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Pricing and Information Disclosure in Markets With Loss-Averse Consumers

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Abstract

We develop a theory of imperfect competition with loss-averse consumers. All consumers are fully informed about match value and price at the time they make their purchasing decision. However, a share of consumers are initially uncertain about their tastes and form a reference point consisting of an expected match value and an expected price distribution, while other consumers are perfectly informed all the time. We derive pricing implications in duopoly with asymmetric firms. In particular, we show that a market may exhibit more price variation the larger the share of uninformed, loss-averse consumers. We also derive implications for firm strategy and public policy concerning firms' incentives to inform consumers about their match value prior to forming their reference point.

Keywords: Loss Aversion, Reference-Dependent Utility, Information Disclosure, Price Variation, Advertising, Behavioral Industrial Organization, Imperfect Competition, Product Differentiation
JEL Classification: D83, L13, L41, M37.

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1 Introduction

Consumer information about price and match value of products is a key determinant of market outcomes. Previous work has emphasized the role of consumer information at the moment of purchase.[1] If consumers are loss-averse, information prior to the moment of purchase matters: Product information plays an important role at the stage at which loss-averse consumers form expectations about future transactions.

In this paper, we develop a theory of imperfect competition to investigate the competitive effects of consumer loss aversion. Our theory applies to inspection goods, with the feature that consumers readily observe prices in the market but have to inspect products before knowing the *match value*—i.e., the fit between product characteristics and consumer tastes. As we argue below, this applies to a number of product categories and, thus, is important for understanding market interaction.

Loss aversion in consumer choice has been widely documented in a variety of laboratory and field settings, starting with Kahneman and Tversky (1979). Loss-averse consumers have to form expectations about product performance. Following Koszegi and Rabin (2006), we postulate that, to make their consumption choices, loss-averse consumers form their probabilistic reference point based on expected future transactions, which are confirmed in equilibrium. Here, a consumer's reference point is her probabilistic belief about the relevant consumption outcome held between the time she first focuses on the decision determining the consumption plan—i.e., when she heard about the products, was informed about the prices for the products on offer, and formed her expectations—and the moment she actually makes the purchase.[2]

We distinguish between "informed" and "uninformed" consumers at the moment consumers form their reference point. Informed consumers know their taste ex ante and will perfectly foresee their equilibrium utility from product characteristics. Therefore, they will not face a loss or gain in product satisfaction beyond their intrinsic valuation.

Uninformed consumers, by contrast, are uncertain about their ideal product characteristic: They form expectations about the difference between ideal and actual product characteristic which will serve as a reference point when evaluating a product along its match value

[1] See, e.g., Varian (1980), Janssen and Moraga-González (2004), and Armstrong and Chen (2009).

[2] For evidence that expectation-based counterfactuals can affect the individual's reaction to outcomes, see Blinder, Canetti, Lebow, and Rudd (1998), Medvec, Madey, and Gilovich (1995), and Mellers, Schwartz, and Ritov (1999). Koszegi and Rabin (2006) and Koszegi and Rabin (2007) have developed the general theory of expectation-based reference points and the notion of personal equilibrium.

dimension. They will also face a gain or a loss relative to their expected distributions of price after learning the taste realization. Since all consumers become fully informed before making their purchasing decision, we isolate the effect of consumer loss aversion on consumption choices and abstract from the effects of differential information at the moment of purchase.[3]

Consumers are loss-averse with respect to prices and match value and have rational expectations about equilibrium outcomes to form their reference point, as in Heidhues and Koszegi (2008). Firms are possibly asymmetric due to deterministic cost differences—this is common knowledge among the firms when the game starts.[4] They compete in prices for differentiated products. Consumers observe equilibrium prices before forming their reference point. Thus, firms can use price as an expectation-management tool. If firms set different prices, uninformed consumers will face either a loss or a gain in the price dimension, depending on whether they buy the more- or less-expensive product. Hence, an (ex ante) uninformed consumer's realized net utility depends not only on the price of the product she buys, but also on the price of the product she does not buy.

A key modeling assumption is that a share of consumers are initially uninformed. These consumers form expectations *before* knowing their match value attributed to a particular product, but *after* learning the prices of the products. This timing with respect to information release and reference point formation appears to be the appropriate modeling choice. This is true, in particular, if price information is provided at the moment consumers become aware of the existence of products, but in which match value is difficult to evaluate without closer inspection.

Let us provide some examples. First, prices of clothing and electronic devices are easily accessible (and are often advertised) in advance while, for inexperienced consumers, the match quality between product and personal tastes is impossible or difficult to evaluate before actually seeing or touching the product. A related example is high-end stereo equipment, including speakers. Price tags are immediately observed, but it may take several visits to the shop (on appointment) or even trials at home to figure out the match value of the different products under consideration—for example, because people differ with respect to the sound they like and how the system sounds in their home.[5]

[3]Our model can be interpreted alternatively as one in which consumers know their ideal taste ex ante, but are exposed to uncertainty about product characteristics when they form their reference point.

[4]In the extension section, we show that our analysis can also be applied to products of different qualities.

[5]Note that in this market segment the retailer typically charges the recommended retail price. Thus, equipment makers effectively set the retail price.

Second, price information on products sold over the internet—for example, digital cameras or CDs of a particular classical concert—is immediately available, while match value is often determined only after listening to some of the material provided online or after studying the product details on the product's web page. Finally, competing services such as long-distance bus rides and flights are differentiated by departure times. Here, consumers are perfectly aware of the product characteristics ex ante—i.e., price and departure time—but learn their preference concerning their ideal point of departure only at some later stage (after forming their probabilistic reference point, but before purchase).

In this paper, we focus on implications of consumer loss aversion on pricing strategies and information disclosure. Our companion paper, Karle and Peitz (2009), provides a detailed account of competitive effects in symmetric oligopoly.

Our first main result is that, in asymmetric markets (and with equal weights assigned to the price and the match value dimension), price variation is larger than in a market without loss-averse consumers (or, equivalently, only ex ante informed consumers).

Our second main result is that, in asymmetric markets, loss aversion—or, more precisely, the presence of more ex ante uninformed, loss-averse consumers—may lead to lower prices. Hence, the standard result that more informed consumers (or more consumers without a behavioral bias) lead to lower prices is challenged in our model when firms are strongly asymmetric, while it holds in symmetric and moderately asymmetric markets. The driving force behind this result is that loss aversion in the price dimension has a pro-competitive effect, while the effect of loss aversion in the taste dimension is anti-competitive. The pro-competitive effect dominates the anti-competitive effect if the size of loss aversion in the price dimension becomes sufficiently large—this is caused by strong cost asymmetries. In those markets, uninformed consumers are reluctant to buy the expensive product and, instead, accept a large reduction in match value when buying the low-price product.

Our paper contributes to the understanding of the effect of consumer loss aversion in market environments and is complementary to Heidhues and Koszegi (2008) and Karle and Peitz (2009).[6] Also, Zhou (2008) considers competitive effects in a model with consumer loss aversion. However, in his paper, consumers do not base reference points on expectations but on past choices. A contribution of our paper is to show that consumer loss aversion increases competition, compared to a setting in which consumers are not subject to this behavioral bias, in strongly asymmetric markets and relaxes it in moderately asymmetric markets.

[6] Our companion paper considers a generalized oligopoly model that abstracts from market asymmetries.

In our modeling effort, we followed Heidhues and Koszegi (2008). Our framework, however, has notable differences to theirs: First, consumers and firms know the market environment; in particular, firms know the actual (asymmetric) cost realizations, whereas in Heidhues and Koszegi (2008), costs are private information. Second, consumers learn posted prices before they form their reference points, whereas in Heidhues and Koszegi (2008), consumers form their reference points before knowing posted prices. Thus, in contrast to Heidhues and Koszegi (2008), in our model, firms can use price to manage consumer expectations. In addition, our model delivers *unique* equilibrium predictions. Our model is enriched by considering heterogeneous consumers who differ according to their knowledge of their preferences when they form their (probabilistic) reference point. Our model delivers novel results. In particular, we show that the price difference between the two products *increases* in the share of uninformed loss-averse consumers, while Heidhues and Koszegi (2008) obtained focal pricing as a consequence of the presence of loss aversion in the population. In other words, in our setting, the behavioral bias increases the observed price difference, whereas in Heidhues and Koszegi (2008), the price variation between asymmetric firms disappears.[7]

More broadly, our paper contributes to the analysis of behavioral biases in market settings, as in Eliaz and Spiegler (2006), Gabaix and Laibson (2006), and Grubb (2009). An important issue in our paper, as in Eliaz and Spiegler (2006), is the comparative statics effects in the composition of the population. In their model this composition effect is behavioral in the sense that the share of consumers with a behavioral bias changes. We do not need to resort to this interpretation, although our analysis is compatible with it: We allow the composition effect to be informational in the sense that the arrival of information in the consumer population is changed (while the whole population is subject to the same behavioral bias).

The informational interpretation lends itself naturally to addressing questions about the effect of early information disclosure to additional consumers. We analyze information disclosure policies by firms and public authorities in the context of our behavioral industrial-organization framework. Thus, we demonstrate the possible use of behavioral models to

[7]Recent empirical work that tracks prices of a large set of products over time in the U.S. economy finds that firms frequently change prices and that price changes are usually big in absolute terms, although many are much smaller; even for individual items, price durations and absolute price changes were found to vary considerably over time (see Klenow and Kryvtsov (2008)). We conclude from this that Heidhues and Koszegi's (2008) theoretical explanation of price stickiness conflicts with observed pricing behavior for a broad set of products. In particular, small price changes as a result of small cost changes are difficult to reconcile with the focal price argument in Heidhues and Koszegi (2008). By contrast, our framework with loss-averse consumers does not feature price stickiness when embedded in a dynamic model in which costs are newly drawn each period.

address policy questions in industrial organization. As stated above, our model has the feature that, absent a behavioral bias, information disclosure policies are meaningless. Thus, to address these issues, the behavioral bias is essential to our model. In particular, we show that private and social incentives to disclose information at an early stage are not aligned. We also show that the more efficient (and, thus, larger) firm discloses information if firms have conflicting interests.

Our analysis contributes to the literature on the economics of advertising (see Bagwell (2007) for an excellent survey). It uncovers the role of advertising as consumer expectation management. Note that at the point of purchase, consumers are fully informed, so that there is no role for informative advertising. However, since consumers are loss-averse, informing consumers about their match value makes these consumers informed in our terminology. Advertising, thus, can remove the uncertainty consumers face when forming their reference point. This form of advertising can be seen as a hybrid form of informative and persuasive advertising because it changes preferences at the point of purchase—this corresponds to the persuasive view of advertising—albeit due to information that is received ex ante—this corresponds to the informative view of advertising. It also points to the importance of the timing of advertising: For expectation management, it is important to inform consumers early on.[8]

Our paper also complements the work on consumer search in product markets (see, e.g., Varian (1980), Anderson and Renault (2000), Janssen and Moraga-González (2004), Armstrong and Chen (2009)). Whereas that literature focuses on the effect of differential information (and consumer search) at the purchasing stage, our paper abstracts from this issue and focuses on the effect of differential information at the expectation-formation stage which is relevant if consumers are loss-averse. Finally, our paper complements the large literature on imperfect competition in differentiated product markets by analyzing the competitive effects of consumer loss aversion.

The plan of the paper is as follows. In Section 2, we present the model. Here, we determine the demand of uninformed consumers. In Section 3, we characterize the duopoly equilibrium. In the accompanying Appendix B, we establish equilibrium uniqueness and equilibrium existence. Our existence proof requires us to bound the parameters of our

[8]Other marketing activities can also be understood as making consumers informed at the stage when they form their reference point. For instance, test drives for cars or lending out furniture, stereo equipment, and the like make consumers informed early on. Arguably, in reality, uncertainty may not be fully resolved even at the purchasing stage. However, to focus our minds, we only consider the role of marketing activities on expectation formation before purchase. In short, in our model firms may use marketing to manage expectations of loss-averse consumers at an early stage. For a complementary view, see Bar-Isaac, Caruana, and Cunat (2010).

model—in particular, the two firms cannot be too asymmetric for equilibrium existence to hold. In section 4, we analyze the impact of the degree of cost asymmetry on equilibrium outcomes. In Section 5, we establish comparative statics results with respect to the share of ex ante informed consumers. In Section 6, we provide two model extensions: We allow for different weights in the gain-loss utility and for different product qualities. Section 7 concludes. Most of the proofs are relegated to Appendix A. Results on equilibrium existence and uniqueness are provided in Appendix B. Additional tables with numerical results are contained in Appendix C.

2 The Model

2.1 Setup

Consider a market with two, possibly asymmetric firms, A and B, and a continuum of loss-averse consumers of mass 1. Firm $i = A, B$ incurs a constant marginal cost of production c_i. The firms' asymmetry consists of a difference in the marginal cost of production. The more efficient firm is labeled to be firm A—i.e., $c_A \leq c_B$. Firms are located on a circle of length 2 with maximum distance, $y_A = 0$, $y_B = 1$. Firms announce prices p_A and p_B to all consumers.

Consumers of mass one are uniformly distributed on the circle of length 2. A consumer's location x, $x \in [0, 2)$, represents her taste parameter. Her taste is initially—i.e., before she forms her reference point—known only to herself if she belongs to the set of informed consumers.

In our model, consumers' differential information applies to the date at which consumers determine their reference point and not to the date of purchase: A fraction $(1 - \beta)$ of loss-averse consumers, $0 \leq \beta \leq 1$, is initially uninformed about their taste. As will be detailed below, they endogenously determine their reference point and then, before making their purchasing decision, observe their taste parameter (which is private information of each consumer). At the moment of purchase all consumers are perfectly informed about product characteristics, prices, and tastes.

All consumers have the same reservation value v for an ideal variety and have unit demand. Their utility from not buying is $-\infty$ so that the market is fully covered.

A remark about our modeling choice is in order: We could alternatively work with the Hotelling line. Our circle model is, in terms of market outcomes, equivalent to the

Hotelling model in which consumers are uniformly distributed on the $[0,1]$-interval and firms are located at the extreme points of the interval. However, the circle model allows for an alternative and equivalent interpretation about the type of information some consumers initially lack: At the point in time consumers form their reference point distribution, they all know their taste parameters, but only a fraction $(1-\beta)$ does not know the location of the high- and the low-cost firm. These uninformed consumers only know that the two firms are located at maximal distance and that one is a high- whereas the other is a low-cost firm.

To determine the market demand faced by the two firms, let the informed consumer type in $[0,1]$, who is indifferent between buying good A and good B, be denoted by $\hat{x}_{in}(p_A, p_B)$. Correspondingly, the indifferent uninformed consumer is denoted by $\hat{x}_{un}(p_A, p_B)$. Since market shares on $[0,1]$ and $[1,2]$ are symmetric, the firms' profits are:

$$\pi_A(p_A, p_B) = (p_A - c_A)[\beta \cdot \hat{x}_{in}(p_A, p_B) + (1-\beta) \cdot \hat{x}_{un}(p_A, p_B)]$$
$$\pi_B(p_A, p_B) = (p_B - c_B)[\beta \cdot (1 - \hat{x}_{in}(p_A, p_B)) + (1-\beta) \cdot (1 - \hat{x}_{un}(p_A, p_B))].$$

The timing of events is as follows. Before the game starts marginal costs (c_A, c_B) realize and become common knowledge among firms.[9]

Stage 1.) *Price setting stage:* Firms simultaneously set prices (p_A, p_B).

Stage 2.) *Reference point formation stage:* All consumers observe prices and

a) informed consumers observe their taste x (for them uncertainty is resolved),

b) uninformed consumers form reference point distributions over purchase price and match value (as detailed in Subsection 2.3 below.)

Stage 3.) *Inspection stage:* Uninformed consumers observe their taste x—i.e., uncertainty is resolved for **all** consumers.

Stage 4.) *Purchasing stage:* Consumers decide which product to buy:

a) Informed consumers make rational purchase decisions;

b) (ex ante) uninformed consumers make rational purchase decisions, based on their utility that includes realized gains and losses relative to their reference point distribution.

[9] As mentioned above, without loss of generality, we consider realizations $c_A \leq c_B$.

We solve for subgame perfect Nash equilibrium where firms foresee that uninformed consumers play a personal equilibrium at stage 2b. Personal equilibrium in our context simply means that consumers hold rational expectation about their final purchasing decision—for the general formalization, see Koszegi and Rabin (2006).

2.2 Demand of informed consumers

Informed consumers ex ante observe prices and their taste parameter and, therefore, do not face any uncertainty when forming their reference point. Hence, their behavior is the same as in the standard Hotelling-Salop model. For prices p_A and p_B, an informed consumer located at x obtains the indirect utility $u_i(x, p_i) = v - t|y_i - x| - p_i$ from buying product i, where t scales the disutility from distance between ideal and actual taste on the circle. The expression $v - t|y_i - x|$ then captures the match value of product i for a consumer of type x. Denote the indifferent (informed) consumer between buying from firm A and B on the first half of the circle by $\hat{x}_{in} \in [0, 1]$. The informed indifferent consumer is

$$\hat{x}_{in}(p_A, p_B) = \frac{(t + p_B - p_A)}{2t}. \tag{1}$$

Symmetrically, a second indifferent (informed) consumer type is located at $2 - \hat{x}_{in}(p_A, p_B) \in [1, 2]$. Without loss of generality, we focus on demand of consumers between 0 and 1 and multiply by 2. We note that cost differences influence the location of indifferent consumers via prices.[10]

2.3 Demand of uninformed consumers

Uninformed consumers do not know their ideal taste x ex ante and, thus, are ex ante uncertain as to which product they will buy after they have learnt their ideal taste x: They, therefore, face ex ante uncertainty in the price and match value dimension and form reference point distributions in these two dimensions.

