing no information, the monopolist increases the consumers' willingness to pay. Now assume that under full information, the monopolist serves exactly half of the consumers, $\hat{r}_f^* = r^m$. Then, the monopolist strictly increases its profit by providing no information and decreasing its price slightly below r^m (thereby creating an

[12] See Anderson and Renault (2006) for a microfoundation of this restriction.

FIGURE 2

INVERSE CUTOFF FUNCTIONS FOR $\eta = 1$ AND $\lambda = \frac{3}{2}$, MATCH VALUES ARE UNIFORMLY DISTRIBUTED ON $[a, b] = [0.2, 1]$



attachment effect). Thus, under no match advertising, the monopolist's profit is strictly larger than under full match advertising, provided that λ is small enough so that consumers inspect the good.

Proposition 3. Suppose the monopolist can only choose between full or no match advertising. Let η be given. If $\hat{r}_f^* \leq r^m$ and λ is not too large, its profit under no match advertising strictly exceeds the full match advertising profit $\pi_f(\hat{r}_f^*)$.

The optimal no match information price p_n^* may be lower or higher than p_f^*. For example, if F is the uniform distribution and a is close enough to zero, we get $p_n^* < p_f^*$; if a is close enough to b so that the monopolist would like to serve all consumers, we get $p_n^* = \frac{1+\eta\lambda}{1+\eta}a > a = p_f^*$.

In general, no match advertising is strictly less profitable for the monopolist than optimal threshold match advertising. To see this, suppose that the optimal cutoff value under Θ^n is given by $\hat{r}_n^* \in (a, b)$. The monopolist's price is then $p(\hat{r}_n^*|\Theta^n, s_n) < \frac{1+\eta\lambda}{1+\eta}\hat{r}_n^*$. If instead it chooses the threshold ITM Θ^x with $x = \hat{r}_n^*$, it can charge $\frac{1+\eta\lambda}{1+\eta}\hat{r}_n^*$ and serve the same share of consumers. Intuitively, this is because under Θ^x, those consumers who trade expect to trade with certainty, whereas under Θ^n, they expect to trade with probability less than one. So in the latter case, they are less attached to the good and therefore less willing to pay for it. The two advertising strategies create identical profits only if it is optimal for the monopolist to serve all consumers, that is, when a is sufficiently close to b.

The result in Proposition 3 depends on the distribution of consumers over types. The condition $\hat{r}_f^* \leq r^m$ is satisfied whenever F is convex (we show this in the Appendix). Suppose in contrast that F is such that the unique optimal price under full match information significantly exceeds the median, that is, $\hat{r}_f^* > r^m$. Under full information, the monopolist then trades with less than half of the consumer population. As discussed above, if it provides no information, it serves the same share of consumers only when it charges a lower price.[13]

□ **Consumer surplus.** We compare consumer surplus under the different advertising strategies. It is straightforward to show that optimal threshold match advertising reduces consumer surplus as compared to full match advertising. Under full match advertising, consumer surplus is given by

$$CS_f = \int_{\hat{r}_f^*}^{b} r dF(r) - p_f^*, \tag{13}$$

whereas under optimal threshold match advertising, it equals

$$CS_t = \int_{\hat{r}_f^*}^{b} r dF(r) - \frac{1+\eta\lambda}{1+\eta} p_f^* - \eta(\lambda-1) \int_{\hat{r}_f^*}^{b} \int_{r}^{b} (\tilde{r}-r) dF(\tilde{r}|\Theta^x, s_H) dF(r|\Theta^x, s_H), \tag{14}$$

where x is the usual cutoff match value. Observe that the loss $CS_f - CS_t$ comes from two sources: an increased price (the second term in CS_t); and a negative expected gain-loss utility in the product dimension (the third term in CS_t). The implication for consumer policy is that forcing the monopolist to provide all relevant details of its products increases consumer surplus, as compared to the partial information disclosure case.

The comparison of surplus under full and no match advertising is less clear. Let $\hat{r}_n^*$ again be the optimal cutoff under no match advertising and $p_n^* = p(\hat{r}_n^*|\Theta^n, s_n)$ the corresponding price. The consumer surplus under this advertising strategy is then given by

$$\begin{aligned} CS_n = {} & \int_{\hat{r}_n^*}^{b} r dF(r) - p_n^* - \eta(\lambda-1) F(\hat{r}_n^*)(1 - F(\hat{r}_n^*)) p_n^* \\ & - \eta\lambda F(\hat{r}_n^*) \int_{\hat{r}_n^*}^{b} \tilde{r} dF(\tilde{r}) - \eta(\lambda-1) \int_{\hat{r}_n^*}^{b} \int_{r}^{b} (\tilde{r}-r) dF(\tilde{r}) dF(r). \end{aligned} \tag{15}$$

The first two terms in the first line capture consumption utility, the third term in the first line is the expected gain-loss utility in the money dimension (consumers may trade with probability less than one), whereas the second line captures gain-loss utility in the product dimension. The sign of $CS_f - CS_n$ is ambiguous. Recall from the previous subsection that both price and cutoff value under no match advertising may be smaller than under full match advertising, $p_n^* < p_f^*$ and $\hat{r}_n^* < \hat{r}_f^*$. Thus, consumption utility may be higher when the monopolist does not release any information. Consumers, however, suffer from negative expected gain-loss utility in both money and product dimension. If the loss aversion parameters are sufficiently large, we have $CS_f > CS_n$.