Three properties of consumer behavior are worthwhile pointing out. First, consumers have gains or losses not about net utilities but about each product "characteristic", where price is then treated as a product characteristic. This is in line with much of the experimental evidence on the endowment effect—for a discussion, see, for instance, Koszegi

[10] E.g., if there are only informed consumers, $\hat{x}_{in} = 1/2 + (c_B - c_A)/(6t)$ in equilibrium . This is closer to B for $c_B > c_A$: The low-cost firm serves a larger market share.

and Rabin (2006). Second, consumers evaluate gains and losses *across* products.[11] This appears to be a natural property for consumers facing a discrete choice problem: They have to compare the merits of the two products to each other. In other words, consumers view the purchasing decision with respect to these two problems as a single decision problem. Third, to reduce the number of parameters, we assume that the gain/loss parameters are the same across dimensions. This appears to be the natural benchmark—again we refer to our companion paper, Karle and Peitz (2009), for an analysis under alternative assumptions.

While our setting is related to Heidhues and Koszegi (2008), our model has three distinguishing features. First, firms' cost realizations are common knowledge among firms. This property is in line with a large part of the industrial organization literature on imperfect competition and is approximately satisfied in markets in which firms are well-informed not only about their own costs but also about their relative position in the market. Second, prices are already set before consumers form their reference point. This property applies to markets in which consumers are from the start well-informed about the actual price distribution they face in the market. This holds in markets in which firms inform consumers about prices (but consumers are initially uncertain about the match value and thus their eventual purchasing decision) or in which prices are publicly posted.[12] Third, a fraction of $(1-\beta)$ of uninformed consumers face uncertainty about their ideal taste x, whereas a fraction of β informed consumers know their ideal taste ex ante. Various justifications for differential information at the ex ante stage can be given. Consumers differ by their experience concerning the relevant product feature. Alternatively, a share of consumers know that they will be subject to a taste shock between forming their reference point and making their purchasing decision. These consumers then do not condition their reference point on the ex ante taste parameter, whereas those belonging to the remaining share do.

Consider an uninformed consumer who will learn that she is located at x after her ideal taste is realized. Suppose firms set prices p_A and p_B. Then the uninformed consumer will buy from firm A if she is located close enough to firm A—i.e., if $x \in [0, \hat{x}_{un}(p_A, p_B)] \cup [2 - \hat{x}_{un}(p_A, p_B), 2]$, where $\hat{x}_{un}(p_A, p_B)$ is the location of the indifferent (uninformed) consumer we want to characterize. Hence, the uninformed consumer at x will pay p_A in equilibrium

[11] Gains and losses also matter in the price dimension because, even though prices are deterministic, they can be different across firms. Hence, a consumer who initially does not know her taste parameter is uncertain at this point in time about the price at which she will buy.

[12] This is particularly appropriate in market environments in which price information has been provided from the outset, while uninformed (or inexperienced) consumers observe the match value only when physically or virtually inspecting the product. We refer back to the introduction for further illustration.

with $Prob[x < \hat{x}_{un}(p_A, p_B) \vee x > 2 - \hat{x}_{un}(p_A, p_B)]$ and p_B with $Prob[\hat{x}_{un}(p_A, p_B) < x < 2 - \hat{x}_{un}(p_A, p_B)]$. Since x is uniformly distributed on $[0, 2]$, we obtain that $Prob[x < \hat{x}_{un}(p_A, p_B) \vee x > 2 - \hat{x}_{un}(p_A, p_B)] = \hat{x}_{un}(p_A, p_B)$—i.e., from an ex ante perspective p_A is the relevant price with probability $\text{Prob}[p = p_A] = \hat{x}_{un}$. Correspondingly, the purchase at price p_B occurs with probability $\text{Prob}[p = p_B] = 1 - \hat{x}_{un}$. Thus, the reference point distribution with respect to the purchase price p is discrete and can be expressed by the cumulative distribution function

$$F(p) = \begin{cases} \hat{x}_{un} & \text{if } p \in [p_A, p_B) \\ 1 & \text{if } p \geq p_B. \end{cases}$$

The reference point distribution with respect to the match value refers to the reservation value v minus the distance between ideal and actual product variety, $s \in [0, 1]$, times the taste parameter t. The distribution of the distance is denoted by $G(s) = Prob(|x - y_\sigma| \leq s)$, where the location of the firm is $y_\sigma \in \{0, 1\}$, and the consumer x's purchase strategy in personal equilibrium for given prices is $\sigma \in \arg\max_{j \in \{A,B\}} u_j(x, p_j, p_{-j})$.[13]

Let us restrict attention to the case $\hat{x}_{un} \geq 1/2$—i.e., firm A has a weakly larger market share than firm B also for uninformed consumers. Since some uninformed consumers will not buy from their nearest firm, $G(s)$ is kinked. This kink is determined by the maximum distance $|x - y_B|$ that consumers are willing to accept buying the more expensive product B, $s = 1 - \hat{x}_{un}$ because $s \leq 1 - \hat{x}_{un}$ holds for consumers close to either A or B, while $s > 1 - \hat{x}_{un}$ only holds for the more distant consumers of A. Hence, the distribution of s is

$$G(s) = \begin{cases} 2s & \text{if } s \in [0, 1 - \hat{x}_{un}] \\ s + (1 - \hat{x}_{un}) & \text{if } s \in (1 - \hat{x}_{un}, \hat{x}_{un}] \\ 1 & \text{otherwise.} \end{cases}$$

Note that if the indifferent uninformed consumer is located in the center between A and B, $\hat{x}_{un} = 1/2$, the expected distance between ideal and actual product taste, $\mathbb{E}[s]$, is minimized and equal to $1/4$.

Following Koszegi and Rabin (2006), after uncertainty is resolved consumers experience

[13] σ is a function of prices and consumer's location x conditional on consumer's expectation about equilibrium outcomes which are incorporated in their two-dimensional reference point distribution. σ states a consumer's personal equilibrium. This equilibrium concept was introduced by Koszegi and Rabin (2006) and requires that behavior-generating expectations must be self-fulfilling in equilibrium.

a gain-loss utility: The reference distribution is split up for each dimension at the value of realization in a loss part with weight $\lambda \geq 1$ and a gain part with weight 1. In the loss part the realized value is compared to the lower tail of the reference distribution; in the gain part it is compared to the upper tail of the reference distribution. This reflects widespread experimental evidence that losses are evaluated more negatively than gains.

The indirect utility of an uninformed consumer $x \in (1 - \hat{x}_{un}, 1]$ purchasing of product A is given by [14]

$$\begin{aligned} u_A(x, p_A, p_B) \quad =& (v - tx - p_A) - \lambda \cdot \text{Prob}[p = p_A](p_A - p_A) + \text{Prob}[p = p_B](p_B - p_A) \\ & - \lambda \cdot t \int_0^x (x - s) dG(s) + t \int_x^1 (s - x) dG(s). \end{aligned} \tag{2}$$

The first term is the consumer's intrinsic utility from product A. The second term is the loss in the price dimension from not facing a lower price than p_A. This term is equal to zero because p_A is the lowest price offered in the market place. The third term is the gain from not facing a higher price than p_A, which is positive. The last two terms correspond to the loss (gain) from not facing a smaller (larger) distance in the taste dimension than x. Analogously, an uninformed consumer's indirect utility from a purchase of product B is given by

$$\begin{aligned} u_B(x, p_A, p_B) \quad =& \underbrace{v - t(1 - x) - p_B}_{\text{Intrinsic utility}} \underbrace{-\lambda \cdot \text{Prob}[p = p_A](p_B - p_A)}_{\text{Loss from facing a higher } p \text{ than } p_A} \\ & \underbrace{-\lambda \cdot t \int_0^{1-x} ((1 - x) - s) dG(s)}_{\text{Loss due to expecting smaller distance than } 1-x} + \underbrace{t \int_{1-x}^1 (s - (1 - x)) dG(s)}_{\text{Gain due to expecting larger distance than } 1-x} \end{aligned} \tag{3}$$

This allows us to explicitly solve a consumer's personal equilibrium by determining the location of the indifferent uninformed consumer $\hat{x}_{un}$.

Lemma 1. *Suppose that $\hat{x}_{un} \in [1/2, 1)$. Then $\hat{x}_{un}$ is given by*

$$\hat{x}_{un}(\Delta p) \qquad = \frac{\lambda}{(\lambda - 1)} - \frac{\Delta p}{4t} - \underbrace{\sqrt{\frac{\Delta p^2}{16t^2} - \frac{(\lambda + 2)}{2t(\lambda - 1)} \Delta p + \frac{(\lambda + 1)^2}{4(\lambda - 1)^2}}}_{\equiv S(\Delta p)}. \tag{4}$$

[14]The indifferent uninformed consumer will be located at $x = \hat{x}_{un}$, therefore $(1 - \hat{x}_{un}, 1]$ is the relevant interval for determining $\hat{x}_{un}$.

where $\Delta p \equiv p_B - p_A$.[15]

We relegate the proof of this lemma to Appendix A.1. The square root, $S(\Delta p)$, is defined for $\Delta p \in [0, \Delta\bar{p}]$ with

$$\Delta\bar{p} \equiv \frac{2t}{(\lambda-1)}\Big(2(\lambda+2) - \sqrt{(2(\lambda+2))^2 - (\lambda+1)^2}\Big), \tag{5}$$

which is strictly positive for all $\lambda > 1$. It can be shown that for $\lambda \geq 3 + 2\sqrt{5} \approx 7.47$, the indifferent consumer satisfies $\hat{x}_{un}(\Delta p) \in [1/2, 1]$ for all admissible price differences, $\Delta p \in [0, \Delta\bar{p}]$. If the degree of loss aversion is smaller, $\lambda < 3 + 2\sqrt{5}$, $\hat{x}_{un}(\Delta\bar{p})$ rises above one. Therefore, we have to define another upper bound on the price difference, $\Delta\tilde{p}$, with $\Delta\tilde{p} < \Delta\bar{p}$ by the solution to $\hat{x}_{un}(\Delta\tilde{p}) = 1$. We can solve explicitly,

$$\Delta\tilde{p} = \frac{(\lambda+3)t}{2(\lambda+1)}. \tag{6}$$

Thus, the upper bound for the price difference (which depends on the parameters t and λ) for which $\hat{x}_{un}$ is given by equation (4) is:

$$\Delta p^{max} \equiv \begin{cases} \Delta\tilde{p}, & \text{if } 1 < \lambda \leq \lambda^c; \\ \Delta\bar{p}, & \text{if } \lambda > \lambda^c. \end{cases} \tag{7}$$

with $\lambda^c \equiv 3 + 2\sqrt{5} \approx 7.47$.[16]

2.4 Properties of demand of uninformed consumers

In this subsection, we establish a number of properties of demand of uninformed consumers and compare them to those of the demand of informed consumers—i.e., we compare $\hat{x}_{un}(\Delta p)$ and $\hat{x}_{in}(\Delta p)$ with one another.

The first property is a continuity property. For $\lambda \to 1$, the indirect utility function of uninformed consumers differs from the one of informed consumers only by a constant.

[15]For $x \in [0, 1]$, a consumer's personal equilibrium is described by

$$\sigma(x, \Delta p) = \begin{cases} A & \text{if } x \in [0, \hat{x}_{un}(\Delta p)], \\ B & \text{if } x \in (\hat{x}_{un}(\Delta p), 1]. \end{cases}$$

[16]Note that $\Delta\tilde{p} \in [t \cdot (\sqrt{5}-1)/2, t) \approx [0.618t, t)$ for $1 < \lambda \leq \lambda^c$ and $\Delta\bar{p} \in (t \cdot 2(\sqrt{3}-2), t \cdot (\sqrt{5}-1)/2) \approx (0.536t, 0.618t)$ for $\lambda > \lambda^c$.

Equation (17) collapses to a linear equation and we obtain $\hat{x}_{un}(\Delta p) = \hat{x}_{in}(\Delta p)$ as a solution in this case.[17]

The next properties refer to the sensitivity of demand with respect to price. The first derivative of $\hat{x}_{in}(\Delta p)$ with respect to Δp is equal to $1/(2t)$ for all Δp.

Remark 1. *Evaluated at $\Delta p = 0$, demand of ex ante uninformed consumers reacts less price sensitive than demand of ex ante informed consumers.*

This can be seen as follows: The derivative of $\hat{x}_{un}(\Delta p)$ with respect to Δp,

$$\hat{x}'_{un}(\Delta p) = -\frac{1}{4t} - \frac{1}{2 \cdot S(\Delta p)} \cdot \Big(\frac{\Delta p}{8t^2} - \frac{(\lambda+2)}{2t(\lambda-1)}\Big),$$

is strictly positive for all $\Delta p \in [0, \Delta p^{max}]$. Evaluated at $\Delta p = 0$, we obtain

$$\hat{x}'_{un}(0) = -\frac{1}{4t} + \frac{(\lambda+2)}{2t(\lambda+1)}.$$

Thus, $\hat{x}'_{un}(0)$ is approaching $1/(2t)$ from below for $\lambda \to 1$ and $1/(4t)$ from above for $\lambda \to \infty$.

Moreover, $\hat{x}_{un}(\Delta p)$ is strictly convex for all $\Delta p \in [0, \Delta p^{max}]$, as illustrated in Figure 1.

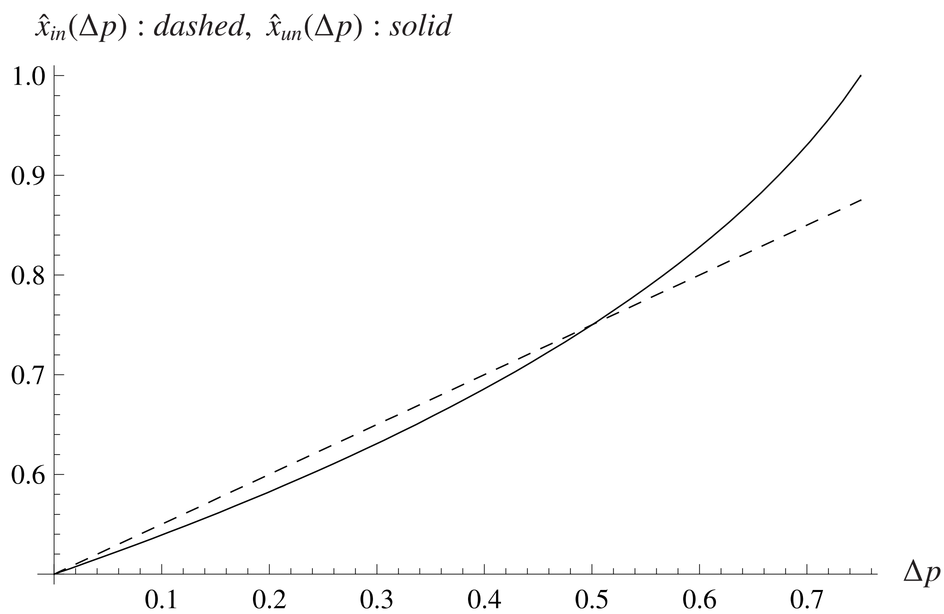
$$\hat{x}''_{un}(\Delta p) = \frac{(3+\lambda)(5+3\lambda)}{64t^2 \cdot (S(\Delta p))^3} > 0$$

We note that the degree of convexity of $\hat{x}_{un}(\Delta p)$ is strictly increasing in λ.

Evaluated at large price differences, the property concerning the price sensitivity, is reversed: For $\Delta p \to \Delta\bar{p}$ the square root, $S(\Delta p)$, turns to zero and $\hat{x}'_{un}(\Delta p)$ turns to infinity. Thus, $\hat{x}'_{un}(\Delta\bar{p}) > \hat{x}'_{in}(\Delta\bar{p}) = 1/(2t)$. Demand of uninformed consumers, evaluated at a large price difference, reacts more sensitive to an increase in the price difference than the demand of informed consumers. (This property is satisfied if the indifferent consumer at this price difference is strictly interior; otherwise some more care is needed, as is done in Section 4.)

Since $\hat{x}'_{in}(\Delta p)$ is constant and $\hat{x}'_{un}(\Delta p)$ continuous and monotone (with the required boundary properties), applying the mean value theorem, there exists a unique intermediate price

[17] Thus, reference-dependence without loss aversion does not cause deviations from standard consumer behavior in this setup. The continuity property holds in our specification where the gain-loss utility in the price and in the match value dimension enter with equal weights. It does not hold for different weights, see Karle and Peitz (2009)



Location of the indifferent informed and uninformed consumer (= demand of firm A) as a function of Δp for parameter values of $t = 1$ and $\lambda = 3$; $\Delta\bar{p} = 0.8348$, $\Delta\tilde{p} = 3/4$ and $\Delta\hat{p} = 0.2789$.

Figure 1: Demand of informed and uninformed consumers

difference $\Delta\hat{p} \in [0, \Delta\bar{p}]$ such that $\hat{x}'_{un}(\Delta\hat{p}) = \hat{x}'_{in}(\Delta\hat{p}) = 1/(2t)$. This critical price difference can be explicitly calculated as

$$\Delta\hat{p} = \frac{t\left(2\sqrt{2}\cdot(2(\lambda+2)) - 3\cdot\sqrt{(2(\lambda+2))^2 - (\lambda+1)^2}\right)}{\sqrt{2}(\lambda-1)},$$

which is strictly positive for all $\lambda > 1$ since $\Delta\hat{p}(\lambda = 1) = 0$ and $\Delta\hat{p}'(\lambda) > 0$.

Hence, we find the following:

Remark 2. *The demand of uninformed (or loss-averse) consumers is less price sensitive than the demand of informed consumers if the price difference is small, $\Delta p < \Delta\hat{p}$.*

The underlying intuition is that, for a small price difference, loss-averse consumers are harder to attract by price cuts because their gain from a lower price is outweighed by their loss in the taste dimension if they buy the other product. Thus, demand of loss-averse consumers reacts less sensitive to price in this range. For large price differences, however, their gain from lower prices starts to dominate their loss in the taste dimension if consumers switch to the cheaper producer.

Remark 3. *The demand of uninformed (or loss-averse) consumers is more price sensitive than the demand of informed consumers if the price difference is large, $\Delta p > \Delta\hat{p}$.*

In Section 4, we will see that this property is a driving force for our comparative static results in asymmetric markets.

3 Market Equilibrium

In this section, we characterize equilibrium candidates rearranging first-order conditions. In Appendix B, we provide conditions under which an interior equilibrium in the asymmetric duopoly exists and under which it is unique. We start by establishing some properties of market demand which will be needed below.

3.1 Properties of market demand

Using results from Section 2.4, we define the upper bound of firm A's demand of uninformed consumers as[18]

$$\hat{x}_{un}(\Delta p^{max}) \equiv \begin{cases} \hat{x}_{un}(\Delta \tilde{p}) = 1, & \text{if } 1 < \lambda \leq \lambda^c, \\ \hat{x}_{un}(\Delta \bar{p}) < 1, & \text{if } \lambda > \lambda^c. \end{cases} \tag{8}$$

Combining (1) and (4), we obtain the market demand of firm A as the weighted sum of the demand by informed and uninformed consumers,

$$\begin{aligned} q_A(\Delta p;\beta) &= \beta \cdot \hat{x}_{in}(\Delta p) + (1-\beta) \cdot \begin{cases} \hat{x}_{un}(\Delta p), & \text{if } 0 \leq \Delta p < \Delta p^{max} \\ 1, & \text{if } t \geq \Delta p \geq \Delta p^{max} \end{cases} \\ &= \begin{cases} \frac{1}{2} - \frac{1}{4t}(1-3\beta)\Delta p + (1-\beta)\frac{(\lambda+1)}{2(\lambda-1)} - (1-\beta)S(\Delta p), & \text{if } 0 \leq \Delta p < \Delta p^{max} \\ \beta \cdot \frac{t+\Delta p}{2t} + (1-\beta), & \text{if } t \geq \Delta p \geq \Delta p^{max} \end{cases} \\ &\equiv \begin{cases} \phi(\Delta p;\beta), & \text{if } 0 \leq \Delta p < \Delta p^{max} \\ \beta \cdot \frac{t+\Delta p}{2t} + (1-\beta), & \text{if } t \geq \Delta p \geq \Delta p^{max}. \end{cases} \end{aligned} \tag{9}$$

The demand of firm A is a function in the price difference Δp, which is kinked at Δp^{max}. Furthermore, it is discontinuous at Δp^{max} if $\Delta p^{max} = \Delta \bar{p}$. It approaches one for $\Delta p = t$.[19]

[18] $\hat{x}_{un}(\Delta \bar{p}) = \frac{\lambda}{\lambda-1} - \frac{2(\lambda+2)-\sqrt{4(\lambda+2)^2-(\lambda+1)^2}}{2(\lambda-1)} \in (\sqrt{3}/2, 1)$ for $\lambda > \lambda^c$—i.e., $\hat{x}_{un}(\Delta \bar{p})$ is less than one for $\lambda > \lambda^c$. This leads to a jump in demand of uninformed consumers at $\Delta \bar{p}$ from $\hat{x}_{un}(\Delta \bar{p})$ to one (see the definition of $q_A(\Delta p;\beta)$), since $\hat{x}'_{un}(\Delta p) \to \infty$ for $\Delta p \to \Delta \bar{p}$.

[19] At $\Delta p = t$, firm A serves also all distant informed consumers which are harder to attract than distant uninformed consumers because the former do not face a loss in the price dimension if buying from the more expensive firm B. For $\Delta p > t$ demand of firm A shows a second kink. We ignore this region since we are interested in cases in which both firms face strictly positive demand.

Firm B's demand is determined analogously by $q_B(\Delta p;\beta) = 1 - q_A(\Delta p;\beta)$. We focus on interior equilibria in which both products are purchased by a strictly positive share of uninformed consumers—i.e., Δp is lower than Δp^{max}. This holds in industries in which firms are not too asymmetric.

The derivative of the demand of A with respect to β expresses how demand changes as the share of ex ante informed consumers is increased. It is the difference between the demand of informed and uninformed consumers:

$$\frac{\partial\phi(\Delta p;\beta)}{\partial\beta} \equiv \phi_\beta = \hat{x}_{in}(\Delta p) - \hat{x}_{un}(\Delta p) = \frac{3}{4t}\Delta p - \frac{\lambda+1}{2(\lambda-1)} + S(\Delta p) \gtrless 0$$

with $\phi_\beta = 0$ at $\Delta p = 0$ and $\Delta p = t/2$. This derivative can be of positive or negative sign.

Lemma 2. *The demand of firm A, $q_A(\Delta p;\beta) = \phi(\Delta p;\beta)$, is strictly increasing and convex in Δp for $0 \leq \Delta p < \Delta p^{max}$.*

The proof is relegated to the appendix. In the remainder, we often refer to ϕ as a shorthand notation for $\phi(\Delta p;\beta)$. The derivative $\partial\phi/\partial p$ is denoted by ϕ'.

3.2 Equilibrium characterization

We next turn to the equilibrium characterization. At the first stage, firms foresee consumers' purchase decisions and set prices simultaneously to maximize profits. This yields first-order conditions

$$\frac{\partial\pi_i}{\partial p_i} = q_i + (p_i - c_i)\frac{\partial q_i}{\partial p_i} = 0 \quad ,i = A, B$$

If the solution has the feature that demand of each group of consumers, informed and uninformed, is strictly positive, first-order conditions can be written as

$$\frac{\partial\pi_A}{\partial p_A} = \phi - (p_A - c_A)\phi' = 0 \qquad (FOC_A)$$

$$\frac{\partial\pi_B}{\partial p_B} = (1-\phi) - (p_B - c_B)\phi' = 0. \qquad (FOC_B)$$

We refer to a solution characterized by these first-order conditions as an interior solution.

We will discuss the issue of sufficiency of first-order conditions as well as the issue of non-interior solutions and non-existence in Appendix B. Since the profit function of the low-cost firm is not quasi-concave we cannot use standard results to establish equilibrium existence. We now turn to the characterization of interior equilibria (p_A^*, p_B^*).

Lemma 3. *In an interior equilibrium with equilibrium prices* (p_A^*, p_B^*)*, the price difference* $\Delta p^* = p_B^* - p_A^*$ *satisfies*

$$\Delta p^* \quad = \quad \Delta c + f(\Delta p^*; \beta), \tag{10}$$

where $\Delta c = c_B - c_A$ *and* $f(\Delta p; \beta) = (1 - 2\phi)/\phi'$.

Proof. Combining (FOC_A) and (FOC_B) yields the required equilibrium condition as a function of price differences. □

Thus, (10) implicitly defines the equilibrium price difference Δp^* as a function of the parameters $\Delta c, \beta, \lambda$, and t, where the latter two parameters affect the functional form of f via ϕ.[20] For $\Delta c > 0$ it is not possible to obtain explicit analytical solutions, see Appendix C for numerical solutions at particular parameter values. Our companion paper, Karle and Peitz (2009), which focuses on symmetric oligopoly, reports the explicit analytical solution for the symmetric duopoly (i.e., the case $\Delta c = 0$).

4 Cost Asymmetries

In this section, we obtain a number of comparative statics results in the degree of cost asymmetry—i.e., the level of $\Delta c = c_B - c_A$.

Proposition 1. *The equilibrium price difference* $\Delta p^*(\Delta c, \beta)$ *is an increasing function of the cost asymmetry between firms* Δc*. Moreover, the price difference reacts more sensitive to* Δc *than in a market in which all consumers are informed ex ante,* $d(\Delta p^*)/d(\Delta c) \geq 1/3$.

The proofs of the propositions of this subsection are relegated to Appendix A.

This result says that the more pronounced the cost asymmetry the larger the price difference between high-cost and low-cost firm. This result shows that standard comparative statics result with respect to cost difference are qualitatively robust to consumers being

[20] Anderson and Renault (2009) face an, at first glance, similar fixed point problem as in (10). They consider a general differentiated product Bertrand duopoly with covered markets in which asymmetries arise due to quality differences between firms. The authors show uniqueness and existence of a pure-strategy price equilibrium under the assumption of strict log-concavity of firms' demand. Although strict log-concavity allows for some convexity of demand, in our setup this property is not met since for large price differences the convexity of the low-price firm's demand rises above any bound—i.e., $\phi'' \to \infty$ for $\Delta p \to \Delta\bar{p}$.

loss averse. However, in our model the marginal effect of an increase in cost differences on price variation is stronger if some consumers are loss averse—recall that a market in which all consumers are informed is observationally equivalent to the standard Hotelling case. Our model thus predicts exacerbated price variation in markets with uninformed loss-averse consumers.[21] We find price variation at an increasing rate in our model. Intuitively, the more efficient firm (firm A) is tempted to use consumer expectation management to increase its market share: Announcing a very low price ex ante makes loss-averse consumers more reluctant than rational consumers to buy from the less efficient firm (firm B) later on.

We next take a look at the individual prices set by the two firms. For comparative statics we use markups $m_i^* \equiv p_i^* - c_i$, $i \in \{A, B\}$ instead of prices because markups are net of individual costs and depend solely on cost differences.[22] Alternatively, we could use individual prices and consider a change of the rival's costs only.

First, we observe that the low-cost firm's markup may be increasing or decreasing, depending on the cost difference Δc and the share of uninformed consumers in the market.

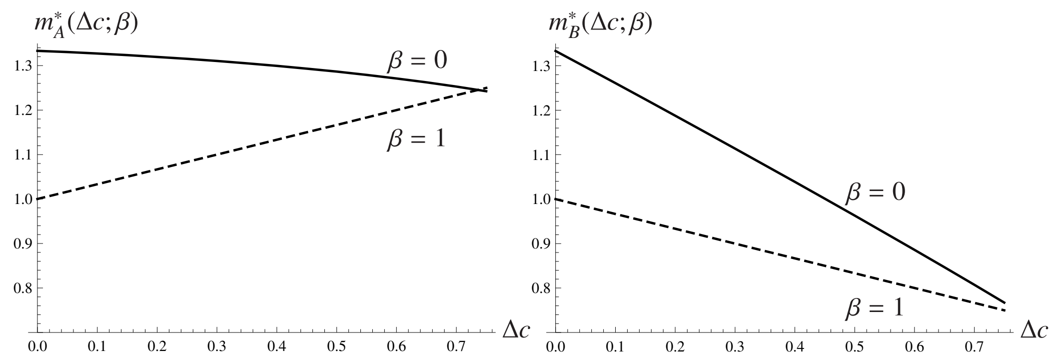
Proposition 2. *For $\beta < 1$ and $\lambda > 1$, the equilibrium markup charged by the low-cost firm $m_A^*(\Delta c) \equiv p_A^*(\Delta c, c_A) - c_A$ is either first increasing and then decreasing in the cost difference if the share of informed consumers β is high, or globally decreasing if β is sufficiently low. For $\beta = 1$ or $\lambda \to 1$, $m_A^*(\Delta c)$ is increasing in the cost difference.*

In the latter case—i.e., for $\beta = 1$ or $\lambda \to 1$—when all consumers are informed or the behavioral bias vanishes we obtain the standard Hotelling result that the low-cost firm faces a larger markup in more asymmetric markets.

While in the standard Hotelling world without behavioral biases ($\beta = 1$) the markup of the more efficient firm is increasing in the cost difference, the proposition shows that a local increase of the cost difference may have the reverse effect under consumer loss aversion ($\beta < 1$, $\lambda > 1$). This holds true in strongly asymmetric markets: The price sensitivity of demand is larger than in the standard Hotelling world due to the dominating loss in

[21] This is different in spirit to Heidhues and Koszegi (2008) who found that price variation is reduced in markets with loss-averse consumers. In Heidhues and Koszegi (2008) consumers do not observe prices before forming their two-dimensional reference point distribution. Firms therefore can deviate from consumers expectations about prices. This creates a discontinuity in consumers' gain-loss utility and yields to a kinked demand curve at the expected price. The kinked demand curve leads to price rigidities for some cost interval and a multiplicity of equilibria. See also Section 3.5 in our companion paper Karle and Peitz (2009).

[22] This follows directly from firms' first-order conditions. Δc affects $p_i - c_i = \phi(\Delta p)/\phi'(\Delta p)$ via Δp.



Equilibrium markups of firm A and B for markets in which either all consumers are uninformed ($\beta = 0$) or informed (=benchmark case, $\beta = 1$) as a function of cost differences Δc for parameter values of $t = 1$ and $\lambda = 3$: $\Delta c^{nd}(\beta = 0) = 0.75963$.

Figure 2: Equilibrium markup of both firms

the price dimension. We observe that, under very large cost differences, firm A's markup might fall below its level in the standard Hotelling world (compare Figure 2).

Second, we consider the markup of firm B.

Proposition 3. *The equilibrium markup charged by the high-cost firm* $m_B^*(\Delta c) \equiv p_B^*(\Delta c, c_B) - c_B$ *is decreasing in the cost difference.*

Note that, for $\beta = 1$, $dm_B^*/d(\Delta c)$ is equal to $-1/3$. As it turns out, the qualitative finding that the equilibrium markup of the high-cost firm is decreasing in the cost difference is preserved under consumer loss aversion. Due to a level effect of high markups we find that firm B's markup is decreasing more strongly than in the standard Hotelling world without behavioral bias. However, the critical market asymmetry for which firm B's markup drops below its Hotelling level has to be larger than for firm A. This is illustrated in Figure 2.

5 The Role of Information

In this section, we focus on comparative statics results with respect to β, the share of initially informed consumers. In other words, we investigate the effects of ex ante information disclosure on market outcomes in asymmetric markets. This allows us to provide a new perspective on information disclosure policies by public authorities and firms. In contrast to traditional work on information disclosure policies, in our theory consumers are fully informed at the moment of purchase, independent of whether or not there is any information disclosure. Our theory hints at the role of timing of information disclosure. With respect to voluntary disclosure, we provide new insights into the firms' advertising and marketing activities.

5.1 The effect of ex ante information on prices and quantities

Our first result concerns the equilibrium price difference. (The proofs to the results of this section are relegated to the Appendix.)

Proposition 4. *The equilibrium price difference $\Delta p^*(\beta)$ is decreasing in β.*

The above proposition says that prices become more equal as the share of initially informed consumers increases, or, in other words, as the population average becomes less loss-averse.

Put differently, a larger share of (uninformed) loss-averse consumers leads to a larger price difference. This is in stark contrast to one of the main findings in Heidhues and Koszegi (2008) who show that, in their setting, consumer loss aversion is a rationale for focal prices. In absence of the behavioral bias firms would condition prices on their marginal costs. Using our terminology, they compare a setting with mass 1 of uninformed consumers—i.e., $\beta = 0$, to a setting with mass 0 of uninformed consumers, which corresponds to a world without behavioral bias. Their message is that consumer loss aversion tends to lead to (more) equal prices; our finding, by contrast, says that consumer loss aversion leads to a larger price difference in a market with asymmetric firms.

Let us now look at the individual prices set by the two firms. Firms have to trade-off the business-stealing effect with the effect on the profit margin. This trade-off changes as the share of informed consumers is changed. We, first, observe that the low-cost firm's price is monotone (i.e., globally increasing or decreasing) or inverse U-shaped in β, depending on the parameter constellation.