□ **A numerical example.** We consider a simple numerical example to illustrate our main result. Specifically, we examine the critical values of the loss aversion parameters and demonstrate how the monopolist's optimal advertising strategy reduces consumer surplus. Throughout, we assume that $a = 0$ and F is the uniform distribution on $[0, b]$.

Suppose the monopolist provides full match information. The optimal price is then $p_f^* = \frac{1}{2}b$, so that half of the consumer population purchases the product. Under optimal threshold match advertising, the monopolist serves the same consumers at price $p_t^* = \frac{1+\eta\lambda}{1+\eta}\frac{1}{2}b$ if λ is not too large. This is the case if for consumers with a good signal, there is no PE cutoff value other than $\frac{1}{2}b$, and inspecting the good is individually rational. The first constraint is satisfied if

$$p_t^* \leq p(\hat{r}|\Theta^x, s_H) \tag{16}$$

[13] Similarly, Proposition 3 fails to hold if the monopolist's production costs are large, so that the optimal price for the monopolist is above r^m.

for $x = \hat{r}_f^*$ and all $\hat{r} \in (\hat{r}_f^*, b]$. The second constraint is satisfied if the consumers' expected utility from inspecting the good is nonnegative. This expected utility can be calculated as

$$CS_t = \frac{1}{2}(b + p_f^*) - p_t^* - \frac{1}{6}\eta(\lambda - 1)(b - p_f^*), \tag{17}$$

where the first two terms capture consumption utility and the third term represents gain-loss utility. We insert p_f^* and p_t^* to get the participation constraint $CS_t \geq 0$. It is equivalent to

$$\left[\frac{3}{4} - \frac{1 + \eta\lambda}{2(1 + \eta)} - \frac{1}{12}\eta(\lambda - 1)\right] b \geq 0. \tag{18}$$

We can show that this inequality implies the constraint in (16) and thus characterizes the set of critical loss aversion parameters for optimal threshold match advertising. For example, if $\eta = 1$ ($\eta = \frac{1}{2}$), it is rational for the consumer to inspect the good whenever $\lambda \leq \frac{7}{4}$ ($\lambda \leq \frac{11}{5}$).

From the left-hand side of (18), we can read off the consumers' surplus under the different advertising strategies. If the monopolist chooses full match information, loss aversion does not matter (so we can set $\eta = 0$), and the consumers' expected utility equals $\frac{1}{4}b$. If the monopolist chooses optimal threshold match advertising, the consumers' surplus is reduced by an increased price and the disutility from uncertainty. The former effect is captured by the second term in the squared brackets of (18) and the latter effect by the third term.

Does the model admit empirically relevant values of η and λ? Unfortunately, there exists no empirical study so far that estimates both parameters simultaneously. However, in many applications it is assumed that $\eta = 1$, so we will use this value in the following. We can then get an estimate of the attachment effect $\frac{1+\eta\lambda}{1+\eta}$ from empirical studies that measure for certain goods both the willingness to accept (*WTA*) and the willingness to pay (*WTP*). In our framework, if the consumer derives intrinsic value r from a good and expects to own it, one has to pay $\frac{1+\eta\lambda}{1+\eta}r$ to this consumer in order to buy the good from her. This is our *WTA*. Conversely, if the consumer does now own the good and does not expect to get it, she purchases the good if the price is at most $\frac{1+\eta}{1+\eta\lambda}r$. This is our *WTP*. In a recent meta-analysis of the *WTA*/*WTP* disparity, Tunçel and Hammitt (2014) find that for ordinary private goods, the average *WTA*/*WTP* ratio equals 1.63 (this value is the geometric mean of the *WTA*/*WTP* ratios from 28 different studies). We substitute $WTP = \frac{1+\eta}{1+\eta\lambda}r$ into $WTA = \frac{1+\eta\lambda}{1+\eta}r$ and get $\frac{1+\eta\lambda}{1+\eta} = \sqrt{\frac{WTA}{WTP}}$. Hence, a *WTA*/*WTP* ratio of 1.63 translates into $\frac{1+\eta\lambda}{1+\eta} = 1.28$. Assuming $\eta = 1$, this implies $\lambda = 1.56$, so that (18) is satisfied. We conclude that our model is applicable for empirically relevant degrees of loss aversion.

5. Robustness

■ We made a number of implicit assumptions in our setup that deserve discussion. In this section, we first study the role of price advertising in our model and show that the commitment assumption is not essential for our results. Then, we demonstrate that our results remain the same if consumers are forced to inspect the good. Finally, we analyze how the market outcome changes when some consumers know their match value.

□ **Price advertising.** So far, we have assumed that the monopolist announces (and commits to) its price p in period 0. In the following, we show that this assumption can be made without loss of generality.

Suppose the monopolist can choose whether to announce its price in period 0 or not. If it does, consumers learn p in period 0. If it does not, consumers only learn p when they inspect the good. To capture this change, we update the setting and our equilibrium definition. The monopolist chooses the ITM Θ, price p, and whether or not it advertises the price in period 0, $a \in \{Y, N\}$, where $a = Y$ represents price advertising and $a = N$ no price advertising. Upon observing ITM Θ and action a, consumers update their price expectation to $E(p|\Theta, a)$. Their plan $\hat{r}(\Theta, s, E(p|\Theta, a))$ is a PPE as defined in Section 3. We assume the same tie-breaking rules.

A (pure-strategy) equilibrium of the price-advertising game is an ITM Θ^*, price $p^*(\Theta)$, action $a^*(\Theta)$, consumer expectations $E^*(p|\Theta, a)$, and plan $\hat{r}(\Theta, s, E^*(p|\Theta, a))$, so that

(i) $E^*(p|\Theta, a) = p^*(\Theta)$ if $a = Y$ or if some consumers inspect the good upon observing Θ and $a = N$;
(ii) for any Θ, the choices $p^*(\Theta)$ and $a^*(\Theta)$ maximize the monopolist's profit given the consumers' plan $\hat{r}(\Theta, s, E^*(p|\Theta, a))$; and
(iii) given $p^*(\Theta)$, $a^*(\Theta)$ and $\hat{r}(\Theta, s, E^*(p|\Theta, a))$, Θ^* maximizes the monopolist's profit.

Consider the case where the monopolist does not advertise its price. For a given advertising strategy and given price expectations, it may have an incentive to surprise consumers with an unexpectedly high price. To illustrate, assume that the monopolist chooses full match advertising and consumers expect some price $p < b$. Then, all consumers with types $r \geq p$ inspect the good and plan to purchase it with certainty. If such a consumer unexpectedly encounters price $p' > p$, her utility from purchasing the good is

$$r - p' - \eta\lambda(p' - p), \tag{19}$$

whereas her utility from not purchasing it is

$$\eta p - \eta\lambda r. \tag{20}$$

Thus, if the consumer purchases the good, she suffers from the unexpected additional expense, $p' - p$; but if she refuses to trade, she suffers from the unexpected loss in the product dimension, r. All consumers with types $r \geq p$ trade with the monopolist if

$$p' \leq \left[1 + \frac{\eta(\lambda - 1)}{1 + \eta\lambda}\right] p. \tag{21}$$

Therefore, the monopolist can increase its price above the expected level without losing any consumer. Such surprises, of course, cannot occur in equilibrium. Consumers' price expectations must be correct in any equilibrium in which at least some of them inspect the good. We get the following result.

Proposition 4. If Θ^+, p^+ is an equilibrium outcome in the original game, Θ^+, p^+, $a = Y$ is an equilibrium outcome in the price-advertising game. Also, if Θ^+, p^+, $a \in \{Y, N\}$ is an equilibrium outcome in the price-advertising game, Θ^+, p^+ is an equilibrium outcome in the original game.

The first statement in Proposition 4 implies that our results from the previous section hold even if we allow the monopolist to hide its price in period 0. Suppose that ITM Θ^+ and price p^+ are optimal for the monopolist when it is forced to announce its price in period 0. In the new setting, if it does not advertise its price, then for any Θ, we can set consumers' price expectations $E^*(p|\Theta, N)$ large enough so that it is rational for all consumers not to inspect the good.[14] This deters any deviation to no price advertising. Given that the monopolist advertises its price, deviations from ITM Θ^+ and price p^+ cannot be profitable. Hence, Θ^+, p^+, $a = Y$ is an equilibrium outcome in the price-advertising game.

The second statement in Proposition 4 implies that there does not exist an equilibrium in which the monopolist gains from hiding its price. However, there can be equilibria in which the monopolist does not advertise its price. If it adopts the optimal threshold ITM Θ^x with $x = \hat{r}^*_f$, it has no incentive to deviate from the expected price $p^*_t = \frac{1+\eta\lambda}{1+\eta} p^*_f$ after choosing no price advertising (we show this in the Appendix).[15] Intuitively, this is because this ITM fully

[14] It is not essential for our argument to choose such extreme out-of-equilibrium beliefs for all ITMs. However, one has to choose such beliefs for ITMs where the monopolist has an incentive to charge a price that exceeds the expected price (as in the example above).

[15] This also implies that our main result remains valid if the monopolist cannot commit to a price.

exploits the consumers' attachment: the marginal consumer experiences negative consumption utility and therefore is willing to change her plans if the price exceeds its expected level. The monopolist cannot profitably charge a higher price than p_t^*. Thus, if λ is not too large for given η, there exists an equilibrium in which the monopolist chooses the optimal threshold ITM Θ^x and does not advertise price p_t^*.[16]

□ **Forced inspection.** We assumed that consumers can choose whether to inspect the product or not. Not inspecting the good is always a credible plan, as it ends the game for the consumer (there is no purchase decision). This option protects consumers against potentially exploitative marketing strategies, as it forces the monopolist to choose an ITM and a price so that each consumer who inspects the good gets an expected utility of at least zero. We now show that this constraint can be binding.

Suppose the consumer has to inspect the good, that is, she learns her true match value even if she does not want to purchase it. Such an assumption may be reasonable if the good is presented in a location that the consumer visits on a regular basis (e.g., a supermarket or shopping mall). It is straightforward to extend the model to this case. We only have to assume that $\hat{r}(\Theta, s, p) \in \mathbb{R}_0^+$ for each ITM Θ, signal $s \in S_\Theta$, and price p, that is, option "N" is no longer available. All other definitions remain unchanged.