Proposition 5. *The equilibrium price charged by the low-cost firm $p_A^*(\beta)$ may be increasing or decreasing in the share of informed consumers β: $p_A^*(\beta)$ is globally increasing, globally decreasing, or first increasing and then decreasing in β. It tends to be decreasing given a small cost difference and increasing given a large one.*

The critical price difference (that implies the critical cost difference) at which price locally does not respond to β (c.p. Δp—i.e., the partial effect) can be solved for analytically. The critical Δp is a function of λ and t and is independent of β:

$$\Delta p^{crit\,\partial p_A}(\lambda, t) \quad = \quad \frac{t}{4(3+5\lambda)}\left((9-(26-15\lambda)\lambda) + \sqrt{3}\cdot|-1+5\lambda|\sqrt{(2(\lambda+2))^2-(\lambda-1)^2}\right)$$

For example, for parameters $\lambda = 3$ and $t = 1$ the critical price difference, at which the price of the low-cost firm reaches its maximum, satisfies $\Delta p^{crit\,\partial p_A}(3, 1) = 0.2534$. It is also insightful to evaluate the derivative in the limit as β turns to 1. In this case, we can also solve analytically for a critical Δp at which the total derivative of p_A is zero—i.e., $\frac{dp_A^*(\Delta p^*(\beta);\beta)}{d\beta} = 0$:

$$\Delta p^{crit\, dp_A}(\lambda, t) \quad = \quad t\frac{3(\lambda(31\lambda + 42) - 41) - \sqrt{21} \cdot |7 - 11\lambda| \sqrt{(\lambda + 3)(3\lambda + 5)}}{2(\lambda - 3)(9\lambda - 1)} \quad \text{at } \beta = 1.$$

For example, $\Delta p^{crit\, dp_A}(3, 1) = 7/26 = 0.2692$ at $\beta = 1$. This means that, given parameters $\lambda = 3$ and $t = 1$, if the equilibrium price difference satisfies $\Delta p^*(1) < 0.2692$ a small decrease in the share of informed consumers leads to a higher price of the more efficient firm, $dp_A^*/d\beta < 0$—the numerical results reported in Tables 2 and 3 in Appendix C illustrate this result. By contrast, for $\Delta p^*(1) > 0.2692$, the opposite holds—i.e., $dp_A^*/d\beta > 0$—as illustrated in Table 4 in Appendix C.

The previous proposition implies that consumers who end up buying from the low-cost firm may actually be worse off when additional consumers become informed ex ante. Consider a change in policy from β to β' with $\beta' > \beta$—this parameterizes the market environment. Note that the majority of consumers buy from the low-price firm in both market environments. For a sufficiently large cost asymmetry, the equilibrium price of the low-cost firm is locally increasing for all environments between β and β'. Hence, all those consumers of the low-cost firm whose ex ante information is constant across the two market environments are worse off under information disclosure to a share of $\beta' - \beta$ of initially uninformed consumers.

We now turn to the high-cost firm. Here, our result is qualitatively similar: The price tends to be decreasing in β for small cost differences and increasing for large cost differences.

Proposition 6. *The equilibrium price of the high-cost firm $p_B^*(\beta)$ may be increasing or decreasing in the share of informed consumers β: $p_B^*(\beta)$ is monotonously increasing, monotonously decreasing, or first increasing and then decreasing in β.*

We solve for critical values at which the price change changes sign:

$$\Delta p^{crit\, \partial p_B}(\lambda, t) \quad = \quad \frac{t}{2(\lambda + 1)(\lambda + 7)}\left((-23 + (\lambda - 10)\lambda) + |5 - \lambda| \sqrt{(2(\lambda + 2))^2 - (\lambda - 1)^2}\right)$$

For instance, $\Delta p^{crit\, \partial p_B}(3, 1) = 0.3201$. At $\beta = 1$ we can solve analytically for a critical Δp at which the total derivative of p_B is zero—i.e., $(dp_B^*(\Delta p^*(\beta);\beta))/d\beta = 0$:

$$\Delta p^{crit\, dp_B}(\lambda, t) \quad = \quad \frac{t\left(3(\lambda(17\lambda + 6) - 55) - \sqrt{15} \cdot |11 - 7\lambda| \sqrt{(\lambda + 3)(3\lambda + 5)}\right)}{4\lambda(3\lambda - 11)}$$

For instance, $\Delta p^{crit\, dp_B}(3,1) = 1/2 \cdot (5\sqrt{35} - 29) = 0.2902$ at $\beta = 1$. Thus, for $\Delta p^*(1) < 0.2902$, we obtain $dp_B/d\beta < 0$ at $\beta = 1 - \epsilon$ (compare Tables 2 and 3), while, for $\Delta p^*(1) > 0.2902$, we obtain $dp_B/d\beta > 0$ at $\beta = 1$ (compare Table 4). Thus, for these parameter values, the overall effect of a marginal increase in β can indeed become positive if cost asymmetries are sufficiently large.

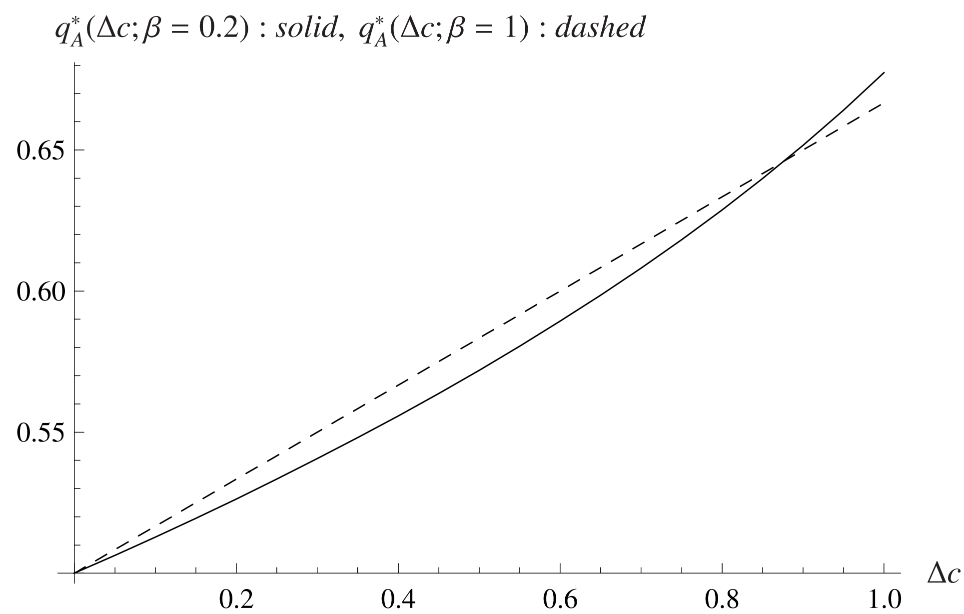
Let us distinguish consumer groups by the product they consume. We observe that $\Delta p^{crit\, dp_B}(\lambda, t) > \Delta p^{crit\, dp_A}(\lambda, t)$ for all λ, t. Hence, for a larger range of cost parameters the price of the high-cost firm is locally decreasing (compared to the low-cost firm). This implies that, focusing on the consumers whose ex ante information remains unchanged, there exists an intermediate range of values of β under which consumers of the low-cost product are worse off, whereas consumers of the high-cost product are better off after an increase in β. Since the high-cost firm sells to fewer consumers than the low-cost firm we call consumers who buy the high-cost product niche consumers. Then, informed niche consumers are more likely to benefit from an increase in β than the other informed consumers.

The above observation helps us to shed some light on *information acquisition* by consumers. A particular application are consumer clubs that provide early information on match value to its members. Whether existing club members have an incentive to attract additional members, depends on the market environment. Our above observation also indicates, that consumer clubs may be more likely to be formed by niche consumers. We also note that a forward-looking club may be willing to cope with increasing prices for a while with the understanding that, as the club further increases in size (reflected by an increase in β) prices will eventually fall.

With respect to equilibrium demand our model generates the following prediction:

$$\begin{aligned}
\frac{dq_A(\Delta p^*(\beta);\beta)}{d\beta} &= \beta \frac{d\hat{x}_{in}(\Delta p^*)}{d(\Delta p^*)} \cdot \frac{d(\Delta p^*)}{d\beta} + \hat{x}_{in}(\Delta p^*) + (1-\beta)\frac{d\hat{x}_{un}(\Delta p^*)}{d(\Delta p^*)} \cdot \frac{d(\Delta p^*)}{d\beta} - \hat{x}_{un}(\Delta p^*) \\
&= \underbrace{\frac{\partial q_A(\Delta p^*)}{\partial(\Delta p^*)}}_{+} \cdot \underbrace{\frac{d(\Delta p^*)}{d\beta}}_{+} + (\hat{x}_{in}(\Delta p^*) - \hat{x}_{un}(\Delta p^*)) \gtrless 0,
\end{aligned}$$

which is positive for small cost (resp. price) differences and negative for large cost (resp. price) differences—see also Figure 3. Hence, in moderately asymmetric markets the demand of the more efficient firm rises, as the share of informed consumers increases, as illustrated in Table 2 in the Appendix. This implies that in a market with loss-averse consumers (and a positive share of uninformed consumers) the market share difference is



Equilibrium demand of firm A for markets with either many uninformed consumers ($\beta = 0.2$) or only informed consumers (=benchmark case, $\beta = 1$) as a function of cost differences Δc for parameter values of $t = 1$ and $\lambda = 3$: $\Delta c^{nd}(\beta = 0.2) = 1.00993$.

Figure 3: Equilibrium demand of firm A

less pronounced than in the standard Hotelling case.[23] Our result is reversed in strongly asymmetric markets in which the demand of the more efficient firm is decreasing in the share of informed consumers (compare Table 4 in the appendix).

5.2 Private incentives to disclose information

In this subsection, we analyze the firms' incentives to disclose information. To address this issue, we investigate the effect of β on profits. Here, private information disclosure can be seen as the firms' management of consumer expectations (i.e., reference points). Note that in our simple setting information disclosure by one firm fully reveals the information of both firms since consumers make the correct inferences from observing the match value for one of the two products.[24]

$$\frac{d\pi_A(\Delta p^*(\beta), p_A^*(\beta);\beta)}{d\beta} = \frac{dp_A^*(\Delta p^*;\beta)}{d\beta} \cdot q_A(\Delta p^*;\beta) + \left(p_A^*(\Delta p^*;\beta) - c_A\right) \cdot \frac{dq_A(\Delta p^*;\beta)}{d\beta} \lesseqgtr 0$$

[23]In spirit, this is in line with Heidhues and Koszegi (2008) who predict equal splits of demand between firms in asymmetric markets.

[24]This is due to our assumption that firms necessarily locate at distance 1 from each other. It applies to either the setting in which uninformed consumers do not know their type before forming their reference point or they do not know the locations of firms in the product space.

$$\frac{d\pi_B(\Delta p^*(\beta), p_B^*(\beta);\beta)}{d\beta} \quad = \quad \frac{dp_B^*(\Delta p^*;\beta)}{d\beta} \cdot q_B(\Delta p^*;\beta) - \left(p_B^*(\Delta p^*;\beta) - c_B\right) \cdot \frac{dq_A(\Delta p^*;\beta)}{d\beta} \lesseqgtr 0$$

We confine attention to a numerical example. The critical value of Δp such that $d\pi_A/d\beta = 0$ at $\beta = 1$ and $\lambda = 3$ and $t = 1$, $c_A = 0.25$, and $c_B = 1$ is $\Delta p = 0.2581$. The critical value of Δp such that $d\pi_B/d\beta = 0$ at the same parameter values as above is $\Delta p = 0.2870$. For comparison, we take a look at table 3 in Appendix C: The critical value at $\beta = 1$ is $\Delta p^*(1) = 0.25$. Hence, the critical values of Δp at $\beta < 1$ are larger than $\Delta p^*(1)$. Moreover, $\Delta p_B^{crit} > \Delta p_A^{crit}$.

Our numerical example shows that increasing the initial share of ex ante informed consumers first none, then one and then both firms gain from information disclosure. Since disclosing information about match value to a positive number of consumers is profitable, such a strategy will be chosen by profit-maximizing firms (if disclosure is not too costly). Our finding provides a rationale for truthfully advertising product characteristics at an early stage, although all consumers would learn them prior to purchase even in the absence of advertising. Without the behavioral bias it would be irrelevant for market demand and market outcomes whether or not a firm advertises product characteristics ex ante.

In case of conflicting interests, it is the more efficient firm which locally gains from information disclosure as an expectation management tool. Thus, our model predicts that it is rather the more efficient firm that advertises product features. This means that one should observe a positive correlation between such advertising and the marginal cost of the firm. For other parameter constellations, we numerically confirmed the robustness of these results.

5.3 The effect of ex ante information on consumer surplus

In this subsection, we analyze the effect of β on consumer surplus. More precisely, we answer the question: How is the surplus of the different consumer groups affected by an increase of the share of informed consumers?

First, consider the change in surplus of informed consumers. The aggregate consumer surplus for informed consumers is given by

$$CS_{in}(p_A(\beta), p_B(\beta)) = \int_0^{\hat{x}_{in}(\Delta p(\beta))} u_A(x, p_A(\beta))dx + \int_{\hat{x}_{in}(\Delta p(\beta))}^1 u_B(x, p_B(\beta))dx$$

The marginal effect of increasing the share of informed consumers on the surplus of the already informed consumers is

$$\frac{dCS_{in}}{d\beta} = \int_0^{\hat{x}_{in}(\Delta p(\beta))} \underbrace{\frac{\partial u_A(x, p_A(\beta))}{\partial p_A(\beta)}}_{=-1} \cdot \frac{dp_A}{d\beta} \cdot dx + \int_{\hat{x}_{in}(\Delta p(\beta))}^{1} \underbrace{\frac{\partial u_B(x, p_B(\beta))}{\partial p_B(\beta)}}_{=-1} \cdot \frac{dp_B}{d\beta} \cdot dx$$
$$= -\hat{x}_{in}(\Delta p)\frac{dp_A}{d\beta} - (1 - \hat{x}_{in}(\Delta p))\frac{dp_B}{d\beta} \gtrless 0.$$

Consumer surplus of informed consumers may increase or decrease in the share of informed consumers. The sign of the derivative is determined by the weighted marginal price changes $dp_i/d\beta$ of the two products. It is positive in markets with small cost differences because both prices decrease in the share of informed consumers ($dp_i/d\beta < 0$). It is negative in markets with large cost differences. In markets with intermediate cost differences, the two prices move in different directions. Thus, some informed consumers are better off, whereas others are worse off in response to an increase in the share of informed consumers.

Second, consider uninformed consumers. Evaluating the ex ante effect on uninformed consumers is more involved because gains and losses relative to their reference point have to be taken into account.

$$\begin{aligned} CS_{un}(p_A(\beta), p_B(\beta)) = \quad & \Big(\int_0^{1-\hat{x}_{un}(\Delta p(\beta))} \tilde{u}_A(x, p_A(\beta), p_B(\beta), \hat{x}_{un}(\Delta p(\beta)))dx \\ & + \int_{1-\hat{x}_{un}(\Delta p(\beta))}^{\hat{x}_{un}(\Delta p(\beta))} u_A(x, p_A(\beta), p_B(\beta), \hat{x}_{un}(\Delta p(\beta)))dx \Big) \\ & + \int_{\hat{x}_{un}(\Delta p(\beta))}^{1} u_B(x, p_A(\beta), p_B(\beta), \hat{x}_{un}(\Delta p(\beta)))dx, \end{aligned}$$

where u_A and u_B represent uninformed consumers' gain-loss utility for distant consumers of A and nearby consumers of B derived in (15) and (16), respectively.

$$\begin{aligned} \tilde{u}_A(x, p_A(\beta), p_B(\beta), \hat{x}_{un}(\Delta p(\beta))) \quad =& (v - tx - p_A) + (1 - \hat{x}_{un})(p_B - p_A) \\ & - \lambda \cdot tx^2 + \frac{t}{2}\Big((1 - \hat{x}_{un})^2 - 2(1 - x)x + \hat{x}_{un}^2\Big), \end{aligned}$$

is the gain-loss utility for nearby uninformed consumers of A. The function $\tilde{u}_A$ differs from u_A only in the taste dimension of the gain-loss utility.