The scope for our results increases if consumers are forced to inspect the good. Recall that there are two reasons why for given η the loss aversion parameter λ must not be too large for threshold match advertising to be optimal. First, under the ITM Θ^x with $x = \hat{r}_f^*$, there is no credible cutoff value above $\hat{r}_f^*$ after observing the good signal if λ is small enough; and second, the consumers' expected utility is nonnegative whenever λ is sufficiently small. If consumers have to inspect the good, the latter requirement on λ can be ignored. Hence, Lemma 1, as well as Propositions 1 and 3, are valid for a (weakly) larger range of loss aversion parameters.

We can use our numerical example to show that for some distributions F, the range of loss aversion parameters for threshold match advertising to be optimal strictly increases. Assume again that F is the uniform distribution on the interval $[0, b]$. If consumers are forced to inspect the good, the monopolist only has to make sure that there is no PE cutoff value $\hat{r} \in (r_f^*, b]$ that yields them a higher expected utility than from always trading. One can show that $p(\hat{r}|\Theta^x, s_H)$ is concave for all loss aversion parameters. Hence, we only have to rule out that "do not buy, regardless of the match value" is a credible plan, which is the case if

$$p_t^* = \frac{1+\eta\lambda}{1+\eta}\frac{1}{2}b \leq \frac{1+\eta}{1+\eta\lambda}b = p(b|\Theta^x, s_H). \tag{22}$$

This inequality characterizes the set of critical loss aversion parameters for optimal threshold match advertising when consumers are forced to inspect the good. If $\eta = 1$ ($\eta = \frac{1}{2}$), the monopolist can fully exploit the consumers' loss aversion whenever $\lambda \leq 1.82$ ($\lambda \leq 2.24$). Thus, there is an open set of loss aversion parameters for which the only credible plan after observing the good signal is "buy always," and the expected utility from this plan is negative.

There is an important intuition behind this result. For the consumer, the two plans "do not inspect the good" and "inspect the good, but never buy it" are not equivalent. Although the first plan is always credible, the second plan may not be. In particular, if the price p is small enough, then not buying the good despite having a large match value close to b is not credible. Formally, this is the case when $p < p(b|\Theta, s)$. If this inequality holds, a rational consumer cannot plan to inspect the good but never to purchase it after observing ITM Θ and signal s. Yet, the best credible plan for the consumer may yield her negative expected utility and therefore be strictly worse than

[16] An alternative marketing strategy would be to commit to a price distribution, that is, offer both sales and regular prices, as in Heidhues and Kőszegi (2014). Given the heterogeneity of consumer types in our model, the full analysis of this game is beyond the scope of this article. However, we conjecture that adding uncertainty in the money dimension creates no additional attachment effect when the monopolist already exploits the consumers' uncertainty in the product dimension.

the plan to never buy the good. The reason for this is that under this plan, the consumer suffers from the negative expected gain-loss utility in the product dimension and (potentially) from the fact that with positive probability she purchases the good, even if the price exceeds her match value.

The models in Heidhues and Kőszegi (2014) and Rosato (2016) build on this mechanism and assume forced inspection. For tractability reasons, both models assume that all consumers have the same type r. Thus, by choosing $p = r$, the monopolist can fully extract the consumers' surplus even without applying marketing strategies that exploit loss aversion. Yet, in their models, the monopolist can increase its profit even further by creating attachment effects, which implies a negative consumer surplus. The key difference in our model is that we assume a heterogeneous consumer population. Hence, under full match information, consumer surplus is strictly positive at the monopolist's price p_f^*. Using threshold advertising, the monopolist can extract this surplus without violating the consumers' individual rationality constraint.

□ **Informed consumers.** We have assumed that initially all consumers have incomplete information about their match value. The monopolist then can alter their expectations in a way that increases demand for its product. In this subsection, we assume that there is a share of "informed consumers" who know exactly their match value so that advertising has no effect on them. Let α be the share of these consumers. For the remaining share $1 - \alpha$ of "uninformed" consumers, the monopolist chooses an optimal advertising strategy so that the profit (as a function of the price) becomes

$$\pi_t(p, \alpha) = (1 - \alpha)\left[1 - F\left(\frac{1 + \eta}{1 + \eta\lambda} p\right)\right] p + \alpha[1 - F(p)]p, \tag{23}$$

whenever for given η the parameter λ is not too large. Recall that the optimal price for uninformed consumers is p_t^*, which is strictly larger than the optimal price for informed consumers p_f^*. Hence, the optimal price converges to p_f^* as the share of informed consumers α approaches unity.[17] As under optimal advertising, uninformed consumers are more likely to purchase the good, the monopolist's profit strictly decreases in α. The implication is that the markup should increase in the share of uninformed consumers.

This prediction differs from what would happen in the inspection cost model of Anderson and Renault (2006). In this model, the highest profit the firm can earn is the monopolistic profit. There is a threshold $\bar{c}$ so that the firm earns the monopolistic profit if inspection costs c are below $\bar{c}$, and both profit and price decrease in c if $c > \bar{c}$. Introducing informed consumers who know their match value and do not incur search costs has no effect on the market outcome if $c \leq \bar{c}$, and strictly increases the firm's profit if $c > \bar{c}$.