Taking derivatives with respect to β, we obtain

$$\frac{dCS_{un}}{d\beta} = \int_0^{\hat{x}_{un}(\Delta p(\beta))} \left(\frac{\partial u_A(x, .)}{\partial p_A} \cdot \frac{dp_A}{d\beta} + \frac{\partial u_A(x, .)}{\partial p_B} \cdot \frac{dp_B}{d\beta} \right) \cdot dx$$

$$
\begin{aligned}
&+\Bigg(\int_0^{1-\hat{x}_{un}(\Delta p(\beta))}\left(\frac{\partial\tilde{u}_A(x,.)}{\partial\hat{x}_{un}}\cdot\frac{d\hat{x}_{un}(\Delta p)}{d\Delta p}\cdot\frac{d\Delta p}{d\beta}\right)\cdot dx\\
&+\int_{1-\hat{x}_{un}(\Delta p(\beta))}^{\hat{x}_{un}(\Delta p(\beta))}\left(\frac{\partial u_A(x,.)}{\partial\hat{x}_{un}}\cdot\frac{d\hat{x}_{un}(\Delta p)}{d\Delta p}\cdot\frac{d\Delta p}{d\beta}\right)\cdot dx\Bigg)\\
&+\int_{\hat{x}_{un}(\Delta p(\beta))}^{1}\left(\frac{\partial u_B(x,.)}{\partial p_A}\cdot\frac{dp_A}{d\beta}+\frac{\partial u_B(x,.)}{\partial p_B}\cdot\frac{dp_B}{d\beta}+\frac{\partial u_B(x,.)}{\partial\hat{x}_{un}}\cdot\frac{d\hat{x}_{un}(\Delta p)}{d\Delta p}\cdot\frac{d\Delta p}{d\beta}\right)\cdot dx.
\end{aligned}
$$

In addition to consumers' intrinsic utility, a price change affects consumers' gains and losses with respect to the price dimension via the varying price difference. A change of the location of the indifferent uninformed consumer $\hat{x}_{un}$ has an impact on consumers' gains and losses in both dimensions. Utility in the taste dimension is affected since an increase of $\hat{x}_{un}$ shifts mass of the reference point distribution to the upper tail.[25] Utility in the price dimension is affected since the probability of buying at a specific price depends on the location at which consumers are indifferent between the two products. The equation of $dCS_{un}/d\beta$ can be further simplified to

$$
\begin{aligned}
\frac{dCS_{un}}{d\beta} =& -\hat{x}_{un}\cdot\frac{dp_A}{d\beta}-(1-\hat{x}_{un})\cdot\frac{dp_B}{d\beta}\\
&+\left((\lambda-1)\hat{x}_{un}(1-\hat{x}_{un})+\Delta p\,(\hat{x}_{un}+\lambda(1-\hat{x}_{un}))\cdot\frac{d\hat{x}_{un}}{d\Delta p}\right)\cdot(-\frac{d\Delta p}{d\beta})\\
&-t\left(\frac{1}{2}(2\hat{x}_{un}-1)\Big((\lambda-1)(2\hat{x}_{un}-1)+2\Big)\right)\cdot\frac{d\hat{x}_{un}}{d\Delta p}\cdot(-\frac{d\Delta p}{d\beta})\gtrless 0. \qquad (11)
\end{aligned}
$$

The first line of equation (11) gives the marginal effect of β on intrinsic utility—this is analogous to the analysis of informed consumers above. The second line gives the marginal effect of β on the gain-loss utility in the price dimension, which is positive. The third line gives the marginal effect of β in the gain-loss utility on the match value dimension, which is always negative.

The overall effect of β on CS_{un} is positive in symmetric and moderately asymmetric markets (Δc small) since the effect of β on individual prices p_i is negative in these markets (compare CS_{in}). By contrast, the effect is negative in strongly asymmetric markets. The surplus result that holds for informed consumers, thus, qualitatively carries over to uninformed consumers.

It can be shown that, for all $\lambda > 1$ and Δc feasible, the sum of the second and the third line of (11) is negative—i.e., the marginal effect of β on the gain-loss utility in the taste dimension dominates its effect in the price dimension of consumers'. However, this does

[25] It can be easily shown that $G(s|\hat{x}'_{un})$ first-order stochastically dominates $G(s|\hat{x}_{un})$ for all feasible $\hat{x}_{un}$, $\hat{x}'_{un}$ with $\hat{x}'_{un} > \hat{x}_{un}$ feasible.

not suffice to obtain that the sign of $dCS_{un}/d\beta$ is changing for a higher level of β in moderately asymmetric markets since the price changes, which determine the sign change of consumer surplus, are weighted differently in case of uninformed instead of informed consumers. Table 3 in the Appendix illustrates that due to the difference in weights the critical β at which the marginal consumer surplus of uninformed consumers switches sign is lower than the critical β for informed consumers.

Remark 4. *In symmetric and moderately asymmetric markets, all consumers whose information is unaffected are better off if more consumers become informed before forming their reference points. By contrast, in strongly asymmetric markets, all these consumers are worse off.*

To determine the overall effect of β on aggregate consumer surplus of both consumer groups, an additional decomposition effect has to be taken into account. This effect stems from the change in consumer surplus of the group of formerly uninformed consumers who become informed. The overall effect of β on aggregate consumer surplus is determined by the first derivative of $CS = \beta \cdot CS_{in}(p_A(\beta), p_B(\beta)) + (1-\beta) \cdot CS_{un}(p_A(\beta), p_B(\beta))$ with respect to β:

$$\begin{aligned}\frac{dCS}{d\beta} &= \beta \cdot \frac{dCS_{in}}{d\beta} + CS_{in} + (1-\beta) \cdot \frac{dCS_{un}}{d\beta} - CS_{un} \\ &= \beta \cdot \frac{dCS_{in}}{d\beta} + (1-\beta) \cdot \frac{dCS_{un}}{d\beta} + (CS_{in} - CS_{un}).\end{aligned}$$

It can be shown that the decomposition effect represented by $(CS_{in} - CS_{un})$ is always strictly positive, since uninformed consumers have a lower average utility level due to the higher weight on losses than on gains. Although some uninformed consumers who receive high match value at low price are better off than their informed counterparts, the average utility of uninformed consumers is lower due to the losses in the taste dimension of consumers located far apart from the product they purchase and the losses in the price dimension of consumers of product B. For illustration, see the tables in Appendix C.

It turns out that the decomposition effect always dominates the group-specific effects of β on consumer surplus. This means that the group of those consumers who become informed is so much better off that its surplus increase always dominates the surplus change of the remaining uninformed consumers and the "old" informed consumers. This holds even in strongly asymmetric markets in which remaining uninformed and old informed consumers are worse off if the share of informed consumers increases. We summarize by the following remark.

Remark 5. *Consumer surplus is increasing in the share of informed consumers, β.*

The policy implications are straightforward: A public authority whose aim is to maximize consumer surplus (and which does not have further distributive concerns about the effects of information disclosure) should always try to increase the share of informed consumers, possibly through the use of mandatory information disclosure rules. In symmetric and moderately asymmetric markets, all consumers will be better off. However, in strongly asymmetric markets most consumers suffer. Those consumers who become informed (due to the policy intervention) exert a negative externality on all other consumers. In such markets, distributive concerns may lead to a reversal of policy.

6 Extensions

6.1 Relative weight on gain-loss utility

Consider consumer preferences for which the intrinsic utility is weighted by one, while the gain-loss utility has a weight of $\alpha > 0$.[26] A change of the relative weight on the gain-loss utility affects the location of the indifferent uninformed consumer. Can this be neutralized by an adjustment of the degree of loss aversion λ? The answer is positive, as the following proposition shows.

Proposition 7. *Suppose that the utility function of uninformed consumers shows an additional weight, $\alpha > 0$, on the gain-loss utility—i.e., all terms except for the intrinsic utility term in* (15) *(resp.* (16)*) are pre-multiplied by α.*
Then, $\forall \lambda' > 1, \alpha' > 0 \; \exists \lambda > 1$ such that

$$\hat{x}_{un}(\Delta p; \lambda, \alpha = 1) = \hat{x}_{un}(\Delta p; \lambda', \alpha'), \tag{12}$$

where $\hat{x}_{un}(\Delta p; \lambda, \alpha)$ is the location of the indifferent uninformed consumer given α-extended preferences. Moreover, $\lambda \geq \lambda'$ for $\alpha' \geq 1$ and $\lambda < \lambda'$ for $\alpha' < 1$.

Proof of Proposition 7. The derivation of the indifferent uninformed consumer with α-extended preferences is analogous to the derivation of the indifferent uninformed consumer for $\alpha = 1$ provided in the proof of LEMMA 1. With α-extended preferences the

[26]For $\alpha = 0$ we are obviously situated in a standard Salop world; for $\alpha = 1$ we are in the setting analyzed above.

location equals

$$\hat{x}_{un}(\Delta p; \lambda, \alpha) = \frac{1+\alpha(2\lambda-1)}{2\alpha(\lambda-1)} - \frac{\Delta p}{4t} - \sqrt{\frac{\Delta p^2}{16t^2} - \frac{(\alpha(2\lambda+1)+3)}{4\alpha t(\lambda-1)}\Delta p + \frac{(\alpha\lambda+1)^2}{4\alpha^2(\lambda-1)^2}}. \tag{13}$$

By solving for λ in equation (12) we receive

$$\lambda(\lambda', \alpha') = \frac{1+\alpha'(2\lambda'-1)}{1+\alpha'}. \tag{14}$$

Since $\lambda(\lambda', \alpha' = 1) = \lambda'$ and $\partial\lambda/\partial\alpha' = 2(\lambda'-1)/(1+\alpha')^2 > 0$, λ shows the required properties. □

The previous proposition points out that, for any change of the relative weight on gain-loss utility, there is a compensating change of the degree of loss aversion, λ, which gives rise to the same demand function as before the change.

6.2 Asymmetric product quality

Our model is easily extended to allow for differences in product quality which are known to consumers at the beginning of the game. An informed consumer's utility function is $u_i(x, p_i) = (v_i - p_i) - t|y_i - x|$. We then distinguish between a quality-adjusted price dimension, which includes easily communicated product characteristics of unambiguous value to consumers, and a taste dimension, which includes those product characteristics whose value depends on the consumer type. We define quality-adjusted (or hedonic) prices $\tilde{p}_i = p_i - v_i$, $i = A, B$, for all consumers and consider those to be relevant for consumers' purchase decision. The main difference arises for uninformed consumers when building their reference point distribution with respect to prices. Here, only the gain and loss in quality-adjusted prices $\Delta\tilde{p} = \Delta p - \Delta v$ matters, $\Delta v \equiv v_B - v_A$. We label firms such that $\Delta c - \Delta v > 0$ and call firm A the more efficient firm. In the following proposition we show that any market with asymmetric quality is equivalent to a market with symmetric quality and adjusted asymmetric costs.

Proposition 8. *For any market with asymmetric quality represented by a vector* $(\Delta v, \Delta c)$ *with* $\Delta c - \Delta v > 0$*, there exists a market with symmetric quality represented by a vector* $(\Delta v', \Delta c')$ *with* $\Delta v' = 0$*,* $\Delta c' > 0$ *such that market equilibria of both markets are the same—i.e.,* $\Delta p^* - \Delta v = \Delta p'^*$*. Moreover,* $\Delta c' = \Delta c - \Delta v$*.*

As a special case, the asymmetry in the former market is generated by quality differences—i.e., firm A sells higher quality in a market with symmetric costs, $\Delta v < 0$ and $\Delta c = 0$. Then, the costs asymmetry in the second market shows the same size, in absolute terms, as the quality difference in the first market, $\Delta c' = -\Delta v$.

In the proof, we show that the optimization problems of the two consumer groups and the firms are the same in both markets.

Proof of Proposition 8. To begin with, consider informed consumers' utility: We find $u_i(x, p_i) = (v_i - p_i) - t|y_i - x| = -\tilde{p}_i - t|y_i - x|$ for all $i \in \{A, B\}$ in the former market and $u_i(x, p_i') = (v_i' - p_i') - t|y_i - x|$ for all $i \in \{A, B\}$ in the latter market. Since in the latter market quality levels are identical ($\Delta v' = 0$), it holds true that $\hat{x}_{in}(\Delta\tilde{p}) = \hat{x}_{in}(\Delta p')$ for $\Delta p' = \Delta p - \Delta v$. If uninformed consumers use quality-adjusted prices for determining their reference point distribution in the price dimension, we also receive $\hat{x}_{un}(\Delta\tilde{p}) = \hat{x}_{un}(\Delta p')$ for $\Delta p' = \Delta p - \Delta v$ by the same argument.

Next, consider the firms' maximization problem in both markets. Firm A solves

$$\max_{\tilde{p}_A} \pi_A(\tilde{p}_A, \tilde{p}_B) = (\tilde{p}_A + v_A - c_A)[\beta \cdot \hat{x}_{in}(\tilde{p}_B - \tilde{p}_A) + (1 - \beta) \cdot \hat{x}_{un}(\tilde{p}_B - \tilde{p}_A)] \quad \text{and}$$
$$\max_{p_A'} \pi_A(p_A', p_B') = (p_A' - c_A')[\beta \cdot \hat{x}_{in}(p_B' - p_A') + (1 - \beta) \cdot \hat{x}_{un}(p_B' - p_A')].$$

Firm A's equilibrium prices are identical if and only if markups in both markets are identical—i.e., $\tilde{p}_A + v_A - c_A = p_A' - c_A'$—and both demand functions are identical—i.e., $\Delta p' = \Delta p - \Delta v$. Analogously, for firm B, this holds true if and only if $\tilde{p}_B + v_B - c_B = p_B' - c_B'$ and $\Delta p' = \Delta p - \Delta v$. Finally, taking markup differences between firms, we obtain $\Delta\tilde{p} + \Delta v - \Delta c = \Delta p - \Delta c$ in the former market and $\Delta p' - \Delta c'$ in the latter market. For $\Delta p' = \Delta p - \Delta v$, both markup differences are the same if and only if $\Delta c' = \Delta c - \Delta v$. □

7 Discussion and Conclusion

In this paper, we have explored the impact of consumer loss aversion on market outcomes in asymmetric imperfectly competitive markets. We did so in a Hotelling-Salop setting, which is a standard workhorse in the modern industrial-organization literature. Consumer loss aversion makes a difference compared to a market in which consumers lack this behavioral bias, if they are uncertain about product characteristics or associated match value at an initial stage, when they form their reference point distribution. Since price information is readily available, firms can use price to manage the reference point distribution of consumers in the price and the match value dimension. Also, firms' information-disclosure policy can be seen as an expectation management tool. Such information disclosure can be achieved through advertising campaigns and promotional activities, which do not generate additional information at the moment of purchase (at this point, consumers would be informed in any case), but inform consumers way in advance of their actual purchasing decision.

We analyzed how firm asymmetries and the share of uninformed loss-averse consumers in the population affect market outcomes. Here, we analyzed industries that are characterized by cost asymmetries. Alternatively, asymmetries with respect to observed product quality may be introduced (as explored in Section 6). Since there is a one-to-one relationship between these two models, our insights are directly applicable to a model in which firms differ in observed product quality. We show that a larger cost advantage may lead to a lower markup of the low-cost firm.

Our theory provides a new perspective on private information disclosure and advertising. Since all consumers are fully informed at the purchasing stage, standard theory would predict that it is irrelevant how far in advance of the purchasing stage information is revealed. Our theory predicts that consumer behavior and market outcomes depend on whether and to what extent match-value relevant information is revealed at an early stage.

Our results have implications for public policy and firms' advertising strategies. There are instances in which consumers would gain from more information whereas both firms would not. Thus, firms refrain from early information disclosure in these instances—namely when the market is symmetric or moderately asymmetric. In these markets, public information disclosure (which allows consumers to learn the products' match values) would enhance the surplus of all consumer groups.

Moreover, our model predicts that advertising and other marketing instruments that allow for voluntary early information disclosure about match value are more prevalent in markets characterized by large asymmetries between firms. In these asymmetric markets, one or both firms gain from information disclosure because this leads to higher prices.

A feature of our setting is that, if a firm releases information on the match value of its product, consumers fully infer the match value of the other product, as well. Future work may want to look at alternative settings in which information is not perfectly correlated across products, giving rise to a richer set of information-disclosure policies.

Appendix

A Relegated Proofs

A.1 Relegated proof of Section 2

Proof of Lemma 1. Using the properties of the reference distributions, we rewrite the utility function further,

$$\begin{aligned} u_A(x, p_A, p_B) \quad =& (v - tx - p_A) + (1 - \hat{x}_{un})(p_B - p_A) \\ & - \lambda \cdot t\Big(\int_0^{1-\hat{x}_{un}} 2(x - s)\, ds + \int_{1-\hat{x}_{un}}^{x} (x - s)\, ds\Big) + t\Big(\int_x^{\hat{x}_{un}} (s - x)\, ds\Big) \\ =& (v - tx - p_A) + (1 - \hat{x}_{un})(p_B - p_A) \\ & - \lambda \cdot \frac{t}{2}\Big(x^2 + 2x(1 - \hat{x}_{un}) - (1 - \hat{x}_{un})^2\Big) + \frac{t}{2}(\hat{x}_{un} - x)^2 \end{aligned} \tag{15}$$

$$\begin{aligned} u_B(x, p_A, p_B) \quad =& (v - t(1 - x) - p_B) - \lambda \cdot \hat{x}_{un}(p_B - p_A) - \lambda \cdot t \int_0^{1-x} 2((1 - x) - s)\, ds \\ & + t\Big(\int_{1-x}^{1-\hat{x}_{un}} 2(s - (1 - x))\, ds + \int_{1-\hat{x}_{un}}^{\hat{x}_{un}} (s - (1 - x))\, ds\Big) \\ =& (v - t(1 - x) - p_B) - \lambda \cdot \hat{x}_{un}(p_B - p_A) - \lambda \cdot t(1 - x)^2 \\ & + t\Big((x - \hat{x}_{un})^2 + (\frac{1}{2} - x - \hat{x}_{un} + 2x\hat{x}_{un})\Big). \end{aligned} \tag{16}$$

Next, we find the location of the indifferent uninformed consumer $x = \hat{x}_{un}$ by setting $u_A = u_B$, where

$$\begin{aligned} u_A(\hat{x}_{un}, p_A, p_B) =& \quad v - t\hat{x}_{un} - p_A + (1 - \hat{x}_{un})(p_B - p_A) - \lambda \cdot \frac{t}{2}\Big(1 - 2(1 - \hat{x}_{un})^2\Big) \\ u_B(\hat{x}_{un}, p_A, p_B) =& \quad v - t(1 - \hat{x}_{un}) - p_B - \lambda \cdot \hat{x}_{un}(p_B - p_A) - \lambda \cdot t(1 - \hat{x}_{un})^2 + 2t(\frac{1}{2} - \hat{x}_{un})^2 \end{aligned}$$

If she buys product A the indifferent uninformed consumer will experience no gain but the maximum loss in the taste dimension. If she buys product B she will experience a gain and a loss because distance could have been smaller or larger than $1 - \hat{x}_{un}$. With respect to the price dimension the indifferent uninformed consumer (like all other consumers) faces only a loss when paying price p_B and only a gain when paying price p_A.

$u_A(\hat{x}_{un}, p_A, p_B) = u_B(\hat{x}_{un}, p_A, p_B)$ can be transformed to the following quadratic equation in $\hat{x}_{un}$,

$$0 = 2t(\lambda - 1) \cdot \hat{x}_{un}^2 - \Big((\lambda - 1)(p_B - p_A) - 4t\lambda\Big) \cdot \hat{x}_{un} + \Big(2(p_B - p_A) + \frac{t}{2}(3\lambda + 1)\Big) \tag{17}$$

Solving this quadratic equation in $\hat{x}_{un}$ leads to the expression given in the lemma. □

A.2 Relegated proof of Section 3

Proof of Lemma 2.

$$\begin{aligned}
\phi' &= \frac{\partial q_A(\Delta p;\beta)}{\partial \Delta p} = -\frac{\partial q_A(\Delta p;\beta)}{\partial p_A} = -\frac{\partial q_B(\Delta p;\beta)}{\partial \Delta p} = -\frac{\partial q_B(\Delta p;\beta)}{\partial p_B} \\
&= \beta \cdot \hat{x}'_{in}(\Delta p) + (1-\beta) \cdot \hat{x}'_{un}(\Delta p) \\
&= -\frac{1}{4t}(1 - 3\beta) - \frac{(1-\beta)}{2(S(\Delta p))} \underbrace{\left(\frac{\Delta p}{8t^2} - \frac{(\lambda + 2)}{2t(\lambda - 1)}\right)}_{\ominus} > 0
\end{aligned}$$

Hence, $\phi' > 0 \quad \forall \Delta p$ feasible and $\forall \beta$. At the boundaries we have

$$\begin{aligned}
\phi'(0;\beta) &= -\frac{1}{4t}(1 - 3\beta) + (1-\beta)\frac{(\lambda + 2)}{2t(\lambda - 1)} > 0 \\
\lim_{\Delta p \uparrow \Delta \bar{p}} \phi'(\Delta;\beta) &= \infty \quad \text{for } \beta < 1 \text{ since } S(\Delta \bar{p}) = 0.
\end{aligned}$$

For $0 \leq \Delta p < \Delta p^{max}$ the demand of A is convex in Δp.

$$\phi''(\Delta p;\beta) = (1-\beta) \cdot \hat{x}''_{un}(\Delta p) = (1-\beta) \cdot \frac{(3+\lambda)(5+3\lambda)}{64t^2 \cdot (S(\Delta p))^3} \geq 0$$

Hence, $\phi'' > 0 \quad \forall \Delta p$ feasible and $\forall \beta < 1$ since $S(\Delta p) \geq 0$. At the boundaries we have

$$\begin{aligned}
\phi''(0;\beta) &= (1-\beta) \cdot \frac{(3+\lambda)(5+3\lambda)}{32t^2 \cdot \frac{(\lambda+1)^3}{(\lambda-1)^3}} > 0 \\
\lim_{\Delta p \uparrow \Delta \bar{p}} \phi''(\Delta p;\beta) &= \infty \quad \text{for } \beta < 1.
\end{aligned}$$

□

A.3 Relegated proofs of Section 4

Proof of Proposition 1.

$$\begin{aligned}\frac{d(\Delta p^*)}{d(\Delta c)} &= -\frac{(\phi')^2}{3(\phi')^2+\phi''(1-2\phi)}\cdot(-1) \\ &= \frac{(\phi')^2}{3(\phi')^2+\phi''(1-2\phi)}\end{aligned} \tag{18}$$

Since the denominator of $d(\Delta p^*(\Delta c))/d(\Delta c)$ being equal to zero is equivalent to the tangent condition (30), we obtain that

$$\frac{d(\Delta p^*)}{d(\Delta c)} > 0 \tag{19}$$

if $\Delta p < \Delta p^{ta}(\lambda, t)$ (where the latter term is defined in Appendix B). Moreover, since $\phi''(1-2\phi) = 0$ for $\Delta c = 0$ (i.e., $\Delta p = 0$) and $\phi''(1-2\phi) \leq 0$ for $\Delta c > 0$ it holds true that $d(\Delta p^*(\Delta c))/d(\Delta c) \geq 1/3$. □

Proof of Proposition 2.

$$\frac{dm_A^*(\Delta p^*(\Delta c))}{d(\Delta c)} = \frac{\partial m_A^*}{\partial(\Delta p^*)}\cdot\frac{\partial(\Delta p^*)}{\partial(\Delta c)},$$

where by (FOC_A)

$$\frac{\partial m_A^*}{\partial(\Delta p^*)} = \frac{\partial p_A^*}{\partial(\Delta p^*)} = \frac{(\phi')^2-\phi''\cdot\phi}{(\phi')^2} \gtrless 0, \tag{20}$$

which may be positive or negative for $\beta < 1$. Firm A's markup is increasing in the price difference if the price difference is rather low and the share of uninformed consumers is not too high. It is decreasing for large price differences and/or if the share of uninformed consumers is high. Using (18) we obtain that

$$\frac{dm_A^*(\Delta p^*(\Delta c))}{d(\Delta c)} = \frac{(\phi')^2-\phi''\cdot\phi}{3(\phi')^2+\phi''(1-2\phi)} \gtrless 0. \tag{21}$$

Hence m_A^* is not strictly increasing in Δp^*. Firm A's markup decreases in the price difference if the price difference—i.e., if the cost asymmetries in the industry, and/or the share of uninformed consumers become too large. (Compare markup of firm B.) □

Proof of Proposition 3.

$$\frac{dm_B^*(\Delta p^*(\Delta c))}{d(\Delta c)} = \frac{\partial m_B^*}{\partial(\Delta p^*)} \cdot \frac{\partial(\Delta p^*)}{\partial(\Delta c)},$$

where by (FOC_B)

$$\frac{\partial m_B^*}{\partial(\Delta p^*)} = \frac{\partial p_B^*}{\partial(\Delta p^*)} = \frac{-(\phi')^2 - \phi'' \cdot (1-\phi)}{(\phi')^2} < 0, \tag{22}$$

which is always negative for all β. Using (18) we obtain that

$$\frac{dm_B^*(\Delta p^*(\Delta c))}{d(\Delta c)} = -\frac{(\phi')^2 + \phi'' \cdot (1-\phi)}{3(\phi')^2 + \phi''(1-2\phi)} < 0. \tag{23}$$

□

A.4 Relegated proofs of Section 5

Proof of Proposition 4. Recall that the equilibrium is implicitly characterized by

$$\Delta p - \Delta c - \frac{1 - 2\phi(\Delta p; \beta)}{\phi'(\Delta p; \beta)} = 0$$

The equilibrium price difference then satisfies

$$\begin{aligned}
\frac{d\Delta p^*(\beta)}{d\beta} &= -\Big(1 - \frac{-2(\phi')^2 - \phi''(1-2\phi)}{(\phi')^2}\Big)^{-1}\Big(-\frac{-2\phi'\frac{\partial\phi}{\partial\beta} - \frac{\partial\phi'}{\partial\beta}(1-2\phi)}{\phi'^2}\Big) \\
&= -\frac{(\phi')^2}{3(\phi')^2 + \phi''(1-2\phi)} \cdot \Big(\frac{2\phi'\phi_\beta + \phi'_\beta - 2\phi'_\beta\phi}{(\phi')^2}\Big) \\
&= -\frac{2\phi'\phi_\beta + \phi'_\beta(1-2\phi)}{3(\phi')^2 + \phi''(1-2\phi)}
\end{aligned}$$

We show that the numerator of $\frac{d(\Delta p^*(\beta))}{d\beta}$, denoted by $N(\Delta p^*; \beta) = -(2\phi'\phi_\beta + \phi'_\beta(1-2\phi))$ is negative: For all Δp with $0 \le \Delta p \le \Delta p^{max}$ and for all $\beta \in [0,1]$, we can rewrite

$$\begin{aligned}
N(\Delta p; \beta) &= -2\phi'\phi_\beta - \phi'_\beta(1-2\phi) = 2((1-\beta)\hat{x}'_{un} + \beta\frac{1}{2t}) \cdot (\hat{x}_{un} - \hat{x}_{in}) \\
&\quad + (\hat{x}'_{un} - \frac{1}{2t})(1 - 2(1-\beta)\hat{x}_{un} - 2\beta\hat{x}_{in}) \\
&= \frac{1}{t}(\hat{x}_{un} - \hat{x}_{in}) + (\hat{x}'_{un} - \frac{1}{2t})(1 - 2\hat{x}_{in}) \\
&= \frac{1}{t}\hat{x}_{un} + (\hat{x}'_{un})(1 - 2\hat{x}_{in}) - \frac{1}{2t}
\end{aligned}$$

$$\begin{aligned}
&= \frac{1}{t}(\hat{x}_{un} + \frac{1}{2}) - \hat{x}'_{un}(2\hat{x}_{in} - 1) \\
&= -2t\hat{x}'_{un} \cdot (\hat{x}_{in} - \frac{1}{2}) + 1(\hat{x}_{un} - \frac{1}{2}) \\
&= -2t\hat{x}'_{un}(\Delta p)(\hat{x}_{in}(\Delta p) - \frac{1}{2}) + (\hat{x}_{un}(\Delta p) - \frac{1}{2})
\end{aligned}$$

Since $N(0;\beta) = 0$ and

$$\begin{aligned}
\frac{\partial N(\Delta p;\beta)}{\partial \Delta p} &= -\frac{1}{t}\Big(2t\hat{x}''_{un}(\Delta p)(\hat{x}_{in}(\Delta p) - \frac{1}{2}) + 2t(\hat{x}'_{un}(\Delta p))(\hat{x}'_{in}(\Delta p)) - \hat{x}'_{un}(\Delta p)\Big) \\
&= -\frac{1}{t}\Big(2t\hat{x}_{un}(\Delta p)(\hat{x}_{in}(\Delta p) - \frac{1}{2}) + 0 - 0\Big) < 0
\end{aligned}$$

it holds that $N(\Delta p^*;\beta) \leq 0$ for all admissible $\Delta p, \beta$.

Consider now the denominator of $\frac{d(\Delta p^*(\beta))}{d\beta}$, denoted by $D(\Delta p^*;\beta) = 3(\phi')^2 + \phi''(1 - 2\phi)$. We show that, on the relevant domain of price differences, $D(\Delta p^*;\beta)$ is strictly positive. We have that

$$\begin{aligned}
D(0;\beta) &= 3(\phi'(0;\beta))^2 + \phi''(0;\beta) \cdot 0 \\
&= 3(\phi'(0;\beta))^2 > 0
\end{aligned}$$

The sign of the derivative is of ambiguous sign:

$$\begin{aligned}
\frac{\partial D(\Delta p;\beta)}{\partial \Delta p} &= 6\phi'\phi'' + \phi'''(1 - 2\phi) - 2\phi''\phi' \\
&= 4\phi'\phi'' + \phi'''(1 - 2\phi)
\end{aligned}$$

Thus $D(\Delta p^*;\beta)$ is not necessarily non-negative. However, since $D(\Delta p^*;\beta)$ is equivalent to the tangent condition (30) which approaches zero at $\Delta p = \Delta p^{ta}(\lambda, t)$ we conclude that

$$\frac{d\Delta p^*(\beta)}{d\beta} < 0 \tag{24}$$

for $\Delta p < \Delta p^{ta}(\lambda, t)$, which is the relevant domain for equilibrium existence. □

Proof of Proposition 5. We evaluate

$$\frac{dp_A^*(\Delta p^*(\beta);\beta)}{d\beta} = \frac{\partial p_A^*}{\partial(\Delta p^*)} \cdot \frac{\partial(\Delta p^*)}{\partial \beta} + \frac{\partial p_A^*}{\partial \beta},$$

where

$$\frac{\partial p_A^*}{\partial(\Delta p^*)} = \frac{(\phi')^2 - \phi'' \cdot \phi}{(\phi')^2} \gtrless 0,$$

which may be positive or negative. Hence p_A^* is not strictly increasing in Δp^*. Firm A's prices decreases in the price difference if the price difference becomes sufficiently large. In terms of the parameters of the model this means that the cost asymmetries in the industry (and the share of uninformed consumers) becomes sufficiently large.

$$
\begin{aligned}
\frac{\partial p_A^*}{\partial \beta} &= \frac{\phi' \phi_\beta - \phi'_\beta \phi}{(\phi')^2} \\
&= -\Big[((1-\beta)\hat{x}'_{un} + \beta \hat{x}'_{in})(\hat{x}_{un} - \hat{x}_{in}) - (\hat{x}'_{un} - \hat{x}'_{in}) \cdot ((1-\beta)\hat{x}_{un} + \beta \hat{x}_{in})\Big] \cdot \frac{1}{\phi'^2} \\
&= -\Big[(1-\beta)(\hat{x}'_{un} - \frac{1}{2t})(\hat{x}_{un} - \hat{x}_{in}) - (1-\beta)(\hat{x}'_{un} - \frac{1}{2t})(\hat{x}_{un} - \hat{x}_{in})\frac{1}{2t}(\hat{x}_{un} - \hat{x}_{in}) - (\hat{x}_{un} - \frac{1}{2t})\hat{x}_{in}\Big] \cdot \frac{1}{\phi'^2} \\
&= -\Big[\frac{1}{2t}\hat{x}_{un} - \hat{x}'_{un}\hat{x}_{in}\Big] \cdot \frac{1}{\phi'^2}
\end{aligned}
$$

The numerator of $\frac{\partial p_A^*}{\partial \beta}$ is independent of β.

$$
\frac{\partial p_A^*}{\partial \beta}(\Delta p = 0) = -\frac{1}{2}\Big(\frac{1}{2t} - \hat{x}'_{un}(0)\Big) \cdot \frac{1}{\phi'(0)^2} < 0
$$

$$
\frac{\partial p_A^*}{\partial \beta}(\Delta p = \Delta \bar{p} - \epsilon) = -\frac{\Big(\frac{1}{2t}\hat{x}_{un} - \hat{x}'_{un}\hat{x}_{in}\Big)}{\phi'^2} > 0
$$

for ϵ small because the numerator is positive for Δp slightly less than $\Delta \bar{p}$. This implies that $\frac{\partial p_A^*}{\partial \beta} = 0$ for a critical $\Delta p \in (0, \Delta p^{max}), \forall \beta$. □

Proof of Proposition 6. We evaluate

$$
\frac{dp_B^*(\Delta p^*(\beta); \beta)}{d\beta} = \frac{\partial p_B^*}{\partial(\Delta p^*)} \cdot \frac{\partial(\Delta p^*)}{\partial \beta} + \frac{\partial p_B^*}{\partial \beta},
$$

$$
\text{where} \quad \frac{\partial p_B^*}{\partial(\Delta p^*)} = \frac{-(\phi')^2 - \phi''(1-\phi)}{(\phi')^2} = -\Big(1 + \frac{\phi''(1-\phi)}{(\phi')^2}\Big) < 0
$$

In contrast to A, the price of B is always decreasing in $\Delta p^*(\beta)$.

$$
\begin{aligned}
\frac{\partial p_B^*}{\partial \beta} &= \frac{-\phi' \phi_\beta - \phi'_\beta (1-\phi)}{(\phi')^2} \\
&= -\Big[-((1-\beta)\hat{x}'_{un} + \beta\frac{1}{2t})(\hat{x}_{un} - \hat{x}_{in}) - (\hat{x}'_{un} - \frac{1}{2t})(1 - (1-\beta)\hat{x}_{un} - \beta \hat{x}_{in})\Big] \cdot \frac{1}{(\phi')^2} \\
&= -\Big[-(1-\beta)(\hat{x}'_{un} - \frac{1}{2t})(\hat{x}_{un} - \hat{x}_{in}) + (1-\beta)(\hat{x}'_{un} - \frac{1}{2t})(\hat{x}_{un} - \hat{x}_{in}) \\
&\quad -\frac{1}{2t}(\hat{x}_{un} - \hat{x}_{in}) - (\hat{x}'_{un} - \frac{1}{2t})(1 - \hat{x}_{in})\Big] \cdot \frac{1}{(\phi')^2}
\end{aligned}
$$

$$= \quad -\Big[-\frac{1}{2t}(\hat{x}_{un}) - (\hat{x}'_{un} - \frac{1}{2t}) + \hat{x}'_{un}\hat{x}_{in} \Big] \cdot \frac{1}{(\phi')^2} \lesseqgtr 0$$

□

B Equilibrium Existence and Uniqueness in Duopoly

B.1 Equilibrium uniqueness

In Proposition 4 we state sufficient conditions under which an interior equilibrium is unique. Given parameters λ and t, the condition states that the cost asymmetry between firms is not too large.[27]

Lemma 4. *An equilibrium is the unique interior equilibrium if*

$$\Delta c < \Delta c^u(\lambda) \equiv \Delta\bar{p} = \frac{2t}{(\lambda - 1)}\Big(2(\lambda + 2) - \sqrt{(2(\lambda + 2))^2 - (\lambda + 1)^2} \Big). \tag{25}$$

In the lemma $\Delta\bar{p}$ depicts the upper bound of Δp such that $S(\Delta p)$ in $\hat{x}_{un}(\Delta p)$ is equal to zero (Cf. equation (5)). It is easy to check that $\Delta c^u(\lambda)$ is strictly decreasing in λ. This means that in markets in which consumers show a higher degree of loss aversion cost asymmetries between firms can be less pronounced to meet the uniqueness condition.