There is some empirical evidence that the prices of advertised products decrease in consumer experience. Thomas, Shane, and Weigelt (1998) examine data from the US automobile market. They find that firms that introduce a high quality good initially set their price above the full information price, and that over time, this price decreases to the full information level. Similarly, Horstmann and MacDonald (2003) find that prices for compact disc players declined in relation to the length the product is on the market. These patterns are consistent with the advertising model that is based on loss aversion, but not with the inspection cost model.

6. Conclusion

■ In this article, we examine the persuasive effects of product information. To this end, we combine Anderson and Renault's (2006) model of informative advertising, and Kőszegi and Rabin's (2006, 2007) framework of expectation-based loss aversion. The optimal advertising strategy for the monopolist is to disclose enough product information so that a fraction of

[17] One can show that if F is convex, the optimal price strictly decreases in α; see the Appendix for details.

consumers plan to purchase the product with certainty, but also to keep these consumers sufficiently uninformed about their individual match values so that some of them purchase the product, even if its price exceeds their intrinsic valuation. These consumers engage in *ex ante* inefficient trade in order to avoid the psychological costs from leaving the monopolist's store empty-handed. We also show that the monopolist can exploit this attachment effect, even if it can only choose between full and no match advertising. In this case, it would provide no product information, and thereby increase its profit above the full information profit level. Naturally, such advertising practices reduce consumer surplus in most cases. Disclosure policies that force firms to display vital product information in each piece of promotional material may therefore increase consumer surplus.

Future research may address two important issues not discussed in this article. First, we assume highly rational consumers who fully understand the informational content of the monopolist's advertisements and can perfectly anticipate their future behavior. The persuasive effect of informative advertising may be even stronger if consumers are partially naive so that some outcomes—match values or prices—are unexpected. Our main result can therefore be interpreted as a lower bound on the persuasive effect of informative advertising. The assumption of partial naivete may uncover new strategies to persuade consumers through incomplete product information.

Second, we focus on a monopolistic setup. When there is competition among firms that advertise their products, the order in which firms reach consumers may influence their market power. In particular, the firm that affects consumers' plans and expectations may first gain a competitive advantage. Analyzing a richer competitive setting may thus provide new insights regarding consumer persuasion.

Appendix

Formal definition of information transmission mechanisms. An ITM Θ with signal set S_Θ is a probability space $([a, b] \times S_\Theta, \beta([a, b]) \times H_\Theta, P)$ where $\beta([a, b]$ is the σ-field of Borel sets in $[a, b]$, H_Θ is a σ-field of subsets of S_Θ, and P is a probability measure over $[a, b] \times S_\Theta$ so that the marginal probability satisfies $P(r \leq \tilde{r}) = F(\tilde{r})$ for all $\tilde{r} \in [a, b]$. □

Proof of Lemma 1. Given the arguments provided in the text, it remains to show that if λ is not too large for given η, then in the PPE $\hat{r}(\Theta^x, s_H, p) = \frac{1+\eta}{1+\eta\lambda} p$, that is, when consumers observe signal s_H, they always purchase it. The PE definition implies that

$$\frac{1 + \eta\lambda - \eta(\lambda - 1)F(\hat{r}(\Theta^x, p, s_H)|\Theta^x, s_H)}{1 + \eta + \eta(\lambda - 1)F(\hat{r}(\Theta^x, p, s_H)|\Theta^x, s_H)}\hat{r}(\Theta^x, p, s_H) = p. \tag{A1}$$

Recall that

$$p(\hat{r}|\Theta^x, s_H) = \frac{1 + \eta\lambda - \eta(\lambda - 1)F(\hat{r}|\Theta^x, s_H)}{1 + \eta + \eta(\lambda - 1)F(\hat{r}|\Theta^x, s_H)}\hat{r}. \tag{A2}$$

If $\hat{r}$ equals the smallest possible type that can occur after observing s_H, $\hat{r} = \frac{1+\eta}{1+\eta\lambda} p$, we have $F(\hat{r}|\Theta^x, s_H) = 0$, so that $p(\hat{r}|\Theta^x, s_H) = p$. Hence, $\hat{r}(\Theta^x, s_H, p) = \frac{1+\eta}{1+\eta\lambda} p$ if (i) there is no other PE cutoff value $\hat{r} \in (\frac{1+\eta}{1+\eta\lambda} p, b]$, and (ii) the utility from always buying after observing s_H is nonnegative. To prove (i), we differentiate $p(\hat{r}|\Theta^x, s_H)$. Define $A(\hat{r}) = 1 + \eta\lambda - \eta(\lambda - 1)F(\hat{r}|\Theta^x, s_H)$, $B(\hat{r}) = 1 + \eta + \eta(\lambda - 1)F(\hat{r}|\Theta^x, s_H)$, and $f^{max} = \max_{r \in [a,b]} f(r)$. Then, we have

$$\begin{aligned} \frac{dp(\hat{r}|\Theta^x, s_H)}{d\hat{r}} &= \frac{A(\hat{r})}{B(\hat{r})} - \frac{\eta(\lambda - 1)f(\hat{r}|\Theta^x, s_H)(2 + \eta + \eta\lambda)\hat{r}}{B(\hat{r})^2} \\ &\geq \frac{1 + \eta}{1 + \eta\lambda} - \frac{\eta(\lambda - 1)f^{max}(2 + \eta + \eta\lambda)b}{(1 + \eta)^2}. \end{aligned} \tag{A3}$$