Proof of Lemma 4. We first consider the case of $\lambda > \lambda^c \approx 7.47$. We can derive a number of useful properties of $f(\Delta p; \beta) = (1 - 2\phi)/\phi'$:

$f(0; \beta) = 0/\phi'(0) = 0\ \forall\beta$, $\lim_{\Delta p \uparrow \Delta\bar{p}} f(\Delta p; \beta) = 0$ since $\lim_{\Delta p \uparrow \Delta\bar{p}} \phi'(\Delta p; \beta) = \infty\ \forall\beta < 1$, and $f(\Delta\bar{p}; 1) = -2\Delta\bar{p} < 0$.

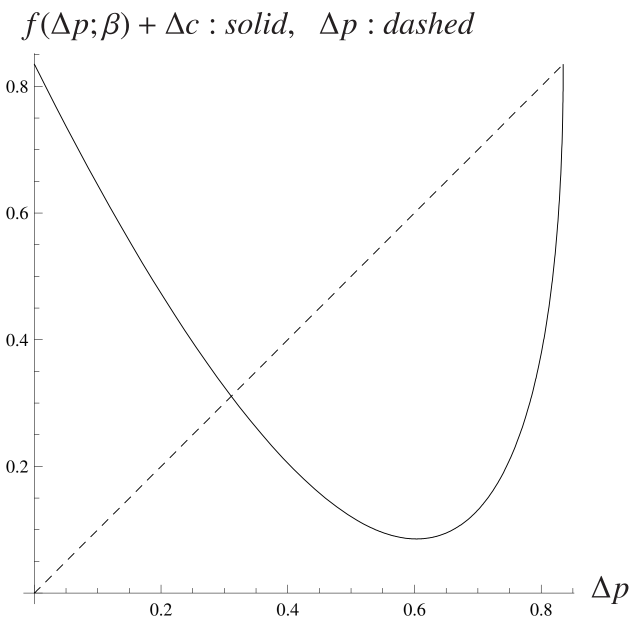
$$f'(\Delta p; \beta) \quad = \quad \frac{-2(\phi')^2 - \phi''(1 - 2\phi)}{(\phi')^2} = -\Big(2 + \frac{\phi''(1 - 2\phi)}{(\phi')^2}\Big) \lesseqgtr 0 \quad \forall\beta < 1,$$

since $f'(0; \beta) = -2 < 0 \quad \forall\beta$ and $\lim_{\Delta p \uparrow \Delta\bar{p}} f'(\Delta p; \beta) = \infty \quad \forall\beta < 1$. Moreover, $f'(\Delta p; 1) = -2 \quad \forall\Delta p$.

It has to be shown that $f(\Delta p; \beta)$ is strictly convex in Δp for $\beta < 1$. We find that

$$f''(\Delta p; \beta) \quad = \quad -\frac{(\phi'\phi''' - 2(\phi'')^2)(1 - 2\phi) - 2(\phi')^2}{(\phi')^3} > 0.$$

[27] Since t turns out to simply scale equilibrium prices (cf. Section 4), we set $t = 1$ in Appendix B.



Equilibrium condition (10) at $\Delta c = \Delta\bar{p}$ for parameter values of $\beta = 0$, $t = 1$, and $\lambda = 3$: $\Delta\tilde{p} = 0.75$, $\Delta\bar{p} = 0.8348$.

Figure 4: Two potential interior equilibria

Figure 4 illustrates the equilibrium condition (10) at $\Delta c = \Delta\bar{p}$. Now, if $\beta < 1$ by continuity of $f(\Delta p)$ for $\Delta p \in [0;\Delta\bar{p})$, $f(0;\beta) = 0$, $\lim_{\Delta p\uparrow\Delta\bar{p}} f(\Delta p;\beta) \to 0$, $f'(0;\beta) < 0$, $\lim_{\Delta p\uparrow\Delta\bar{p}} f'(\Delta p;\beta) = \infty > 1$, and strict convexity of $f(\Delta p)$ for $\beta < 1$, we know that, for $\Delta c > \Delta\bar{p}$, there are two candidate interior equilibria since the $(f(\Delta p)+\Delta c)$-curve shifts up and intersects the Δp-line twice. At $\Delta c = \Delta\bar{p}$ a second solution to $\Delta p = f(\Delta p;\beta < 1)+\Delta\bar{p}$ does not arise due to the discontinuity of ϕ (resp. $f(\Delta p;\beta < 1)$) at $\Delta\bar{p}$. Moreover, for values of Δc lower than $\Delta\bar{p}$, $(f(\Delta\bar{p};\beta < 1) + \Delta c)$ is always smaller than $\Delta\bar{p}$ and no other equilibrium can exist.

If $\beta = 1$, $f(\Delta p;\beta)$ is strictly decreasing for all Δp and at most one intersection between $f(\Delta p;1) + \Delta c$ and Δp exists (standard Hotelling case).[28]

Secondly, in the case of $1 < \lambda \leq \lambda^c$ all uninformed consumers buy from firm A at $\Delta p = \Delta\tilde{p}$, which is smaller than $\Delta\bar{p}$.[29] Since f is continuous here, $f(\Delta\tilde{p};\beta) < 0$, and $f(\Delta p;\beta) = (1 - 2(\beta\hat{x}_{in}(\Delta p) + (1-\beta)))\cdot 2t/\beta$ is strictly decreasing for $\Delta p > \Delta\tilde{p}$, $\Delta c < \Delta\bar{p}$ is sufficient to rule out other equilibria in this case. □

We also can provide conditions that non-interior equilibria do not exist. For the sake of brevity, in the following proposition we restrict attention to the case $\beta = 0$.

[28] In this case an analytical solution for (10) can be determined: $\Delta p^* = \Delta c/3$.

[29] Cf. Figure 4.

Lemma 5. *Suppose all consumers are uninformed ($\beta = 0$) and the degree of loss aversion, $\lambda \in (1, 1 + 2\sqrt{2}]$. Non-interior equilibria do not exist if*

$$\Delta c \leq \Delta c^{ni}(\lambda) \equiv \Delta 2\tilde{p}(\lambda) = \frac{\lambda + 3)t}{(\lambda + 1)}. \tag{26}$$

Proof of Lemma 5.
The candidate non-interior equilibrium is $p_A^{**} = c_B - \Delta p^{max}$, $p_B^{**} = c_B$. The associated profits are $\pi_A^{**} = (c_B - \Delta p^{max} - c_A) \cdot 1 = (\Delta c - \Delta p^{max})$ and $\pi_B^{**} = 0$. Note that for $\Delta p^{**} = \Delta p^{max}$ setting $p_B = c_B$ is the local best response of firm B.

We consider a non-local deviation by firm A to $p_A = c_B$. The associated profit is $(c_B - c_A)\phi(0)$ at $p_A = c_B$. Hence, a sufficient condition for the non-existence of non-interior equilibria is

$$\Delta c - \Delta p^{max} \leq (c_B - c_A)\phi(0) = \frac{\Delta c}{2}.$$

This is equivalent to

$$\Delta c \leq 2\Delta p^{max}.$$

For $\lambda \in (1, 1 + 2 \cdot \sqrt{2}]$, Δp^{max} is equal to $\Delta\tilde{p}(\lambda) = (\lambda + 3)t/(2(\lambda + 1))$, which completes the proof. □

Combining Lemmata 4 and 5 we obtain the following proposition:

Proposition 9. *For $\Delta c < \min\{\Delta c^u, \Delta c^{ni}\}$, any equilibrium is unique and interior.*

B.2 Equilibrium existence

For any interior solution, concavity of the profit functions would assure that the solution characterizes an equilibrium.

$$\frac{\partial^2 \pi_A}{\partial p_A^2} = -2\phi' + (p_A - c_A)\phi'' < 0 \tag{SOC_A}$$

$$\frac{\partial^2 \pi_B}{\partial p_B^2} = -2\phi' - (p_B - c_B)\phi'' < 0. \tag{SOC_B}$$

Given the properties of ϕ —particularly that ϕ is strictly increasing and convex in Δp for $\beta < 1$— SOC_B holds globally, while SOC_A is not necessarily satisfied. Using that

$(p_A - c_A) = \phi/\phi'$ by FOC_A, SOC_A can be expressed as follows

$$-2(\phi')^2 + \phi\phi'' < 0. \tag{27}$$

It can be easily shown that (27) is satisfied for small Δp, while it is violated for $\Delta p \to \Delta\bar{p}$, as ϕ'' goes faster to infinity in Δp than $(\phi')^2$.[30] This violation of SOC_A reflects that firm A may have an incentive to non-locally undercut prices to gain the entire demand of uninformed consumers when Δp is large. The driving force behind this is that loss aversion in the price dimension increasingly dominates loss aversion in the taste dimension if price differences become large. Moreover, excessive losses in the price dimension if buying the expensive product B make also nearby consumers of B more willing to opt for product A.

The next proposition clarifies the issue of equilibrium existence. It deals with the non-quasiconcavity of firm A's profit function by determining critical levels of market asymmetries and the degree of loss aversion such that firm A has no incentive to non-locally undercut prices. Here, we make use of the increasing convexity of firm A's profit function in $-p_A$ which yields that stealing the entire demand of uninformed consumers is the unique optimal deviation of firm A. For notational convenience, we focus on the most critical setting for equilibrium existence. This is the one in which all consumers are uninformed.[31]

Proposition 10. *Suppose all consumers are uninformed ($\beta = 0$) and the degree of loss aversion, λ, lies within the interval $(1, 1 + 2\sqrt{2}]$. An interior equilibrium with prices (p_A^*, p_B^*) exists if and only if*

$$\Delta c \leq \Delta c^{nd}(\lambda) \equiv \Delta p^{nd}(\lambda) - f(\Delta p^{nd}(\lambda); 0), \tag{28}$$

with $\Delta p^{nd}(\lambda)$ being implicitly determined by the following non-deviation condition

$$\Delta p^{nd}(\lambda) = \left\{0 \leq \Delta p < \Delta p^{max} \mid \Delta p = \Delta p^{max} - \frac{\phi(\Delta p) \cdot (1 - \phi(\Delta p))}{\phi'(\Delta p)}\right\}. \tag{29}$$

Before turning to the proof, let us comment on this proposition. The result shows that an equilibrium exists if firm A has no incentive to non-locally undercut prices. In fact,

[30] This implies that π_A is not globally concave. It is easy to check that it is neither globally quasi-concave. This is illustrated in Figure 5. Moreover, the non-concavity of π_A is increasing in Δp (resp. $-p_A$) for $\Delta p \leq \Delta p^{max}$ (resp. $p_A \geq p_B - \Delta p^{max}$).

[31] Adding more informed consumers always makes the non-quasiconcavity problem less severe since the demand of informed consumers is linear. Thus, the derived upper bound on cost asymmetries with only uninformed consumers is sufficient for existence with a positive share of informed consumers.

the incentive to undercut prices increases in more asymmetric industries or for more loss-averse consumers. For a low degree of loss aversion ($1 < \lambda < 1 + 2\sqrt{2} \approx 3.828$), an equilibrium exists if the cost difference between firms is not too large (see (28)).[32] In this case, an equilibrium exists for all values of β. However, if the degree of loss aversion rises further, equilibria only exist if there is a sufficiently large share of informed consumers which reduces the undercutting incentive of firm A. This tradeoff is illustrated in Table 1 below.

Table 1: Non-deviation condition

Variation of Δp^{nd} and Δc^{nd} in β and λ. ($t = 1$)

	$\lambda = 3$		$\lambda = 6$		$\lambda = 9$	
β	$\Delta p^{nd}(\lambda,\beta)$	$\Delta c^{nd}(\lambda,\beta)$	$\Delta p^{nd}(\lambda,\beta)$	$\Delta c^{nd}(\lambda,\beta)$	$\Delta p^{nd}(\lambda,\beta)$	$\Delta c^{nd}(\lambda,\beta)$
0.8	0.648337	1.75869	0.372669	1.07069	0.294726	0.857815
0.6	0.543254	1.45317	0.23824	0.686206	0.150303	0.440498
0.4	0.459237	1.22329	0.107415	0.314749	0.000320	0.000959
0.2	0.377489	1.00993	-	-	-	-
0.0	0.278889	0.75963	-	-	-	-

In the proof we first provide the critical level of Δc for which the equilibrium condition in (10) is satisfied for candidate interior equilibria. We next identify the set of candidate interior equilibria which are robust to local and non-local price deviations of firm A.

Proof of Proposition 10.

1. To find an upper bound on Δc for which the equilibrium condition (10) is satisfied we determine the point at which $f(\Delta p; \beta)$ is a tangent on the Δp-line. In Figure 4 this corresponds to an upward shift of the $f(\Delta p; \beta)$-curve.
   Tangent condition:

$$f'(\Delta p; \beta) = 1 \qquad \Leftrightarrow \qquad 3(\phi')^2 + \phi''(1 - 2\phi) = 0 \tag{30}$$

   It is sufficient to consider $\beta = 0$ as the most problematic case with respect to existence. The reason is that for $\beta > 0$ there is a positive weight on the demand of

[32] Note that according to experimental work on loss aversion λ takes the value of approximately 3, which is within this range.

informed consumers which is linear. Denote the critical price difference that satisfies (30) at $\beta = 0$ as $\Delta p^{ta}(\lambda)$. We note that it is decreasing in λ.

Then, the equilibrium condition in (10) is fulfilled if and only if Δc satisfies the following condition

$$\Delta c \leq \Delta c^{ta}(\lambda) \equiv \Delta p^{ta}(\lambda) - f(\Delta p^{ta}(\lambda); 0). \tag{31}$$

$\Delta c^{ta}(\lambda)$ is uniquely determined by $\Delta p^{ta}(\lambda)$, using equilibrium condition (10) because at the tangent point there is a one-to-one relationship between the two variables.[33]

2. At this step, we show that a solution to the first-order condition is a local maximizer. Suppose, by contrast, that, at $\Delta p = \Delta p'$, SOC_A is not satisfied. Then, at $\Delta p'$, firm A's profit takes a minimum and $\Delta p'$ cannot be an equilibrium. Now, define $\Delta p^s(\lambda)$ as the critical price difference which satisfies the second-order condition of firm A (27) with equality. There is a unique $\Delta p^s(\lambda)$ for any given λ because the convexity of π_A is strictly decreasing in p_A. Thus, SOC_A holds for $\Delta p \leq \Delta p^s(\lambda)$. We next show that SOC_A implies the tangent condition—i.e., $\Delta p^s(\lambda) < \Delta p^{ta}(\lambda)$. Rearranging (27) and (30) leads to

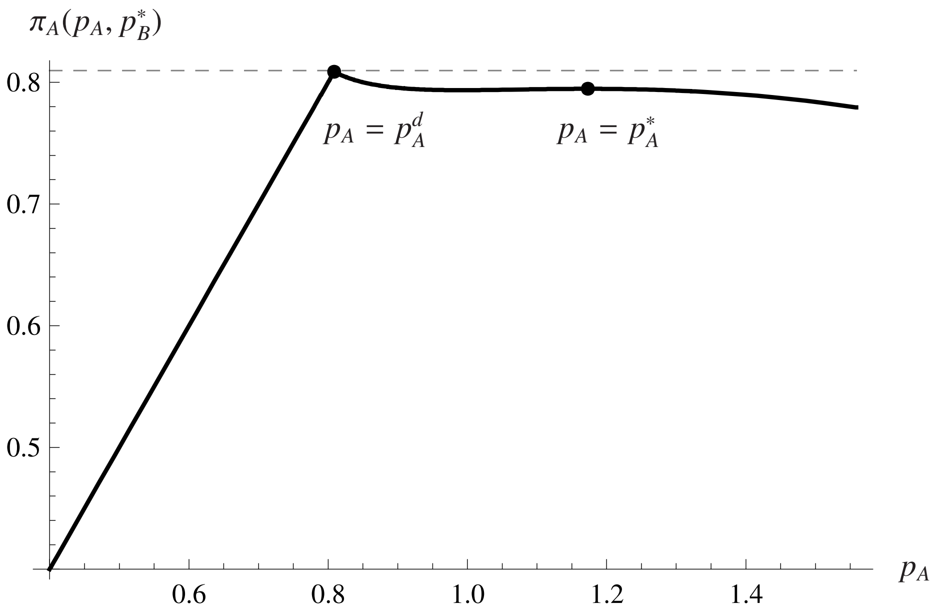
$$\frac{\phi}{2} \leq \frac{(\phi')^2}{\phi''}, \tag{27'}$$

$$\frac{(2\phi - 1)}{3} \leq \frac{(\phi')^2}{\phi''}. \tag{30'}$$

Hence, $\Delta p^s(\lambda) < \Delta p^{ta}(\lambda)$ holds if and only if $\phi/2 > (2\phi - 1)/3$. This inequality is satisfied for all $\phi \in [1/2, 1]$.