Hence, if λ is not too large, $p(\hat{r}|\Theta^x, s_H)$ strictly increases for all $\hat{r} \in (\frac{1+\eta}{1+\eta\lambda} p, b]$, which proves (i). To prove (ii), we calculate the period-0 expected utility EU from always buying after observing signal s_H. It is given by

$$EU = \int_{\frac{1+\eta}{1+\eta\lambda} p}^{b} r dF(r|\Theta^x, s_H) - p - \eta(\lambda - 1)\int_{\frac{1+\eta}{1+\eta\lambda} p}^{b} \int_{r}^{b} (\tilde{r} - r) dF(\tilde{r}|\Theta^x, s_H) dF(r|\Theta^x, s_H). \tag{A4}$$

Hence, we get

$$\lim_{\lambda \to 1} EU = \int_p^b r dF(r|\Theta^x, s_H) - p > 0, \tag{A5}$$

where the last inequality follows from the fact that F is continuous and strictly increasing. Hence, if λ is not too large, always buying after signal s_H is the unique PE. This completes the proof. □

Proof of Proposition 2. Let η, λ be given. We construct an ITM Θ^* so that if the monopolist chooses this ITM and price p_f^*, its profit exceeds $\pi_f(\hat{r}_f^*)$. Let ε be a small, positive number. We specify that Θ^* pools consumers with match values from the interval $[b-\varepsilon, b]$ and the share $\Delta \in (0,1)$ of consumers with match values from the interval $[\hat{r}_f^* - \varepsilon, \hat{r}_f^*)$, that is, both groups of consumers observe signal s_H. All remaining consumers with types from the interval $[a, \hat{r}_f^*)$ observe signal s_L. All consumers with types from the interval $[\hat{r}_f^*, b-\varepsilon)$ observe type-specific signals, so that they learn their true match value. These consumers always purchase the good after observing Θ^*, their type-specific signal and price p_f^*. We show that if ε is sufficiently small and Δ is sufficiently small relative to ε, the PPE specifies that consumers always purchase the good after observing Θ^*, s_H, and price p_f^*. By construction, total demand then exceeds $1 - F(\hat{r}_f^*)$, which implies the result. A lower bound on expected utility in period 0 from always buying after observing s_H is given by

$$\begin{aligned}
&\frac{[1-F(b-\varepsilon)](b-\varepsilon) + \Delta[F(\hat{r}_f^*) - F(\hat{r}_f^* - \varepsilon)](\hat{r}_f^* - \varepsilon)}{[1-F(b-\varepsilon)] + \Delta[F(\hat{r}_f^*) - F(\hat{r}_f^* - \varepsilon)]} - p_f^* \\
&- \eta\lambda \frac{1-F(b-\varepsilon)}{[1-F(b-\varepsilon)] + \Delta[F(\hat{r}_f^*) - F(\hat{r}_f^* - \varepsilon)]}\varepsilon \\
&- \eta\lambda \frac{\Delta[F(\hat{r}_f^*) - F(\hat{r}_f^* - \varepsilon)]}{[1-F(b-\varepsilon)] + \Delta[F(\hat{r}_f^*) - F(\hat{r}_f^* - \varepsilon)]}(b - p_f^* + \varepsilon).
\end{aligned} \tag{A6}$$

The first line is a lower bound on consumption utility, whereas the second two lines constitute a lower bound on gain-loss utility. Note that if $r \in [b-\varepsilon, b]$, the largest possible loss is ε; and if $r \in [\hat{r}_f^* - \varepsilon, \hat{r}_f^*)$, the largest possible loss is $b - p_f^* + \varepsilon$. Observe that for $\Delta \to 0$, the lower bound converges to $b - \varepsilon - p_f^* - \eta\lambda\varepsilon$, which in turn converges to $b - p_f^* > 0$ for $\varepsilon \to 0$. By continuity, if ε is sufficiently small and Δ is sufficiently small relative to ε, expected utility from always buying after signal s_H is strictly positive. It remains to rule out that the PPE cutoff value $\hat{r}(\Theta^*, s_H, p_f^*)$ lies above $\hat{r}_f^*$). Denote by r_H^m the median of the distribution $F(r|\Theta^*, s_H)$. Note that $r_H^m \in (b-\varepsilon, b)$ if Δ is sufficiently small relative to ε. Without loss of generality, we therefore assume that $r_H^m \in (b-\varepsilon, b)$. In the following, we show that if ε is sufficiently small and Δ is sufficiently small relative to ε, then (i) there is no PE cutoff in $(\hat{r}_f^* - \varepsilon, b-\varepsilon)$, (ii) there is no PE cutoff in $[b-\varepsilon, r_H^m]$, and (iii) any PE cutoff value in (r_H^m, ∞) is not a PPE cutoff value. To show (i), note that for each $\hat{r} \in (\hat{r}_f^* - \varepsilon, b-\varepsilon)$, we have

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$$\lim_{\Delta \to 0} p(\hat{r}|\Theta^*, s_H) = \frac{1+\eta\lambda}{1+\eta}\hat{r}, \tag{A7}$$

which strictly exceeds p_f^* if ε is sufficiently small. To show (ii), note that for each $\hat{r} \in [b-\varepsilon, r_H^m]$, we have $p(\hat{r}|\Theta^*, s_H) \geq b - \varepsilon$, which exceeds p_f^* if ε is sufficiently small. To show (iii), note that the expected utility from a PE cutoff value (r_H^m, ∞) is less than $\frac{1}{2}(b - p_f^*)$, and thus strictly smaller than the term in (A6) if ε is sufficiently small and Δ is sufficiently small relative to ε. This completes the proof. □

Proof of Proposition 3. Let η be given. Suppose the monopolist chooses no match information. Let $\hat{r}$ be the consumers' cutoff value after observing this advertising strategy. It is implicitly defined by $p(\hat{r}|\Theta^n, s_n) = p$. In the following, we abbreviate $p(\hat{r}|\Theta^n, s_n) = p_n(\hat{r})$. The monopolist's profit as a function of the cutoff value is given by $\pi_n(\hat{r}) = [1 - F(\hat{r})]p_n(\hat{r})$. We show that $p_n(\hat{r})$ is strictly increasing and concave on $[a, b]$ if λ is not too large. Define $A(\hat{r}) = 1 + \eta\lambda - \eta(\lambda - 1)F(\hat{r})$ and $B(\hat{r}) = 1 + \eta + \eta(\lambda - 1)F(\hat{r})$. Then, we can calculate

$$\frac{dp_n(\hat{r})}{d\hat{r}} = \frac{A(\hat{r})}{B(\hat{r})} - \eta(\lambda - 1)(2 + \eta + \eta\lambda)\frac{f(\hat{r})\hat{r}}{B(\hat{r})^2} \tag{A8}$$

and

$$\frac{d^2 p_n(\hat{r})}{d\hat{r}^2} = -\frac{\eta(\lambda - 1)(2 + \eta + \eta\lambda)}{B(\hat{r})^2}\left[2f(\hat{r}) + f'(\hat{r})\hat{r} - \frac{2\eta(\lambda - 1)f(\hat{r})^2\hat{r}}{B(\hat{r})}\right]. \tag{A9}$$

Thus, if λ is not too large, we have $\frac{dp_n(\hat{r})}{d\hat{r}} > 0$ and $\frac{d^2 p_n(\hat{r})}{d\hat{r}^2} \leq 0$ at all values $\hat{r} \in [a, b]$. We now can show that the monopolist earns strictly more under no match than under full match advertising if $\hat{r}_f^* \leq r^m$ and λ is not too large. Note that $p_n(r^m) = p_f(r^m)$ and hence $\pi_n(r^m) = \pi_f(r^m)$. Further note that $p_n(a) = \frac{1+\eta\lambda}{1+\eta}a > a = p_f(a)$. Recall that $p_n(\hat{r})$ is concave if λ is not too large. In this case, we have $p_n(\hat{r}) > p_f(\hat{r})$ for all $\hat{r} \in [a, r^m)$, which proves the claim whenever $r_f^* \in [a, r^m)$. Suppose that $\hat{r}_f^* = r^m$. Note that $\frac{dp_n(\hat{r})}{d\hat{r}} < 1$ at $\hat{r} = r^m$. Hence, from the first-order condition $\frac{d\pi_f(\hat{r})}{d\hat{r}} = 0$ at $\hat{r} = r^m$, it follows that $\frac{d\pi_n(\hat{r})}{d\hat{r}} < 0$ at $\hat{r} = r^m$. As $\pi_n(r^m) = \pi_f(r^m)$, we get $\pi_n(\hat{r}_n^*) > \pi_f(r^m)$ for some $\hat{r}_n^* < r^m$, which completes the proof of the claim. Proposition 3 then follows from the fact that inspection with a cutoff at some $\hat{r}_n^*$ in the case of no match advertising with price $p_n(\hat{r}_n^*)$ is the PPE if λ is not too large. □

Mathematical details from "constrained information disclosure." We show that $\hat{r}_f^* \leq r^m$ if F is convex. The monopolist's profit as a function of the cutoff value $\hat{r}$ is

$$\pi_f(\hat{r}) = [1 - F(\hat{r})]p_f(\hat{r}). \tag{A10}$$

This function is strictly concave so there is a unique optimal cutoff value. Note that

$$\frac{d\pi_f(\hat{r})}{d\hat{r}} = -f(\hat{r})\hat{r} + 1 - F(\hat{r}). \tag{A11}$$