3. Due to the increasing convexity of π_A in $-p_A$ a candidate interior equilibria which locally satisfy SOC_A might be ruled out as an equilibrium because a non-local deviation may be profitable. This is the case when the convexity is sufficiently large: A non-local price decrease becomes a profitable deviation for firm A—an example of this kind is presented in Figure 5. Given the increasing convexity of π_A, the unique optimal deviation of firm A (if it exists) is characterized by firm A serving the entire market of uninformed consumers—i.e., p_A^d such that $\Delta p^d = \Delta p^{max}$. Decreasing p_A^d further is not profitable since firm A does not attract more marginal consumers, while its profit margin goes down for all inframarginal consumers. Hence, in the following we will restrict our attention to price deviations by firm A that steal the

[33] For $\Delta c^u(\lambda) \leq \Delta c < \Delta c^{ta}(\lambda)$ there might arise two candidate interior equilibria. However as we see next, the second one does not survive the local SOC_A criterion.



Profit of firm A, $\pi_A(p_A, p_B^*)$, as a function of its own price p_A given $p_B = p_B^*$ for $\Delta c = 1$ ($c_A = 0, c_B = 1$) and parameter values of $\beta = 0$, $t = 1$, and $\lambda = 3$: $p_A^* = 1.17309$, $p_A^d = p_B^* - \Delta p^{max} = 0.80863$, $p_B^* = 1.55863$, $\Delta p^* = 0.385537$, and $\Delta p^{max} = \Delta\tilde{p} = 3/4$.

Figure 5: Non-existence

entire demand of uninformed consumers. If deviating is profitable, firm A sets $p_A^d = p_B^* - \Delta p^{max}$. For $\beta = 0$, firm A's deviation profit π_A^d is equal to $(p_A^d - c_A) \cdot 1$ since $\phi(\Delta p^{max}; 0) = 1$. Using that $p_A^d = p_B^* - \Delta p^{max}$ we receive

$$\begin{aligned} \pi_A^d = & \left(p_B^* - \Delta p^{max} - c_A\right) \cdot 1 & \\ = & \left(\frac{1-\phi}{\phi'} + \Delta c - \Delta p^{max}\right) \cdot 1 & \text{by } FOC_B \\ = & \left(\Delta p^* + \frac{\phi}{\phi'} - \Delta p^{max}\right) \cdot 1 & \text{by (10)} \end{aligned} \tag{32}$$

For the candidate interior equilibrium, firm A's profit is equal to $\pi_A(\Delta p^*) = (p_A^* - c_A)\phi$, which in turn is equal to ϕ^2/ϕ' by FOC_A.

Thus, a deviation of firm A is not profitable if and only if $\pi_A(\Delta p^*) \geq \pi_A^d$. Rearranging yields

$$\Delta p^* \leq \Delta p^{max} - \frac{\phi \cdot (1-\phi)}{\phi'}. \tag{33}$$

This is the required non-deviation condition. We define $\Delta p^{nd}(\lambda)$ as the non-trivial solution different from Δp^{max} to (33) holding with equality. We have

$$\Delta p^{nd}(\lambda) = \Delta p^{max} - \frac{\phi(\Delta p^{nd}(\lambda); 0) \cdot \left(1 - \phi(\Delta p^{nd}(\lambda); 0)\right)}{\phi'(\Delta p^{nd}(\lambda); 0)}.$$

Lemma 6 below shows that $\Delta p^{nd}(\lambda)$ is uniquely determined by this non-deviation condition if the trivial solution, Δp^{max}, is excluded. Furthermore, the set of non-negative $\Delta p^{nd}(\lambda)$ is non-empty for $\lambda \in (1, 1 + 2\sqrt{2}]$.

Again by using the equilibrium condition (10), an interior equilibria exists if and only if $\Delta c \leq \Delta c^{nd}(\lambda) \equiv \Delta p^{nd}(\lambda) - f(\Delta p^{nd}(\lambda))$.[34]

4. Taken together, due to increasing convexity of π_A, the non-deviation condition implies local concavity of the firms' profit function and therefore, as shown above, the tangent condition. Thus any price difference resulting from a candidate interior equilibrium which satisfies the non-deviation condition can be supported in equilibrium, as $\Delta p^{nd}(\lambda) < \Delta p^{s}(\lambda) < \Delta p^{ta}(\lambda) < \Delta p^{max}(\lambda)$. This provides a bound on the admissible cost asymmetry that is given in the proposition.

□

Lemma 6. *For $\beta = 0$ and $\lambda \in (1, 1 + 2\sqrt{2}]$, $\Delta p^{nd}(\lambda)$ is the unique non-trivial solution (i.e., $\Delta p \neq \Delta p^{max}$) to the non-deviation condition in* (29)*,*

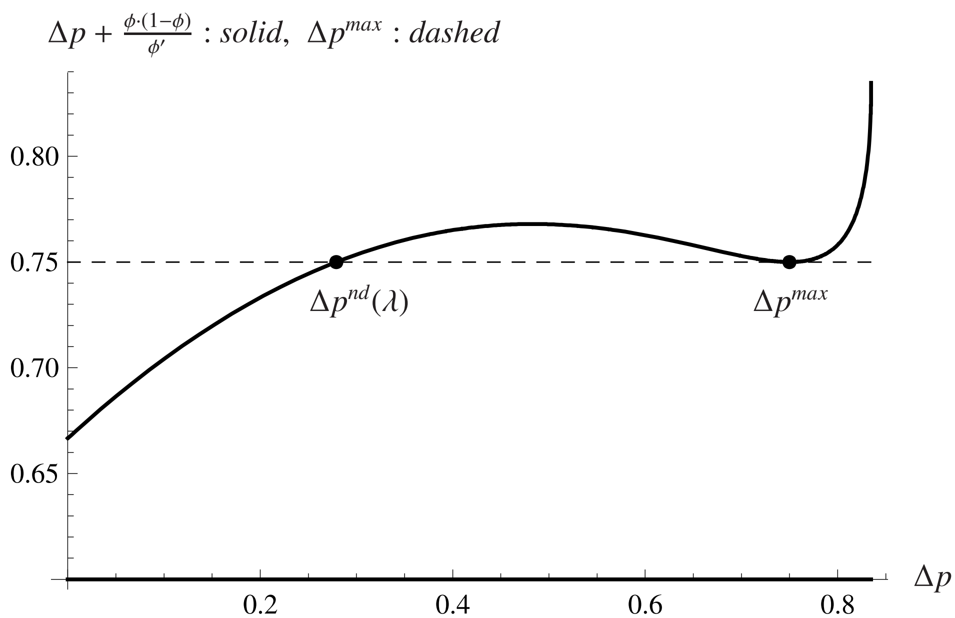
$$\Delta p = \Delta p^{max} - \frac{\phi(\Delta p; \beta) \cdot (1 - \phi(\Delta p; \beta))}{\phi'(\Delta p; \beta)}.$$

Moreover, $\Delta p^{nd}(\lambda)$ is non-negative.

Proof of Lemma 6. Note that the non-deviation condition is trivially satisfied at $\Delta p = \Delta p^{max}$ since $\phi(\Delta p^{max}; \beta) = 1$ for $\beta = 0$ (see Figure 6 below for a graphical illustration of the non-deviation condition). It can be shown that $A(\Delta p) \equiv \Delta p + \phi(1 - \phi)/\phi'$ approaches Δp^{max} from above for $\Delta p < \Delta p^{max}$. For $\Delta p \geq 0$ but Δp being small, $A(\Delta p)$ is strictly increasing and strictly concave. Moreover, $A(\Delta p)$ is continuous and exhibits at most one maximum for $\Delta p \in [0, \Delta p^{max})$. Taken together, there exists a unique $\Delta p \in [0, \Delta p^{max})$ at

[34] For $\beta > 0$ we have to be more careful to have a uniqueness statement. Fix some $\beta > 0$. For $\Delta c^{u}(\lambda) \leq \Delta c < \Delta c^{nd}(\lambda)$ (where, in an abuse of notation, the latter critical value is adjusted for β), the equilibrium condition (10) may not make a unique selection—i.e., there might arise a second solution to (10), Δp^{**}. This solution can be ruled out because, by construction, Δp^{**} is larger than $\Delta p^{ta}(\lambda)$ and, hence, larger than $\Delta p^{nd}(\lambda)$. The unique interior equilibrium that survives the non-deviation condition would be selected by the following existence criterion $\Delta c < \min\{\Delta c^{nd}(\lambda), \Delta c^{u}(\lambda)\}$.

which the non-deviation condition is satisfied if and only if, at $\Delta p = 0$, $A(\Delta p)$ is smaller or equal than Δp^{max}. For $\beta = 0$, $A(0) = (\lambda+3)/(4t(\lambda+1))$ and $\Delta p^{max} = \Delta\tilde{p} = (\lambda+3)t/(2(\lambda+1))$. It is easy to check that $A(0) \leq \Delta p^{max}$ if and only if $\lambda \in (1, 1+2\sqrt{2}]$. Denoting the solution to the non-deviation condition by $\Delta p^{nd}(\lambda)$ completes the proof.[35] □



Non-deviation condition of firm A, as a function of the price difference Δp for $\Delta c = 0.25$ ($c_A = 0.25, c_B = 0.5$) and parameter values of $\beta = 0$, $t = 1$, and $\lambda = 3$: $\Delta p^{nd}(3) = 0.27889$, $\Delta c^{nd}(3) = (\Delta p^{nd}(3) - f(\Delta p^{nd}(3); 0)) = 0.75963$, $\Delta p^{max} = \Delta\tilde{p} = 3/4$, and $\Delta\bar{p} = 0.83485$. Non-deviation for $\Delta p \leq \Delta p^{nd}(3) = 0.27889$.

Figure 6: Non-deviation in asymmetric industries

If the degree of loss aversion becomes sufficiently high ($\lambda > 1 + 2\sqrt{2} \approx 3.828$), the set of non-negative $\Delta p^{nd}(\lambda)$ becomes empty. Here deviating is profitable even for symmetric industries ($\Delta c = 0$). However, restricting the share of uninformed consumers can reinforce existence of symmetric equilibria in this case.

To provide a concrete numerical example on equilibrium existence and uniqueness, for $\lambda = 3$, $t = 1$ and $\beta = 0$, the following price differences arise $\Delta p^{nd}(3) = 0.27889$, $\Delta p^{u}(3) = 0.31072$, $\Delta p^{s}(3) = 0.48259$, $\Delta p^{ta}(3) = 0.69532$, $\Delta p^{max} = \Delta\tilde{p} = 0.75$, and $\Delta\bar{p} = 0.83485$. Moreover, $\Delta c^{nd}(3)$ is equal to $(\Delta p^{nd}(3) - f(\Delta p^{nd}(3); 0)) = 0.75963$—i.e., an equilibrium exists for $\Delta c < 0.75963$. The other critical values are $\Delta c^{u}(3) = 0.83485$, $\Delta c^{ta}(3) = 1.40396$, and $\Delta c^{ni}(3) = 1.5$. Since $\Delta c^{nd}(3) < \Delta c^{u}(3)$ the equilibrium is the unique interior equilibrium. Since $\Delta c^{nd}(3) < \Delta c^{ni}(3)$ there does not exist a non-interior equilibrium. For

[35] We receive $\Delta p^{nd}(1 + 2\sqrt{2}) = 0$ and, for $\lambda \to 1$, $\Delta p^{nd}(\lambda) \to \Delta p^{max}$.

equilibrium values at $\Delta c = 0.25$ and 0.75 see Tables 2 and 3 in Appendix C. An example for non-existence at $\beta = 0$ is provided in Figure 5 with $\Delta c = 1$.

C Tables

Table 2: Small Cost Differences:

The table shows the analytical solution of the market equilibria for parameter values of $t = 1$, $\lambda = 3$, $c_A = 0.25$, $c_B = 0.5$:

β	$p_A^*(\beta)$	$p_B^*(\beta)$	$\Delta p^*(\beta)$	$q_A(\Delta p^*)$	$\hat{x}_{in}(\Delta p^*)$	$\hat{x}_{un}(\Delta p^*)$	π_A^*	π_B^*	CS^*	CS_{in}^*	CS_{un}^*
1.0	1.33333	1.41667	0.0833333	0.541667	0.541667	0.532453	0.586806	0.420139	1.37674	1.37674	1.16648
0.8	1.37274	1.45643	0.0836887	0.539995	0.541844	0.532597	0.606272	0.439961	1.29508	1.33717	1.12672
0.6	1.41524	1.49932	0.0840806	0.538326	0.54204	0.532755	0.627281	0.461361	1.21022	1.29448	1.08382
0.4	1.46121	1.54572	0.0845149	0.536662	0.542257	0.532931	0.650008	0.484522	1.12178	1.24832	1.03742
0.2	1.51103	1.59603	0.0849986	0.535002	0.542499	0.533127	0.674653	0.509652	1.02934	1.19828	0.987112
0.0	1.56518	1.65072	0.0855405	0.533347	0.54277	0.533347	0.701446	0.536986	0.932421	1.14388	0.932421

Table 3: Intermediate Cost Differences

The table shows the analytical solution of the market equilibria for parameter values of $t = 1$, $\lambda = 3$, $c_A = 0.25$, $c_B = 1$:
Prices of both firms are first increasing and then decreasing in β.

β	$p_A^*(\beta)$	$p_B^*(\beta)$	$\Delta p^*(\beta)$	$q_A(\Delta p^*)$	$\hat{x}_{in}(\Delta p^*)$	$\hat{x}_{un}(\Delta p^*)$	π_A^*	π_B^*	CS^*	CS_{in}^*	CS_{un}^*
1.0	1.5	1.75	0.25	0.625	0.625	0.605992	0.78125	0.28125	1.14063	1.14063	0.834921
0.8	1.5039	1.758	0.254109	0.62324	0.627054	0.60798	0.781477	0.285586	1.07357	1.13519	0.827071
0.6	1.50553	1.76414	0.25861	0.621651	0.629305	0.61017	0.780502	0.289112	1.00758	1.13188	0.821115
0.4	1.50448	1.76803	0.263546	0.62026	0.631773	0.612585	0.778104	0.29165	0.942908	1.13111	0.81744
0.2	1.50029	1.76925	0.26896	0.619097	0.63448	0.615251	0.774048	0.293008	0.879835	1.13332	0.816464
0.0	1.49248	1.76737	0.274896	0.618194	0.637448	0.618194	0.768092	0.292988	0.818625	1.13897	0.818625

Table 4: Large Cost Differences:

The table shows the analytical solution of the market equilibria for parameter values of $t = 1$, $\lambda = 3$, $c_A = 0.25$, $c_B = 1.25$: Non-existence for $\beta = 0$ (see Figure 5). $q_A(\Delta p^*)$ is decreasing in β—i.e., uninformed consumers are easier to attract than informed consumers. Reason: Due to large price differences loss aversion in price dimension dominates loss aversion in taste dimension. Uninformed consumers are more willing to buy the less expensive product.

β	$p_A^*(\beta)$	$p_B^*(\beta)$	$\Delta p^*(\beta)$	$q_A(\Delta p^*)$	$\hat{x}_{in}(\Delta p^*)$	$\hat{x}_{un}(\Delta p^*)$	π_A^*	π_B^*	CS^*	CS_{in}^*	CS_{un}^*
1.0	1.58333	1.91667	0.333333	0.666667	0.666667	0.648371	0.888889	0.222222	1.02778	1.02778	0.673468
0.8	1.5623	1.90417	0.341863	0.66734	0.670931	0.652973	0.875753	0.217615	0.974147	1.04598	0.686806
0.6	1.5361	1.88738	0.351282	0.668631	0.675641	0.658117	0.859926	0.211208	0.923306	1.06911	0.7046
0.4	1.5043	1.86596	0.361666	0.670654	0.680833	0.663868	0.841199	0.202865	0.87537	1.09757	0.727236
0.2	1.46663	1.83971	0.373075	0.673535	0.686538	0.670284	0.819444	0.192519	0.830299	1.13163	0.754968
0.0	-	-	-	-	-	-	-	-	-	-	-

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