We show that this expression is nonpositive at $\hat{r} = r^m$. We distinguish between two cases. First, assume that $f(r^m) \geq \frac{1}{b-a}$. As F is convex, we also have $r^m \geq \frac{1}{2}a + \frac{1}{2}b$ and thus $f(r^m)r^m \geq \frac{1}{2}$, which shows the claim for this case. Next, assume that $f(r^m) < \frac{1}{b-a}$. As F is convex, we have $f(r^m) = \frac{1}{\xi(b-a)}$ for some $\xi \in (1, 2)$ and $r^m \geq a + \frac{1}{2}\xi(b-a)$. We therefore get

$$f(r^m)r^m \geq \frac{1}{\xi(b-a)}\left[a + \frac{1}{2}\xi(b-a)\right] \geq \frac{1}{2}, \tag{A12}$$

which proves the claim. Hence, we must have $\hat{r}_f^* \leq r^m$. □

Proof of Proposition 4. The proof of the first statement is in the text. To prove the second statement, we show that in any equilibrium of the price-advertising game, the monopolist is either indifferent between advertising the price or not, or it strictly prefers price advertising to no price advertising. Suppose there is a pure-strategy equilibrium with $a^*(\Theta^*) = N$ in which the monopolist's profit is strictly larger than if it chooses $a(\Theta^*) = Y$. By the equilibrium conditions (ii) and (iii), there must be some consumers who inspect the good; otherwise, its profit is zero and it would do better to choose full match advertising, $p = p_f^*$ and $a = Y$. By condition (i), all consumers therefore correctly anticipate the price so that $\hat{r}(\Theta^*, s, E^*(p|\Theta^*, N)) = \hat{r}(\Theta^*, s, p^*(\Theta^*))$ for any signal $s \in S_{\Theta^*}$. Hence, the monopolist is indifferent between advertising or not advertising the price, a contradiction. □

Mathematical details from "price advertising." We show that under optimal threshold match advertising, there is no incentive to deviate from the expected price $p_t^* = \frac{1+\eta\lambda}{1+\eta}p_f^*$. Suppose that the monopolist chooses ITM Θ^x with $x = \hat{r}_f^*$ and deviates from the expected price p_t^* to $p' > p_t^*$. Then, for a consumer with type $r > \hat{r}_f^*$, the utility from purchasing the good is

$$r - p' - \eta\lambda(p' - p_t^*) - \eta\int_{\hat{r}_f^*}^{r}(\tilde{r} - r)dF(\tilde{r}|\Theta^x, s_H) - \eta\lambda\int_{r}^{b}(\tilde{r} - r)dF(\tilde{r}|\Theta^x, s_H), \tag{A13}$$

whereas her utility from not purchasing the good is

$$\eta p_t^* - \eta\lambda\int_{\hat{r}_f^*}^{r}\tilde{r}dF(\tilde{r}|\Theta^x, s_H) - \eta\lambda\int_{r}^{b}\tilde{r}dF(\tilde{r}|\Theta^x, s_H). \tag{A14}$$

The new cutoff value r is thus defined by

$$[1 + \eta F(r|\Theta^x, s_H) + \eta\lambda(1 - F(r|\Theta^x, s_H))]r + \eta(\lambda - 1)\int_{\hat{r}_f^*}^{r}\tilde{r}dF(\tilde{r}|\Theta^x, s_H) = (1 + \eta\lambda)p' + \eta(\lambda - 1)p_t^*. \tag{A15}$$

Denote by $r(p')$ the cutoff as a function of the deviation price. Implicit differentiation yields us

$$\frac{dr}{dp'} = \frac{1 + \eta\lambda}{1 + \eta F(r|\Theta^x, s_H) + \eta\lambda(1 - F(r|\Theta^x, s_H))}, \tag{A16}$$

which is strictly larger than 1 whenever $r > \hat{r}_f^*$. The monopolist's profit (as a function of the price) for $p' > p_t^*$ then is

$$\pi(p') = [1 - F(r(p'))]p'. \tag{A17}$$

The first-order condition shows that for any $p' > p_t^*$ we have

$$\frac{d\pi(p')}{dp'} = 1 - F(r(p')) - f(r(p'))\frac{dr(p')}{dp'}p' < 1 - F(\hat{r}_f^*) - f(\hat{r}_f^*)\hat{r}_f^* = 0. \tag{A18}$$

Thus, there is no incentive to deviate from the expected price p_t^*. □

Mathematical details from "informed consumers." We show that if F is convex, the optimal price strictly decreases in α. The first-order condition for the optimal price p_t^α is

$$\frac{d\pi_t(p,\alpha)}{dp} = (1-\alpha)\left[1 - F\left(\frac{1+\eta}{1+\eta\lambda}p\right) - f\left(\frac{1+\eta}{1+\eta\lambda}p\right)\frac{1+\eta}{1+\eta\lambda}p\right] + \alpha\left[1 - F(p) - f(p)p\right] = 0. \tag{A19}$$

Using implicit differentiation, we get

$$\frac{dp_t^\alpha}{d\alpha} = -\frac{F(p_t^\alpha) + f(p_t^\alpha)p_t^\alpha - F(\beta p_t^\alpha) - f(\beta p_t^\alpha)\beta p_t^\alpha}{(1-\alpha)\left[2f(\beta p_t^\alpha)\beta + f'(\beta p_t^\alpha)\beta^2 p_t^\alpha\right] + \alpha\left[2f(p_t^\alpha) + f'(p_t^\alpha)p_t^\alpha\right]}, \tag{A20}$$

where we abbreviate $\beta = \frac{1+\eta}{1+\eta\lambda}$. As $\beta < 1$ and F is convex, $\frac{dp_t^\alpha}{d\alpha}$ is strictly negative. □

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